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Abstract

Wireless communication is growing day by day to satisfy the need for voice and high data speed from the industry and users. To meet this demand we are upgrading communication system to 5G networks. This new technology has raised the demand of high data rate with voice and Quality of service (QoS) of signal parameters. These all also leads to the requirement of energy requirements. This high requirements also creates many issues related to human health and environment congestions. This paper is addressing the issue and challenges related to energy consumption, challenges in the development of low energy network, green energy concept in every parameter of 5G communication. We need to make a way to maintain demand and supply ration with green energy in all aspects. Here in this paper survey is done for the energy and resource relevant parameter and techniques for various domain like spectrum allocation and sharing, network density at different level, antenna designs, Internet of things (IoT) future applications, cell traffic, hardware solutions, resource allocations, energy harvesting and transfer, deployment and planning. In this paper, we address the effect of high energy requirement in upcoming 5G technology, the effect of high energy and power on the environment, green energy solution on different parameters and designs.

Keywords: Green Communication; 5G Communication; IoT; Renewable energy[Suggested Citation >](#)[Show Contact Information >](#)

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This paper focuses on an efficient method to recognize the English alphabets written in real time. For a perfect documented work or even for the formal written communication, a writer is expected to minimize the literature mistakes, i.e., spelling mistakes, grammatical errors, punctuation mark misplaced, etc. It would be interesting to device some technique if such mistakes could be recognized by non-human intervention in case of handwriting. Hence, a training-less system has been developed that is capable of recognizing the English alphabets in the real time and thereby the words, and make the suggestions to the writer regarding the wrong word. We have designed a digital pen which has an accelerometer and uses an efficient algorithm for the detection of the English letters. The technique is simple, based on the waveform analysis of the strokes made while writing a letter, the digital pen recognized the letters with the accuracy of 84% which after inclusion of the nearest mapping algorithm leads to the efficiency of over 96%. In this paper we discuss results only pertaining to recognition of capital alphabets which is not written in cursive writing style.

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SEISMIC RESPONSE ANALYSIS OF PARALLEL STRUCTURES COUPLED BY FRICTION DAMPERS SUPPORTED ON DIFFERENT TYPES OF SOIL

C C PATEL¹

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ABSTRACT The friction damper with appropriate parameters is effective for seismic response control of parallel connected structures, assuming both structures are supported on the stiff ground and neglecting soil-structure interaction. In reality, the stiff ground will not always be found at the site. In this paper, the seismic performance of friction damper connecting dynamically the dissimilar parallel structures supported on different types of soil is studied. The governing equations of motion for coupled structures considering soil parameters have been formulated. The response of structures connected by friction damper with optimum parameters, supported on different types of soil, subjected to real earthquake ground excitations is investigated. The results indicate that decrease in soil stiffness affects the performance of friction damper for seismic response control of parallel coupled structures. The nature of ground motion excitation also affects the performance of friction damper connecting parallel structures supported on different types of soil.

Keywords: *Friction damper, Passive control, Parallel structures, Seismic effect, Soil-structure interaction*

INTRODUCTION

To protect the structures against random nature natural disturbances like strong wind and earthquake loads is challenging task for the civil engineering community. The seismic protection can be achieved by conventional design approach of designing a structure with adequate ductility to absorb excessive energy during natural disturbances, sufficient strength to withstand natural forces and appropriate stiffness to maintain structural integrity and serviceability. Seismic protection by implementing energy dissipation devices and control mechanisms into structures is another effective alternate to the conventional design approach. These control strategies are able to modify dynamically the response of structure in a desirable manner, thereby termed as protective systems for the new structures and the existing structures can be retrofitted or strengthened effectively to withstand future seismic events. According to energy consumptions during their operation, control systems can be classified as an active, passive, semi-active and hybrid system. The passive control devices do not require any external power for their operation and offers the control forces at the location of passive devices. The various passive

control mechanisms are friction dampers, viscous dampers, visco-elastic dampers, tuned liquid dampers tuned mass dampers. The current status of passive control of buildings in Japan by Kasai *et. al.* [1], a full-scale damper tests and analysis in 5 story steel frame by Kasai *et. al.* [2] and many others confirm the effectiveness of passive energy dissipation devices for seismic protection.

Friction damper devices are displacement dependent control devices; dissipate input energy through frictional work. The friction damper is nearly unaffected by the number of applied loading cycles, loading amplitude, and temperature, and exhibits non-linear behavior. Friction damper has advantages such as simple mechanism, low cost, less maintenance, powerful energy dissipation capacity as compared to other devices, and insensitivity to the frequency content of excitation.

Amongst the various control techniques, connecting parallel structures (if possible) using appropriate mechanisms is an effective alternate for seismic protection. The concept is to exert control force upon one another to reduce the overall response of the dynamically dissimilar coupled structures, but alter the dynamic characteristics of the unconnected structures, enhances undesirable torsional response, when the structures have asymmetric geometry and increases the base shear of the stiff structure.

Bhaskararao and Jangid [3] studied the harmonic response of two adjacent single-degree-of-freedom (SDOF) structures connected with friction damper. They found that the response to be periodic, occurring under three different modes of vibration. Bhaskararao and Jangid [4] have investigated the seismic response of two adjacent multi-degree-of-freedom (MDOF) buildings connected with friction damper with same slip force in all dampers as well as different slip force of friction damper. They found that by appropriate slip force of friction damper connecting the adjacent buildings of different fundamental frequencies, reduces the responses of the building effectively. During the above and many other coupled structures analysis studies, they assumed that coupled buildings are supported on rigid soils and effects of soil-structure interaction (SSI) are neglected.

From the studies of the earthquakes, the period of the supporting soil is also important parameter regarding the seismic response of the structure is the concern. The behavior of the structure partly dependent on the nature of the supporting soil and similarly the behavior of the supporting stratum is modified by the presence of the structure. The soil structure interaction may be considered as the interdependent response relationship between a structure and its supporting soil. The stiffness and mass properties of the structure, as well as stiffness of soil, are responsible for the nature and amount of the interaction. The interaction effect, associated with the stiffness properties of the structure is termed as kinematic interaction and corresponding to the mass of the structure is termed as inertial effect [5]. The response of the structure may influence by sub-soil in the ways like, (i) the seismic excitations from the bedrock may be attenuate or amplify during the transmission through overlaying soil to the foundation, (ii) the presence of the soil overlaying bedrock may change the dynamic properties of the fixed base structures and

(iii) the material damping and radiation damping may dissipate significant amount of vibration energy of the flexibly supported structures in the supporting medium. In a seismic area, for heavy and slender buildings, rigid foundation structures are normally used. When the structure is subjected to ground motion, the building foundation is forced to displace horizontally due to base shear, and to rotate at the base due to overturning moments set by the horizontal inertial forces in the mass of the building by ground acceleration. These effects cannot be neglected are more important when structure subject to strong ground motion. In short, it can be said that the ground motion experienced by structures is a function of the earthquake source, local site effects, travel path effects and SSI effects.

In the present study, two parallel MDOF structures connected by friction dampers are analyzed. The objective of the study is to (i) formulate the equations of motion for the damper connected system on soil, (ii) investigate the response of coupled system considering supported on different types of soil, and (iii) to determine the performance of the friction damper connecting the parallel structures.

MODELING OF CONNECTED SYSTEM WITH SSI

Let two structures, Structure 1 and Structure 2 have 6 and 3 stories, respectively connected with friction damper with rigid foundation slab, resting on the soil as shown in Fig. 1, with mass, damping coefficient and shear stiffness values for i^{th} storey are m_{i1}, c_{i1} and k_{i1} for Structure 1 and m_{i2}, c_{i2} and k_{i2} for Structure 2, respectively. Let f_s be the limiting force in friction damper also termed as slip force. Depending upon the system parameters and excitation level, the friction interface may remain in stick condition (non-slip mode) or slip condition (slip mode). The two structures are assumed to be symmetric with their symmetric planes of the structures so that the problem can be simplified as a two-dimensional problem as shown in Fig. 1. Both structures are assumed to be subjected to the same ground acceleration \ddot{x}_g ; the governing equation of motion for coupled structure resting on rigid ground can be written as

$$M\ddot{x} + C\dot{x} + Kx + \Lambda F = -MI\ddot{x}_g \quad (1)$$

where M, C and K are the mass, damping and stiffness matrices of the combined structure system, respectively; x is relative displacement vector with respect to the ground, and the first 6 position is Structure 1's displacement and last 3 position is Structure 2's displacement; \dot{x} and \ddot{x} represent the first and second time derivatives of x , respectively; $F = \{f_{d1}, f_{d2}, f_{d3}\}^T$ is friction damper force vector; Λ is a matrix of zeros and 1s, where 1 will indicate where the damper force is being applied; I is a vector with all its element equal to unity. Let x_0 and θ_0 be the translation and rotation of the foundation, respectively. The rotational component of ground motion is neglected. The

rotational degree of freedom of the Structure 1 and 2 are also neglected. The soil stiffness and damping to horizontal motion are k_s, c_s ; and to that of rocking motion are k_θ, c_θ . Let h_i is height of i^{th} degree of freedom. The governing equations of motion for the coupled system on soil can be written as, following two additional equations along with Eq. (1).

$$\sum_{i=1}^9 m_i \ddot{x}_i + \sum_{i=1}^9 m_i \ddot{x}_g + \sum_{i=1}^9 m_i \ddot{x}_0 + \sum_{i=1}^9 m_i h_i \ddot{\theta}_0 - c_s \dot{x}_0 - k_s x_0 = 0 \quad (2)$$

$$\sum_{i=1}^9 m_i h_i \ddot{x}_i + \sum_{i=1}^9 m_i h_i \ddot{x}_g + \sum_{i=1}^9 m_i h_i \ddot{x}_0 + \sum_{i=1}^9 m_i h_i^2 \ddot{\theta}_0 - c_\theta \dot{\theta}_0 - k_\theta \theta_0 = 0 \quad (3)$$

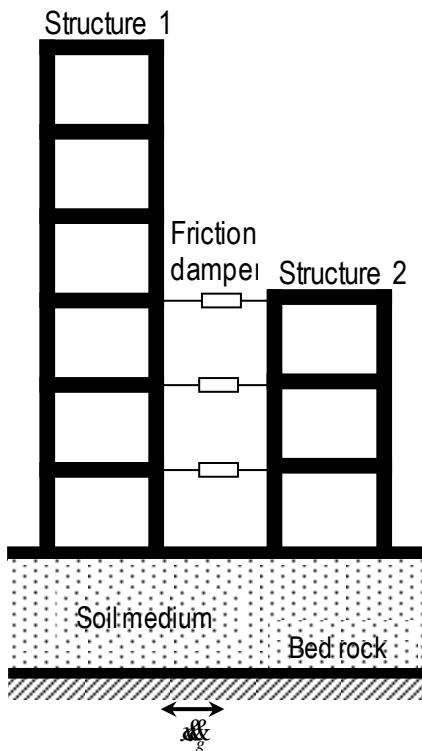


Figure 1. Two parallel structures connected by friction dampers

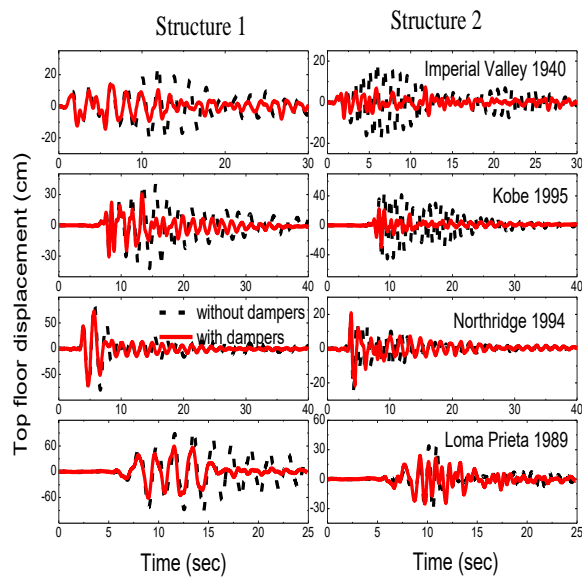


Figure 2. Time history of top floor displacement response of parallel structures connected with friction damper supported on rigid ground

For considered structures, the masses of two structures were assumed to be same, and the damping ratio in each structure was taken as 2 percent. The stiffness of each floor of the structures was chosen so that they would yield fundamental time periods of 2 sec (soft

structure) and 1 sec (stiff structure) for Structure 1 and Structure 2, respectively. For the uncontrolled system the first three natural frequencies corresponding to first three modes of the Structure 1 are 3.1416, 9.2423, 14.8059 rad/sec, and that of the Structure 2 are 6.2832, 17.6052, 25.4402 red/sec, respectively. The floor height of each floor is considered 3.2 m. The soil stiffness and damping for translational and rocking motion are considered according to Tongaonkar and Jangid [6]. The earthquake time histories considered are: Imperial Valley (1940) with peak ground acceleration (PGA) 0.32g (g is acceleration due to gravity), Kobe (1995) with PGA 0.63g, Northridge(1994) with PGA 0.84g, and Loma Prieta (1989) with PGA 0.57g. To investigate the effect of soil condition on the performance of friction damper, the seismic response of the structures are calculated for the cases; Case-I uncontrolled structures on rigid ground; Case-II structures are connected with friction damper of optimum slip force for response supported on rigid ground and Case-III structures are connected with friction damper of optimum slip force for response supported on soft ground. The time histories of the top floor displacement and top floor acceleration response of connected structures on rigid ground for considered earthquake are shown in Fig. 2. The reduction in the peak displacement response and peak acceleration response of the structure, for uncontrolled structure on rigid ground; structures are connected with damper of optimum slip force, supported on rigid ground; and structures are connected with damper of optimum slip force for response supported on soft soil are shown in Table 1. It is observed that friction damper is effective for seismic response control of parallel connected structures. However, when coupled structures are supported on soft ground the percentage reduction in seismic response of the parallel structures connected by friction damper of optimum slip force decreases. The decrease in damper efficiency is different for different earthquake. Thus, the soil condition affects the damper performance, and soft soil decreases the effectiveness of the friction damper for seismic response control fo parallel coupled structures.

CONCLUSIONS

The dynamic behavior of two MDOF parallel structures connected with friction damper supported on different types of soil subjected to real earthquake ground motion excitations is studied. From the trends of the results following conclusions are drawn.

- (1) The friction damper is found to be effective for seismic response control of parallel connected structures.
- (2) The decrease in soil stiffness decreases the performance of friction damper for seismic response of coupled structures.
- (3) Dynamically dissimilar structures balancing the base shear and moment at the base of both the structure results the percentage reduction of controlled response of structure supported on different soil is very small.
- (4) On different soil conditions, the performance of friction damper also affected by ground motion excitations

Table 1. Seismic response of friction damper connected parallel structures supported on different soil medium

Earthquake	System	Displacement response		Acceleration response	
		x_1 (cm)	x_2 (cm)	$\frac{a_2}{a_1}$ (g)	$\frac{a_3}{a_1}$ (g)
Imperial Valley, 1940	Case – I	26.06	18.08	0.505	0.76
	Case – II	16.73(35.81)#	07.35(59.33)	0.37(26.60)	0.46(39.17)
	Case – III	17.93(31.20)	9.00(50.23)	0.383(24.21)	0.50(34.57)
Kobe, 1995	Case – I	41.24	46.22	1.26	2.23
	Case – II	28.16 (31.73)	24.85(46.23)	1.11(10.65)	1.56(30.05)
	Case – III	29.61(28.20)	26.89(41.82)	1.15(8.79)	1.64(26.36)
Northridge, 1994	Case – I	89.37	27.25	1.489	1.58
	Case – II	69.90(21.76)	24.49(10.12)	1.29(13.55)	1.63(-3.44)
	Case – III	71.59(19.89)	25.04(8.10)	1.32(11.09)	1.61(-1.89)
Loma Prieta, 1989	Case – I	92.52	33.87	2.10	1.51
	Case – II	69.08(25.34)	29.11(14.04)	1.25(40.46)	1.404(07.24)
	Case – III	72.67(21.46)	30.25(10.68)	1.41(32.98)	1.419(06.01)

The value within parenthesis indicates percentage reduction

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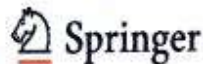
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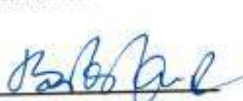


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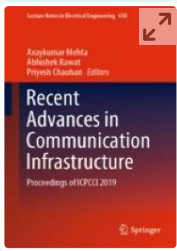
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Wide usage of internet and connectivity of more devices on the wireless network increases the usage of TCP layer that increases heavily leading to congestion. Congestion in the network is responsible for heavy traffic, increasing delay, and packet loss, which reduces the quality of service. Various techniques are developed for congestion control in dense traffic networks. Random early detection (RED) is one of the widespread techniques for congestion control. In this article,

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Keywords

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In today's developing technology, industries are playing important role for the betterment of life and society. But in industries many functions are running under hazardous conditions, so demand of human free interaction arises, which can be fulfilled by robotics. In Chemical, Oil & Gas, Petrochemicals and many manufacturing industries today we need human safety on head, and it can be done by robots. This paper implies such type of mobile robot which can be used in complex industries. The work is based on Image processing and Centroid Algorithm. The physical quantities like (temperature, pressure, humidity, stress, PH) and leakage of gases and liquids, fire, spark and many human safety related things which can be encountered by this mobile robot. By using this robot, the main achievement is human safety and simultaneously cost effective, precision and all far away data can be easily available through IoT (Cloud) ^[1]. Also, it works without any disincentive at particular of desired time in day or night, where particular place requires physical quantities measurement. In this project the main components are Controller (Raspberry Pi), Four DC Motor for each wheel, Pi Camera for image detection and processing, motor driver logic and physical quantities sensor ^[2].

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Chapter 19

Fake News Polarization for Sentiment Analysis

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ABSTRACT

The popularity of the internet has increased the use of e-commerce websites and news channels. Fake news has been around for many years, and with the arrival of social media and modern-day news at its peak, easy access to e-platform and exponential growth of the knowledge available on social media networks has made it intricate to differentiate between right and wrong information, which has caused large effects on the offline society already. A crucial goal in improving the trustworthiness of data in online social networks is to spot fake news so the detection of spam news becomes important. For sentiment mining, the authors specialise in leveraging Facebook, Twitter, and Whatsapp, the most prominent microblogging platforms. They illustrate how to assemble a corpus automatically for sentiment analysis and opinion mining. They create a sentiment classifier using the corpus that can classify between fake, real, and neutral opinions in a document.

INTRODUCTION

Knowledge sharing has been an important aspect in this 21st century and this has become more effective with the usage of the common platform we all know the Internet. Internet users use many communication tools and the most widely used is microblogging platforms are Facebook, Twitter, and WhatsApp. which contains arbitrarily large text posts (Zhang, Dong, and Yu 2018). This Corpus can be in form of

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real emotions, fake emotions, or objective texts. (Parikh and Atrey 2018). The Corpus, which is available online, promises a once-in-a-lifetime opportunity for NLP and related areas. One of the fields with a lot of real-world applications is sentiment analysis. Sentiment analysis can be used by a user to research products or services before purchasing a product or buying a service. Marketers can use this to research public opinion of their company and products. Last but not least organizations can also use this to gather critical feedback about problems in newly released products. The popularity of the internet has increased the use of e-commerce websites and news as well (Lin et al. 2014). So it can be helpful to other users to make decisions making. It can be very useful to make business competitive. But many users or organizations post spam news to promote or defame a brand or specific product or people. Spam news is Very common nowadays on e-commerce websites. Many business organizations hire people to post fake news on their behalf (Jiang, Cao, and Chen 2013). As a factor, spam news recognition has grown increasingly extremely important in recent years. Online user reviews for both products and companies have had a major impact on others' basic buying decisions. Despite the difficulty with which the surveys are available and the considerable consequences for merchants, there is a growing driving factor to manage the audits, which are often benefit-driven (Mukherjee, Liu, and Glance 2012). Entrepreneurship on the internet Audit spam is rapidly replacing websites that provide client audits.- Bitter or positive reviews that aren't worthy; surveys that are written despite the fact that the analysts have never used the business. As an outcome, auditing spam identification has become increasingly important in recent years. Today, plenty of researchers are taking aim at them (Jindal, Liu, and Lim 2010). Spam surveys can be categorized into three parts. The detailed comparative study of the previously available techniques is shown in Table 1 and Table 2.

- Untruthful News or Reviews: Those undeserving positive news that is presented on advance a particular brand or item regardless of the possibility that those brand or item not meriting that as well as a negative survey that is presented on slander a particular brand or item regardless of the possibility that those brand or item are great.
- News or reviews on brands only: Those surveys that do not give any remark concerning an item or administration however give clear remark for brand or vendor. This can be helpful yet it does not give any insights about item or administrations so we can consider as spam.
- Non-reviews on news: That news that contains advertisements, question-answer, or other content irrelevant to the product or services.

In this examination range, there are fundamentally two methodologies ready to manage this issue. One is supervised learning and the second one is unsupervised learning. Both have a few points of interest and downsides. In supervised learning analysts have great precision yet there is a required great measure of space information or data about setting (e.g. what is being looked into, examples of the analysts, and so on). So this technique is not by any means helpful for individuals without this sort of area learning. In an unsupervised approach, this sort of data about the setting is not required. So these sorts of research can be exceptionally valuable for everybody (Ramesh Babu Durai and Duraisamy 2011). Be that as it may, there is one primary downside of precision. This kind of methodology does not give great exactness.

Challenges and Issues

The major challenges and issues of the problem:

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- **High complexity:** There is an immeasurable number of item audits on the web so recognition of survey spam is extremely mind-boggling. It is altogether different from email and webspam locations. Since for such spam, it is anything but difficult to discover preparing information for model building and to assess the subsequent models yet it is not such case with survey spam recognition.
- **Consideration of sentiment of news:** Now and again it is additionally conceivable that news is composed in a negative tone however it is an honest survey so we need to likewise consider the sorts of supposition of reviews.
- **Low accuracy of fake news detectors:** Numerous scientists have executed distinctive strategies to identify fake audits. However, all past techniques have less exactness in recognizing fake or spam surveys. We must enhance this precision.

In this chapter, we try to improve the accuracy of spam news and review detection. The main aim of this chapter is to improve the overall accuracy of fake news as well as spam review.

EXISTING SOLUTIONS

The summarized comparative analysis is presented in Table 1 along with its limitations, used methods, advantages, and parameters. The observed parameters from all these methods in terms of accuracy, threshold, precision, recall, and a decision is shown in Table 2.

PROPOSED FRAMEWORK

This research work is divided in to three main part. The primary part is in charge of getting and pre-preparing the survey from the input side or the web. Before arranging the surveys, the second stage is an information phonetic assessment, which does a semantic inquiry on the information from the previous segment. The third segment performs survey characterization of the audits into two class's spam or non-spam surveys. The below Figureure portray a diagram of the proposed structure.

a. Data Linguistic Analysis Component

The data language evaluation phase conducts a diversity of linguistic tasks on new data gathered from the preceding section. It excecuted like you see in *figure 1*,

1. **Text or Sentence Filter:** This component is basically used to cleave the entire data into individual syntax. Often. these data start with a capital letter, which is the equivalent of a syntax split sign. If words such as Pvt., Ltd.,etc comes before the “.” Symbol, it’s best to put it at the ending of the sentence. “/” as well as “?” are examples of diacritical marks. Syntax splitting is also implemented using “;” and “.”
2. **Tokenization:** This section organises the content into very simple entities, such as numbers, accentuation, and words.

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3. **Part-of-speech (POS):** Not all of the words in source content information are relevant for tilt analysis. Every token is provided a part-of-speech (POS) label, which might be a descriptive word, verb, or qualifier.

Table 1. Comparison with the existing solution

Sr No	Paper Name	Advantages	Limitation	Used Method	Parameters
1	Chinese Review Spam Classification Using Machine Learning Method (Xi 2012)	Good accuracy (around 93%) with SVM method.	They don't explore the effect of review spam detection for another product dataset.	SVM	Accuracy
2	Review Spam Detector with Rating Consistency Check (Sharma and Lin 2013)	-They use an algorithm that is not context-dependent. -Easy to deploy. -Result of this is very effective even though they do not use context.	When the system is unable to decide about review then it flags a potential list of evidence to determine spam or not spam review.	Unsupervised Method	Accuracy
3	Using Unanticipated Rules for Find Abnormal Review Patterns (Jindal, Liu, and Lim 2010)	They formulate the problem of review spam detection as finding unexpected rules. The technique is domain-independent.	Gives low accuracy for spam detection.	Unsupervised methods	Accuracy
4	Towards Online Review Spam Detection (Lin et al. 2014)	Good accuracy result with SVM, Avg accuracy logistic regression, and low accuracy unsupervised method.	Result accuracy is not better than previous research of others.	SVM, Logistic Regression (Supervised Method), and Unsupervised Methods for each experiment	Accuracy
5	Detecting Product Review Spammers using Activity Model (Jiang, Cao, and Chen 2013)	They improve the prediction model that using the behavioral approach to detect review spammers who try to manipulate review ratings on some target product group.	They get average accuracy of detection of review spammer through the use of user behavior.	Unsupervised methods	Precision, recall, F-measure
6	Chinese Spammer Review Detection System Development and Construction (Xu et al. 2013)	Chinese Spam Design and Implementation news Detection System.	-It's poor than other methods for large datasets.	Naïve Bayes(Supervised Method)	Accuracy
7	Topic-Based Mixture Modeling and Semi-Supervised Training Improve Twitter Sentiment Analysis (Xiang and Zhou 2014)	-Used their algorithm of a large amount of low-cost un-annotated data to improve accuracy	Needed to improve the accuracy in distinct domains	Semi-supervised learning (topic-based method)	Accuracy,
8	Sentiment Analysis and Opinion Mining (Social media as Twitter) (Da Silva, Coletta, and Hruschka 2016)	Good accuracy in SSL approach	SSL depends on a small initial sample of labeled data -Unsupervised approach results are worse compare to SSL	SSL(wrapper-based, topic-based), unsupervised approach	Accuracy, Precision, Recall, threshold

Fake News Polarization for Sentiment Analysis*Table 2. Parameters observed*

Ref.	Accuracy	Recall	Precision	Threshold	Decision
(Xi 2012)	Yes	No	No	No	No
(Sharma and Lin 2013)	Yes	No	No	No	No
(Jindal, Liu, and Lim 2010)	No	No	No	No	No
(Lin et al. 2014)	Yes	No	No	No	No
(Jiang, Cao, and Chen 2013)	Yes	No	No	No	No
(Xu et al. 2013)	Yes	No	No	Yes	No
(Xiang and Zhou 2014)	Yes	No	No	No	No
(Da Silva, Coletta, and Hruschka 2016)	No	Yes	Yes	Yes	No

4. **Removing words:** This procedure removes or filters English stopwords from a document by eliminating every token from the stopword list that equals a stopword, or simply put, it removes popular words with no significance.

b. Fake News Classification Component

This is our most important component in the proposed framework. This component classifies the given text into the Fake or original class. This component works as follows:

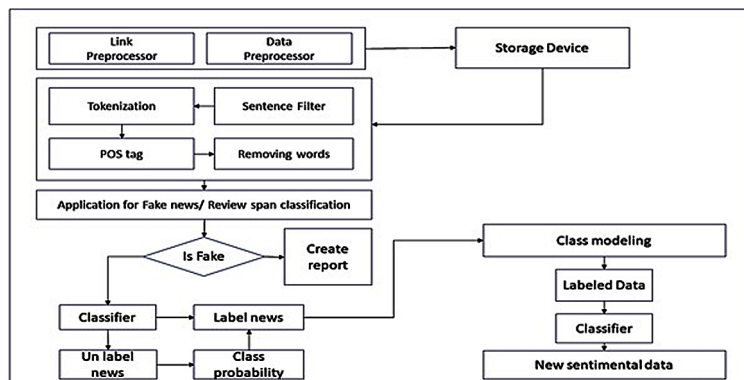
Application of unsupervised method: In the first place we check the survey content against taking after four criteria for grouping of audit into spam or non-spam These criteria are given below:

1. **Questions in news or review:** The news which contains the question is typically utilized with the end goal of investigating. So the survey related to the question is for the most part not being considered an honest review.
2. **Product/company comparisons:** Numerous Competitor organizations compose undeserving negative surveys for the contender's item, with an accentuation to guide the analysts to their particular items/administrations. So these sorts of surveys are additionally not being considered honest news. For example, A news channel or paper writes: "Product X does not work. I bought Product B and now I am happy with this product".
3. **News written in capital letters:** News that starts with a capital letter is considered spam or false. because most of these surveys are used to gain attention or for ads. news with all capital letters should be ignored. For example: "THIS PERSON IS NOT GOOD FOR OUR COUNTRY".
4. **URL links in News:** The analysts in some cases leave a connection to their site or it is a commercial. In the vast majority of the cases, the analyst composes the post to leave the connection and the survey is futile. So, these sorts of surveys are additionally not being considered honest news.

If the survey falls flat against these criteria then we can name that the audit can be a "spam of fake" survey. At that point, we apply the SVM managed procedure to the rest of the non-spam audit to order it encourage into "spam or fake" and "no spam or real" class.

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Figure 1. Proposed diagram of sentiment data analysis



c. Application of the Supervised Method

Next, we apply directed systems to the rest of the audit to characterize spam or non-spam. Building a classifier can be used to implement regulated systems. Illustrations which may be physically labeled or user names are used to create this classifier. For the most part utilized managed calculations are Support Vector Machines (SVM), Naive Bayes classifier, and Maximum Entropy. SVMs are more fitting for audit spam orders. The proposed framework will utilize an SVM classifier for the arrangement as research has demonstrated that SVM performs better when information is substantial. In an SVM-based order, two arrangements of archives are required: preparing and a test set. A preparation set is utilized to prepare the programmed classifier to take in the qualities of reports, and a test set is utilized to arrange inconspicuous records. Machine Learning begins with gathering preparing datasets. following steps are used to prepared a classifier while preparing the information.

Once you select any supervised allocated address at that time the selection process is done .so now we can familiarize with how grammer or syntax are represented. A lot of frequently acclimated appearance in allocation are how many Term attendance and their frequency are present . These appearances cover n-grams or uni-grams and they are presence or not. So basically these appearances accept on the whole and propitious acclimated in classification.

The bag-of-words approach is one strategy of translating argument into appearance. An aspect of the affection set is anniversary chat, and an anniversary certificate is represented by a set of absolute numbers. In the document-gram model, the area anniversary aspect of the set represents the abundance of that chat and may be explicitly described as:

Take, for example, $f_1 \dots f_m$, which is a predefined set of m occurrences that can appear in a document; examples also include chat “diseases” or the bigram “particularly unwell.” Take, for example, $n_i(k)$, which is the number of times f_i appears in certificate d . Then we may say that the certificate agent $d = (n_1(k), n_2(k), \dots, n_m(k))$ represents the anniversary certificated.

An argument is represented in one of the models as an irregular aggregation of words, behindhand grammar, and even text structure, resulting in the lack of logical abstractions in the input data processing. To abate compounds loss, the N-gram archetype is utilised, in which anniversary sub-sequence of breadth n is specified as a feature, rather as anniversary conversation. Since this approach increases the complexity of the process, it is unable to account for ongoing dependencies while preserving conversation

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adjustment inside N-words. So a size 1 N-gram is labeled a “unigram,” a size 2 is called a “bigram,” a size 3 is called a “trigram,” and a size 4 or more is usually called a “N-gram.” Below is an N-gram set of an example news speech.:

“I did not like the blue pen.”

Bigrams: [“I did”, “not like”, “the blue pen”]

Trigrams: [“I did not”, “like the blue pen”]

Unigrams: [“I”, “did”, “not”, “like”, “the”, “blue”, “pen”]

d. Text Classification Component

A classifier is established using tagged news(tweet), and it is then used to assess the profitability of each unlabeled bargain (this primary footfall occurs alone once). Next that, a sample of tweets with a stylish anticipation college rather than an aplomb start are selected. They’re then included in the labelled tweets dataset, which is then used to create an affair model, from which anniversary tweets’ affair distributions are recorded. Then, clusters that support the affair distributions are recognized, and an accurate effect paradigmatic for the each cluster is generated. The unlabeled tweets are categorized using the consistent effect admixture archetypal. An acknowledged action occurs until a certain number of samples have been completed or no further tweets have been found to be the answer to the set of labelled tweets.

As apparent from a simulation study, SVM gives the simplest accurateness as a neighborhood of all classifiers, so we’ll use SVM as a capital algorithm for assessment spam allocation and affect the analysis.

This proposed framework for analyzing spam or fake news detection. We also explained how the anniversary basic framework will work. Our new access is predicated on the affiliation of the unsupervised and supervised methods. We accept SVM for supervised adjustment because it’s best for this blazon of problems like analysis spam detection.

CONCLUSION

Detection of spam/fake news becomes a crucial analysis botheration nowadays. Now a days firm or group organizations in eCommerce are establishing advanced their efforts to acquisition the simplest arrangement for analysis fake news detection. Although, a number of the algorithms and methods accept been utilized in exposition fake apprehension gives satisfactory outputs, However, no algorithm or approach can guarantee that all obstacles will be fulfilled. The extended strategy is based on improving the success rate of spurious detection. There are an enormous charge in e-commerce for such applications because every alignment wants genuine news analysis arrangement to apperceive how users feel about their articles and services. We proposed access for audition spam in auberge news. The proposed access is predicated on accumulation methods from abstracts mining and argument mining. The proposed address anatomy and apparatus were presented and explained. It involves the afterward accomplish for audition spam: abstracts accretion and pre-processing abstract linguistic assay and assuredly analysis spam classification. it’s chip access of supervised adjustment (SVM) and unsupervised method. it’s congenital to access the accurateness of spam detection. It can yield advantages of both SVM supervised adjustment and unsupervised adjustment to advance accurateness results. Testing the acceptable arrangement was performed by application two abstracted datasets. These after-effects gave a bright appearance that the

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arrangement is in a position of audition spam analysis with over ~91% accuracies. During the appraisal, it had been accessible to ascertain that it's achievable and reliable to body arrangement able of classifying analysis argument into spam and non-spam chic automatically. However, it's bright that an abundant amount of opinions are difficult to allocate due to the complication of the animal language. The proposed system's limitation includes an area annex of opinions. The proposed arrangement can allocate alone auberge analysis into spam and non-spam class.

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[Mayurkumar Ladumor](#) ([/profile/MAYURKUMAR.LADUMOR-4208257](#)), [Shreyas Charola](#) ([/profile/SHREYAS.CHAROLA-4206385](#)), [Shobhit K. Patel](#) ([/profile/shobhit-k..patel-4275439](#)), [Vigneswaran Dhasarathan](#) ([/profile/Vigneswaran.Dhasarathan-4241912](#)).

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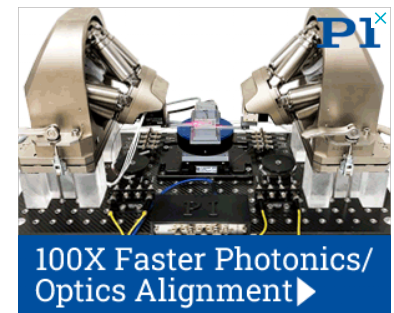
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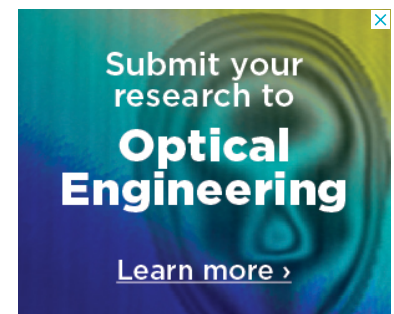
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Graphene-based highly efficient C-shaped metasurface for terahertz absorber

Charola, Shreyas ; Ladumor, Mayurkumar ; Patel, Shobhit K. ; Dhasarathan, Vigneswaran

We have presented graphene-based metasurface tri-layer highly efficient broadband solar absorber. Below metasurface and above dielectric layer a monolayer graphene sheet is inserted to achieve maximum average absorption in visible terahertz (430 THz to 770 THz) spectrum. We demonstrated a broadband solar absorber with 85% absorptance in the visible terahertz band. The single C shaped unit cell of metasurface solar absorber made up of tungsten separated by the tungsten ground plane by a silicon dioxide dielectric layer. The proposed absorber also investigated to manipulated absorptance of absorber by varying different parameters of structure. The graphene metasurface solar absorber has a potential application for the development of terahertz lasers and sensors.

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
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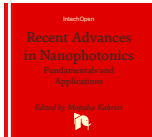


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Improving QoS in 4G Network during Handoff by using Fuzzy Logic based More Precision Handover Algorithm (FMPHA)

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Abstract— As mankind is developing in every phase of its existence, so does the wireless communication technology and its need. In this paper, an attempt to reduce ping pong effect which initiates numerous unnecessary handovers 4G networks is carried out. Ping pong effect is a severe issue in LTE/ LTE-A since it causes loss of data and power (both of UE and of eNB) and results in a hike in data management cost. This happens when a UE moves alternatively among two or more eNBs causing the data link to switch to and fro. Hence an attempt to reduce this numerous execution of HO before it reaches its completion phase is done. An algorithm named Fuzzy logic based More Precision Handover algorithm (FMPHA) is introduced. The tool that solved fuzzy trials is none other than Fuzzy Inference Tool (FIS) of MATLAB. A study of QoS aware during X2 interface based handover (i.e. horizontal handover) in LTE/LTE-A networks is propounded. An introduction to ping pong effect, which causes numerous unnecessary handovers, reasons for its occurrence, its consequences and possible approaches to solve it are also presented. The proposed work and its comparison with FPEHS is shown. The simulation is done in Fuzzy Inference Tool of MATLAB.

Keywords- 4G, LTE/LTE-A, QoS, Fuzzy logics, handover, Horizontal handover algorithms, X2 handover, X2 interface, ping pong effect

I. INTRODUCTION

In this F1 speed era everyone needs information about the subject of their interest quick and prompt. The flaws in the seamless data link are inadmissible. A need to further improve it still prevails despite of innumerable researches in this direction. This work consists following :

- Introduction to 4G LTE technology and its architecture
- The QoS and its highest significance in communication link

- Types of HO
- About X2 interface and issues related to it.
- What is ping pong effect and approaches to detect and reduce ping pong effect
- Introduction to fuzzy inference system; rules and working

Figure1 shows the overview of the research. Section II has the information about 4G, LTE, LTE-A, it's architectural flow and a brief account of each and every functional blocks. Section III explains about QoS active during different parts of a session and its major role in handover. Section IV consists of the classification (i.e types) of handovers overall as well as of those which are specific to LTE/LTE-A. Section V gets focused to X2 interface based handovers in LTE-A. Section VI gives in and out ideas about ping pong effect.

II. 4G LTE/LTE-A AND IT'S ARCHIRECTURE

Basically 4G is a set of standards sometimes called IMT-A standards (International Mobile Telecommunication standards) given by ITU-R. We consider two technologies under this standard: LTE (Long Term Evolution) standardised by 3GPP (3rd generation partnership project) and Wi-MAX (Worldwide Interoperability for Microwave access (IEEE 802.16)). Wi-MAX is used to create MAN (Metropolitan Area Network). A faster wireless broadband connection can be accessed by it.

A. LTE

LTE (Long Term Evolution) is a new radio access technology (RAT) introduced in the release 8 of 3GPP (3rd Generation Partnership Project) which is a smooth transition from HSPA+ (High Speed Packet Access+) release7 to 4G.

LTE is sometimes called E-UTRAN (Evolved –Universal terrestrial radio access Network). However, the technical requirements that were originally mentioned by the ITU-R organisation in its IMT-A specification [2] is not satisfied by LTE proposed by 3GPP release 8 and 9.

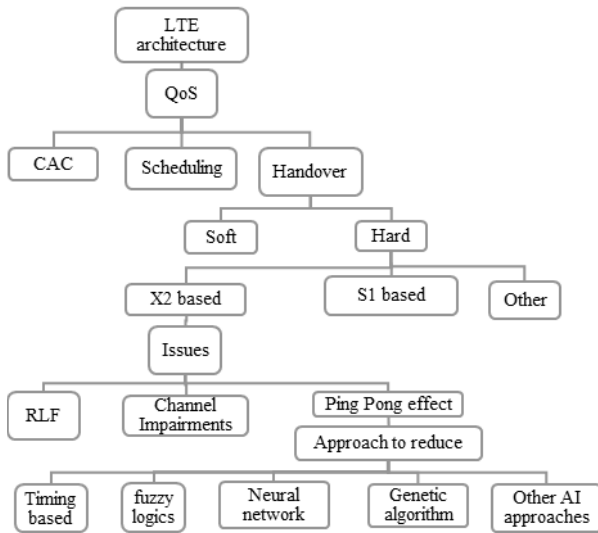


Fig. 1. Overview of followed channel for getting information related to work

So came LTE-A (LTE advanced) release 10 in September 2009 by 3GPP which has the specifications of 4G system to assure the requirements laid by ITU-R[11] organisation of IMT-A. In this article, a special focus is on LTE rather than on Wi-MAX. The general feature of LTE and LTE-A are as shown in Table 1 [1].

TABLE I. FEATURES OF LTE AND LTE-A

Sr. no	Two technologies	
	LTE	LTE-A
1.	Packet switched	Packet switched
2.	Pk downlink: 100Mbps Pk uplink : 50 Mbps	Pk downlink: 1Gbps Pk uplink : 500 mbps
3.	Increased capacity, coverage and speed then 3G	Increased capacity, coverage, and speed then LTE.
4.	Both supports standardised flexible BW: (1.25, 2.5, 5, 10, 15, 20) MHz based on the availability of BW, transmission BW can be selected.	
5.	Supports different frequency bands and are compatible with the systems which are employed within 900 MHz, 2.1GHz, and 2.5 GHz spectrums.	

B. LTE architecture

To understand the handovers, its types, and the importance of QoS, we need to understand the basic building blocks of LTE architecture. Following flowchart describes the sectional blocks of LTE architecture [13]. The EPC and E-UTRAN are jointly referred to as evolved packet system (EPS).

- MME: It’s a key control plane component which manages network access and mobility.

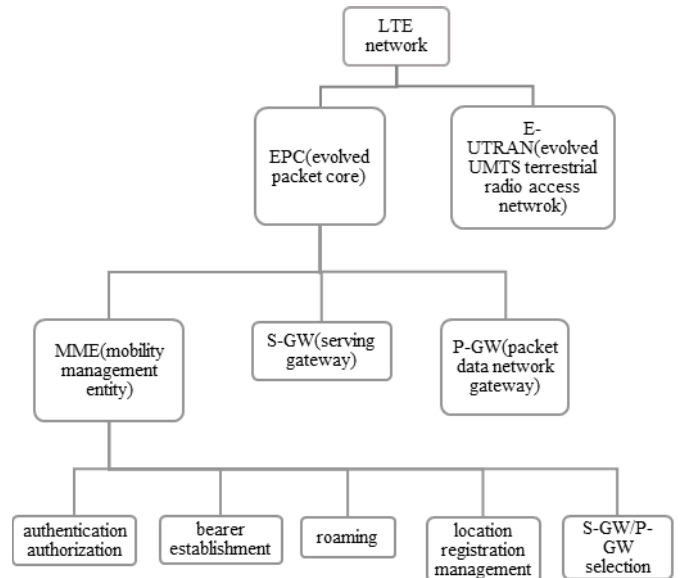


Fig. 2. LTE architecture

- S-GW (Serving Gate Way): The data routing and forwarding between UE and eNB is done by S-GW.
- P-GW (PDN(Packet Data Network) Gate Way) The access to an external packet data network required by the UE is served by assigning an IP address to it. This is the function of P-GW.
- EPC is a flat all-IP-based core network that can be accessed through the 3GPP radio access including HSPA, HSPA+, LTE and non-3GPP radio access like CDMA2000, Wi-MAX, allowing handover procedures within and between both access types.
- ENodeB is the ace module of E-UTRAN which performs operations related to radio interface such as scheduling and handover. The eNB is directly connected to UE (User Equipment) and packet core network via EPC (Evolved Packet Core) [13].

III. QoS AND ITS MAJO ROLE

QoS is the set of specifications of the performance requirements laid by the users of the telecommunication services and which are provided by the service providers. QoS is classified by the instants where it acts more significantly in a data transfer link as shown in figure 3 [15].When a call is initiated ,the UE requests for the bandwidth, after the available bandwidth allocation, the classifier decides for the packets’ priority. The priority is based on channel conditions. The packets are received from subscriber and forwarded to scheduling module. The scheduling module is responsible for the allocation of data link resources to the user.

It has to take into account the QoS satisfaction, user fairness, and optimising the system performance [7].

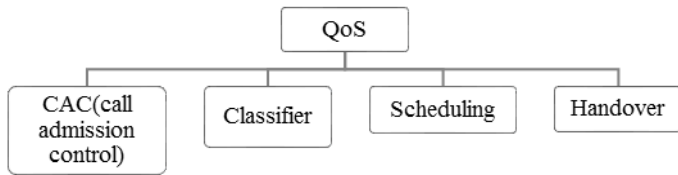


Fig. 3. QoS Classification

IV. HANDOVER

A. Role of QoS in handover

Handover is a crucial juncture in a data link management; reason being its complexity grows up as it proceeds. Handover means the transfer of an ongoing call from one eNB to another eNB or from one femtocell to another within the same eNB. Figure 4 shows the classification of handover.

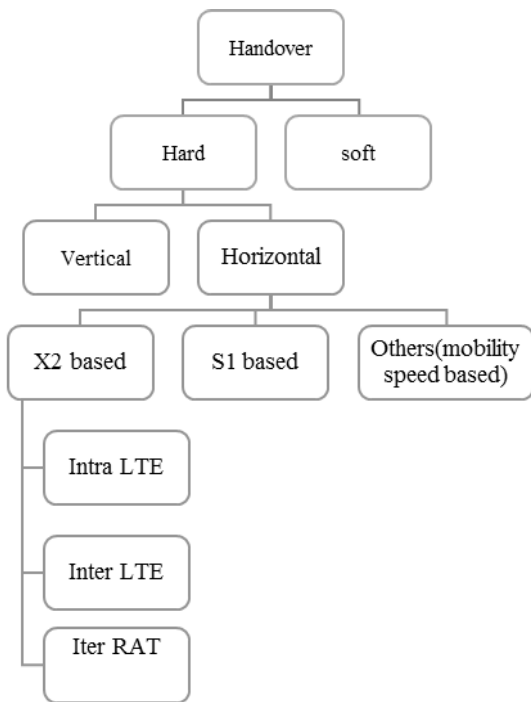


Fig. 4. Types of handover

Basically the job of handover is to provide users to pass over a continuing call or data session from one server to another without any distortions/interruptions in communication link. The process of handover undergoes several rigorous messaging between the entities that performs it. The basic reason to trigger handover is the following equation.

$$RSRP_t > RSRP_s + HOM \tag{1}$$

Which means the handover is triggered when the RSRP (Reference Signal Received Power) of target cell is greater than the RSRP of source cell plus HOM (Hand Over Margin). This is referred as LTE hard handover algorithm in [6]. The handover procedure is divided in four phases namely: measurement, decision, execution, and completion; which are described above in figure 5.

V. THE X2 INTERFACE

There are two interfaces in the LTE: X2 and S1. The X2 is the interface which is the interconnection between eNBs and E-UTRAN and the S1 interface is the interface which is the interconnection between eNB and MME/ S-GW ([4]- [5]). The patent ETSI TS 136 420[19] consists its detail. The X2 interface is newly evolved in release 8 LTE-A network. It's a 'logical interface' between two eNBs [18].

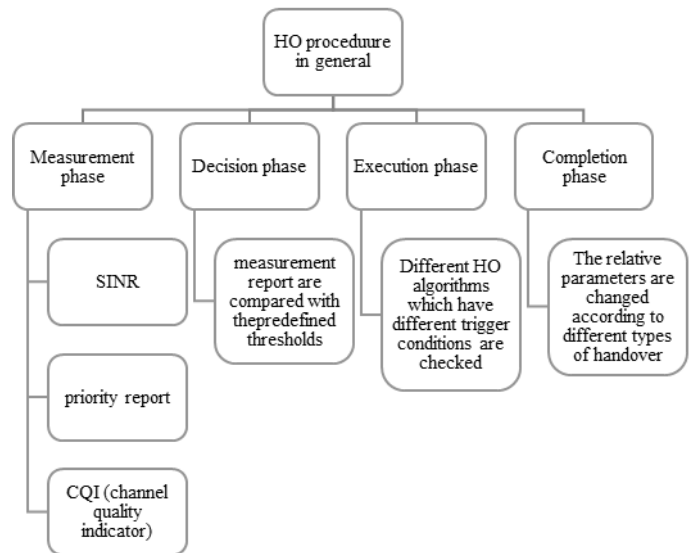


Fig. 5. Handover procedure in brief

A. X2 Functionality

The exchange of information between eNBs to perform various functions mention below is supported by the X2 interface.

- User mobility to perform handovers between eNBs.
- Load balancing: load is shared by the available resources.
- CoMP (Co-ordinated Multi-Point transmission or reception): The neighbouring eNBs co-ordinates over X2 interface.
- To optimise the network.
- Update regarding configuration of eNBs, target cell activation.

- Mobility optimisation: To sync the process of handover.
- General management like resetting and initialising X2 interface when needed.

X2 interface consists of two planes control plane and user plane. The above are the control plane signalling procedures which has been standardised to ensure the interoperability of eNBs from different vendors [16]. The other key functions are described by the X2 application protocol, specified in [17].

VI. ISSUES WITH X2 INTERFACE BASED HANDOVER

There are three issues known with the X2 interface based handover. They are: RLF (Radio Link Failure), channel impairment and the ping-pong effect [11]. The two of them: RLF and channel impairment are even applicable to other types of handover.

A. RLF

The physical layer of the OSI model is responsible for the sending and receiving of the bit stream over the channel in form of EM waves. So RLF is basically a physical layer problem. Several methods are recently invented to detect RLF. It's also sometimes referred as absence of dedicated channel in LTE system [9] describes the way of detecting RLF.

B. Channel Impairment

Channel impairment is a problem in which very less human control is possible. The impact of outdated and missing feedbacks towards handover is a factor responsible for performance degradation of the system. The imperfect channel feedback reports in a practical LTE-A system can be categorized in two feedback reports: CQI (Channel Quality Indicator) reports and RSRP (Reference Signal Received Power) reports. The imperfections in the above two reports critically impact the system performance [11].

VII. PING PONG EFFECT

It is the third and one of the most critical issues in LTE handover which degrades the performance of handover. Due to it there is increase in number of intra E-UTRAN handover which leads to frequent call drops, inefficiency and degradation of network performance.

Ping pong effect is observed when a mobile terminal executes handover between two cells back and forth due to natural fluctuations in radio measurement. Following are the possible factors responsible for the ping pong effect.

- Coverage parameters
- User location area
- UE movement and speed are among main causes.
- The effects of Ping pong effect are:
- Unnecessary numerous handovers
- Delayed handover
- Ongoing session/call truncation

- Data loss
- Several copies of similar measurement reports that leads to ambiguity to serving eNB
- Power wastage
- Higher data link or network management cost suffered by the service provider.

All of the above effects are liable to a steep decline in QoS. Presently there are following approaches known to reduce or to detect the ping pong movement of the UE [14]

- Timing based
- fuzzy logic based
- Neural network
- Genetic algorithm
- Other AI techniques

One of the ways to address this issue is by retaining the connected path between the source eNB and SGW/MME during the ping pong type of movement and thus postponing the completion of HO by some fraction of second [10].

VIII. INTRODUCTION TO FUZZY INFERENCE SYSTEM AND THE PROPOSED ALGORITHM

This section deals with the work we proposed. It includes introduction and working of fuzzy inference system which is available as fuzzy inference tool in MATLAB. The importance of membership function choice of it and working of it is explained.

A. Proposed Algorithm

According to [20], the HO procedure will be triggered only after satisfying the above equation:

$$RSRP_t > RSRP_s + HOM$$

Where $RSRP_t$ is the reference signal received power of target eNB and $RSRP_s$ is the reference signal received power of source eNB. HOM stands for handover margin. In the standard LTE handover decision process, parameter $RSRP$ is the linear average value of reference signal power across the specified bandwidth.

B. The FMPHA

In fuzzy logic based more precision HO algorithm (FMPHA) the fuzzy inference process plays the key role in making decision of handover. It is shown in figure 6.

C. Parameters for the membership function and fuzzy rules

The FMPHA uses four membership functions which are inbuilt in FIS of MATLAB. Namely Z shaped, S shaped, Gaussian, and Triangular. The parameters of fuzzy inputs

are as given in [17]. The fuzzy inference engine converts the aggregated fuzzified data by using mamdani model by the following expression

$$\mu_{AHO} = \max_k [\min[\mu_{ACS}(CSNR), \mu_{ADS}(TSNR), \mu_{ACB}(CBW), \mu_{ADB}(TBW), \mu_{ARE}(RE)]],$$

for $k = 243$.

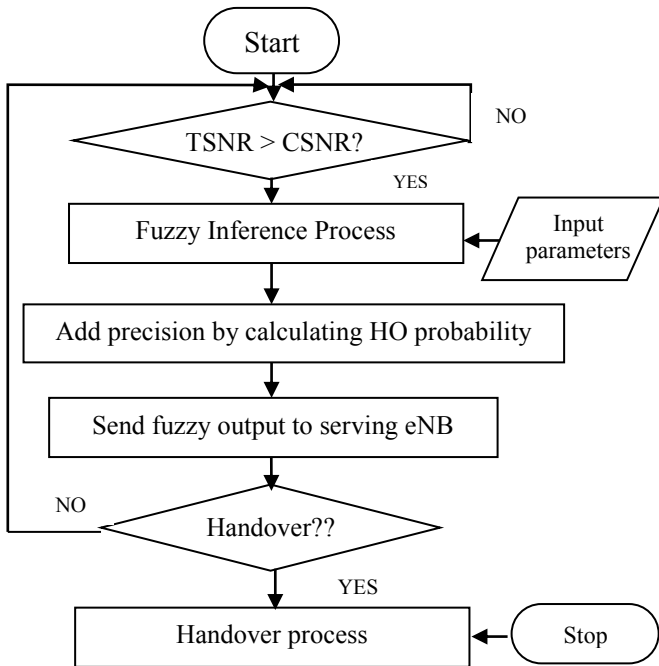


Fig. 6. The handover decision flow of FMPHA

The Defuzzification is done by the centroid method (centre of gravity method)[21]. The Defuzzification function is as follows

$$HO^* = \frac{\int x \mu_{AHO}(x) dx}{\int \mu_{AHO}(x) dx}$$

Where HO^* is the score of the handover decision.

D. The Fuzzy Inference System

According to [17] the fuzzy inference system is as follows. The fuzzy inference system is divided into four parts to aid easy understanding; Fuzzification, fuzzy inference engine, rules and Defuzzification.

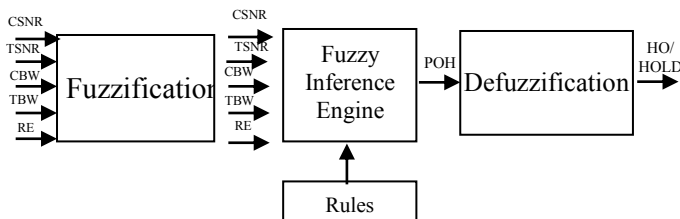


Fig. 7. Fuzzy process

It takes five parameters which results in one output in IF-THEN format. The inputs are: current SNR, detected SNR, bandwidth of target, bandwidth of source eNB and energy of an UE are given as input to a fuzzy logic analyser.

E. Fuzzy Sets For The Proposed Work

1. Current SNR: T(CSNR)= {Bad, Good, Excellent}
2. Detected SNR: T(TSNR)= {Bad, Good, Excellent}
3. Current bandwidth: T(CBW)= {Low, Medium, High}
4. Detected bandwidth: T(TBW)= {Low, Medium, High}
5. Remaining energy: T(RE)= {Low, Medium, High}
6. Probability of HO: T(POH)= {Low, Medium, High}

This is the aid to determine the requirement of handover by employing four different membership functions which are Z shape, S shape, Gaussian, and triangular functions which fuzzes the five input parameters into fuzzy terms and give a single output called probability of handover (POH) as output. The Fuzzification is the process that converts numerical values into levels of membership function terms such as low, medium and high. The role of fuzzy inference engine is to infer the grades of the membership functions that are defined by the rules and give output again into grades of the output membership function. The job of Defuzzification is to convert those fuzzy grades into crisp value again in the output which actually decides whether to handover or hold. The FMPHA used Mamdani method in its fuzzy inference engine.

F. Adding precision to the fuzzy output term

Instead of just two fuzzy terms hold and HO in the output of the system proposed in [17], the above propounded work consists of three fuzzy terms in the output fuzzy term. This addition of one extra fuzzy has resulted in making the fuzzy inference system more precise when the need is to take decision in critical cases.

IX. SIMULATION RESULTS AND DISCUSSION

The simulation results show that the number of handovers is less in case of FMPHA in comparison with FPEHS proposed in [17]. Here we have five inputs and each input has three fuzzy terms; so the total number of rules is 243(that is 35). Out of 68 rules given in [17], twenty cases are the critical cases where the handover decision depending on the considered facts matters the most. There were only two fuzzy terms in FPEHS namely hold and handover while in FMPHA, there are three fuzzy terms which says probability of handover is Low, Medium and High.

TABLE II. TABLE SHOWING THE COMBINATIONS OF INPUT PARAMETERS

Different combinations of parameters tp be inputted in FIS	
CSNR vs TSNR	CBW vs RE
CBW vs TBW	TSNR vs RE
CSNR vs CBW	TBW vs RE
CSNR vs RE	

Above table shows seven simulations done in fuzzy inference tool of MATLAB. Now out of these seven readings decision was taken based on the following conditions.

$$FPEHS = \begin{cases} HO, & n(HO) > n(HOLD) \\ HOLD, & n(HOLD) > n(HO) \end{cases}$$

$$FMPHA = \begin{cases} HO, & n(Low) + n(Medium) < n(High) \\ HOLD, & n(Low) + n(Medium) > n(High) \end{cases}$$

Where n(HO) denotes number of handovers
 n(HOLD) denotes number of hold
 n(LOW) denotes probability of HO is LOW
 n(MEDIUM) denotes probability of HO is MEDIUM
 n(HIGH) denotes probability of HO is HIGH

In FMPHS, handover will be triggered if and only if the number denoting probability of HO is HIGH. 20 critical cases are selected out of 68 rules for which output is HO in FPEHS. In these 20 cases, it's difficult to decide whether to handover or hold. The decision of POH to be High or Low is decided on seven different readings. For instance, out of seven outputs number of HOLD is 4 and number of HO is 3 resulting the final decision to be HOLD. Table IV compares the final number of HOLD and HO in both FPEHS and that in FMPHA. The proposed FMPHA can reduce the unnecessary numerous handovers to 3 out of 20 critical cases compared to 13 out of 20 cases in FPEHS. The tables showing decision making in both FMPHA and FPEHS is shown in table below.

TABLE III. (A) DECISION OF FPEHS (B) DECISION OF FMPHA

HO	HOLD	DECISION	LOW	MEDIUM	HIGH	DECISION
4	3	HO	1	4	2	HOLD
5	2	HO	1	3	3	HOLD
4	3	HO	3	2	2	HOLD
4	3	HO	3	3	1	HOLD
4	3	HO	1	4	2	HOLD
4	3	HO	3	1	3	HOLD
2	5	HOLD	4	1	2	HOLD
3	4	HOLD	2	3	2	HOLD
3	4	HOLD	4	1	2	HOLD
4	3	HO	2	1	4	HO
5	2	HO	2	4	2	HOLD
4	3	HO	3	1	3	HOLD
3	4	HOLD	2	3	2	HOLD
3	4	HOLD	4	1	2	HOLD
4	3	HO	2	1	4	HO
3	4	HOLD	4	0	3	HOLD
5	2	HO	0	5	2	HOLD
5	2	HO	0	3	4	HO
4	3	HO	3	1	3	HOLD
2	5	HOLD	2	3	2	HOLD

(A)

(B)

The fuzzy inference system analyse the interdependency of 5 input parameters to execute HO. The effect of parameters on the HO decision is checked by taking two inputs at a time given to FIS. The ping pong effect that causes numerous

handovers while deciding the target eNB, gets reduced in the proposed work by adding precision of three levels(Low, Medium, High) instead of just two(hold and HO) in FPEHS. Seven results namely TSNR vs CSNR, TBW vs TBW,CSNR vs CBW, CSNR vs RE, CBW vs RE, TSNR vs RE and TBW vs RE decides the final HO decision.

TABLE IV. COMPARISON OF NUMBER OF HANDOVERS IN FPEHS AND IN FMPHA

Comparison table		
Technique	Hold	HO
FPEHS	7	13
FMPHA	17	3

Number of Handovers in two techniques

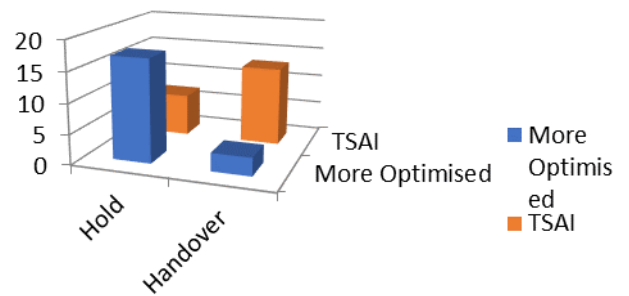


Fig. 8. Graph of comparison of number of HOLD and HO in FMPHA and in FPEHS

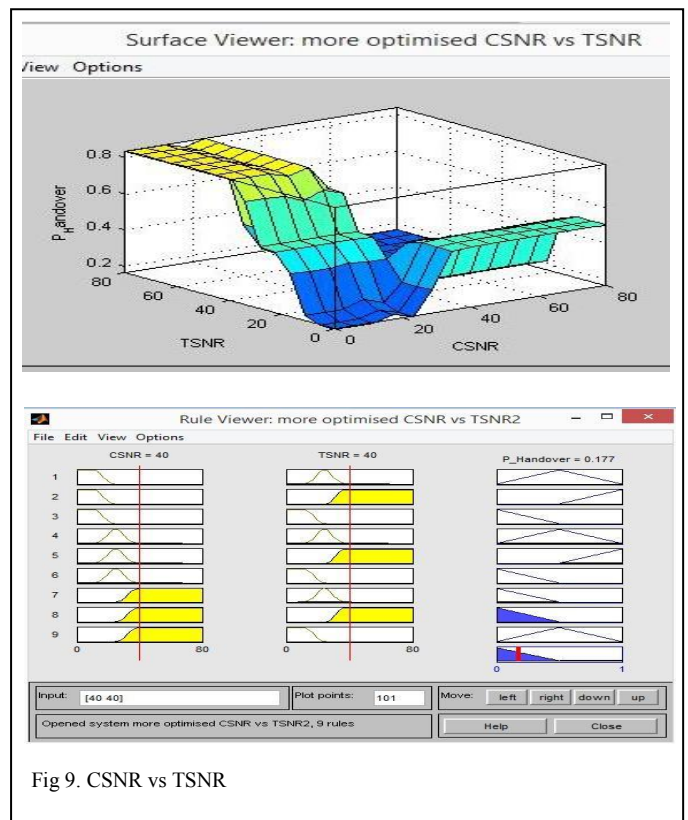


Fig 9. CSNR vs TSNR

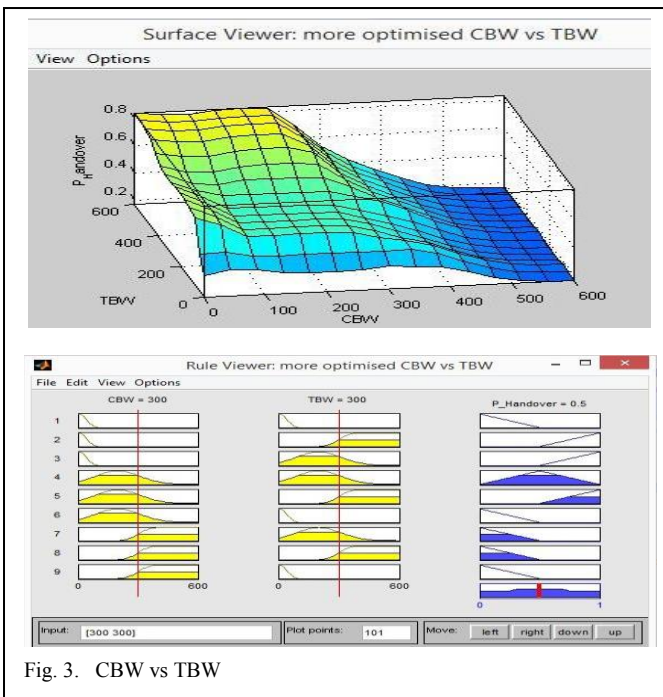


Fig. 3. CBW vs TBW

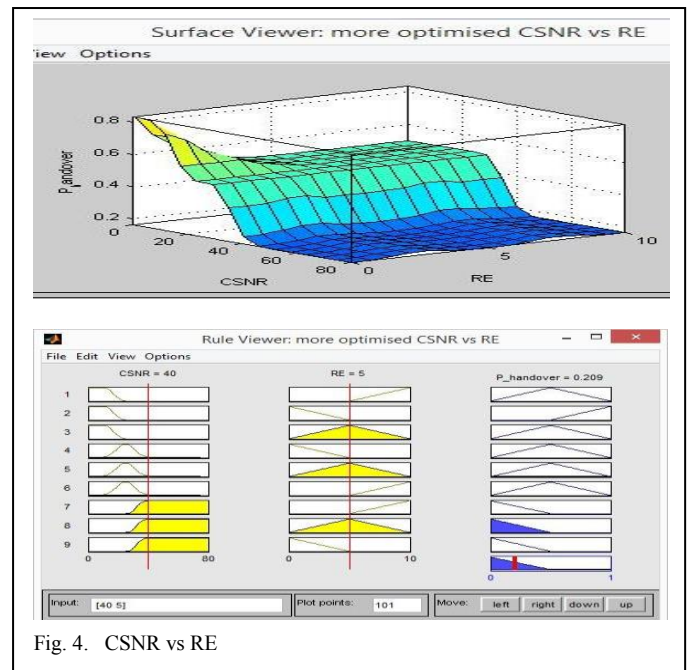


Fig. 4. CSNR vs RE

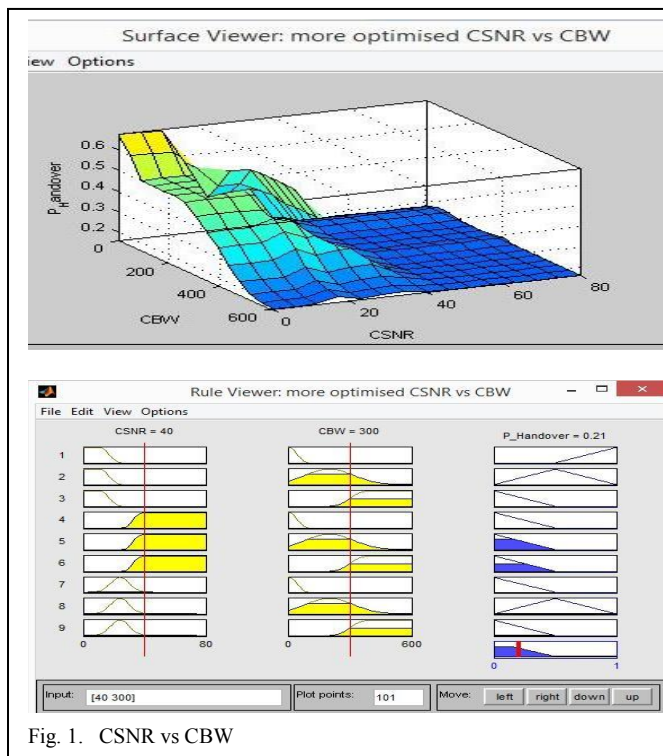


Fig. 1. CSNR vs CBW

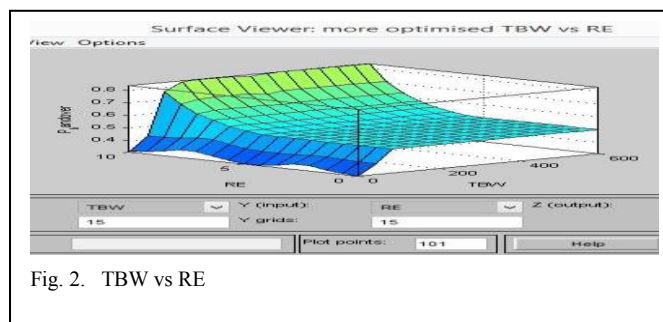


Fig. 2. TBW vs RE

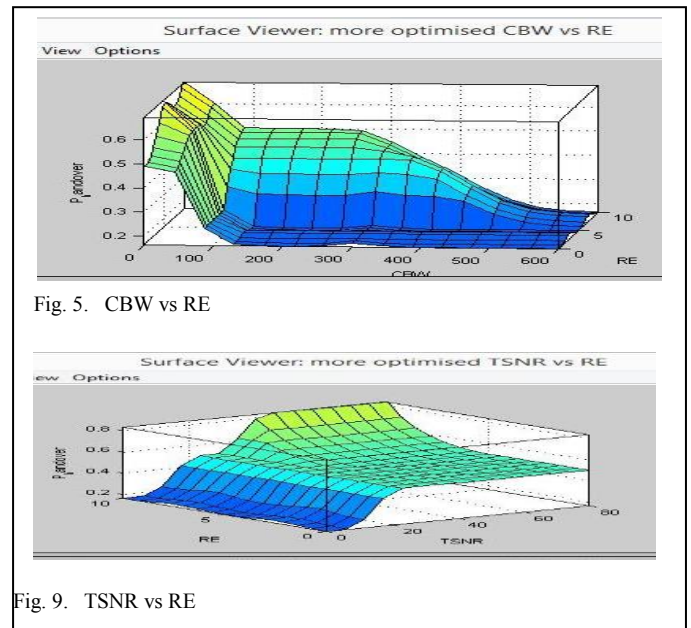


Fig. 5. CBW vs RE



Fig. 9. TSNR vs RE

X. CONCLUSION

In this work a productive insight to 4G technology, issues in LTE handover, and approaches to solve them are analysed. It shows how maintenance of QoS plays a vital role in any communication technology keeping in mind the limitations of the flaws of data link, radio channel, session management entities, and processing time of functional blocks is presented. The significant aspects of intra LTE handover, problems surrounding it, and available solutions for its detection/reduction are discussed.

XI. FUTURE SCOPE

- The hardware implementation of the above proposed work on a board.

- We worked on the handover part out the three classifications of the QoS namely CAC (Call Admission Control), Scheduling and Handover. QoS is indeed a very abstract topic, there may be more parts of QoS too, so still more work is required to be done on the rest part.
- We can add more precision to the above proposed precision algorithm by adding more levels in the out like very low, low medium, high and very high. But the results then will be the subject of research of the other parameters too.
- We took CSNR, TSNR, CBW, TBW and RE as inputs to find probability of handover. Other types of inputs that governs handover can be added or replaced to reduce the resultant number of handovers and thereby reduce the ping pong effect.
- The choice and number of membership function does matters a lot in optimising the results. Here we have used three membership functions but still more can be added.
- More precision can even be added by choosing more number of membership functions to the inputs and outputs. Here the choice of membership functions is a topic of research. FIS has 11 inbuilt membership functions and we may make functions of our own in order to add more precision in the handover decision.
- We worked on horizontal handover; there are many problems still yet to be explored in vertical handover. The same principle of more precise handover decision can be applied to vertical handover.

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FLEXURAL BEHAVIOUR OF HYBRID ARCH PROFILE PRECAST RC BEAM

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ABSTRACT— The current paper focuses on a detailed study of structural behaviour for an RCC beam with Hybrid profile consisting of a concrete arch tied with steel reinforcement. The beam comprises of Concrete arch, compression reinforcement, and tension reinforcement. New beam involves the idea that incorporates traditional construction materials (steel and concrete) in such a manner that it optimizes the performance of the beam constituents. Finite element analysis of the beam was conducted using standard software packages and its behaviour under flexural loading was compared with experimental findings. The deflection behaviour of the steel reinforcement was observed to be highly critical at loading beyond design load. The maximum difference between experimental deflection and numerical study in steel and concrete is 5.63% and 3.01% respectively.

Keywords —Hybrid arch profile, Arch beam, Finite element Analysis, Flexural behaviour

1. INTRODUCTION

The precast industry has been developing with the development of specific technologies. The aim of this work is to make use of the maximum strength with optimum utilization of materials to achieve maximum performance objectives. However, there is still a need to ensure that proper regulatory approvals and satisfactory performance can be demonstrated so that precast structural beams can be incorporated into construction projects. This work is focused on the improvement of the performance of the RC precast beam specifically in flexure. The main emphasis is on reducing the self weight of the precast beam so as to facilitate the lifting and assembling operation during the construction process of the precast building.

Harries et al. conducted the field testing and numerical modelling of the hybrid

composite beam used for bridge deck that showed the maximum deflection under the vehicular load [1]. In 2008 Hillman [2] conducted the product application of hybrid composite beam system under service loading for a brick deck structure. The stress and deformation values were within permissible values mentioned in applicable standards. The dynamic application of the hybrid bridge was studied by John et. al. in 2014 [3]. On-field monitoring and numerical analysis of the hybrid beam was conducted by Aboelseoud and Mayers in 2015[4-5]. The research work conducted by Shainur Ahsan in 2012[6] showed the effectiveness of this hybrid system for its effective utilization in practice. In the current work the hybrid arch profile beam has been developed for a shorter span in such a way that it can be utilized in precast structural systems. The focus is to study its experimental behaviour under flexural loading. The experimental investigation is also compared numerical using standard finite element software package ANSYS 15.0.

2. EXPERIMENTAL PROGRAM

2.1 BEAM GEOMETRY:

The rectangular section of normal RC beam comprises of tension zone and compression zone and the respective stresses are resisted by steel and concrete respectively. The compression zone of concrete utilizes its full strength whereas the tensile zone utilizes the strength of steel and strength of concrete in this tensile zone is completely ignored or hardly utilized. Thus, to optimize the use of material the concrete is complete removed from the tensile zone and to transfer the tensile stresses on the steel, the concrete is casted such that it forms an arch profile. The horizontal thrust generated by the concrete arch is resisted by side blocks that provided on both sides of the beam. The profile of the newly developed beam is portrayed in figure 1. To resist the tensile forces generated by bending effect is resisted by steel which is bonded to the full development length in the side block of the beam. These beams have great advantages because they are much lighter than concrete and steel beams of similar size reducing the transportation and lifting costs.

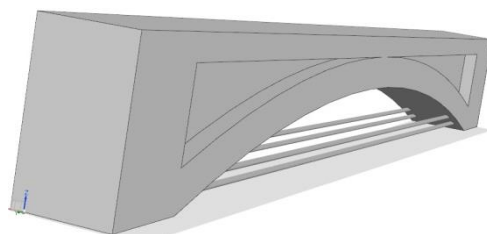


Fig. 1: Beam geometry

The beam has a maximum width of 175mm and depth of 300mm. Simple supports were provided 2.3m apart and two point loading was provided to study the flexural behavior of the hybrid beam.

2.2 FLEXURAL TESTS

The beam was loaded using two point load system as shown in figure 2, to generate pure bending at the central one-third part of the beam. Strain gauges were installed in concrete at the center of the beam on upper section and middle section. A strain gauge was also provided in the steel to clearly understand its deformation pattern with the increase in loading.



Fig.2: Flexural Test Setup

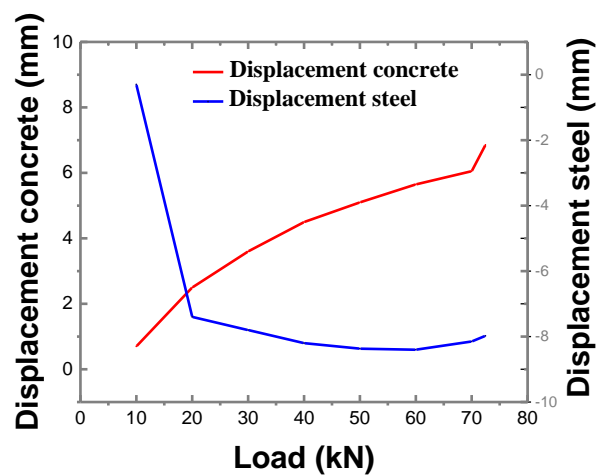


Fig. 3: Force deformation behavior of steel and concrete.

Load-deformation behavior of concrete and steel is portrayed in figure 3. The behavior of concrete at the compression fibre shows a regular parabolic pattern. The upward spike at the end is due to sudden shear failure of the beam. The deformation of steel initially is in upward direction due to tension generated in steel at the initial phase of the loading. This is also due to the fact that the bars which sags slightly due to its self-weight, retains a straight profile hence at the initial phase of loading, the deformation in upward direction is achieved at very lower load value of 20 kN. Thereafter the deformation is constant as the bars are completely tensed and contribute in taking tensile force generated in beam due to flexural loading on the beam. It is also seen that as loading approaches the design value the concrete arch is fully compressed and without the end restrains, as the arch deflects slightly in downward direction resulting the steel deflecting with arch in downward direction.

The similar deformation behaviour is observed in the analytical study as well (refer figure 4 and figure 5).

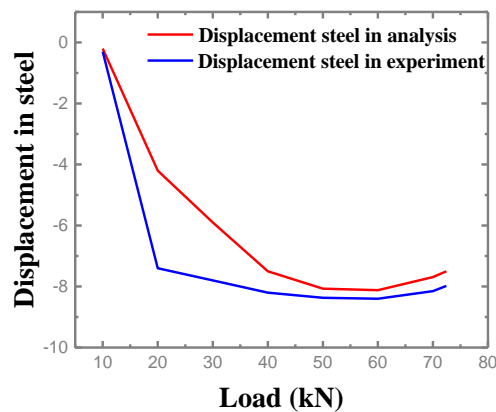


Fig. 4 Comparison of Load-deformation behaviour of steel in numerical and experimental study.

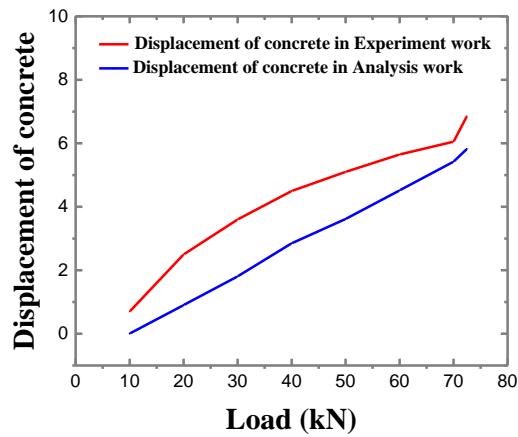


Fig. 5: Comparison of Load-deformation behaviour of concrete in numerical and experimental study.

3. CONCLUSION

Following conclusions can be derived from the finite element and experimental for the arch profile beam.

Self-weight of the newly developed arch beam is observed to be reduces by 41% as compared to conventional rectangular beam with same dimensional properties.

From the experiment study it was observed that the bottom reinforcement is instrumental in increasing the rigidity of the beam.

Axial thrust of the arch is resisted by the bottom reinforcement in the form of tension and reduces the deflection of the beam.

The experimental investigation also suggests that the arch profiled beam shall be provided with proper shear reinforcement to resist against the large stress concentration at joints of flange and web.

The maximum difference in deflection of beam in steel and concrete between experimental and numerical study is 5.63% and 3.01% respectively.

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Abstract

Document Sections

- I. Introduction
- II. Definition of Consistency
- III. Selected NLP Approaches of the Reviewer-Manuscript Match-Making System
- IV. Conference Dataset Description

Abstract:

Peer-review process is an important part of scholarly communication. The quality of a conference also depends on its peer-review process. The selection of a competent reviewer to review a submitted manuscript in a conference, is a crucial facet of a peer-review process. This selection relies on the adopted match-making approach along with the constraint optimization reviewer allocation algorithm. The match-making approach needs to be consistent with its decision of selection and allocation of the reviewers. In this work, we proposed a framework for evaluating the consistency of various standard NLP approaches that are used for match-making process in a conference. The consistency analysis was performed over a real multi-tracked conference organized in 2019. We showed that the Contextual Neural Topic Modeling (CNTM) with word embedding technique was most consistency among all the 13 approaches that we chose to analyze.

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A Consistency Analysis of Different NLP Approaches for Reviewer-Manuscript Matchmaking

[Nishith Kotak](#) , [Anil K. Roy](#), [Sourish Dasgupta](#) & [Tirthankar Ghosal](#)

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Abstract

Selecting a potential reviewer to review a manuscript, submitted at a conference is a crucial task for the quality of a peer-review process that ultimately determines the success and impact of any conference. The approach adopted to find the potential reviewer needs to be consistent with its decision of allocation. In this work, we propose a framework for evaluating the reliability of different NLP

approaches that are implemented for the match-making process. We bring various algorithmic approaches from different paradigms and an existing system Erie, implemented in IEEE INFOCOM conference, on a common platform to study their consistency of predicting the set of the potential reviewers, for a given manuscript. The consistency analysis has been performed over an actual multi-track conference organized in 2019. We conclude that Contextual Neural Topic Modeling (CNTM) with a balanced combinatorial optimization technique showed better consistency, among all the approaches we choose to study.

Keywords

Reviewer-manuscript matching Semantics analysis Consistency analysis

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Notes

1. Due to the data privacy and confidentiality conditions, the original conference's name is not revealed.

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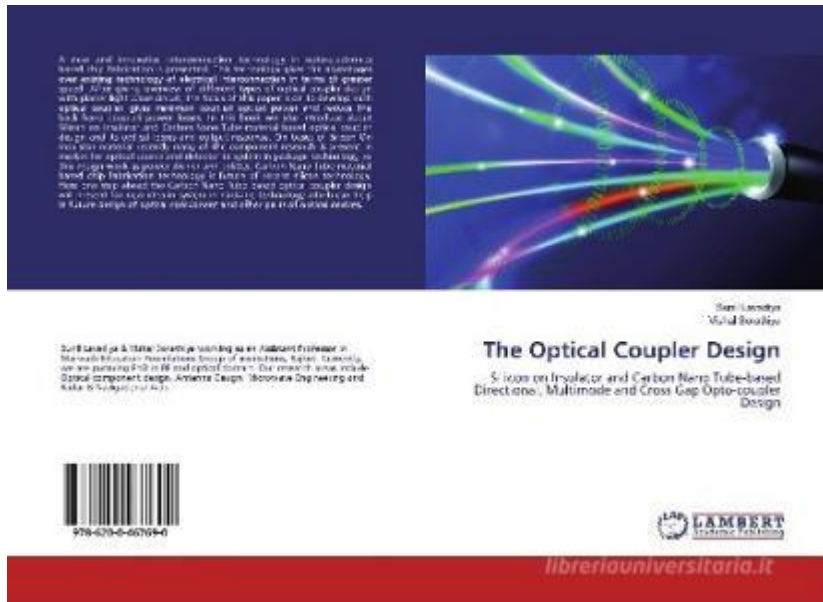
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The Optical Coupler Design

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A new and innovative interconnection technology in opto-electronics based chip fabrication is presented. This technology gives the advantages over existing technology of electrical interconnection in terms of greater speed. After giving overview of different types of optical coupler design with planer light wave circuit, the focus of this paper is on to develop such optical coupler, gives maximum coupled optical power and reduce the back hand coupled power losses. In this book we also introduce about Silicon on Insulator and Carbon Nano Tube material based optical coupler design and its optical losses and output response. On bases of Silicon On Insulator material recently many of the component research is present in market for optical source and detector in system in

package technology, so this design work as power divider and splitter. Carbon Nano Tube material based chip fabrication technology is future of recent silicon technology. Here one step ahead the Carbon Nano Tube based optical coupler design will present for new idea in system in package technology which can help in future design of optical component and other parts of optical devices.

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Polarization of THz Signals Using Graphene-Based Metamaterial Structure



Vishal Sorathiya and Sunil Lavadiya

Abstract Graphene-based Terahertz devices have attracted huge attention because of their ultrathin design and tunable property. The graphene-based polarizer can be formed using a single or multilayer of graphene sheet over the dielectric substrate. The different shapes and size of the engraved graphene geometry make possible to design different band and different mode of the polarizer which was ultrathin in design. The graphene-assisted polarizer also has the tunable by various physical parameters such as chemical potential, frequency, scattering rate. The graphene-based polarizer also provided unusual material properties like negative refractive index which makes the overall polarizer structure a metamaterial device. The proposed book chapter provides the fundamentals of graphene-based polarization devices. The chapter includes the mathematical modeling of the graphene-based polarizers devices and numerical investigation techniques used to identify the performance of the graphene-based polarizer structure. The chapter also includes a detailed comparative analysis of the previously published and available polarization devices in the market.

Keywords Graphene · Polarizer · Terahertz · Tunability

1 Introduction

Metamaterials (MMs), a modern form of the artificial substance that was recently investigated in terms of their non-traditional electromagnetic properties. These features are used to achieve numerous results such as negative refractive index [1], perfect lensing [2], bolometer [3], etc. On the other way, Graphene owns exceptional optical, electrical, and mechanical properties, such as large young modules, high

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Paper ID: 89

Design of Shock-free Conical Nozzles

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ABSTRACT

Conventional conical nozzles consist of a circular-arc throat profile with tangentially attached conical section. This configuration leads to formation of a weak shock as reported in several earlier works. This article presents a method that eliminates the weak shock by incorporating slight modifications in the throat profile. The modified throat profile is analysed using method of characteristics (MOC) and validated by inviscid computational fluid dynamics (CFD) simulation.

Paper ID: 95

Transition of Stratified-Wavy Flow to Intermittent Flow Pattern: Non-Linear Analysis of Pressure Fluctuations

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ABSTRACT

Gas-liquid two-phase flow is commonly observed in petroleum and chemical industries. Stratified flow pattern is simpler form of gas-liquid two-phase flow in which higher density fluid flows under the lower density fluid with non-disturbed interface. Small alteration of flow rate, chemical and physical properties of phases and pipe orientation or geometry leads to transition from stratified to wavy and then intermittent flow. Intermittent flow is associated with sudden pressure surge, erosion-corrosion and fatigue stress in the pipeline. This causes pipe failure at bend, T- and I-sections. Such failures lead to hazards and economic losses for the industries. It is required to develop a realistic approach for predicting the transition of such patterns in order to avoid intermittent flow inside pipe. In current study, transition from stratified to wavy and then intermittent flow patterns have been identified experimentally using recurrence network analysis of recorded pressure fluctuations for different flow conditions. The recorded time series of instantaneous pressure fluctuations have been analyzed using traditional recurrence quantification and recurrence network analysis. The two coefficients: recurrence rate and entropy have been used for differentiating the dynamics between these two-phase flow patterns.

Paper ID: 101

Relative study of a Plain Circular Bearing and Two-Lobe Journal Bearing Lubricated with Micropolar Fluid

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ABSTRACT

The consequences of the performance characteristics of micropolar lubricant for a plain circular bearing and two lobe journal bearing was investigated and compared with Newtonian fluid. Modified Reynold's equation with proper conjecture for both the bearing hydro-dynamically lubricated with Micropolar lubricant is used to obtain the characteristics of fluid flow equation. Finite width bearing having $L/R=2$ is solved by applying the FDM. The results show a strong influence on the load carrying capacity of journal bearings by using micropolar lubricant for both the bearings. The static characteristics i.e. pressure, load, stiffness and damping coefficients and also dynamic characteristics i.e. critical mass, threshold, whirl frequency ratio were evaluated for the eccentricity ratio of 0.3. The computational result holds that the effect of micropolar parameters plays a very significant role on the performance (static and dynamic) of journal bearing and also the stability of both the bearings is enhanced by using micropolar fluid in comparison with Newtonian fluid.



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A NOVEL EXPERIMENTAL STUDY ON UTILIZATION OF RECYCLED PLASTIC WASTE IN GEOPOLYMER CONCRETE

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ABSTRACT — This paper represents test results of compressive and splitting tensile strength carried out on the geopolymer concrete modified with three types of recycled plastic forms (RPF). The RPF comprises powder, granules and aggregates from polyvinyl chloride (PVC), high density polyethylene (HDPE), and post-consumer road side plastic wastes (RPW) were replaced with the constituents namely fly ash, sand and aggregates respectively. All three types of RPF were added in varying proportions from 0% to 15% by weight of respective constituents of concrete. The results revealed that splitting tensile strength increased up to 35%, 34% and 27% for RPF granules, powder and aggregates respectively at the dosage of 10% of RPF as optimum fractions. The compressive strength was adversely influenced by RPF powder and showed reduction at low rate. However, except the powder form, the granule and aggregates showed excellent increment of strength up to 30% at 10% dosage of RPF. It was concluded that the usage of RPF in aggregate and granule forms at 10% replacement by weight of the conventional constituents can be potentially utilized for Geopolymer concrete (GPC) and showed excellent improvement of the strength properties.

Keywords — Geopolymer concrete, recycled plastic waste, compressive strength, splitting tensile strength.

1. INTRODUCTION

Plastic is one of the most consumptive materials all over the world [1]. Management and safe disposal of plastic waste has become a compulsion to keep the environment clean and healthy. Utilization of plastic waste as construction material may be one of the solutions towards green and healthy environment [2].

Cementitious concrete is one of the energy intensive materials being the second major source of generation of carbon dioxide after automobile and needs an attention to get an alternative. GPC prepared with industrial wastes namely fly ash and alkaline activator has emerged as one such alternative to the cement based concrete in recent decades. After being first coined by Prof. Glukhovsky in the former Soviet

Union in the middle of 20th century, later in 1970s Prof. J. Davidovits [3-5] researched on a chemistry of geopolymer binder and its application as a construction material. Usage of pozzolanic materials viz. fly ash, red mud and alkaline activators makes GPC an environment friendly and less energy intensive construction material. Noticeable work has been carried out by many researchers on the usage of waste plastic in concrete as well as in GPC. A. Bhogayata et. & all [6] tested the concrete blended with recycled plastic and had a thickness of less than 20micron.Reduction in strength up to certain extent was observed. Though it was still a bearable way of disposal of plastic. Physical and mechanical behavior was tested for waste PET bottle fibres used in conventional concrete by Luiz A. Pereira de Oliveira & João P. CastroGomes [7]. Zainab Z. Ismail and their fellow colleagues [8] used waste plastic in concrete mixture as aggregate replacement, it is mentioned that, the compressive strength values of all specimen containing waste plastic likely to decrease below the values for the reference specimen, with increasing the amount of waste plastic at all curing periods. This may be characterized to the decrease in the adhesive bonding between the plastic waste surface & cement paste. R. A. Patel, Ankur Bhogayata and their fellows [9] worked on Flexural response of Geopolymer concrete beam containing metalized plastic waste, the stress strain behavior of beam was analyzed which highlighted that, for analytical study moment resistance capacity was decreased 12.92%, 4.54% and 3.72% in shear reinforced beam, over reinforced beam and under reinforced beam respectively.

The objective of this experimental study deals with the assessment of addition of recycled plastic forms (RPF) in GPC by replacing the conventional constituents for the possibilities to utilize hazardous plastic waste as a construction material. The polyvinyl chloride (PVC) waste recycled into powder form, High density polyethylene (HDPE) pipes were recycled into granules of 2mm average size and road side plastic wastes (RPW) melted to form lumps were grinded into 10mm average sized particles (Fig.1) which were utilized in the fraction range of 0 to 15% by weight of the conventional concrete constituents of GPC namely fly ash, sand and aggregates respectively. The alkaline activator solution was produced by NaOH and Na_2SiO_3 solutions as shown in Fig. 1.

2. EXPERIMENTAL PROGRAM

2.1 Material & Mix design

Recycled plastic waste was mixed as a replacement of Flyash, Sand and 10mm aggregate, concrete mix was prepared using low calcium, Class F fly ash (ASTM-C618) obtained from the Wanakbori Thermal Power Station, Gujarat, India, as it is much preferred in making of GPC due to the high content of amorphous alumino silicate phases and greater workability. Specific gravity of Fly ash used was 2.4. The chemical composition of Fly ash was obtained by X-ray fluorescence test which is shown in Table 1.

Recycled plastic waste in different form was added as a partial replacement of Flyash, sand and 10mm aggregate in variation of 0%, 5%, 10%, and 15% by weight of conventional constitute. A combination of sodium silicate (Na_2SiO_3) solution and sodium hydroxide (NaOH) solution was used as the alkaline binder. It is proposed that the alkaline binder needs to be rendered by combining both of the solutions together at least one-day advance to use [10-11]. Table 2 shows mix design and curing details adopted for this experimental work.



(a) PVC Powder (b) HDP Granules (c)RPA Granules (d)NaOH Pellets (e) Na_2SiO_3

Figure 1 Material Used

Table 1 Chemical analysis of Flyash

Table 2 Mix Design and curing details

Oxide	Percentage (%)	Constituent	Value	Unit
Silica (SiO_2)	50	Fly Ash	368	kg/m^3
		Sand	554.4	kg/m^3
Alumina (Al_2O_3)	28	10 mm aggregate	443.52	kg/m^3
		20 mm aggregate	850.08	kg/m^3
Ferric Oxide (Fe_2O_3)	12			
Calcium Oxide (CaO)	6.5	NaOH solution	46	kg/m^3
		Na_2SiO_3	138	kg/m^3
Magnesium Oxide (MgO)	06	Extra water	29.44	kg/m^3
		NaOH Molarity	16	Molar
Potassium Oxide(K_2O)	1.5	Curing Time	24	hours
Sodium Oxide (Na_2O)	0.2	Curing Temperature	100°	Celsius
Titanium Dioxide (TiO_2)	0.1	Type of curing	Oven Curing	

2.2 Tests

A. Strength Test of hardened mass

The mechanical strength of Geopolymer concrete with and without plastic waste was measured by conducting compressive strength test and splitting tensile strength test as per the standard mentioned in IS 516 – 1959. The results of Compressive strength and splitting tensile strength for GPC modified with different proportions of RPW are shown in figure 2 and figure 3 respectively

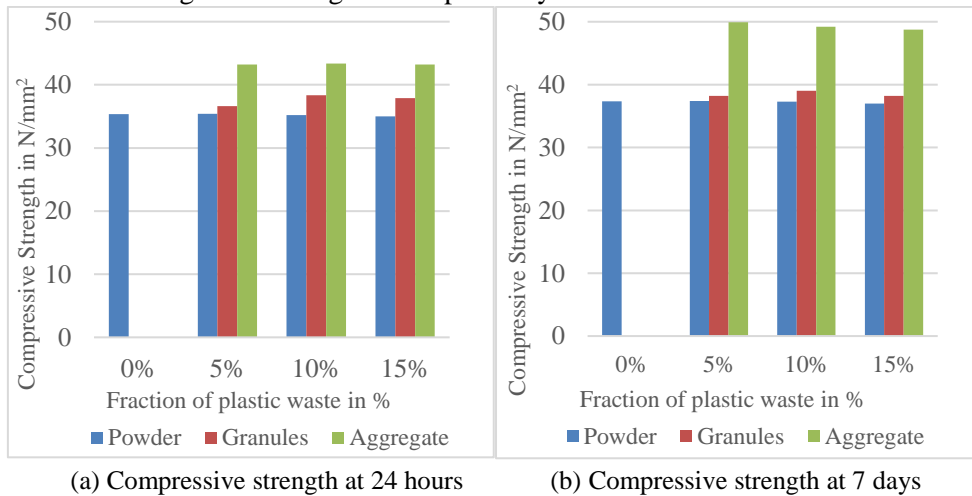


Figure 2 Compressive strength test results

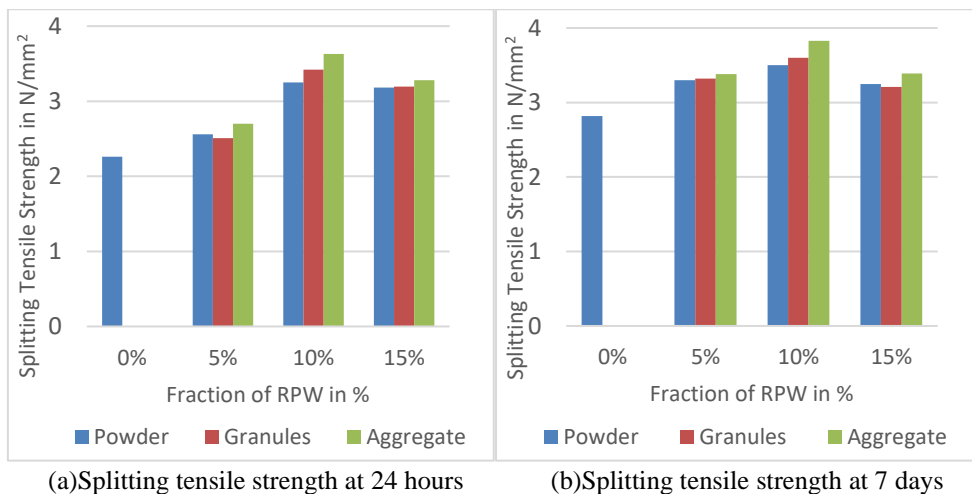


Figure 3 Splitting tensile strength test results

3. RESULT DISCUSSION

An analysis was made on the strength characteristics by conducting the experiment on GPC cubes and cylinders with PVC powder, HDP granules and RPA, which shows following results,

- Compressive strength of the concrete increases when the percentage of replacement of plastic granules is increased up to 10%, this can be explained as the better packing and rearrangement of the RPF aggregates particles in the concrete, then after compressive strength decreases
- Maximum compressive strength obtained 49.9 N/mm² at 5% plastic granules replaced with 10 mm aggregate followed by 49.2 N/mm² at 10% Plastic granules replaced with 10 mm aggregate at the age of 7 days of curing in GPC.
- Split tensile strength of the concrete increases when the percentage of replacement of plastic granules is increased up to 10%, then after split tensile strength decrease. It was observed that the plastic granules increased the crack resistance of the hardened mass due to its better bonding capacity with the other constituents.
- The presence of plastic granules in GPC prevents the sudden break and increases the fracture properties of the material

4. CONCLUSION

Following conclusions could be made based on the experimental study:

- The incorporation of HDP granules, PVC powder and RPW in GPC as replacement of sand, flyash and natural grit by 10% by weight exhibited excellent improvement in splitting tensile strength
- The incorporation of RPW in GPC as replacement of natural grit by 10% by weight exhibited excellent improvement in compressive strength.
- The experimental study showed potential of the utilization of plastic waste in GPC. The present study could provide a base for the future experimental works in the field.

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Simulation and Fabrication of High Gain Diffracted Ground-Based Metamaterial Microstrip Patch Antenna for C Band

[Sunil Lavadiya](#) , [Vishal Sorathiya](#) & [Sudipta Das](#)

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Abstract

A novel structure of microstrip patch antenna is presented for high gain enhancement and broadband wireless applications. The manuscript describes a comparative analysis of the patch antenna with the multiple split-ring resonators loaded patch antenna. The design performance was examined using different parameters like return loss, frequency resonance, voltage standing wave ratio, gain, and directivity. Gain

DURABILITY PROPERTIES OF CONCRETE CONTAINING USED FOUNDRY SAND

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ABSTRACT

This paper represents test results of Rapid Chloride Penetration Test (RCPT), Acid and Sulphate attack test carried out on the concrete containing used foundry sand (UFS) replaced with fine aggregate. UFS is major byproduct of metal casting industry. During the experimental work, the replacement of UFS from 0% to 100% of weight of fine aggregate in concrete without any replacement of material. Water cement ratio is fixed 0.50 for M25 grade of concrete and perform the above tests, the results revealed that percentages of replacement of used foundry sand was decreases from 0% to 60%, chloride penetration was decrease as compare to normal concrete test result, but after 60%, chloride penetration slightly increases but not more than control mix. Acid cured cube strength was increases up to 20% and then

after starts decreasing up to 100%. Sulphate cured cube strength was increases up to 40% and then after starts decreasing up to 100%. So, as we increase the percentage of used foundry sand there was an increase in durability property of concrete.

1. INTRODUCTION

Ferrous and non-ferrous metal casting industries produce several million tons of by-product in the world. In India, approximately 2 million tons of used foundry sand is produced yearly. Used foundry sand (UFS) is major by-product of metal casting industry and successfully used as a land filling material for many years. But use of UFS for land filling is becoming a problem due to rapid increase in disposal cost. To use the UFS in large volume, research has been carried out for its possible large-scale utilization in making concrete as partial replacement of fine aggregate.

Rafat Siddique and team evaluated durability properties of concrete containing used foundry sand as partial replacement from 0% to 60% with fine aggregate and concluded that concrete with foundry sand mixes showed good resistance to carbonation and rapid chloride penetration resistance was observed under the category of very low [1]. Gurpreet Singh and their fellows investigated durability properties of concrete mixtures, in which natural sand was replaced with five percentage (0%, 5%, 10%, 15% and 20%) of waste foundry sand (WFS) by weight and showed that WFS decreased the

chloride ion penetration in concrete [2]. Eknath and their fellow investigated the comparative study of the properties of concrete containing ferrous & non-ferrous foundry waste sand replaced with four (0%, 10%, 20% and 30%) percentage by weight of fine aggregate & results showed that water absorption is minimum with 20% ferrous WFS & with 10% nonferrous WFS [3]. All the researchers reported that WFS can be suitably used in making structural grade concrete.

The objective of this experimental study deals with the assessment of durability properties of UFS replaced with the conventional constituents in concrete for the possibilities to utilize industrial waste as a construction material. For this experimental investigation, industrial waste like UFS that might have no potential application except land filling was collected from local industries nearby the Rajkot city.

2. EXPERIMENTAL PROGRAM

2.1 MATERIALS USED:

Locally available river sand was used as fine aggregate as per IS 383:1970 and UFS collected from Shiji Industry nearby Rajkot city was used as replacement of natural sand, crushed angular aggregate with maximum grain size of 20 mm and downgraded was used as coarse aggregate as per IS 383: 1970, Portland Pozzolana Cement (PCC) conforming to IS 1489 (Part 1): 1991 was used obtained from ultratech cement.

2.2 TESTS

A. Rapid Chloride Penetration Test

This test performs as per the ASTM C 1202 at the age of 56 days. This test method covers the determination of the electrical conductance of concrete to provide a rapid indication of its resistance to the penetration of chloride ions. The test method also provides an indirect measure of the permeability of the concrete, a critical parameter in all durability-related distress mechanisms. The lower the permeability, the longer the concrete will survive chemical and environmental attack.

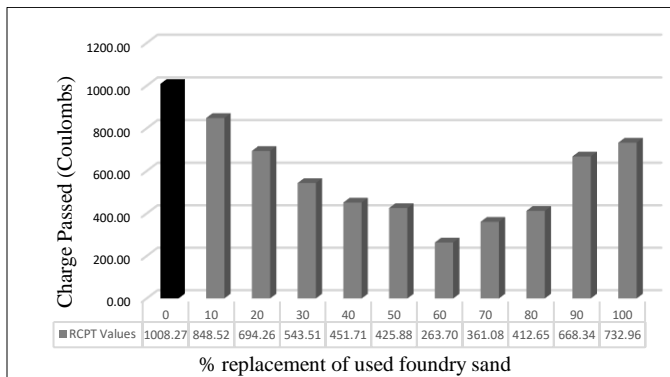


Figure 1 RCPT Test Graph

B. Acid Attack and Sulphate Attack Test

For determining the resistance of concrete specimens to aggressive environment such as acid attack and sulphate attack, the tests have been performed at the age of 56 days. The cubes were cast and kept at a temperature of $27^{\circ}\text{C} \pm$

2°C for 24 hours. After 28 days of curing, the cubes were immersed in a 5% concentrated sulphuric acid (H_2SO_4) & 5% hydrochloric acid (HCl) by weight of water for acid attack test and the other cubes were immersed in a 5% sodium sulphate (Na_2SO_4) solution & 5% magnesium sulphate ($MgSO_4$) by weight of water for sulphate attack test. After 56 days of curing weight difference and the compressive strength of cube were measured.

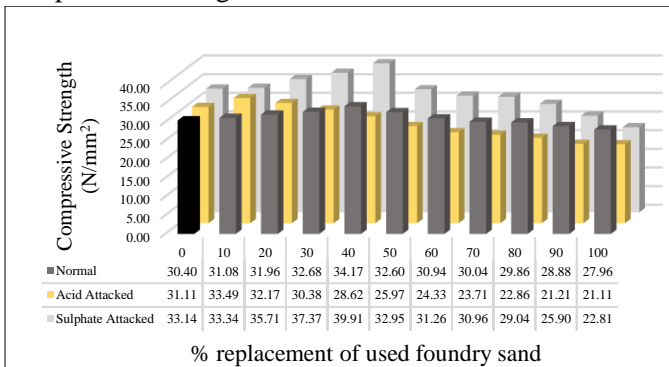


Figure 2 Acid & Sulphate Attack Test Graph



(a) RCPT Disc Specimen



(b) Acid Cured Cube



(c) Sulphate Cured Cube

Figure 3 Experimental Test Specimens

3. CONCLUSION

Following conclusions could be made based on the experimental study: (1) The incorporation of UFS in concrete as replacement of natural sand exhibited excellent improvement in durability. (2) The experimental study showed potential of the utilization of industrial waste in concrete production. The present study could provide a base for the future experimental works in the field.

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EXPERIMENTAL INVESTIGATION OF BEAMS SUBJECTED TO TORSION WITH DIFFERENT STRENGTHENING PATTERN USING GFRP

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ABSTRACT

This paper presents the results of the experimental investigation of the beams subjected to torsion. Strengthening of the beams will be done using glass fiber reinforced polymers (GFRP) sheets with different strengthening patters. Total five typical beams are to be cast in which one beam will be kept as reference beam without any strengthening and other beams will be applied various strengthening patters. These four different strengthening patterns are namely full wrap (WF90°), partial wrap (WP90°), cross pattern at 45° (X45°) and inclined pattern at 45° (V45°). It is observed that maximum additional capacity is achieved in WF90°; however, X45° is the most effective pattern amongst all considered in this study.

Keywords: *Torsion, Beams, Strengthening of Structures, GFRP Laminate*

1 INTRODUCTION

Structural strengthening of the existing structure is the need of today which is the continuous process nowadays [1]. In many situations arises like accidental loading, overloading seismic loading or structural distress due to which structural strengthening is required [2-4]. FRP strengthening of the structures is the most favorable method of strengthening nowadays due to a safe, reliable & convenient method of application, light in weight, higher strength, high chemical resistance and moldable in any shape [5]. Type of strengthening method depends on the type of damage like flexural, shear or torsional.

Repair and rehabilitation of engineering structure may prove more economical over reconstruction [6]. Previously the retrofitting of the structure was done by replacing inferior

quality or damaged concrete and steel bar by another new steel bar or by some potential material. Hence, considering all the advantageous properties this option of strengthening is the most economical one.

Torsion in the structure is very typical phenomena which take place due to the imbalance of stiffness about joints, in case of the beam to beam connection or structure is subjected to seismic loading particularly the corner elements. Many times, torsional effects in such cases are not considered or ignored in analysis and failure or distress takes place due to this. Appropriate strengthening pattern should have been applied to restore the loss of strength. Total five beams are considered in this study with the same configuration from shape, size, concrete grade and reinforcement point of view. Here, in this study the elements are strengthened in torsion with different strengthening schemes and best effective approach is derived.

2 EXPERIMENTAL PROGRAM

Design parameters of all the beams cast are mentioned in Table 1. The first beam is kept as reference beam without any kind of strengthening. The second beam is applied with fully wrapped with GFRP sheet in the perpendicular direction of the axis of the beam (WF90°). The third beam is strengthened with partially wrapped with 10 cm wide GFRP strips at an interval of 10 cm at 90° to the axis of the beam (WP90°). The fourth beam is wrapped with 10 cm wide GFRP strips at 45° to the axis of the beam in V shape at the interval of 10 cm (V45°). While in the last case, X pattern is formed with 10 cm wide strips (X45°). These all five beams are applied with torsional moment up to failure.

Table 1: Design Parameter of Beams

Parameter	Value
Torsional Moment (kN m)	18
Width of Beam (mm)	180
Depth of Beam (mm)	230
Top Reinforcement	3#16
Bottom Reinforcement	3#20
Stirrups	#10 @ 150 mm c/c

2.1 Material Properties

The beams are cast using M25 grade of concrete. Various properties of the ingredients like cement, sand, and aggregates are derived in the Material Testing Laboratory of Marwadi Education Foundation. The casting of beams is done using machine mix concrete. Properties of the GFRP laminates are shown in Table 2. A special type of epoxy is used to apply laminates on the beams. Properties of the epoxy used are mentioned in Table 3.

Table 2: Properties of GFRP Laminates

Properties	Value
Thickness per ply	0.358 mm
Ultimate Tensile Strength	2300 MPa
Rupture Strain	0.045 mm/mm
Modulus of Elasticity	76000 MPa

Table 3: Properties of Epoxy Resin

Properties	Value
Mixed Density	1,16 kg/lit.
Vol. Solid	100 %
Mixing Ratio by Weight	Part A:B = 100:34.5
Consumption	0.4 to 1.0 kg/m ²
Pot life	65 min at 30°C
Tensile Strength	45 MPa

2.2 Test Setup

Two brackets are made from C-sections in the institute workshop with variable internal gaps to accommodate different sizes of the beam which are applied at the ends in opposite directions. One cross girder is placed over the ends of the brackets. Finally, loading is applied at the center of the cross girder so that it would transfer equal load on either side. Due to loading one bracket would rotate in a clockwise direction while other would rotate in an anticlockwise direction. The loading frame used is of capacity 550 kN. A testing arrangement under torsion is shown in Fig. 1.

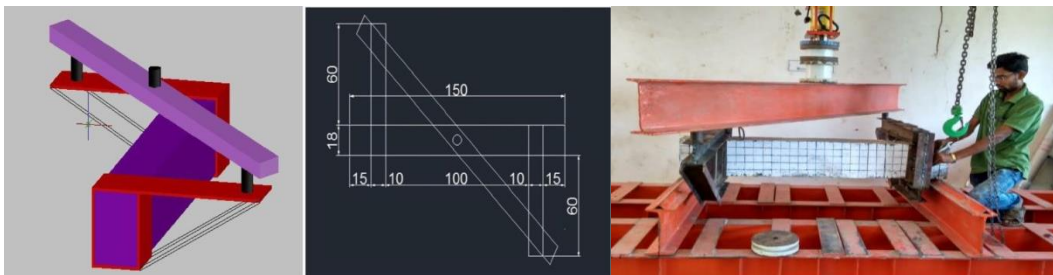


Fig. 1: Test setup for beam subjected to torsion.

2.3 Experimental Results

All the five beams are tested in loading frame with a rate of 0.5 kN per minute. During testing close observation is made for the first crack developed. Twisting angle of the beam during the test is also observed for all at ultimate load. All the beams are initially designed for a torsional moment of 18 kNm. It is observed that what additional capacity of carrying torsional moment due to different strengthening pattern is achieved.



Fig. 2: Strengthening Pattern and Failure of N1



Fig. 3: Strengthening Pattern and Failure of WF90°

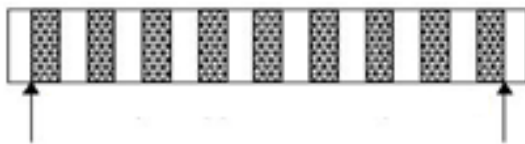


Fig. 4: Strengthening Pattern and Failure of WP90°



Fig. 5: Strengthening Pattern and Failure of V45°



Fig. 6: Strengthening Pattern and Failure of X45°

Structural elements subjected to torsional moments are subjected to shear and diagonal cracks as observed and the beam fails in shear ultimately. Fig. 2-6 shows schematic diagram of strengthening pattern and their failures. As expected, the first crack is observed at 16.9 kN in the reference beam. Torsional capacity at this load is 20.28 kNm at this level compared to design moment of 18 kNm. Hence, 20.28 kNm is the actual torsional capacity of all the black beams and moments in addition to that is the contribution of the GFRP strengthening. Table 4 shows the cracking load, ultimate load, cracking moment, ultimate moment and twisting angle of all five beams.

Table 4: Test Results of All Beams

Beam	Cracking Load (kN)	Ultimate Load (kN)	Cracking Moment (kN.m)	Ultimate Moment (kN.m)	Twist Angel (Radian)	Additional Capacity (%)
N1	16.9	40.8	20.28	48.96	0.104	--
WF90°	22.6	55.9	28.52	65.08	0.251	40.63
WP90°	18.4	42.3	22.08	50.76	0.157	8.88
V45°	20.5	49.8	24.60	59.76	0.209	21.30
X45°	21.8	52.4	26.16	62.88	0.244	28.99

But obvious maximum additional capacity is achieved in WF90°. This is because the full wrap is applied on the beam which has provided full confinement to the beam. Also, maximum GFRP sheet has been consumed, whereas, minimum additional capacity is achieved in WP90°. Material consumed in case of WP90° and V45° is almost same but V45°

has performed better because of the orientation of GFRP sheets. Critical shear is directly converted into the axial tension of the GFRP sheets, which has improved the additional capacity. X45° with additional capacity of 28.99% has performed in best effective manner. This can be suggested as the best option amongst the patterns considered in this study.

3 OBSERVATIONS AND CONCLUSIONS

Important findings derived from the experimentation are summarized below.

- All the beams are failed in diagonal shear cracks developed due to torsion. Hence, it can be seen that the assembly generated by the candidate has performed well and applied pure torsion to all the beams.
- No flexural or shear cracks are observed in any of the beams, beams failed due to torsion only. Delamination of the GFRP sheets are observed and then cracks developed in the beams in the majority of the strengthened beams.
- The best performer pattern amongst all is full wrapping in the beam WF90°. 40.63% additional torsional capacity is observed in this case.
- X wrapping has performed well in the best efficient way with an additional capacity of 28.99%. Although, additional capacity is less compared to full wrap, however, material consumption is low compared to that. Hence, this type X45° can be considered as the best option for the torsional strengthening.
- V45° has an additional capacity of 21.30% which is again good compared to other option WP90° with same spacing of sheet and the same thickness of strips aligned vertically.
- The lowest performer in comparison is WP90° with additional capacity of 8.88% where the strips are aligned vertically.

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Terahertz Antenna: Fundamentals, Types, Fabrication, and Future Scope



Sunil Lavadiya and Vishal Sorathiya

Abstract Terahertz technology has grown in popularity in recent years due to the rapid development of wireless communication applications. To begin, the evolution of Terahertz antennas is briefly studied, and the fundamental concepts of THz antennas are employed. THz antennas are then classified as dielectric antennas, metallic antennas, recent novel material antennas. Following that, the most recent scientific advances in THz horn antennas, photoconductive antennas, on-chip antenna, microstrip antennas, lens antennas, on-chip antenna, graphene sheet-based THz antenna will be discussed. The technological challenges like the smaller size and relatively high loss for the developing THz antennas are addressed, along with promising methods. This chapter also discusses THz antenna designing technology and the critical problems and potential study directions for THz antennas. THz technologies open the new door for the application like radio astronomy, radar imaging, remote sensing, graphene-based plasmonic resonator, broadband communication, high data rate, high switching RF components, and fast-pulse optical time-domain spectroscopic techniques.

Keywords Terahertz antennas · Quantum cascade laser · Photoconductive antenna · Technological challenges · Graphene

1 Introduction

The popularity of wireless communication gadgets and the huge data traffic have reached a new era of accelerated growth [1]. A vast number of systems are now moving from PCs to cellular devices like mobiles, which are easier to bring and run in real-time, however, these conditions often results in a quick rise in data usage

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Grain boundary effects on the structural, microstructural and transport behavior of sol – gel grown PrMnO₃ nanoparticles

M. J. Keshvani, Savan Katba, Sadaf Jethva, Malay Udeshi, D. D. Pandya, N. A. Shah, Ashish Ravalia, Bharat Kataria, and D. G. Kuberkar

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Grain boundary effects on the Structural, Microstructural and Transport behavior of Sol – Gel Grown PrMnO₃ Nanoparticles

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Abstract. In this communication, we report the results of the studies on the grain boundary (GB) effect on the structural, microstructural and transport properties of nanostructured PrMnO₃ (PMO) manganites synthesized by acetate precursor based sol – gel method. As synthesized PMO samples were sintered at various temperatures to understand the role of sintering temperature in modifying the structure – property correlations in the context of GB effects. Structural analysis using X-ray diffraction studies reveal the single phasic nature of all the PMO samples while TEM analysis reveals uniform particle size distribution with agglomeration effect observed in samples sintered at higher temperatures. SEM micrographs depict the increase in grain size with sharp grain boundaries in the samples sintered at a higher temperature. Size-dependent resistivity behavior of the PMO samples have been understood in the light of grain size modification and GB effect.

INTRODUCTION

ABO₃ type perovskite oxides exhibit several interesting features of fundamental as well as technological interests. The rare earth perovskites, ABO₃, have been intensively studied because of a large variety of physical phenomena such as superconductivity, ferroelectricity and colossal magnetoresistance (CMR) [1, 2] exhibited by them. In all these phenomena, the electronic properties are intimately related to the lattice. Many of the interesting phenomena involve a complex interplay between the spin, charge, and orbital degrees of freedom, accompanied with subtle displacements in the crystal lattice. With the divalent doping, normally alkaline earth element specially Ca, Sr, Ba, Pb, etc, creates remarkable modifications electrical, transport and magnetic properties like metal to insulator transition (M-I), paramagnetic to ferromagnetic transition (PM-FM), charge ordering (CO) state with one more magnetic transition ferromagnetic to antiferromagnetic transition etc. Pr_{1-x}Ca_xMnO₃ (PCMO) does not show high conductivity associated with ferromagnetism in a cubic or rhombohedra phase. PCMO shows insulator-metal (I-M) transition under applied magnetic fields [3, 4]. Due to the smaller size of Pr as compared to La, change in the structural properties exists [5]. The ferromagnetism appears due to the high intrinsic magnetic moments of Pr in Pr based manganites. Keeping in mind all the above important features, aspects and observations on mixed valent manganites and especially on Pr based systems, in this communication, structural, microstructural and transport (ρ -T) properties of the sol-gel grown PMO nanoparticles have been studied in the light of GB and size effects.

EXPERIMENTAL DETAILS

Single phasic pure PMO samples were synthesized by employing acetate precursor based sol-gel method [6, 7]. High purity Pr acetate [$\text{Pr}(\text{CH}_3\text{CO}_2)_3 \times \text{XH}_2\text{O}$] and Mn acetate [$\text{Mn}(\text{CH}_3\text{CO}_2)_2 \times 4\text{H}_2\text{O}$] were taken as starting materials in appropriate stoichiometric ratio and respective mixed solutions were heated and stirred using magnetic stirrer at $\sim 95^\circ\text{C}$ for ~ 2 hrs and heated at $\sim 250^\circ\text{C}$ for ~ 12 hrs on hot plate to evaporate the water content from the solution. The brownish colored powder was then calcined at 350°C in a furnace for 6hrs. The final black powder of PMO was then pressed into the pellet followed by sintering at different temperatures (700(P7), 800(P8), 900(P9) and 1000°C (P10)) for 12hrs. All the samples were characterized by their structural properties using X-ray diffraction (XRD) measurements at room temperature. To understand the particle size and size distribution, transmission electron microscopy (TEM) has been carried out. For surface morphology, scanning electron microscopy (SEM) measurements were carried out at room temperature. Transport properties were studied using standard four-probe dc method in the temperature range: 200 – 300K, since below 200K, resistance measurement limit was reached.

RESULTS AND DISCUSSION

Figure 1 shows the XRD patterns of all the four PMO samples under study. All the samples possess single phasic nature without any detectable impurity within the measurement range. Peaks in the XRD patterns shift toward lower 2θ indicating an enhancement in lattice parameters and unitcell volume with increase in sintering temperature. Crystallite size (CS) have been calculated using Scherrer's formula [$\text{CS} = 0.9 \lambda / B \cos\theta$] for all the samples. CS increases from $\sim 29\text{nm}$ (P7) to $\sim 41\text{nm}$ (P8), $\sim 49\text{nm}$ (P9) and $\sim 65\text{nm}$ (P10) with an increase in sintering temperature. Enhancement in CS with sintering temperature can be ascribed to the agglomeration effect between the two or more crystallites resulting in the larger crystal formation. Fig. 2(a) & (b) shows the TEM images of P7 and P10 samples sintered at lower 700°C and higher 1000°C temperatures.

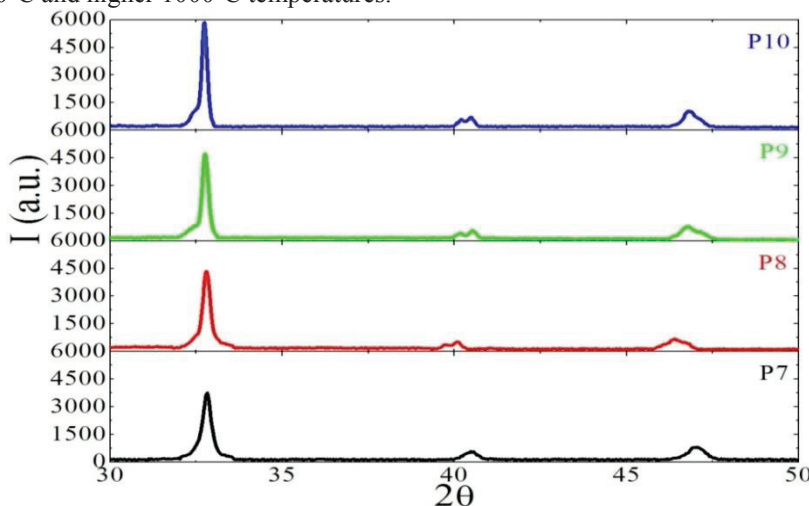


FIGURE 1. XRD patterns of Sol-Gel grown PMO manganites sintered at different temperatures.

It can be seen from Fig. 2(a) & (b) that, particle sizes for presently studied PMO manganites are in the nanoscale range. Sharp size distributions can also be seen in Fig. 2(a), for both the sintered samples. Particle size increases with increase in sintering temperature which may be due to the removal of boundaries at higher sintering temperatures. One can notice that the particle morphology looks like distorted in nature, as shown in TEM image of P7 in Fig. 2(a). This distorted morphology is removed in higher temperature sintered samples. Clear (distortion free) image of TEM can be seen for P10 sample in Fig.2(b). In both the samples, the homogenous growth of the particles can be seen in the TEM images. In order to understand the effect of sintering temperature on the grain morphology of the presently studied nanostructured PMO manganites, SEM measurements were carried out at room temperature. Fig. 2(c) & (d) shows the SEM images of P7 and P10 samples. It can be clearly seen from the SEM images that grain size increases with increase in sintering temperature due to agglomeration effect and hence number of grain boundaries gets suppressed. Also, in higher temperature sintered sample (P10), grain boundaries are slightly clear as compare to those in that P7. In general, XRD, SEM, and TEM studies show, that sintering temperature provides thermal energy to the smaller crystallites (XRD), particles (SEM) and grains (SEM) which get agglomerated resulting in the large sized crystallites / particles / grains by removing the distorted boundaries between them.

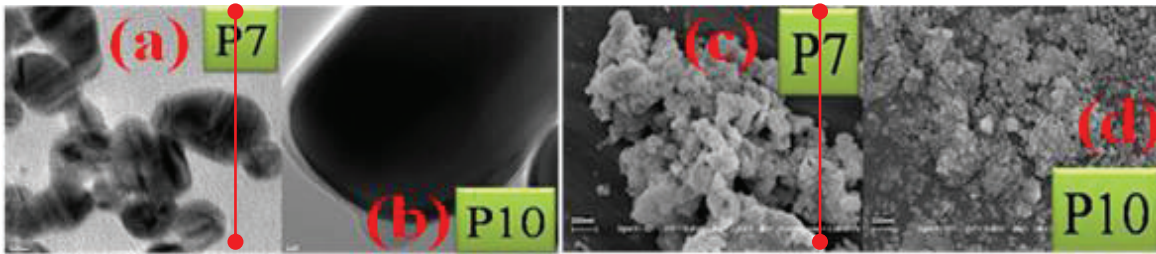


FIGURE 2. Typical TEM images of (a) P7 and (b) P10 and SEM images of (c) P7 and (d) P10 for Sol-Gel grown nanostructured PMO manganites sintered at 700°C and 1000°C.

Figure 3 shows the temperature dependent resistivity of presently studied nanostructured PMO manganites sintered at different temperatures. All the four samples exhibit insulating nature throughout the temperature range (200 – 300K) studied. This can be due to the strong effect of Mn^{3+} Jahn – Teller ion induced distortion in MnO_6 octahedra. Resistivity increases with increase in sintering temperature which may be due to the increased insulating grain size and a reduced number of distorted conducting grain boundaries. This suggests the effective structure – property correlations in the presently studied nanostructured PMO samples.

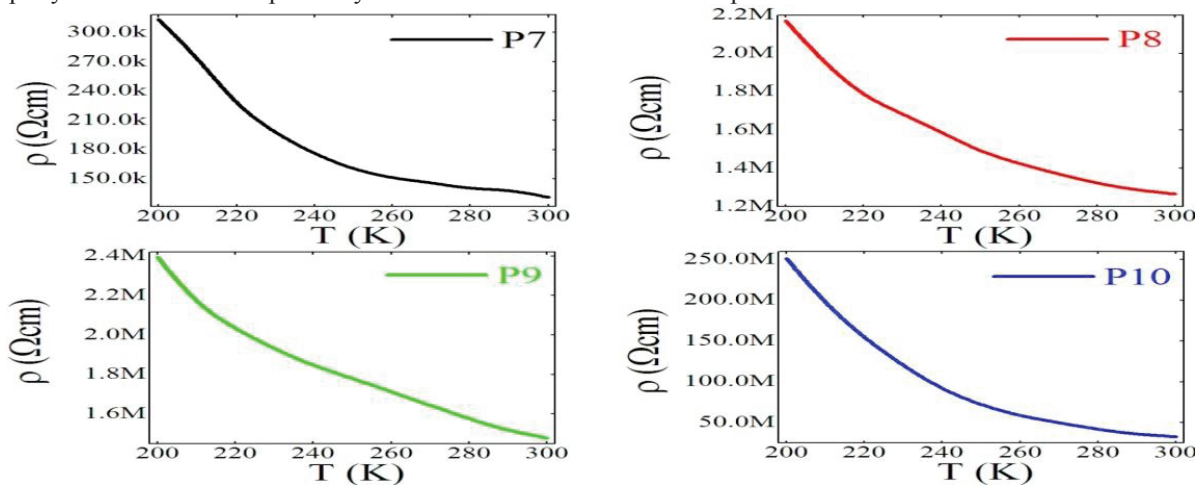


FIGURE 3. Temperature dependent resistivity for sintered nanostructured PMO manganites at different temperatures.

CONCLUSION

In summary, we have successfully synthesized single phasic PMO, using low cost Sol – Gel method which were sintered at different temperatures. XRD reveals the single phasic nature without any detectable impurity. Crystallite sizes were found to be in between ~29 to ~65nm range. Size of the particles gets enhanced with increase in sintering temperature mainly due to agglomeration effect between smaller particles at higher sintering temperatures. High resistive nature and insulating electronic phase has been discussed in the context of a strong effect of Mn^{3+} Jahn – Teller ion induced distortion in MnO_6 octahedra. Variation in resistivity with sintering temperature has been understood based on increased insulating grain size and reduced number of distorted conducting grain boundaries in higher temperature sintered samples and suggesting a strong structure – property correlations at nanoscale level.

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Vadodra Chapter

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Chapter 18

Sustainable Product Development: A Tool to Manage People, Planet and Profit in Covid World.

Dr. Rhuta Mehta¹ Ms. Nirali Karia²

Abstract

Sustainable products can be defining as those products that are offering an environmental, social and economic profits while caring for the public health and environment over their whole life cycle, from the mining and getting of the raw materials until the final disposal of the products developed.

Sustainable product development has marked its importance and presence during the pandemic time where, Covid-19 has created massive destruction and disturbance at an international level that has changed the entire socio-economic system that results in the de-globalization of almost all economic activities. Economies of all over the world have been impacted due to Covid-19 in the almost all the business including production, retail, hospitality, entertainment, aviation etc.

The purpose of this research topic is to comprehend and draw the attention towards the importance of sustainable product development, and its role as a tool to manage the 3P's i.e. People, Planet and Profit in Covid world even to identify the loopholes.

Conversation with all those founders of such products and the organizations, it has been observed that such entrepreneurs, even after working hard, are facing the resistance while putting their sustainable products in market. The issue is not related to the

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development or manufacturing of sustainable products, but it is about the lack of awareness among people about such products.

Introduction

In the perspective of the preface provided by the Charter of the United Nations, development is defined as the endorsement of social progress and enhanced quality standards of living in the larger autonomy. This extensive explanation of development is convoluted by adding the adjective "sustainable". The earliest meaning of sustain is to support, or to uphold the course of or to keep into being. Where the one more meaning is to provide with food and drink, or the necessities of life. Still another definition is to endure without giving way or yielding. The point to emphasize here is that the term 'sustainability' has ideological and political content as well as ecological and economic content. There is a struggle, worldwide, to determine how 'sustainable development' or 'sustainable capitalism' will be defined in the discourse on the wealth of nations (ibid., p. 153).

Popular mythology suggests that there is mostly one environmental movement, that it began with Earth Day in 1970, and that it is mainly concerned with preserving extra-urban nature (wilderness). Improved environmental performance of products and services has lately become one of the major tactical and operational targets of producers. This is because of the influences from different stakeholders including government, consumers, societies and the business partners. Markedly, diverged producers differently executed their environmental practices for sustainable product development depending on various driving factors such as customer awareness about it, legislation, economical reimbursement and competitive strategies, etc.

During the time of covid, we have lately realized that few practices of living the life followed by our ancestors were something important which were directly and indirectly affecting and was

playing a role in maintaining our health as well as the environment. The practices that were so normal and regular in the early days have now turned into something called innovation and or maybe we can call it the trend of living life today. Sustainable product development in that case is now becoming a tool to manage the people, planet and profit in the times of covid. Like there were lot many people who lost their jobs during covid and then there were the other few whose business came to an end due to covid. In such a time, the products that were made out of certain things which aren't harmful to the society and were under the head of sustainable products; played its role and such organizations grew pretty in these times. Like it was quite a normal thing to use the cow dung as a "dhup" (incense stick) in the earlier times, but covid now taught our generation to use it as one of the best ways to improve your breathing and maintain immunity.

Literature review:

One of the most recent developments in the emergence of the concept of "sustainable product development" which deals with elementary demands, essential product functions, and the system in which product function, the nature, availability, and selection of resources, and the distribution of those resources among nations and generation. In the last ten years, many companies all over the world have become aware of the fact that both economically and ecologically, proactive policies and preventive measures are far more attractive than after-the-event and end-of-pipe technologies. As a result, the 'pollution prevention' concept became increasingly popular (J.C. Van Weenen, 1995)

Waste is generally meant for discarding because it acts as a source of pollution (Pongracz & Pohjola 2004). However, if it is used in any other process such as feedstock it may be considered as a co-product (Brown 2003). For example; In India, 69.9% population resides in rural areas (The Hindu 2011), where a cow is major cattle

and generates 9 – 15 kg dung/day (Werner, et al. 1989; Brown 2013).

The need for introducing environmental requirements into the design and development of new products has already been discussed for more than a decade (Pezzoli K., 1997). Environmental requirements are mainly considered as an unavoidable "must", which generates additional design constraints and increases the cost (Bhamra TA 1999, Borland 1998, Fiksel J. 1996)

Current practices of product development in manufacturing companies are still predominately based on traditional cost/profit models (Asiedu Y, 1996) aiming at the high quality of product at a low cost and high profit. Users learn about products, their environmental, societal, and economic impacts and their use, and environmental aspects of changes in consumer behavior, and they develop ideas on how to influence corporate strategies. It is argued that too close a link to customers may hinder innovations as the company may only pay attention to current customers (Christensen and Bower, 1996, Danneels 2003) resulting in a strong niche orientation. (Brockhoff, 1997,1998)

Objectives of the study

1. To understand the significance of sustainable products and their' design development for people, the planet, and profit.
2. To understand the purpose and process adopted by the various companies for sustainable product development.

Research methodology

Qualitative research has been carried out to fulfill the stated objectives. Through telephonic interviews of ten entrepreneurs engaged in sustainable product development and production, the required data has been collected. Interpretation is based on researchers' own perception and understating.

Analysis

Research Analysis included the details collected from those companies, which included their product line, financial support, and source, inception idea about the start-up and their customer pool.

1. **Gaukriti** is the inventor of India's first handmade recyclable paper out of cow dung. These papers consist of seeds of vegetation that will grow in plants of Tulsi, Gander, Cumin, and such plants after being dumped.

Product line by Gaukriti: This company has come up with innovations in more than 70 products which include bags, bangle box, calendars, diaries, envelopes, and wedding cards and so on. During the hard times of covid, they also came up with masks made out of cow dung papers including the vegetation seeds too. Before the festival of Raksha Bandhan arrives, they also start manufacturing the rakhis made out of cow dung which are plantable too.

Interview Gist:

In our conversation with Mr. Bhimrao Sharma, we analyzed that the production of such an innovative product as cow dung paper was not an easy task. The idea behind coming up with such a product was protecting the cows from not being taken care by the owners while she is not giving milk and the second was protecting the environment. We came to know that there are times when cows stop giving the milk or give the least milk than its average capacity, during such times the cow owners either leave the cow or stop feeding the cow in the same amount that it needs on its daily basis. This is why, there were lot many cows found on the road who were not getting proper food and shelter. By coming up with a concept of making papers from cow dung, cow now became a monetary source even when she is not giving milk. Hence, the least owners now let their cows run on the road.

Talking about the manufacturing of paper; along with cow dung, cotton waste is also the other raw material that is used. Out of 40

Kgs of cow dung and the basic raw material, 100 Kgs of paper is manufactured at the unit of Gaukriti. While in the normal papers, 24 trees are cut down to manufacture at least 1000 kgs of paper. At the same time, the paper made at Gaukriti has 12 types of different seeds including fruits and vegetables which are suitable to grow in every different weather and soil condition.

The main reason Mr. Bhimrao highlights about least acceptance and sale of such products in our market is the lack of awareness among people about such products. There could be various ways that he suggests to push such products in the market and the government can play a big role in it, but we haven't reached there yet and so, most of the products that are manufactured are exported to other countries.

Resources: The main raw material for manufacturing these papers is cow dung which is bought by Gaukriti at the rate of Rs. 10 per kg from different cow owners. Along with that the cotton waste is also bought and the seeds of different vegetation are also added in these papers which makes the papers recyclable.

Customer Pool: In our conversation with Mr. Bhim rao, we analyzed that as such there are no fixed and major customers to their business. The handicraft stores can be a great medium to sell such things but still, there is the least acceptance of keeping such products even at the stores. The main selling at present is done through online mediums like Amazon and Flipkart. Other than that, a maximum of products are exported to different countries like USA and Italy.

1. **MKV Enterprise** is a manufacturer and a supplier of Areca Plates, Bagasse plates, earthenware, Bamboo products, Fiber products, and Organic products. They are leading merchant and trade exporters of such sustainable products.

• **Product line by MKV Enterprise:** The product range offered by MKV Enterprise is as below:

1. **Areca products** include bowls, cups, rectangle plates, round plates, areca-shaped bowls, and square plates.
2. **Bagasse products** include bowls, containers, meal trays, and plates.
3. **Earthenware products** include biryani pots, cooking pots, clay cups, glass, flower pots, frying pan, ice cream pots, kitchen sets, long handle pots, diyas, rice cooker, S type pots, serving bowls, water filters, water jug, and water pot.
4. **Bamboo products** include bowls, glass, mugs, utensils, water bottles and water glasses.
5. **Coconut shell products** include coconut shell agapai, incense stick stand, bird feeder, bowls, designed bowls, forks, earrings, candle holder, hair clips, ice cream bowl, gift box, oval cups, salad cups, soup cups, semi-polished cups, spoons, teacups, and wine glasses.
6. **Banana leaf** is the other product altogether that is exported to Arabian countries.

Interview gist:

In a conversation with Mr. Kamal Venu, we analyzed that maintaining and offering such a large range of products is not easy, but still taking inspiration from his father; he is working to take this organization to a height. He tried and collects the maximum range of such sustainable products under him so that such customers don't have to keep searching in market for finding these products. There are very few organizations in India that are working hard to bring such products among us, make them available easily among us, and MKV Enterprise is one such among them.

The organization is particularly in the manufacturing of Earthen and Areca products, the other products are bought from different manufacturers and provided at this same platform for the ease of customers.

The thing we analyzed and discussed here again was the lack of awareness and acceptance for using such products in the Indian market and so the maximum of the products are exported to the countries like Europe, Australia, Israel, Canada, the US and other Arabian countries.

Customer Pool: As in the case of Gaukriti, the major customers are not Indians but the people in other countries so the export amount is higher than the local buying.

1. **Other companies:**

The other companies that we were able to understand and know about were:

1. **Plantable** – This is into the making of recyclable papers with seeds providing a range of papers, diaries and wedding invitations.
2. **Fabrefine** – This is into recycling the old jeans into items like handbags and other accessories for females.
3. **Earthen** – This is into manufacturing the products like plates, bowls and spoons out of the palm leaves.
4. **Dinearth** – This is into manufacturing tableware and crockery out of sugarcane bagasse pulp without any plastic or wax coating.
5. **Greenvale eco-products** – This is into manufacturing the products like plates and bowls from sugarcane wastage.
6. **Champs Agro Unit** – This is into the manufacturing of eco-friendly handicraft items out of banana fiber like papers, gift boxes, dairy covers, and other products from palm fibers, and jute wine bags.
7. **Green-o-Tech India** – This is into collecting the paper waste and converting it into stationery products. The other initiative we would mention about them is they plant one tree on recycling of every 100kg of paper waste.
8. **Ecoware** – This is into manufacturing the products like bowls, boxes, cups and plates out of common crop waste.

Discussions

From this research study, we analyzed and understood that there are many organizations and the entrepreneurs behind such organizations that are working on developing sustainable products and their' manufacturing and selling. And to our surprise, we came to know that most of the products are that are manufactured by such units are exported only. And in our conversation with such entrepreneurs, we realized that they are into exporting such products just because there is least awareness of such products in our country. The other thing that we realized is, there are least efforts by the government for pushing such products in the market. India is and has always been rich in terms of agricultural products and major sustainable products are from agricultural by-products and other such things. So we have options always open for such products but it is just the lack of awareness of using such products in our market and such products are in-demand in foreign markets and so are exported in maximum numbers.

Implications of the study:

With this research study, we analyzed that there are lot many organizations coming up with the manufacturing of sustainable products with a motive to protect Mother Nature and the interest of our future generations. We as responsible humans shall support such business organizations by using such products a maximum of times. Such organizations bring up not only innovations in products but are also generating more employment opportunities. The profit is not only earned in terms of monetary resources but also the environment is protected and nothing can be a better profit than protecting the nature for future.

As seen, we always try and imitate the foreign markets and style of living and habits, we also saw that maximum products are exported from our country and then people from our country are inquiring there for such products, but never took care of looking in our own

country for such products. For now, exporting the products in maximum is good, as the earning comes into foreign currency and so ultimately our economy gets support and growth. But we must also focus on the point that we shall not earn compromising on our health and not taking care of the environment that we live in.

We as researchers of this study will like to make points to the future entrepreneurs that; the coming generation will be more careful and concerned about protecting the environment and start using such products and promoting such products. Jumping into innovating and bringing such products in the market right now may seem difficult, but we are sure that the future of such products is going to be the brightest.

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9	Vijay PartapRana and S. K. Patidar	ranavijay563@gmail.com	NIT Kurukshetra	Waste Management in a Pulp and Paper Industry	



affected because the very nature of ingredients is changing and now is in short supply. The indigenous nature of painting is also changing because now those who are capable to buy synthetic colors are resorting to using it and the less affluent ones; who form the larger portion of the social fabric, are keeping away from practicing the art and culture which was at one time an integral part of their lives. Therefore the art forms are on the verge of extinction. This study discusses the nature and types of ethnic paintings of Jharkhand. Through a theoretical enquiry substituted by empirical evidence it delves on the effect of climate change on the environment and subsequently on their art forms. The paper has implications for academicians, Government agencies and researchers and art lovers apart from environmentalists.

Key words: indigenous, paintings, Jharkhand

Tracer based estimation of alteration in chemical weathering sourcing H^+ ion and water sources in upper Chandra glacierized catchment

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Abstract

Chemo-dynamics of glacier stream in upper Chandra basin has shown a significant variation in weathering processes and ionic composition in recent past decades. Multiannual record of hydro chemical indices ($Ca^{2+}+Mg^{2+}/Na^++K^+$), (Ca^{2+}/Na^+), (Mg^{2+}/Na^+) and C-ratio) in association with negative mass balance indicate the chemical weathering characteristics governed by carbonation via atmospheric CO_2 (CAC). During positive mass balance, atmospheric mediated carbonation is either suppressed or dominant in association with sulphide oxidation coupled with carbonate dissolution (SO/CD). Decadal late (2003-2015) variation of electrical conductivity in melt water has shown a significant difference in statistics ($P = 0.01$ for both ions, significant at $\alpha < 0.05$) as well as in percentage composition (92.14%) when compared to their early record. Decrease in ionic concentration and uniform dominancy among ions ($Ca^{2+} > Mg^{2+}$ and $HCO_3^- > SO_4^{2-}$) is the indicative of increased glacier discharge (dilution effect) and similar geology respectively. Thus, present study is focussed to identify the major water source components that responsible for discharge in glacier stream. Possible water source components (surficial melt, rain water and subglacial melt) bound to stream water were considered as end member indices, mixing plot is generated among them where it is shown that all stream water get accommodated inside the vertices of three end members. Further, isotopic values ($\delta^{18}O$) of rain water during rain events abruptly effects the isotopic composition of stream water (rainfall-runoff characteristics) and thereby confirms itself as a water source components of the stream discharge during ablation season. Moisture sources of rain water having the influence of Westerly's and ISM along with the factors (temperature, relative humidity and amount effect) controlling its isotopic composition is also identified. The $\delta^{18}O$ and d-excess variation in the rainfall reflects that south west monsoon is spanning the short stretches during summer while rest of the period is influenced by mid-latitude westerly.

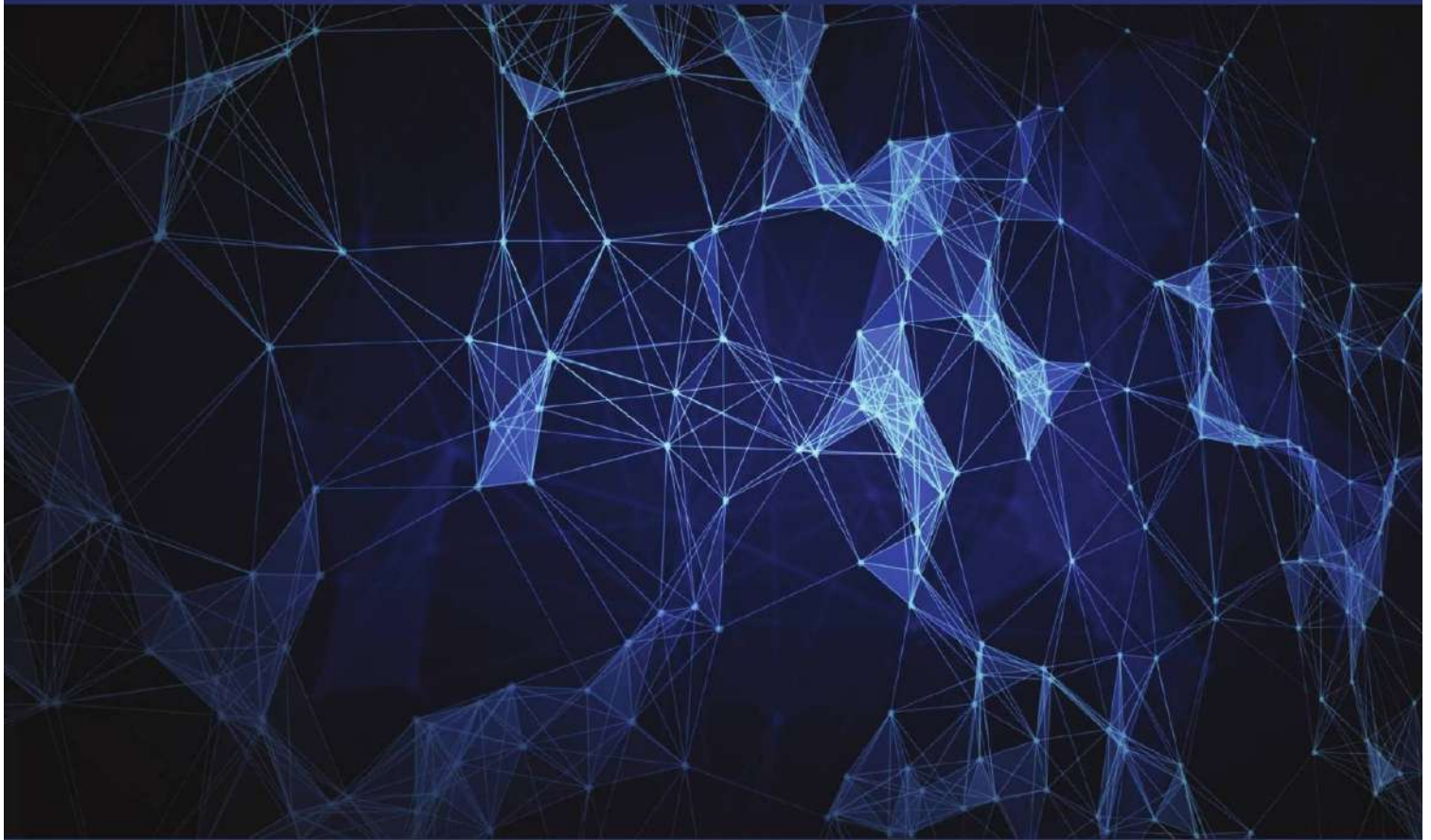
Key words: Chemical weathering, mixing plot, rainfall-runoff

Air Pollution "Holiday Effect" resulting from the Indian Color Festival

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Abstract

This study focuses on the investigation of the variation of the concentration of air pollutant (PM_{10} , $PM_{2.5}$ & CO_2) during Holi festival at the Rajkot city, Gujarat, India. There were 4 sites selected (i.e., 3 urban and 1 rural site), on which sampling was done for the study period of 27 Feb 2018 to 3 March 2018. 24 hrs monitoring for pollutants was carried out using fine dust sampler for mass measurement while Airveda Air Quality Monitor was used for the real time pollutant data. It had been observed that due to sudden shock load due to biomass burning at holi having resulted in hasty increment in fine particle concentration, which is reported even low in pre and post holi festival days. $PM_{2.5}$ concentration, during pre and post holi was recorded as $35.3 \pm 8.13 \mu g/m^3$ and $41.4 \pm 5.8 \mu g/m^3$, which are under the Indian standards, whereas during holi 24 hr average concentration is



T. H Goda
Prof. A. N Desai

Non-Conforming Element an inventive approach in Finite Element Method



In this book, Infrastructure is the basic facilities and installations that help a government or community run, including roads, schools, phone lines, sewage treatment plants and power generation. An example of Infrastructure is the basic roads and power lines for a new housing development. Infrastructure means connectivity like road, rail, ports and telecommunications. These are basic to economic development and growth. Housing, education and health services also constitute part of infrastructure development which ensure improvement in quality of life.

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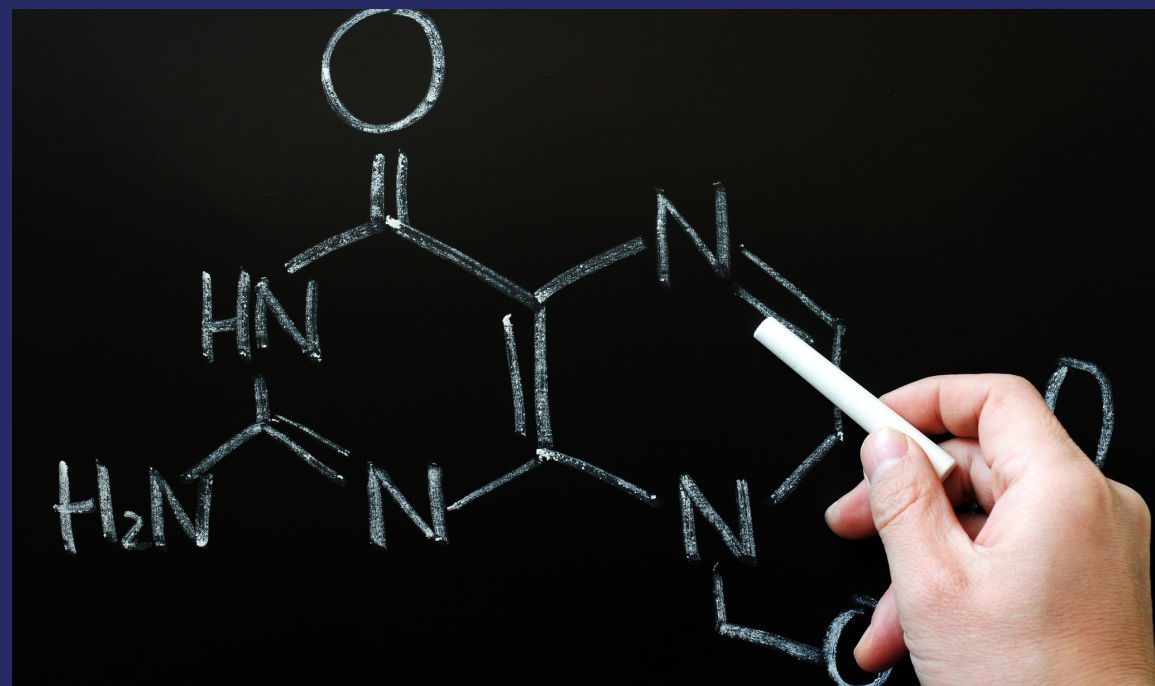
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This book is intended for the students of organic chemistry. Our text book can serve as a supplement for Heterocyclic Chemistry lecture text book. It can also be used as a 'stand-alone' text book for undergraduate and postgraduate levels for all Indian universities. This book is written in the form of "a lecture series" for easy reading and understanding. Numerous Synthesis, Mechanisms and Reactions of various heterocycles (Quinolines, Isoquinolines, Benzodiazines, Benzo[b]furans and Benzo[b]thiophenes) are provided throughout the textbook. I hope that this book will be very helpful for the aspirants of all competitive exams related to chemistry like IIT-JAM, CSIR-UGC (NET/JRF), GATE, SET, TIFR, BARC, IISc, DRDO, ONGC NPTC etc.

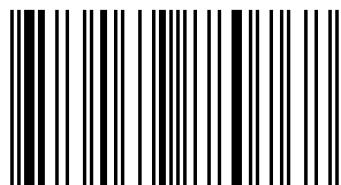


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In this book we have attempted to highlight the concepts of general organic chemistry relevant to students of UG and PG levels of all Indian universities. We have written this book in a readable and easily understandable way. Numerous MCQs are provided throughout the book. We believe that, this book will be very helpful for the aspirants of all competitive exams like IIT-JAM, CSIR-UGC (JRF/NET), GSET, GATE, TIFR, DRDO, ONGC etc. The fundamentals of this objective chemistry are written according to the need of the students. We have taken particular care to ensure that the book is free of errors.

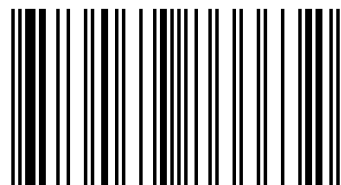


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REVIEW

Eminence of Microbial Products in Cosmetic Industry

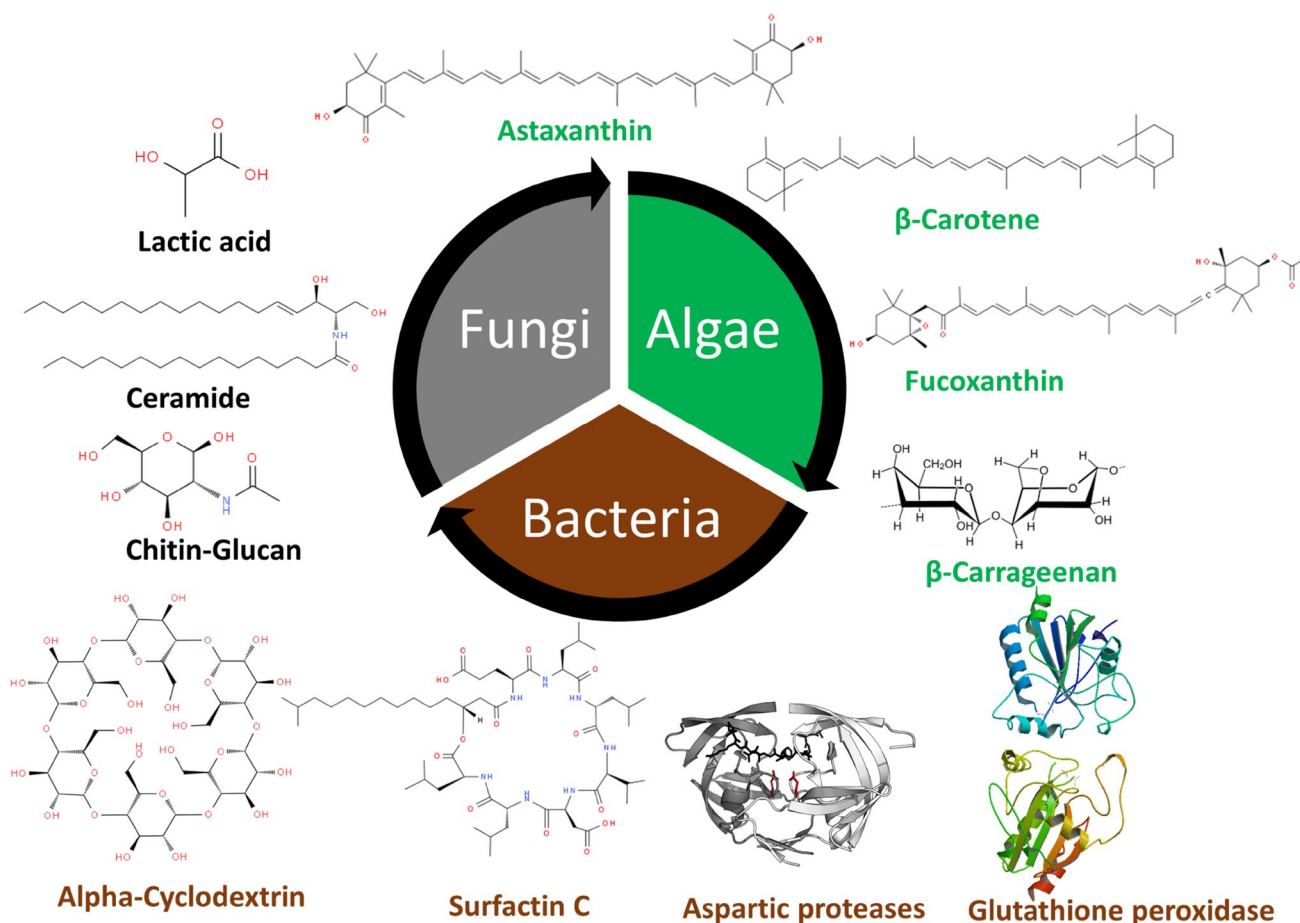
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Abstract

Cosmetology is the developing branch of science, having direct impact on the society. The cosmetic sector is interested in finding novel biological alternatives which can enhance the product attributes as well as it can substitute chemical compounds. Many of the compounds are having biological origin and are acquire from bacteria, fungi, and algae. A range of biological compounds, like bio-surfactant, vitamins, antioxidants, pigments, enzymes, peptides have promising features and beneficial properties. Moreover, these products can be produced commercially with ease. The review will encompass the importance and use of microbial compounds for new cosmetic formulations as well as products associated with it.

Graphic Abstract



Extended author information available on the last page of the article

Keywords Cosmetics · Microbiology · Biosurfactants · Formulations · Cyclodextrin · Emulsions

1 Introduction

Cosmetics products are the mixture of compounds derived from either biological origin or chemical sources. Cosmetic industry is remarkably prime marketed as over the counter products [1]. However, there are limited guidelines which regulates the full prescription of active ingredients as it is usual cosmetic type formulation [2]. Also, cosmetic products do not provide any monographs governing their formulation and chemicals used, since cosmetic sector is not under stringent control. The US Food, Drug, and Cosmetic Act (FFDCA) in 1938 was first governing body to regulate the key ingredients used in cosmetics industry [3].

Currently, international cosmetics market revenue is estimated to increase up to \$429.8 billion by 2022, with compound annual growth rate of 4.3% during the period 2016–2022 (Research and Markets) [4]. The major global cosmetics market is branched into America, Europe and Asia–Pacific. Among Asia–Pacific countries, India represents emerging market for different cosmetic products and has grown rapidly over the last few years. During past decades, India has witnessed a sharp influx of many international brands in the biological derived cosmetic products. Furthermore, the aggressive marketing strategy by the companies, to use ecofriendly and ayurvedic ingredients in cosmetic products have also significantly contributed in elevating the cosmetic market [5]. These biologically derived products have not only found an immense appeal among urban and rural consumers but also in matured population acquainted with the traditional herbal and ayurvedic ingredients [6]. As per the statistic given by Confederation of Indian Industries (CII), currently Indian cosmetic industry is approximately 600 million US dollar and is expected to grow by 15–20% annually.

Cosmetic products are, combination of chemicals, generally used to augment the appearance or odor of the human body [7]. These products are mainly sold at retail counters including super marts, exclusive brand outlets, mouth to mouth and specialty stores. There is a considerable increase in demand for cosmetics over last few decades owing to the development of third world economy and improved standard of living and specialty stores. Furthermore, a shifting preference of beauty products from synthetic to biologically derived sources also have significantly fostered the progress of cosmetics market [8]. In order to withstand and retain market position, cosmetic manufacturing companies are implementing various strategies for identification of biological derived products. The trend to use cosmetics from biologically origin satisfies the upcoming demand of consumers with possible effectiveness [9]. Moreover, the use

of herbal cosmetics and organic ingredients from different biological sources have drastically reduced the chances of any possible side effects and hazards of the products. This ultimately, have increased the usage of biological products in cosmetic market. Various strategies are used to develop cosmetic formulations, by involving usage of compounds from bacterial, fungal and algal origin.

The current review represents the role of various microbial compounds having application in cosmetic industry. Various compounds including enzymes and metabolites, originating from diverse microbial sources, and their role in cosmetic industry has been discussed.

2 Microbes: An Unveiled Treasure of Novel Compounds

Traditionally, biological derived ingredients from plants and various other organism remain a prominent source of novel compounds. Among the diverse sources exists on life, microbes represents one of the cheapest, renewable and novel sources for any chemicals [10]. The omni-present microbial diversity on earth reflects the largest group adapted under different predominant physicochemical conditions [11]. Microbes exist over range of natural habitats including from soil, extreme environments, oceans, glaciers and ponds. The diversity within communities of bacteria,

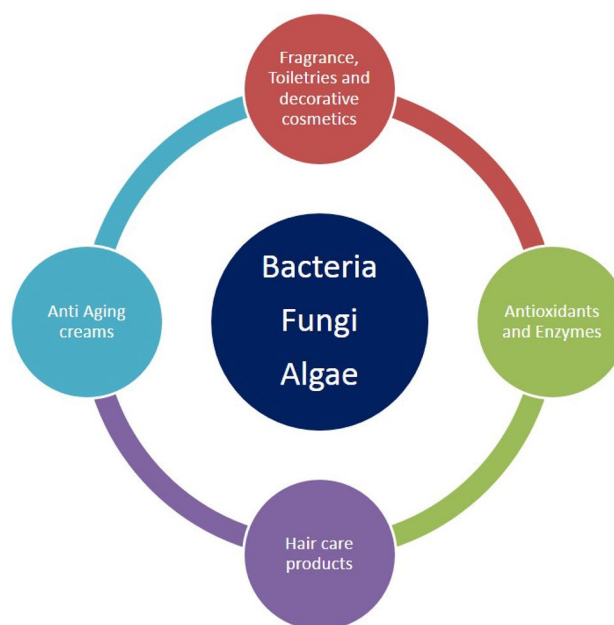


Fig. 1 Main categories of cosmetics

actinomycetes, archaea, lichens, and fungi represents the richness of compounds present in them (Fig. 1). The microbial community represent 30 phylum, majority of which are unculturable and found in different environments [12]. Even though, there is a presence of diversity of microbes in nature, very few of microbes are commercially utilized in cosmetics industry. Hence, the abundantly present but underutilized biodiversity represent a potential opportunity for future biotechnology and cosmetic application [13].

Studying the chemistry of biological active compounds, isolated from microbes, has tremendously accelerated in recent years. Primarily, the growing demand for bio-molecules is due to their prospective efficacy in cosmetics, drugs, fine chemicals and functional personal-care products [14]. Microorganisms are favorable resources since production of metabolites from microbes is feasible and scale up can be achieved in large quantities with reasonable cost [15]. Moreover, the microbes have ability to adapt and survive distinct conditions that differ from other habitats and accumulate unique bioactive compounds which is not found in other organisms. Microbes are rich in fatty acids, enzymes, peptides, vitamins, lipopolysaccharides and pigments with beneficial properties for cosmetic applications [16] (Fig. 2). Furthermore, unique compound such ceramides, mycosporine-like amino acids carotenoids, and fatty acids such as omega-3, 6, and 9, are obtained from microbes having enormous application in cosmetic industry [17] (Fig. 2). Increasing consumer demand for biological ingredients and cosmetic products have forced cosmetics industry to explore microbial source [18]. Therefore, the development of new active ingredients for cosmetics products and exploration of biodiversity for such active ingredients have engaged cosmetic companies to protect biodiversity and capitalize market potential and gain competitive advantage.

3 Bacteria and Associated Use in Cosmetic Products

Biological compounds, besides medical, pharmaceuticals and food industries, have mottled application in cosmetic industries. Many biological molecules, directly or indirectly, have found key role in the production of various compounds, like esters, aroma compounds and active agents, far and wide used in cosmetic industries. The major advantage of using microbial ingredients is its biocompatibility; additionally, they do have other benefits like simplified process, improved and consistent quality of product and environmental footprint. Of several, microbes, bacteria secretes copious biologically active compounds with significant commercial values; to mention few Oligosaccharides, Exopolysaccharides (EPS), Biosurfactants, Enzymes, Peptides, Vitamins etc. (Table 1). These compounds, replacing

chemical compounds, found their application in various cosmetic products used either for beautification or for improving health of the target.

3.1 Oligosaccharides

Cyclodextrins, are a group of compounds made up of cyclic oligosaccharides with α -(1,4) linked glucopyranose moiety bound together in a ring and have noteworthy contribution in cosmetic formulations [19]. Cyclodextrin, majorly, is used to reduce the volatility of esters in perfumes and room freshener gels. They also are used abundantly in detergents for steady and sustain release of aroma, thus leading to long lasting effect [20]. Cyclodextrin powders, of smaller size, are used as odor control in talcum, diapers, menstrual discs, pads, napkins, etc. The commercial production of cyclodextrin is more popular by enzymatic transformation rather than chemical synthesis. Therefore, the production of cyclodextrinase enzyme has been extensively carried out by using bacteria strains. *Bacillus subtilis* Strain 313, *Brevibacterium* sp. Strain 9605, *Brevibacillus brevis* Strain CD 162, *Microbacterium terrae* KNR 9 are some of the prominent strains used for the production of cyclodextrin [21–24]. Cyclodextrin glucanotransferase (EC 2.4.1.19) obtained from alkalophilic *Bacillus agaradhaerensis* is a widely sought enzyme in the potential cosmetic preparations [25].

3.2 Biosurfactants

Besides cyclodextrin, biosurfactants are used in preparation of various cosmetic products, owing to the multi-functional property such as detergent, foaming, emulsifying agent and skin hydrating properties. Moreover, biosurfactants are relative non-toxic, and are bio-degradable. In nature, biosurfactants are widely produced by bacteria followed by fungi and other microbes. Most of the biosurfactants belong to fatty acids, neutral lipids, glycolipids and lipopeptides. Furthermore, biosurfactants such as rhamnolipids, are approved by US EPA as safe for use in food products, cosmetics, and pharmaceuticals [26]. One of the most prominently used biosurfactant is Mannosylerythritol lipid (MEL). The basidiomycetous yeast of *Pseudozyma* sps (*P. antarctica*, *P. aphidis*, *P. rugulosa*, and *P. parantarctica*) are well known to produce appreciable amount of MEL. MEL are widely used in the production of various cosmetic products such as lipsticks, lipmakers, eye shades, soap, sprays, powders, nail care, body massage oils and accessories [27, 28]. Another major application for biosurfactants is in anti-wrinkle cosmetics and cleansing products. The use of surfactin derivative lipopeptides has extremely benefited the Japanese cosmetic industry [29]. The most prominent source of surfactin is the *Bacillus* sps (*B. subtilis*, *B. pumilus* A, *B. licheniformis* and *B. amyloliquefaciens*) [30]. Owing to the excellent foaming

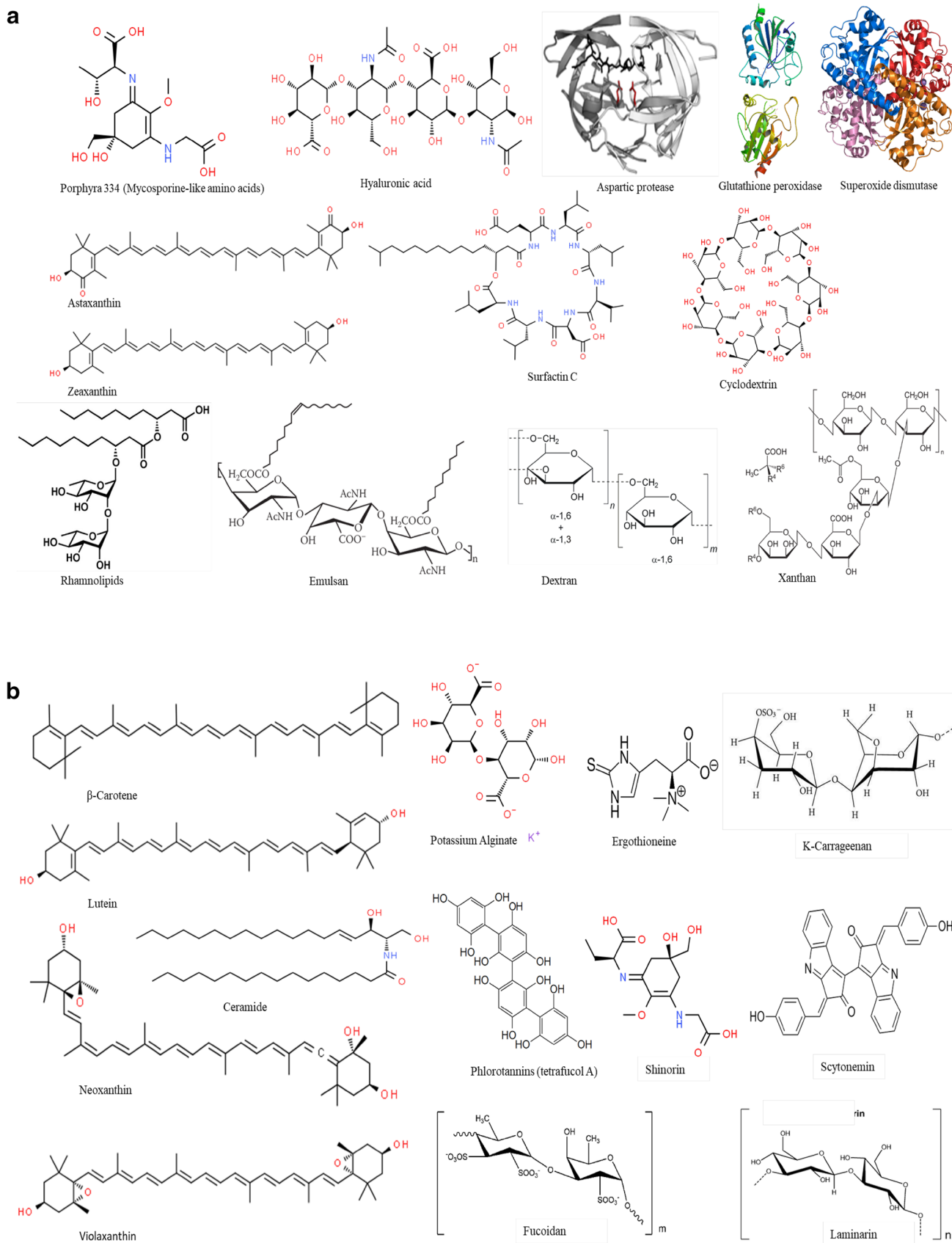


Fig. 2 Key structures of various compounds derived from microbial, fungal and algal sources used in cosmetics industry

Table 1 The bacterial and fungal bio-molecules, source, origin and applications explored in this review

Molecule class	Cosmetic application	Compound	Species	Origin	References
Secondary metabolites	UV and Photo-protective potential, protection from oxidative damage	Mycosporine-like amino acids (MAAs)	<i>Pseudonocardia</i> sp. <i>Actinosynnema mirum</i> <i>Streptomyces avermitilis</i> <i>Streptomyces lividans</i> <i>Corynebacterium glutamicum</i> <i>Aurantiochytrium</i> sp.	Actinomycetes (Actinobacteria)	[53]
Pigments	Improves skin, Antioxidant	Astaxanthin	<i>Paracoccus</i> , <i>Agrobacterium aurantiacum</i> <i>Thraustochytrids</i> , <i>Rhodotorula</i> , <i>Phaffia rhodozyma</i>	Bacteria Fungi	[54] [55, 56]
Exopolysaccharide	UV protectant, antioxidant, skin hydration Brightening agent, smoothing agent Moisture retainer, Gelling agent Thickening, gelling, emulsification Gelling and thickening	Zeaxanthin Dextran Alginate Xanthan Glucuronan	<i>Corynebacterium autotrophicum</i> <i>L. mesenteroides</i> , <i>Streptococcus mutans</i> <i>P. aeruginosa</i> and <i>A. vinelandii</i> <i>Xanthomonas</i> spp. <i>Sinorhizobium meliloti</i> MSN1CS and <i>Gluconacetobacter hansenii</i> <i>Streptococcus thermophilus</i> ,	Bacteria Bacteria	[57, 58] [10, 33–37, 50–52, 59]
Biosurfactants	Skin repair, Anti-aging Detergent, foaming, emulsifying agent and skin hydrating properties	Hyaluronic acid Viscosin, Rhamnolipids Mannosylerythritol lipid	<i>Pseudomonas</i> sp. <i>Pseudozyma</i> sp., <i>Usnilago</i> sp., <i>Candida antarctica</i> ,	Bacteria Fungi	[26, 60] [30, 61]
Cyclodextrins	Sustainable release of aroma, reduce foaming	Surfactin Emulsan Sophorolipid alpha-cyclodextrin, beta-cyclodextrin, gamma-cyclodextrin	<i>Bacillus subtilis</i> , <i>Bacillus pumilus</i> A, <i>B. licheniformis</i> and <i>B. amyloliquefacien</i> <i>Acinetobacter calcoaceticus</i> <i>Candida</i> sp. <i>Bacillus subtilis</i> Strain 313, <i>Brevibacterium</i> sp. Strain 9605, <i>Brevibacillus brevis</i> Strain CD 162, <i>Microbacterium terrae</i> KNR 9	Bacteria Bacteria Fungi Bacteria	[29, 62–64] [26] [65] [19–22, 25]
Enzymes	Treat stretch marks, Scar tissues Skin regeneration Hair Removal Antioxidants, free radical scavenging, anti-aging	Aspartic proteases Collagenases Keratinases Superoxide dismutase Catalases Glutathion peroxidase	<i>Aspergillus</i> , <i>Penicillium</i> , <i>Rhizopus</i> , <i>Mucor</i> , <i>Humicola</i> , <i>Thermoascus</i> , <i>Thermomyce</i> , <i>Conidiobolus coronatus</i> <i>Clostridium histolyticum</i> , <i>Vibrio alginolyticus</i> , <i>Bacillus cereus</i> <i>Microsporium</i> , <i>Epidermophyton</i> , <i>Trichophyton</i> , <i>Chrysosporium</i> , <i>Scopulariopsis brevicaulis</i> , <i>B. subtilis</i> and <i>B. licheniform</i> <i>Sulfolobus acidocaldarius</i> , <i>Marinomonas</i> , <i>Thermus thermophilus</i>	Fungi Bacteria Bacteria Bacteria	[41] [48, 66] [44, 45, 67] [39, 40, 68, 69]

properties and low CMC (critical micelles concentration) properties, surfactin are extensively used in topically applied dermatological products and in cosmetic formulation of oil and water emulsions [31].

3.3 Exopolysaccharides

The distinctive biocompatibility and non-toxic nature of microbial exopolysaccharides (EPS) has helped considerably to exploit its use in cosmetic industry. Moreover, hydrophilic EPS have high water retention ability which helps to maintain a hydrated environment in skin formulations. One of the very well know EPS produced from glucose polymer is dextran. Dextran is obtained from *Leuconostocaceae* family of microbes such as *Leuconostoc mesenteroides* and *Streptococcus mutans* [32]. In cosmetics dextran is used as skin smoothing and brightening agent, as it promotes the firmness of skin, promotes radiance, and reduce the appearance of wrinkles. Dextrans also has anti-inflammatory property as it improves the blood flow, augmented nitric oxide (NO) synthesis in the human epidermal keratinocytes cells [33]. Usually alginates are obtained from seaweeds, however bacteria belonging to *Pseudomonas* genera are well known to produce copious amounts alginate as EPS. *Pseudomonas aeruginosa* and *Azotobacter vinelandii* are known to produce alginate which can retain water [34]. Hence, alginate is used as thickener, gelling agent and excipient in skin and cosmetic formulations. The bacterial genus *Xanthomonas* are known to produce complex hetero-polymer EPS known as Xanthan [35]. Xanthan also has thickening properties and assist in gelling hence used in skin formulation to help in skin-smoothing and moisturizing. It also reduces the trans-epidermal water loss in keratinocytes cells. Furthermore, xanthan are also used as emulsifiers and foaming agent in skin formulation [36, 37].

3.4 Proteins, Enzymes and Peptides

In addition to biosurfactants, proteins and peptides also have contributed significantly in the cosmetic industry. Proteins and peptides, since ancient time, are used for improving the quality of the skin, hair or nails. Extensive research has been carried out in the same horizon and identified numerous applications of proteins in the cosmetic industry.

Superoxide dismutase (SOD) and Peroxidase (catalase, glutathione peroxidases, lactoperoxidases) works synergistically as exfoliate. These enzymes serve as scavengers of free radicals and prevent the skin, from the ultra violet light, when applied on the skin surface [38]. Another similar enzyme Lactate dehydrogenase (LDH) capable of catalyzing the reduction of NADH and pyruvate leading to NAD⁺ and lactate as the end product. The above reaction, on the exposure of UV, gets diminished; but, in presence of LDH

the subunits remain intact in the cells and allow cell to carry out normal functioning [38]. In past, *Marinomonas* sp., *Sulfolobus acidocaldarius* and few other extremophiles such as *Thermus thermophilus* were used for the production of SOD and/or peroxidase [39]. But, with advances in technology, genetically engineered lactic acid bacteria with high yield and improved stability, have been favorable choice for the production [40].

Proteases are well known enzymes for hydrolyzing the peptide bonds of keratin, collagen and elastin of the skin. Bacterial originated alkaline aspartic proteases from various alkaliphilic bacterial sources have been used to treat skin disorders such as xerosis (dryness of skin), ichthyoses (scaly skin), psoriasis (skin flaking and inflammation) [41]. Furthermore, proteases such as keratinases are known to treat stretch marks, scar tissues and regenerate the epithelial cells to accelerate healing. Commonly, keratin hydrolysates are used in skin topical ointments and creams for heels, knees or elbows which offers external smoothness and reduce damage to the skin. Keratinase is also used in enzymatic peeling treatment, in hair removing and hair growth delaying. *Bacillus licheniformis* has been used commercially for keratinase production commercially exploited organism for keratinase production [42]. Few thermophilic organisms such as *Thermoanaerobacter*, *Thermosiphon*, and *Thermococcus* are also used for production of keratinase [43]. Other Gram-positive bacteria such as *Lysobacter*, *Nesterenkonia*, *Kocuria*, *Microbacterium* and Gram-negative bacteria such as *Vibrio*, *Xanthomonas*, *Stenotrophomonas*, *Chryseobacterium*, *Feravidobacterium*, *Thermoanaerobacter*, and *Nesterenkonia* are also potentially known to produce keratinases enzyme [44]. Fungal species of *Microsporium*, *Epidermophyton*, *Trichophyton*, *Chrysosporium*, are well known keratinophilic fungi and also have potential ability to degrade keratin fibers [45]. Along with enzymes, specific peptides (digest of proteins) have also been widely used in cosmetic preparations. The soluble peptides are used in gels, emulsions, powders and lotions; while, insoluble peptides are used in facial mask [46]. These peptides, for commercial purpose, are generated by controlled action of proteases; which, majorly are secreted from several *Bacillus* spp. [47, 48]. Also, Penta-peptides are widely used for reducing facial wrinkles and roughness [49].

3.5 Hyaluronic Acid

Hyaluronic acid (HA), is a glycosaminoglycan (GAG) consisting of β -4-glucuronic acid (GlcUA) and β -3-N-acetylglucosamine (GlcNAc) [50]. HA is extensively used as dermal filler in cosmetic surgery. Furthermore, many skin lotion, and serums contains sodium hyaluronate as its active ingredient as it boost moisture retention, reduces skin wrinkles and improves skin firmness and elasticity [51]. HA

is obtained in large scale from animal tissues from rooster combs. However, microbes belonging to *Streptococcus* genus are also able to synthesize HA. Recently, genetically modified culture of *Bacillus* species are used for the production of HA [52].

4 Fungi and Associated Use in Cosmetic Product

Fungi are ambiguous and most diverse organisms. The kingdom Fungi comprises of incredible biodiverse members bridging a comprehensive range of life habitats, life form, size and morphology. The recent high throughput estimates that 5.1 million of fungal species exist in our ecosystem [70]. Numerous potential cosmetics products are developed from fungi for skin care, anti-oxidants and hair products. Among fungi, mushrooms are rich in secondary metabolites known to have various medicinal properties. Compounds such as Schizophyllan derived from *Schizophyllum commune* are known for protective effect of UV rays on skin and benefit in reducing inflammation of skin [71].

4.1 Lactic Acid

Lactic acid is extensively used in cosmetics skin cream to retain skin moisture, impart smoothness and suppleness of skin. High concentration (up to 12%) of lactic acid is used in skin peeling cream as an exfoliating agent, for skin lightening and to reduce acne eruption [72]. Furthermore, poly-L-lactic acid (PLLA) is used as a bio-stimulatory filler and in removal of facial folds, decrease wrinkles and photo-damage [73]. Fungi species of *Rhizopus* genera are known to produce lactic from fermentation of glucose aerobically and has low substrate cost compared to bacterial source such as *Lactobacillus* [74].

4.2 Ceramides

Ceramides is used in cosmetics as skin hydrating agents since the stratum corneum of human epidermal layer contains considerable amount of ceramides. Ceramides are only found in eukaryotic cells and animal origin (e.g. cows). However, concerns regarding infectious diseases have instigated to explore alternative sources to obtain ceramides. Moreover, plant derived ceramides are structurally different from animal ceramides and hence this limits its use in cosmetics. Ceramides from various fungal species have been produced and used in cosmetics [75]. *Candida albicans*, *Agaricus bisporus*, *Armillaria tabescens* have used in production of Glycosyl ceramides [76]. Furthermore, attempt to obtained ceramides using metabolic engineering in yeast (*Saccharomyces cerevisiae*) also have been developed [77].

4.3 Chitin-glucans

Chitin-glucans are copolymers obtained from the cell wall of fungi and works very well as a good moisturizers [78]. A very renowned example of chitin-glucan is Chitosan. Chitosan are used as antimicrobial agents against dental plaque and readily used in toothpaste formulations [79]. Chitosan along with hyaluronic acid and collagen is also used in hair setting lotions and gels to produce a coating which adds thickness, volume, strength and prevent hair damage. Furthermore, chitosan nanoparticles loaded with minoxidil is used for sustained release of minoxidil for effective transdermal transport and hair growth [80].

4.4 Antioxidants

L-ergothioneine is a powerful anti-oxidant is extracted at high concentrations from mushrooms such as *Portabellas* and *Criminis* species [81]. Owing to the excellent antioxidant properties ergothioneine guards the skin from oxidative and DNA damage and hence it is used in anti-aging creams and lotions [82]. Similarly, Gallic acid is a potentially known to have anti-bacterial and free radical scavenging activities. *Aspergillus niger*, *Fusarium solani* and *Trichoderma viridae* are known to produce gallic acid [83, 84]. Trehalose is another antioxidant compound found in various mushrooms such as *Lentinula edodes*, *Grifola fondosa*, *Pholiota nameko* and *Auricularia auricula-judae*. Trehalose has high water retaining capacity and excellent antioxidant property. This makes it useful as in moisturizer creams in cosmetics products.

5 Algae and Associated Use in Cosmetic Products

Algae represent an enormous bio-diverse species with more than 72500 reported in phylo-genetic classification [85]. Production of bioactive compounds from algae can be easily manipulated by altering and harnessing the physiological culturing conditions [86]. Compounds isolated from algae, including carotenoids, phycobilins, fatty acids, polysaccharides, vitamins, sterols, polyphenols, lipids, or proteins, have demonstrated antioxidant, anti-aging, photo-protective and anti-inflammatory activities [87] (Table 2).

5.1 Skin Ageing

Collagen has been validated to slow down skin ageing and enhance the suppleness of skin. Collagen, along with elastin fibers are normally present in skin, helps to maintain youthful, vibrant skin and keeping it flexible and intact after being stretched. The phlorotannins extracts of sea kelp

Table 2 Chief cosmetic ingredients from algae

Class	Cosmetic ingredient	Cosmetic application
Chlorophytes	β -carotene	Anti-aging creams and UV protectant
	Lutein	Sun-screen lotions
	Neoxanthin	
	Violaxanthin	
Phaeophytes	Potassium Alginate	Skin care serum and hair gels
	Phlorotannins	Anti-aging creams
	Phloroglucinol	UV protection, skin whitening
	Fucoidan	Sun-screen lotions
	Fucoxanthin	De-pigmenting agent
	Laminarin	Skin protecting cream
Rhodophytes	Carrageenan	Thickening and moisturizing agent in skin cream
	Astaxanthin	Anti-ageing ointments, lipsticks
	Porphyra-334	Sun-screen lotions
	Shinorin	Sun-screen lotions

Eisenia bicyclis and brown alga *Ecklonia cava* are proved to benefit the skin by reducing the elastase activity significantly [88, 89]. Furthermore, green microalgae such as *Chlorella*, restores the firmness of skin by protecting collagen and elastin fibers against the enzymes, collagenase and elastase which degrades the skin [90] are used as anti-wrinkling agent commercially in skin cream (Dermochlorella®). Astaxanthin found in *Haematococcus pluvialis* is remarkably known to regenerate skin tone, elasticity and retain the moisture content of corneocyte layer, thereby resulting in lowering skin wrinkles [91]. Hexadecatetraenoic acid, obtained from Antarctic Sea ice diatom, *Stauroneis amphioxys* and Hexadecapentaenoic acid from marine green microalga *Anadyomene stellata* are used in cosmetic preparation for preventing wrinkling, sagging, anti-aging and boosting collagen deposition [92]. The brown algal extract of *Macrocystis pyrifera* is known to induce the hyaluronic acid synthesis, by promoting the synthesis of syndecan-4 in extracellular matrix of dermal tissues [93]. Algae oil based nano-emulsion has demonstrated to inhibit the ramifications of UVA-induced skin impairment by extenuating epidermal water depletion, skin inflammation, and development of melanocytes [94] (Table 3).

5.2 UV-Photoprotective and Anti-photoaging Compounds

Algae are recognized to produce a range of UV-protective compounds, like mycosporine-like amino acids (MAAs), phycobiliproteins, flavonoids [108], carotenoids [100], scytonemin [105] and several other photo-protective compounds. MAAs are found in most of algal and cyanobacterial species and are preferred as UV photo-protective compounds. MAAs are known to absorb UV light between 300–365 nm and have high molar coefficient [87]. These

properties help them to absorb the UV light more efficiently and scatter the radiation, without generating free radicals. Furthermore, members belonging to the Rhodophyceae (red algae), Ochrophyta, Phaeophyceae (brown algae), and Chlorophyceae (green algae), were exposed to high intense solar rays, demonstrated the accumulation a high level of MAAs, which acts as a protective sunscreen and prevent desiccation of cells. These MAAs are widely employed in sunscreen lotion and creams such as Helioguard 365™ (Mibelle AG Biochemistry, Switzerland) and Helionori™ (Biosil Technologies, France). Algal derived flavonoids such as anthocyanins are effectively validated as an alternative skin care treatment for treating radiation dermatitis during radiation therapy [69].

5.3 Skin-Lightening and De-pigmenting Agents

Melanin pigment imparts the color to the skin and plays an essential role in shielding the skin from damaging effect of UV light and prevents the carcinogenesis. However, overproduction of melanocytes causes hyper-pigmentation or skin darkening. Furthermore, as ageing occurs, the regulation, control and distribution of melanocytes becomes irregular, causing appearance of dark and discolored spots on the skin. Tyrosinase is one of the prominent enzyme for melanin synthesis; inhibiting tyrosinase is an effective strategy to reduce hyperpigmentation. The tyrosinase inhibiting activity of compounds phlorotannin and 7-phloroecol extract obtained marine brown seaweed, *Ecklonia cava* has been validated to reduce melanogenesis and can be used as potential skin-whitening agent [109]. Astaxanthin belonging to carotenoids family obtained from *H. pluvialis* are also well known to decreases melanin by 40% in trans-epidermal cells. This helps to defend skin from flakes, reduce age spots, blemishes, and thus making astaxanthin an attractive component

Table 3 Origin, function of potential biomolecules from algae

	Species name	Type	Compound	Function	References
1	<i>Alaria esculenta</i>	Macroalgae	Lipophilic extract	Reduce progerin in aged fibroblast	[93]
2	<i>Fucus vesiculosus</i>	Macroalgae	Laminaran, fucoidan and alginate	Increasing expression integrin molecules	[95]
3	<i>Turbinaria conoides</i>	Macroalgae	Laminaran, fucoidan and alginate	Antioxidant	[59]
4	<i>Porphyra umbilicalis</i>	Macroalgae	Mycosporine-like amino acids	Photo-protective potential	[96]
5	<i>Synechocystis</i> , <i>Nostoc</i> , <i>Gloeocapsa</i> , <i>Gloeocapsopsis</i> , <i>Scytonema</i>	Microalgae	Mycosporine-like amino acids	Photo-protective potential	[97]
6	<i>Gracilaria chilensis</i> , <i>Scytosiphon lomentaria</i> <i>Macrocystis pyrifera</i> , <i>Callophyllis conceptionensis</i> , <i>Ulva</i> sp. and <i>Enteromorpha</i> sp.	Macroalgae	Polyphenols	Macromolecular antioxidants	[98]
7	<i>Ecklonia stolonifera</i>	Macroalgae	Phlorotannins, Oxylipins	Matrix metalloproteinase (MMPs) inhibition activity	[99]
8	<i>Dunaliella salina</i> , <i>Chlorella species</i>	Microalgae	Beta-carotene	Photo-protective potential against UV, Anti-oxidant	[100, 101]
9	<i>Muriellopsis</i> sp., <i>Chlorella zofingensis</i> , <i>Scenedesmus</i> sp. and <i>Chlorella protothecoides</i>	Microalgae	Lutein	Anti-oxidant	[102, 103]
10	<i>Haematococcus pluvialis</i>	Microalgae	Astaxanthin	Potent antioxidant and scavenger of free radicals	[91]
11	<i>Chlorella</i> sp.	Microalgae	Sporopollenin	Anti-wrinkle potential	[87]
12	<i>Scytonema</i> sp., <i>Lyngbya aestuarii</i>	Microalgae	Scytonemin	UV-A sunscreen	[104, 105]
13	<i>Sargassum macrocarpum</i>	Macroalgae	Sargafuran	Anti-acne activity against <i>Propionibacterium. Acnes</i>	[106]
14	<i>Spirulina platensis</i>	Microalgae	Crude extract in skin cream	Wound healing effect of keratinocyte cell	[107]

in sunscreen and after sun lotions [87]. Zeaxanthin, obtained from microalgae *Nannochloropsis oculata*, are validated to exhibit anti-tyrosinase activity and can be exploited for skin whitening treatment [110]. The fucoidan present in *Undaria pinnatifida* and *Fucus vesiculosus* extract, demonstrated an antioxidant activity and improved efficacy in skin brightening application, spot reduction and skin protection in topological application studies [111].

5.4 Anti-oxidants

The ageing processes in dermal cells are accelerated due to increase in lipid peroxidation, caused by superoxide anion, OH⁻ radicals and H₂O₂ [87]. The anti-oxidants compounds play a vital role in shielding the human dermal tissues from the scavenging effects of such free radicals. Among algae, the rhodophyceae members are predominantly acknowledged for their anti-oxidant potential owing to abundantly presence of colored pigments such as phycoerythrin, phycocyanin and allophycocyanins, carotenoids and xanthophylls [112]. These algal pigments have been commercially exploited in many cosmetic applications such as Pure Clay Red Algae Mask[®] by L'Oréal Paris. The free radical in skin cells generated due to photo-oxidation

is readily quenched by cyanobacterial MAAs such as scytonemin, asterina-330, shinorine, and palythine [105]. β -carotene is another potential antioxidant produced by *Dunaliella salina* and is converted to vitamin A, which is essential for good vision, healthy skin and maintenance of mucous membrane [100].

5.5 Hair Care

The commonly used ingredient Sericin protein in hair conditioning and skin formulations, is generally produced by *Bombix mori* (Silk worm), and can also alternatively obtained from microalgae *Chlorella vulgaris* and *Arthrospira platensis* [113]. 7-phloroecol are validated to promote stimulation of hair growth in dermal papilla cells (DPCs) and outer root sheath cells (ORS) [114]. Algal oil rich in omega-3 is known for its ability to reduce dry and brittle hair, scratchy and itchy scalp, decrease dandruff, and hair fall. Microalgae derived Docosahexaenoic Acid (DHA) and Eicosapentaenoic acid (EPA), regularly used in hair oils, hair serum, hair gels and spray, provide deep nourishment to the hair follicles and scalp to make the hair strong and healthier.

6 Conclusion

The rising trend to use biological and eco-friendly products, have augmented a sharp demand of such products in cosmetic Industry. The cosmetic manufacturing companies are continuously placing efforts to extract and use such microbial compounds on industrial scale. The advances in biotechnology, genetic improvement of organism, and immense microbial biodiversity has considerably boosted the use of novel biologically derived compounds in cosmetics. Cosmetics essentially requires interaction and penetration to multilayers of skin and different cell types hence biosurfactants, anti-oxidants, anti-aging etc. property compounds produced by microbial sources serves best replacement to chemical entities available in market. Some of these biologically derived products may cause adverse effect, hence methodical and systematic rigorous assessment by means of clinical research is required to understand the true potential before any validation.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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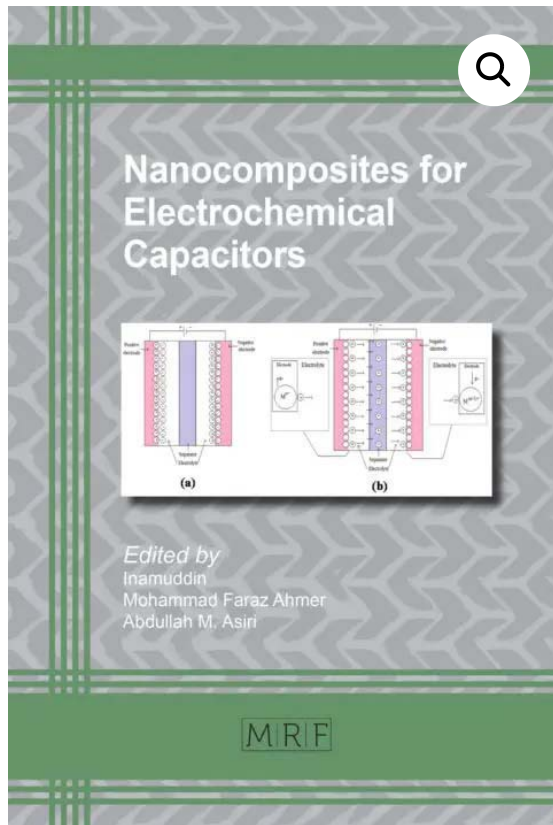
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Description

Investigation of cationic exchange activity and electrochemical performance of hybrid polyaniline-zirconia nanofibers

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A new and novel nanocomposite cation exchanger polyaniline-zirconia (PANI-ZrO₂) has been synthesized using a chemical oxidative polymerization of aniline by the incorporation of zirconia nanoparticles via three different chemical polymerization pathways. The PANI-ZrO₂ composite was examined for its cation exchange property and utilized for the fabrication of supercapacitor electrodes in the symmetric two electrode cell configuration. The aqueous polymerized PANI-ZrO₂ composite showed high specific capacitance (387 F g⁻¹) and capacitance retention of up to 81% after 2500 charge-discharge cycles. The excellent electrochemical performance of the composite is mainly attributed to its nanofibrous structure and high electronic conductivity.

Keywords

Polyaniline-ZrO₂ Nanocomposite, Chemical Polymerization, Nanofibers, Cationic Exchanger, Pseudocapacitor

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Chapter 3

Myco-Nanoparticles: A Novel Approach for Inhibiting Amyloid- β Fibrillation



Aditya Saran, Rajender Boddula, Priyanka Dubey, Ramyakrishna Pothu, and Saurabh Gautam

3.1 Introduction

The requirement of eco-friendly and green technology in the area of material science is of a great interest due to its distinct biological applications. “Nanotechnology” belongs to one of the imperative areas of modern material science due to its key importance in the development of drug delivery, gene therapy, antibacterial agents, electronics, magnetic resonance imaging, and separation science, to name a few (Sonvico et al. 2005; Wilkinson 2003; Nie et al. 2007). Therefore, the advancement in the synthesis of nanoparticles with varying shape, size, chemical composition, and morphology is indispensable. There are various protocols described for the synthesis of different types of nanoparticles such as chemical, physical, biological, and hybrid methods (Mohanpuria et al. 2008; Luechinger et al. 2009). The synthesis of nanoparticles via chemical and physical channel has gained a huge attention recently (Iravani et al. 2014). However, these methodologies are complicated, expensive, and

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require the use of different types of toxic reagents resulting in restricted biomedical applications. As a result, there is a considerable and urgent need for nontoxic, reliable, eco-friendly, and “green” route techniques for the synthesis of such nanoparticles, especially for biomedical applications. In order to achieve this, the utilization of biological methods using different microorganisms for the synthesis of nanoparticles has emerged as a unique field of research (Li et al. 2011; Prasad et al. 2016). Based on the site of synthesis of nanoparticles by the microorganisms, the process can be classified into two types: intracellular and extracellular synthesis (Talham 2002). The intracellular synthesis is defined as the transportation of metal ions (building block of respective nanoparticles) in the presence of enzymes into the microbial cell (Otari et al. 2015). However, when the metal ions are absorbed at the surface of the microbial cell, forming nanoparticles, it is known as extracellular synthesis of nanoparticles (Zhang et al. 2011). In the following sections, we have described in detail the biological modes for the synthesis of different metallic nanoparticles.

3.2 Biosynthesis of Nanoparticles Using Microorganisms

3.2.1 Gold Nanoparticles (AuNPs)

Michael Faraday for the first time observed that the colloidal gold solutions have different properties from bulk gold (Stephen and Macnaughton 1999). The synthesis of different dimensions (1D, 2D, and 3D shapes) and hollow structures of AuNPs offers an imperative biological application (Kowalczyk et al. 2010). AuNPs are the nontoxic carriers in the area of gene and drug delivery (Ghosh et al. 2008). Their ability to interact with thiol group offers a selective means of controlled intracellular release. The extracellular synthesis of AuNPs has been reported using *Fusarium oxysporum* (fungus) and *Thermomonospora* sp. (actinomycete) (Southam and Beveridge 1996). Moreover, the intracellular synthesis of AuNPs by fungi *Verticillium* sp. has been reported by the same group (Beveridge and Murray 1980). The bacterium *Rhodopseudomonas capsulata* was also used for the synthesis of the AuNPs with different shapes and sizes by modulating the pH (Zhou et al. 2007). The alkalotolerant actinomycete (*Rhodococcus* sp.) has also been reported in the intracellular synthesis of AuNPs (Ahmad et al. 2003b). Alkalotolerant *Rhodococcus* sp. has been known to produce AuNPs under alkaline conditions (Klaus et al. 1999). Nanocrystals and nanoalloys synthesis has been reported using *Lactobacillus* (Mukherjee et al. 2001). The synthesis of AuNPs with distinct shapes (cubic, spherical, and octahedral) has been reported from filamentous cyanobacteria (Klaus-Joerger et al. 2001). Synthesis of AuNPs from blue green alga *Spirulina platensis* has also been reported recently (Suganya et al. 2015).

3.2.2 Silver Nanoparticles (AgNPs)

Silver nanoparticles are gaining significant attention due to their potent antibacterial activity against Gram-positive and Gram-negative bacteria (Fayaz et al. 2010; Aziz et al. 2014, 2015). They have also been reported to possess anticancer and antioxidant properties (Mohanta et al. 2017). AgNPs are capable of physical interaction with the cell surface of various bacteria (Dakal et al. 2016). Studies have reported that AgNPs can break the cellular membranes of microorganisms which further results in an enhanced anti-microbial activity (Franci et al. 2015). The synthesis of AgNPs by bacteria has been shown to be influenced by silver-resistant genes, *c*-type cytochromes, cellular enzymes (nitrate reductase), peptides, and reducing cofactors (Hamedi et al. 2017). The synthesis of the AgNP film from fungi such as *Fusarium oxysporum*, *Verticillium*, *Aspergillus flavus*, or *Mucor hiemalis* has been demonstrated by various workers (Ahmad et al. 2003a; Bhainsa and D'souza 2006, Aziz et al. 2016). AgNPs synthesis using aqueous extract of the seaweed *Sargassum muticum* has also been reported recently (Madhiyazhagan et al. 2015). Another study has reported that when *Pseudomonas stutzeri* AG259 bacterium was kept in the concentrated aqueous solution of silver nitrate, it led to the reduction of the Ag⁺ ions and subsequently the formation of AgNPs in the periplasmic space of the bacteria (Pugazhenthiran et al. 2009).

3.2.3 Alloy Nanoparticles

Alloy nanoparticles are of enormous interest for in situ applications due to their flexible properties (Oezaslan et al. 2011). Alloy nanoparticles are contributing to different fields of science and technology such as optical materials, catalysis, electronics, and coatings (Cortie and McDonagh 2011; Ferrando et al. 2008). An alloy nanoparticle of gold and silver has been used for the catalytic reduction of methylene blue (Tripathi et al. 2015). *Trichoderma harzianum* has been used as a stabilizing and reducing agent in the synthesis of gold-silver alloy (Tripathi et al. 2015). *F. oxysporum* has been used for the synthesis of gold and silver alloy (Senapati et al. 2005). The biosynthesis of alloy of gold and silver nanoparticles under microwave irradiation by their metal precursors and *Jasminum sambac* leaves extract has also been illustrated earlier (Yallappa et al. 2015). Another study has demonstrated the synthesis of gold and silver alloy nanoparticles using yeast cells via extracellular routes (Zheng et al. 2010). The synthesis of gold and silver alloy nanoparticles from fungal strain *Fusarium semitectum* was also reported which was demonstrated to be stable for many weeks (Sawle et al. 2008).

3.3 Nanoparticles Synthesis Using Fungi

As compared to various other groups of microorganisms, fungi are an important group of microorganisms responsible for the synthesis of large amount of metal nanoparticles (Syed et al. 2013; Aziz et al. 2016). This could be due to their capability of synthesizing monodisperse nanoparticles with well-defined shape and size (Mukherjee et al. 2002). Fungal strains consist of large number of enzymes and proteins facilitating the formation of nanoparticles; moreover, these strains are also easy to handle (Mohanpuria et al. 2008; Prasad et al. 2016). A study has reported wherein fungus *Verticillium luteoalbum* was used to synthesize gold nanoparticles using extracellular enzymes (Gericke and Pinches 2006). Another study has reported the synthesis of silver nanoparticle when fungus *Aspergillus niger* was incubated with silver nitrate solution (Gade et al. 2008). The enzymes and proteins produced by fungus facilitated the stability of nanoparticles, as reported in that study. The nanoparticles were shown to have a size distribution between 5 and 25 nm and were monodispersed in nature. In another study, *Fusarium oxysporum* was also used to synthesize CdS nanoparticles (Shakibaie et al. 2010). The authors concluded that the release of reductase enzymes in the presence of *F. oxysporum* led to the formation of CdS nanoparticles. *Aspergillus fumigates* is another fungal strain known for synthesis of metal nanoparticles at wide level (Bhainsa and D'souza 2006). The presence of reductase enzymes facilitates the biosynthesis of metal nanoparticles of different chemical compositions (Adelere and Lateef 2016). Mukherjee *et al.* have reported the synthesis of gold nanoparticles by the intracellular reduction of metal ions in *Verticillium* sp. (Mukherjee et al. 2001). Another study reported the biosynthesis of Ag, Au, Zn, and, Ag-Au nanoparticles using fungi *Volvariella volvacea* (Philip 2009). Another species *Trichothecium* sp. was used for the biosynthesis of gold nanoparticle (Ahmad et al. 2005). Authors showed that the shaking phase results in the formation of intracellular nanoparticles; however, an stationary phase (without shaking) also leads to the formation of extracellular nanoparticles (Ahmad et al. 2005). *Penicillium brevicompactum* was reported for the biosynthesis of silver nanoparticles using nitrate reductase enzyme (Hemath Naveen et al. 2010). An interesting study reported the biosynthesis of monodispersed silver nanoparticles using *Aspergillus fumigates* within 10 min (Bhainsa and D'souza 2006). This biosynthesis method for nanoparticles has been reported to be significantly rapid as compared to chemical and physical methods (Bhainsa and D'souza 2006). Based on abovementioned findings by various workers, it can be deduced clearly that biosynthesis of nanoparticles using fungal-based method is a rational, green, cost-effective, faster, and nontoxic approach. This is primarily due to the capability of fungi for reduction of the metal ions by an enzymatic process.

3.4 Introduction to Protein Aggregation

The specific functional and structural properties of protein aggregates play a key role in many routine physiological activities (Alsberg et al. 2006). However, the misfolding during protein assembly and aggregation could lead to several neurological disorders and diseases such as Huntington's, Alzheimer's, Parkinson's, and prion diseases to name a few (Lashuel et al. 2002). The protein aggregates defined as amyloids found in the patients with these disorders were characterized histologically more than 150 years ago (Aguzzi and O'Connor 2010).

3.4.1 Types of Protein Aggregates

Based on morphological analysis, protein aggregates can be categorized into two classes: ordered aggregates (amyloid) and disordered aggregates (amorphous) (Fink 1998). Amyloid fibrils are most commonly found extracellularly; however, there are various reports showing the presence of intracellular amyloid fibrils as well (Takahashi et al. 1989; Friedrich et al. 2010). Amyloids are known to have ordered structure with a high proportion of β -sheets (cross- β structure) and are known to demonstrate apple-green birefringence upon binding with dye Congo red (Fink 1998; Rambaran and Serpell 2008; Tycko 2011; Chiti and Dobson 2006). On the other hand, amorphous aggregates lack any ordered secondary structure (Fink 1998; Baneyx and Mujacic 2004; Villaverde and Carrio 2003).

3.4.2 Mechanism of Protein Aggregation

The mechanism of protein aggregation has been categorized into three different types such as nucleation dependent protein aggregation (seeded polymerization), templated assembly model, and nucleated conformational conversion mechanism (Philo and Arakawa 2009; Invernizzi et al. 2012; Idicula-Thomas and Balaji 2007; Gsponer and Vendruscolo 2006). Nucleation dependent polymerization consists of a rate limiting step, termed as lag phase, wherein oligomers form a critical nucleus and increase its size by the formation of the larger aggregates known as amyloids (Jarrett and Lansbury 1993; Eichner and Radford 2011). However, in template assembly model the protein aggregate functions as a template for straight addition of monomers (Griffith 1967). Nucleated conformational conversion mechanism consists of both the aforementioned mechanisms (Chatani and Yamamoto 2018). The latter aggregation pathway initially includes the formation of amorphous nuclei, which is followed by template assembly aggregation mechanism (Serio et al. 2000). The amyloid aggregates are known to follow the nucleation dependent polymerization pathway (Morris et al. 2009; Fink 1998; Eichner and Radford 2011).

3.4.3 *Therapeutic Intervention of Protein Aggregation Diseases*

Proteins tend to misfold and form aggregates under the specific stress conditions leading to the various human pathological disorders (Ross and Poirier 2004). Therefore, in order to control this, efforts are ongoing globally on controlling and/or reversing the formation of amyloid aggregates responsible for various neurodegenerative disorders (Sharma et al. 2012; Wang et al. 2013; Uversky 2007). Different approaches have been reported in the literature to deal with protein aggregation such as small peptides (Xiong et al. 2015), osmolytes (Macchi et al. 2012), antibiotics such as rifampicin (Tomiya et al. 1994), naturally derived polyphenols (Nedumpully-Govindan et al. 2016), and compounds based on amyloid binding dyes (Hasegawa et al. 2007). However, we will discuss about the nanoparticles as therapeutic agents for protein aggregation diseases.

3.4.4 *Nanoparticles as Therapeutic Agents*

Various studies have been reported on the effect of different nanoparticles on amyloid aggregation (Brambilla et al. 2011; Kogan et al. 2006; Araya et al. 2008). Gold and silver nanoparticles have been utilized in biomedical sciences (cancer treatment, controlled drug delivery, biomedical imaging, etc.) due to their apposite properties such as low toxicity, tunable stability, biocompatibility, small dimensions, and the possibility to interact with a variety of substances (Belanova et al. 2018). Recent studies have demonstrated that gold nanoparticles are capable of crossing the blood–brain barrier as well (Cabuzu et al. 2015; Cheng et al. 2014). Liao et al. have illustrated the effect of gold nanoparticles on amyloid aggregation (Liao et al. 2012). The authors showed that bare gold nanoparticles were able to abolish the formation of large fibrils and giving rise to fragmented fibrils and spherical oligomers (Liao et al. 2012). Authors further demonstrated that due to negative surface potential of gold nanoparticles, these act as nano-chaperones and further redirect and inhibit the amyloid aggregation. Recently a study demonstrated the biosynthesis of gold nanoparticles via extracellular mode using fungus *Fusarium oxysporum* (Mukherjee et al. 2002). The authors demonstrated that the extracellular synthesis of nanoparticles provided various advantages such as homogeneous catalysis when the nanoparticles were synthesized in solution form (Mukherjee et al. 2002). Xiong et al. have designed LVFFARK and LVFFARK-functionalized nanoparticles in order to prevent the amyloid- β protein aggregation (Xiong et al. 2015). A study reported that peptide-gold nanoparticles irradiated with microwave are capable of selective binding to β -amyloid and inhibiting the amyloidogenesis (Araya et al. 2008). Obulesu and Jhansilakshmi (2016) have synthesized redox nanoparticles such as nitroxide radical, 2,2,6,6 tetramethylpiperidiny-*N*-oxyl. They concluded

that piperine in association with redox nanoparticles confers improved prevention against Alzheimer's disease *in vitro*.

Another interesting study has attempted to interfere with amyloid- β aggregation growth and distantly re-dissolve these deposits via local heat dissipation of gold nanoparticles by selective binding to the aggregates (Kogan et al. 2006). Association with aggregates also allowed both, noninvasive exploration and dissolution of molecular aggregates. Therefore, based on abovementioned finding a conclusion can be drawn that a promising therapeutic approach for controlling the protein aggregation can be developed using different aspects of nanotechnology.

3.5 Future Prospect

Based on a recent study, it is estimated that Alzheimer's disease caused by amyloid plaques has affected about 44 million people worldwide (Alzheimer's Association 2015). This figure is expected to rise to 115 million by 2050 (Alzheimer's Association 2015). Presently, there is no competent therapy available for treating the patients with Alzheimer's disease. Moreover, another disadvantage of many of the available drug candidates is the incapability to cross the blood–brain barrier (Patel and Patel 2017). In that scenario, nanotechnology has emerged as a potential therapy in order to control the Alzheimer's disease due to the capability of various nanoparticles to cross the blood–brain barrier (Saraiva et al. 2016) and control the production and aggregation of amyloid plaques (Fig. 3.1). However, there are certain issues which have to be addressed to improve their efficacy. For example, the drug-loaded nanoparticles in comparison with the free drug, are currently limited quantitatively into the brain. Therefore, more focus should be paid on the development of systems transporting pharmacologically significant quantity of drugs into the brain. Moreover, a complete understanding of mechanisms of Alzheimer's disease will contribute towards the accurate application of targeted nanoparticles.

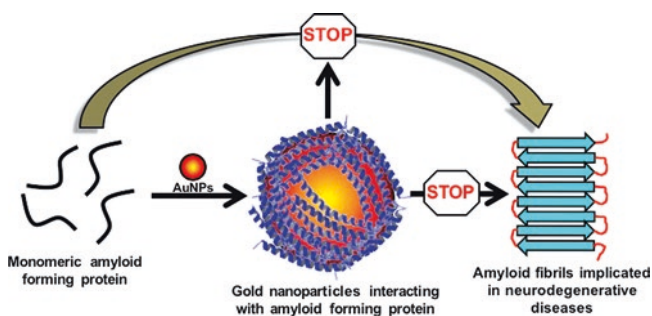


Fig. 3.1 Representative diagram showing the interaction of gold nanoparticles with the amyloid forming protein (e.g. amyloid β -peptide) in order to prevent its aggregation

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Chapter 8

Nanofabrication of Myconanoparticles: A Future Prospect



Rajender Boddula, Priyanka Dubey, Saurabh Gautam, Ramyakrishna Pothu, and Aditya Saran

Abstract Nanofabrications of nanomaterials are widely used in electronic industries related to integrated circuits and visual display. There in electronics the more popular word is nanolithography. The synthesis methods of myconanoparticles (MNPs) are eco-friendly, easy and less costly than chemically synthesized nanomaterials. Till now a full control over the fungal growth is possible, but the same is not possible for the synthesis of MNPs either through intra- or extracellular environment. Myconanoparticles are generally large in size with high standard deviation and less uniformity. The lack of uniformity and some specific structural requirement for optical properties is a big challenge for the applicability of MNPs. Fabrication is a method which can be applied for reshaping the MNPs. Nanofabrication is the future of MNPs processing for its wide-scale practical and industrial applications.

Keywords Nanofabrication · Myconanoparticles · Reshaping of nanoparticles · Etching · Surface functionalization

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8.1 Introduction

Fungi are eukaryotic organism which occurs as a single cellular entity to multicellular form. As being more evolutionary developed from Kingdom Monera, fungi have more complex cytology and genetics. Fungi secrete many intracellular and extracellular enzymes other than various other excretions. These different excretions play as a reducing agent for the synthesis of nanoparticles. Myconanoparticles have low production cost and are easy to synthesize, and synthesis procedures are devoid of any harmful chemicals (Prasad 2016, 2017). Many different nanoparticles can be synthesized from fungi such as gold, silver, zinc, cadmium, silica, platinum, titanium and ferrous nanoparticles (Ravindra and Rajasab 2014). Nanoparticles have large applications in different sectors such as pharmaceuticals, diagnostics, catalysis, electronics, etc (Prasad et al. 2016). The potential of application of metal nanoparticles (MNPs) is too high, but in reality it was not being utilized commercially. Still on the commercial and industrial scale, chemically synthesized nanoparticles are used. There has been a lot of work done on the green synthesis of nanoparticles via fungi. Here this chapter will address the scientific reasons behind the hurdles in the application of MNPs and suggest some ways out to overcome it.

8.2 Size, Shape and Morphology of Myconanoparticles

As we know the synthesis process of nanoparticles through fungi is not fully controlled. Only the growth of fungi can be controlled. Mainly the nanoparticle follows the bottom-up synthesis process via reduction. Due to presence of different enzymes and molecules, the size, shape and morphology are not fully controlled. The size and the shape vary greatly. The variations in the size of myconanoparticle are shown by few examples listed below in Table 8.1.

There are many ingredients present in the extra- and intracellular environment of fungi whose functions in the nanoparticle synthesis are unknown. Additionally for a precise synthesis, the concentration of the ingredients and their molar ratio must be maintained which is not possible in the case of fungi or its crude extract. This is the main reason behind the wide size variations of MNPs.

8.2.1 Obstacles in the Application of Myconanoparticles

Mostly the standard deviation for the size is so high for the MNPs that it cannot be accepted for practical application. For a targeted drug delivery through nanoparticles as carrier inside the nucleus, the size of nanoparticle must be ≤ 5 nm. Nearly same types of limitations are there in every application. Even if the size and shape are in control, morphology needs to be addressed. For an example, if a nanoparticle is to be used as catalyst in ELISA, then its surface must be modified so that it can be

Table 8.1 Myconanoparticles synthesized through different fungi

Nanoparticle type	Fungal species	Size (in nm)	References
Gold	<i>Aspergillus oryzae</i>	10–60	Ni et al. (2008)
	<i>Trichothecium</i> sp.	5–200	Ahmad et al. (2005)
	<i>Colletotrichum</i> sp.	20–40	Tsung et al. (2006)
	<i>Verticillium luteoalbum</i>	<10–100	Wen et al. (2013)
	<i>Verticillium</i> sp.	2–20	Tsung et al. (2006) and Saa et al. (2014)
Silver	<i>Rhizopus nigricans</i>	35–48	Kim and McIntyre (2006)
	<i>Trichoderma</i> sp.	5–40	Foroughi-Abari and Cadien (2012)
	<i>Mucor hiemalis</i>	5–15	Aziz et al. (2016)
	<i>Penicillium fellutanum</i>	5–25	Leskelä and Ritala (2002)
	<i>Cladosporium cladosporioides</i>	10–100	Balaji et al. (2009)
	<i>Fusarium semitectum</i>	10–60	Stepanova and Dew (2011)
Zirconia	<i>Fusarium oxysporum</i>	3–11	Cui (2011a)
Zinc oxide	<i>Aspergillus terreus</i>	54.8–82.6	Binupriya et al. (2010)
Cadmium	<i>Fusarium oxysporum</i>	5–20	Ahmad et al. (2002)
Silica	<i>Fusarium oxysporum</i>	5–15	Gericke and Pinches (2006)
Platinum	<i>F. oxysporum</i> f. sp. <i>lycopersici</i>	10–100	Mukherjee et al. (2001a)
Titanium	<i>Fusarium oxysporum</i>	6–13	Gericke and Pinches (2006)
Magnetite	<i>Fusarium oxysporum</i>	20–50	Mukherjee et al. (2001b)

A high size variation of myconanoparticles synthesized through a particular species in the same set of growth condition

attached to detection antibody. Nanoparticle bio interfaces must be addressed properly. For the practical application of MNPs, there is a strong need of fabrication in order to get desired shape, size and surface modification.

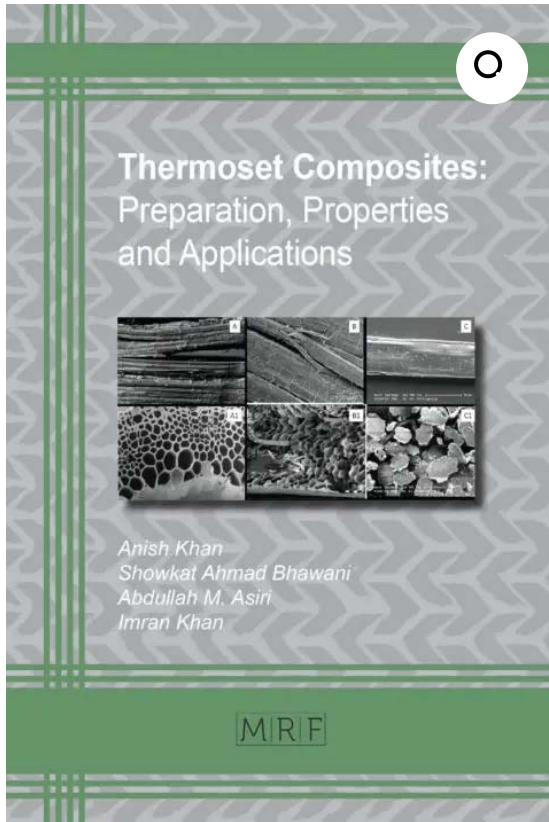
To overcome these obstacles, two approaches can be made: (1) development of methods to synthesize MNPs precisely and (2) reshape the synthesized MNPs to desired shape, size and morphology. At present there are some approaches already in use for reshaping the nanoparticles. Nanolithography is a technique being used in electronic industry and R&D to get desired pattern, size and functional surface.

8.3 Nanofabrication

It is method of fabricating nanoparticles to a desired shape, size and surface modification. For the nanofabrication, two types of approach are possible – ‘bottom up’ and ‘top down’. In the bottom-up approach, nanomaterial is synthesized precisely by adding atom by atom, molecule by molecule or cluster by cluster. Here in ‘bottom-up’ approach, synthesis process is well focused and addressed. Majority of the



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Description

Waterborne Thermosetting Polyurethane Composites

Sashivinay Kumar Gaddam, Pothu Ramykrishna, Aditya Saran, Rajender Boddula

This chapter provides a background of waterborne thermosetting polyurethane composite synthesis, physico-chemical properties and their applications as coatings, adhesives and printing inks. The reinforcement of waterborne polyurethane dispersion (PUD) matrix with different inorganic nanofillers develops cross-linking networks and leads to their high modulus, strength, durability, and resistance towards weather and chemical attacks.

Thereby, a brief survey on different functionalization methods of nanofillers for the development of advanced waterborne PUD thermosetting composites with specific properties, including shape memory, fire retardancy, corrosion resistance and antimicrobial activity, is given.

Keywords

Waterborne Polyurethanes, Thermoset, Composites, Metal/Metaloxide Nanoparticles, Carbohydrates, Clays, Carbon Nanomaterials

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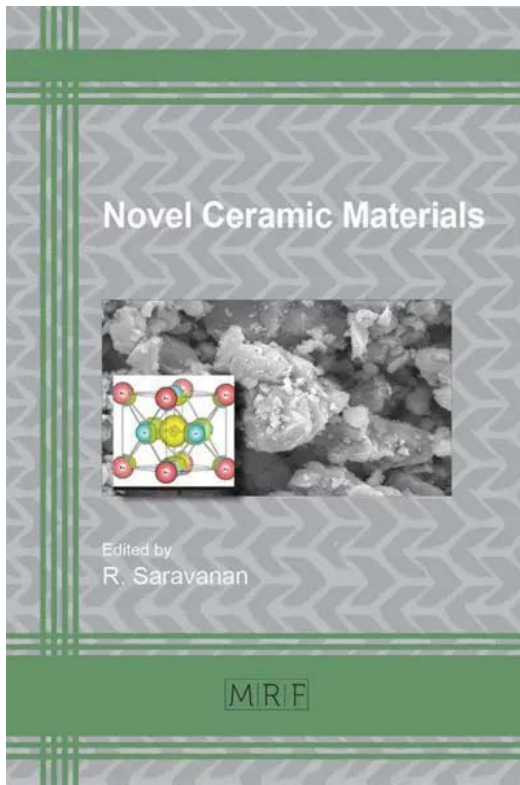
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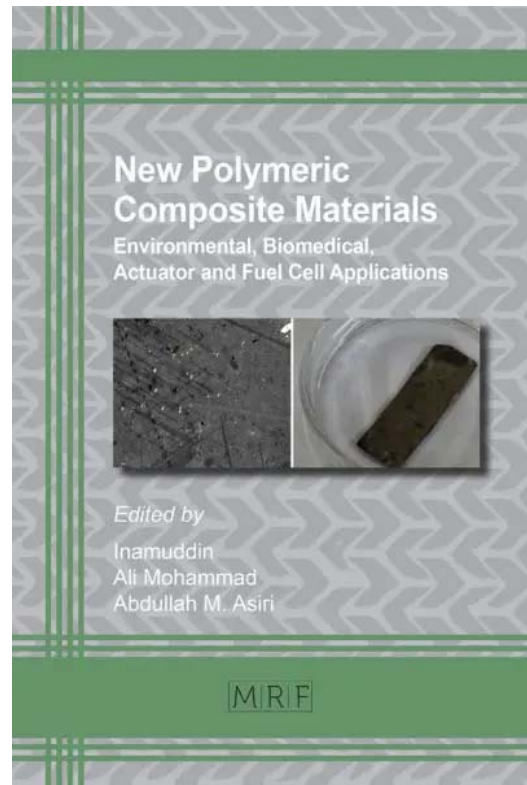
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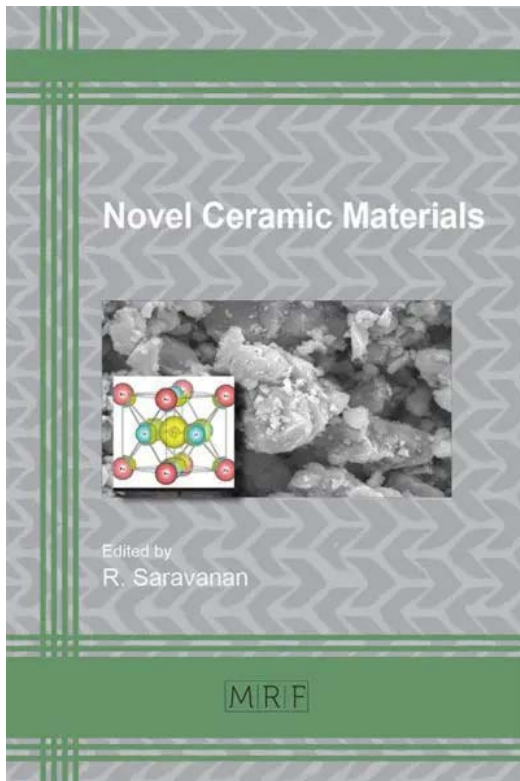
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Jing Zhang · Yeon-Gil Jung *Editors*

Advanced Ceramic and Metallic Coating and Thin Film Materials for Energy and Environmental Applications

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Editors

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Preface

The field of research into advanced metallic and ceramic thin film materials for energy and environmental applications has been rapidly moving forward. This book provides the latest information of the developments in the field. It also gives the perspective of future research. This book collects the contributions by several established worldwide researchers from academia, industry, and a government research laboratory. The book covers the fundamental mechanisms, processing, and applications of advanced thin film and coating materials.

The book covers a broad range of topics related to thin film and coating materials, including overview of advanced ceramic and metallic coatings, surface modification, magnetic materials, thermoelectric materials, solar energy materials, solid oxide fuel cells, coatings in solid-phase microextraction process, and modeling and simulation of thin film materials.

This book is primarily aimed at researchers in thin film and coating fields in both academia and industry. It can be used as a reference book for graduate and undergraduate students in materials science and mechanical engineering.

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Chapter 5

Microwave-Processed Copper Zinc Tin Sulphide (CZTS) Inks for Coatings in Solar Cells

Prashant R. Ghediya and Tapas K. Chaudhuri

5.1 Introduction

Solar electricity, generated from sunlight by solar cells, is environmentally clean, carbon-free and renewable. It has the potential to meet the terawatt energy demand of the world, provided it is available at par with grid electricity. The prevalent solar cells made from silicon (Si) or cadmium telluride (CdTe) or copper indium gallium selenide (CIGS) generate electricity that are still too expensive. Hence, there is a frantic search for new materials for solar cells which will generate cost-competitive electricity [1]. One such promising candidate is earth-abundant, low-cost and non-toxic kesterite copper zinc tin sulphide/selenide. Copper zinc tin sulphide (CZTS) is a *p*-type semiconductor with a direct band gap of about 1.5 eV and absorption coefficient of above 10^4 cm^{-1} in the solar spectrum [2]. CZTS exists in tetragonal kesterite structure with lattice constants: $a = 0.5435 \text{ nm}$, $c = 1.0843 \text{ nm}$. The absorber layer is the heart of TFSCs. The CZTS film in a thin film solar cell (photovoltaic device) acts as the *p*-type photoactive absorber layer. The absorber layer is the most critical part of a cell because major processes required for photovoltaic effect occur here. The processes of absorption of solar radiation, generation of electron-hole pairs and separation of charges take place in this layer. Hence, effect of light on conductivity (photoconductivity) of CZTS films is as important as the dark conductivity itself. In other words, understanding of electrical and photoelectrical properties of CZTS is essential for development of

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Indoor Air Quality Assessment during Construction Activities in Rajkot City

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Abstract : *Due to a rapid increase in the population of India, there is hyper increase in the demand of residential areas resulting in a large number of constructional activities. Constructional activity also leads to an increase in the indoor air pollution for fixed area or for a specific location. Construction activities that contribute to indoor air pollution include land clearing, operation of diesel engines, demolition, burning, and working with toxic materials. All construction sites generate high levels of air pollutions (typically from concrete, cement, wood, stone, silica) and this can carry for very far distances over a long period of time. Due use of this raw materials in construction work there is release of the pollutant such as PM_{2.5}, PM₁₀, Humidity, Temperature, CO₂, AQI, TOC which leads to the harmful health effect to the workers and near living society peoples. Among this all pollutants the major amount of the pollutant which is generated is PM₁₀, with the size of less than 10 micron in diameter which is invisible with naked eye. In major cities there is between 20-150 micrograms of particulates (PM10 10 micron) per cubic meter of air.*

Keywords: Air Quality Index, Construction Activity, Indoor Pollution

I. Introduction

Air constitutes 80% of the man's daily intake of material by weight. We breathe about 22000 times a day on an average, inhaling 16kg of air/day. This suggests how important fresh unpolluted air is for human beings. But due to rapid industrialization, overpopulation many air pollutants are added into the atmosphere effecting human being, animals, plants and materials. We cannot control the flow of air as air pollutants after being emitted from the source travels to a considerable distance depending upon the atmospheric condition. Some of the effects of air pollution are global warming, ozone depletion and acid rain. The Minister for Environment, Forests & Climate Change, Shri Prakash Javadekar, launched The National Air Quality Index (NAQI), also known as IND-AQI, in New Delhi on 17th September 2014 under the Swachh Bharat Abhiyan. Due to a rapid increase in the population of India, there is hyper increase in the demand of residential areas resulting in a large number of constructional activities. With a demand of smart city, need of constructional activity will be at more pace as of today (Esplugues et. al 2010). Constructional activity also leads to

an increase in the indoor air pollution for fixed area or for a specific location. Construction activities that contribute to indoor air pollution include land clearing, operation of diesel engines, demolition, burning, and working with toxic materials. All construction sites generate high levels of air pollutions (typically from concrete, cement, wood, stone, silica) and this can carry for very far distances over a long period of time. Due use of this raw materials in construction work there is release of the pollutant such as PM_{2.5}, PM₁₀, Humidity, Temperature, CO₂, AQI, TOC which leads to the harmful health effect to the workers and near living society peoples. Among this all pollutants the major amount of the pollutant which is generated is PM₁₀, with the size of less than 10 micron in diameter which is invisible with naked eye. In major cities there is between 20-150 micrograms of particulates (PM₁₀ 10 micron) per cubic meter of air. The amount of the PM₁₀ over worldwide on the basis of year 2003-2010, as now there will big change in the countries as in the modern era (WHO 2000; WHO 2006). According to the World Health Organization (WHO) it is today the single biggest environmental health risk with around 3.7 million premature deaths worldwide per year because of the ambient air pollutions (WHO, 2010). Among the most serious indoor air quality health issues is the potential exposure to construction/renovation-generated pollutants in the society areas. The constructions sites or renovation sites provides many potential exposure opportunities to pollutants (Zhao et. al, 2008). As the use of the raw materials for the construction activities such as cement, fine sand, red bricks, soils which lead to the PM_{2.5} and PM₁₀. The application of tile adhesive, roofing materials, paints, and other products used during construction work provide point sources of volatile organic compounds (VOCs). There is also production of CO₂ by the use of the transport vehicles of supply of raw materials and used for the construction works like digging then filling the concrete trucks, and by the smoking of the workers working at the sites. Similar type of study was carried out by Mandarick et al, 2018 for a photocopying shop at different location within shop.

1.1 Monitoring Benefits

❖ Air quality monitoring helps in better understanding the various sources, levels of different air pollutants, effects of policies of air pollution control, and exposure of various substances in the air.

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PROCEEDINGS

SOLID WASTE MANAGEMENT

ASSESSMENT OF DISPERSION, RETENTION TIME AND FRACTION OF PM₁₀₋₂₀, AND PM_{0.23-1} IN IRON ORE MINES**ARTI THANKI***Department of Environmental Science and Engineering, Marwadi University, Rajkot, India: ankita.thanki105864@marwadiuniversity.ac.in**ABHISHEK GUPTA**Department of Environmental Science and Engineering, Marwadi University, Rajkot, India: abhishek.gupta@marwadieducation.edu.in**SNEHA GAUTAM**Department of Environmental Science and Engineering, Marwadi University, Rajkot, India: Sneha.gautam@marwadieducation.edu.in**KOUSHIK SINGHA ROY**Department of Environmental Science and Engineering, Marwadi University, Rajkot, India: koushikshingha.roy@marwadieducation.edu.in**ADITYA KUMAR PATRA**Department of Environmental Science and Engineering, Marwadi University, Rajkot, India: patrakaditya@gmail.com**ABSTRACT**

The measurement study of the generation, dispersion and retention was carried out at Kiriburu (KIOM) and Meghahatuburu (MIOM), iron ore mines, Odisha state of India. The six days' average concentrations of particulate matter (PM) with two wide size ranges (PM₁₀₋₂₀, and PM_{0.23-1}) were monitored in two iron ore opencast mines. Monitoring was done for three days at the same location at each mine. The increment average concentrations ranged from 15.48-16.74 µg m⁻³ for PM₁₀₋₂₀ and 13.03-29.35 µg m⁻³ for PM_{0.23-1} in KIOM and 88.65-92.8 µg m⁻³ for PM₁₀₋₂₀ and 7.89-9.54 µg m⁻³ for PM_{0.23-1} in MIOM respectively. Require them to reach the surface are monitored on average 1-2 minute for PM. The retention time of fine PM varies 4-8 minute for KIOM and 1-12 for MIOM, while coarse PM varies 4-5 minute for KIOM and 1-10 for MIOM. The good relationship was obtained between retention time and retention fraction in both KIOM and MIOM. Fine PM shows the higher retention time as compared to coarse PM. The values of retention fraction vary with 10.03-13.96% for PM_{0.23-1} and 10.58-11.94% for PM₁₀₋₂₀ in KIOM whereas 0.67-1.62% for PM_{0.23-1} and 0.72-0.43% for PM₁₀₋₂₀ in MIOM. The results of this study reveal that relationship between retention time and retention fraction with mining activity and gives the roughly information about time require by PM to reach the surface.

Keywords Dispersion, opencast mine, PM₁₀₋₂₀, PM_{0.23-1}, retention time, retention fraction

INTRODUCTION

Field study of the generation of particulate matter (PM) from different mining operations was found to know contribution of PM through mining activities are done earlier in different countries (Gautam et al. 2012; Gautam et al. 2018). Some earlier research done on health effects due to generation of PM in and around mining activities (Patra et al. 2016). This paper deals with measurement of PM with two size ranges (PM₁₀₋₂₀, and PM_{0.23-1}) in two iron ore opencast mines. Some studies show that coarse PM was obtained higher in concentration as compared to fine PM during mining operations (Onder and Yigit, 2009). However, this all studies not shown the retention time, retention fraction and require time of PM to reach the surface when mining activities running on the bottom area of mines.

Earlier studies indicated concentrations generations due to individual mining operations and assessment of PM in and around the mining area (Chaulya 2004; Chakraborty et al., 2002). Few dispersion pattern studies of PM in opencast mines are found to show the pit retention time (Winges, 1981; Fabrick, 1982). Wings (1981) given expression of particulate deposition, fraction of PM with result varies from 0.14 to 0.73, while Fabrick (1982) proposed expression with wind speed, width and particle deposition velocity with results varies from 0.23 to 1.0 for 10 µm to 95 µm respectively. Recent no studies could not find to know pit retention studies in opencast mines. There is some gap to estimate the retention time and travel time of PM inside the opencast mines. The paper represents a wide ranging dust generation and dispersion of study in two iron ore opencast mine in India. This study aimed at estimating the incremental contribution of PM during mining activities inside the mines and to estimate travel time, retention time, and a retention fraction of PM to know how much concentration of PM comes from bottom to top, and require time to stay in the mines with concentration.

MATERIAL AND METHODS

The research work on PM was carried out in two iron ore opencast mines, namely Kiriburu iron ore mines (KIOM) and

Meghahatuburu iron ore mines (MIOM). It has a general trend N70E to S 70W with an average dip of 600 to the West for KIOM and N 370 E direction for MIOM.

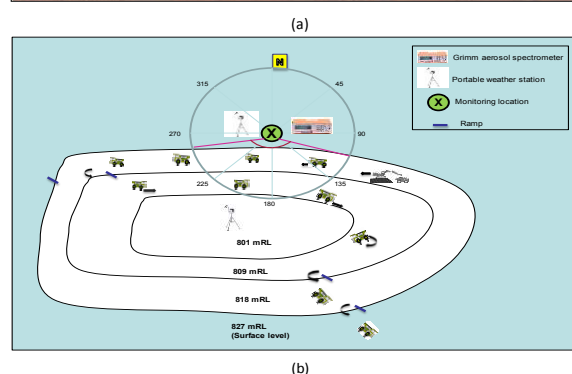


Fig. 1. Mine layout sampling location at KIOM; (a) pictorial view and (b) schematic diagram.

In KIOM, surface RL is 827 m. It has 3 benches with first and second bench 9 m high and the bottom third bench is 8 m high. The pit bottom RL is 801 m (Figure 1). In MIOM, At MIOM, the bench height is 10 m. At the experiment site surface

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PROCEEDINGS SOLID WASTE MANAGEMENT

ASSESSMENT OF VARIATION OF PARTICULATE MATTER CONCENTRATION INSIDE AN OPENCAST COPPER MINE

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ABSTRACT

The measurement study of the dispersion and travel time of particles ($PM_{0.23}$ to PM_{20}) was carried out at Malang hand Copper Project, one of the deepest copper opencast mines, Madhya Pradesh state of India. The eight days average concentrations of particulate matter (PM) with 15 particle size in range were measured. No study is reported to identify the dispersion profile and require time of PM between the benches inside the mine. This research work is good approach to know about the exposure of enhanced level of PM concentration on mine worker. The results of field study provide an understanding of the relationship between the dispersion of the particulate matter generated due to mining activities with their respective depths. The particulate matter concentration and meteorological studies were monitored by GRIMM portable aerosol spectrometer and portable meteorological station respectively. The correlations study provided influence of wind speed and wind direction on particulate matter during its travel from source to surface. The R^2 value of relationship between depth and time of particulate matter was noted to vary between 0.57 to 0.64. The results of time analysis of different size of particulate matter also indicated that wind speed and wind direction significantly affect the movement and transport properties of particulate matter from bottom to surface of the mines. Empirical equations developed to know about relationship between concentrations of particulate matter with 15 channel range size and depth is also proposed.

Keywords Opencast mine; Dispersion; Particulate matter; Time analysis; IBM SPSS

INTRODUCTION

In the current state-of-art, generation of huge quantity of particulate matter (PM) during mining activities is a subject of immense concern with regard to human health and environment [1]. Earlier studies have showed that PM from different kind of mining operations lead to adverse effects on health (i.e. black lung, asthma, cardiovascular diseases and lung cancer) [2]. However, some researcher provided information about generation, estimation, and contribution of particulate matter during mining operations in opencast mines [3, 4].

It is important to note that surface mine is one of the most important contributors to modern societies and it involves removal of overburden to get access to the minerals of interest. Also, this mining method is applicable to minerals located at shallow depth and degradation of air quality is major problem in such mining areas [5-7]. There are several sizes (i.e. PM_1 , $PM_{2.5}$, PM_{10} etc.) of PM which are responsible for reduced air quality that results in adverse effects on human health [5, 7]. Therefore, the study of dispersion of PM is always an important and interesting line of research as it determines the level and duration of exposure of particulate matter on mines workers. The particulate matter from source travels and finally is distributed in all benches. Hence, the concentration of particulate matter contributed to the enhanced concentration at all bench of mines. Similarly the travel time of PM that is required of particulate matter to escape from the mines is important as long travel time indicates a high exposure of particulate matter on mine workers. The travel time of PM is not same for all sizes as the coarse particulate matter settle faster compared to fine particulate matter, attributed to higher settling velocities. However, no work has yet been reported on the dispersion behavior and travel time of PM. The transportation of PM in opencast mines depends on wind speed and direction. The

wind flow pattern depends on mine geometry and depth of mines. Therefore the wind speeds is measured high in shallow mines and less in deeper opencast mines [9]. Some earlier studies carried out in opencast mines to know about dispersion of PM and wind flow pattern inside opencast mines with the help of tracer studies [9] and used to smoke to suggest the movement of PM in different place of opencast mines [10]. Some researchers used computational fluid dynamics to estimate the wind flow pattern and dispersion of particulate matter inside the mines [11]. However, no field work has been carried out to identify the dispersion behavior of PM with different size range from source to surface.

Therefore, the present paper is focused on extensive study of dust dispersion study in Malanjkhanda copper project in India to know about contribution of mining to the particulate matter concentration and behavior of particulate matter as they travel from source to surface. The correlations study provided influence of wind speed and wind direction on particulate matter during its travel from source to surface. An empirical relationship between concentrations of particulate matter and depth is also proposed through source to surface of the mine.

MATERIAL AND METHODS**STUDY SITE**

The study was conducted in Malanjkhanda Copper Project (MCP) of Hindustan Copper Limited (HCL). MCP is the single largest copper deposit in India constituting nearly 80% of country's reserve and contributing about 70% of HCL's copper production. Surface RL (reduced levels (RL, mRL refers to depth / height of a place in meter above a reference datum / mean sea level) at the mine site is 580 m and the designed ultimate pit depth is 376 mRL. At present mining is being carried out at 400 and 412 mRL using 4.6 m³ and 9.2 m³ capacity electric shovels, 50 and 85 T dumpers and 165 mm

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ASSESSMENT OF FINE PARTICLE PROFILE IN SURFACE MINE USING AN ARTIFICIAL NEURAL NETWORK MODEL

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ABSTRACT

Particulate matter (PM) is a major pollutant in and around opencast mine areas. The problem of degradation of air quality due to opencast mine is more severe than those in underground mine areas. Prediction of dust concentration must be known to implement control strategies and techniques to control air quality degradation in the workplace environment. In this paper, the assessment of fine PM concentration profile in seven channels size in which ranges, from $PM_{0.23}$ to $PM_{1.6}$ in Malanjkhanda Copper Project (MCP), Madhya Pradesh state of India, and which was highly prejudiced by mining operations was estimated and tested by implementing Artificial Neural Network (ANN). In particular, the model utilizes the input data for prediction where the eight days average concentrations of PM, local meteorological data (wind speed, temperature, relative humidity) from one of the deepest copper opencast mine. ANN models were developed and tested to predict $PM_{0.23-0.3}$, $PM_{0.3-0.4}$, $PM_{0.4-0.5}$, $PM_{0.5-0.65}$, $PM_{0.65-0.8}$, $PM_{0.8-1}$, $PM_{1-1.6}$ concentration profile at MCP. The performance of the ANN model was evaluated in terms of the correlation coefficient between the real and the forecasted data. The result shows strong agreement between the experimental results (PM concentration and meteorological data) and the model. The findings of this work are important in understanding fine PM variation inside the mine at the workplace and the associated exposure of mine workers.

Keywords Opencast Mine; Particulate Matter; Model Performance; Artificial Neural Networks

INTRODUCTION

Generation of huge quantity of PM during mining activities is of concern for the environment as well as human health [1, 2]. Earlier studies show that PM from different kind of mining operations contribute to significant adverse effect on human health in the form of black lung, asthma, cardiovascular diseases and lung cancer [3]. However, only a few studies have provided information about generation, estimation and contribution of PM during mining operations in opencast mines [4-6].

The study for dispersion of PM is therefore important because it will determine the level and duration of exposure of PM on mines workers. The PM travels and distributed in all benches from source [7]. Thus, the concentration of PM contributes to the enhanced concentration for all benches of mine. With opencast mines going deeper day by day due to higher production, the study of dispersion and movement of PM in the mine needs attention.

Air quality modeling is an approach to assess the concentration in the workplace or the surrounding environment [8, 9]. These developed models are used to generally assess particle concentration profiles in a workplace environment and evaluate the results against air quality regulations. Models are being used for extensive evaluation of PM concentration profile under different meteorological parameters in an area [10, 11].

Several empirical models have been developed to estimate the concentration of PM in a workplace environment [12, 13]. Statistical approaches sometimes under-perform the PM concentration from different sources [14]. Recently, Artificial Neural Network (ANN) model is being used for predicting concentration from the source then the evaluation is done by the experimental data. It shows fast processing with several input and output variables [15]. Earlier studies reported that ANN based air quality models give better results than the other statistical model with good accuracy [16-18]. ANN models have been very accurate in many environmental application areas, especially indoor environment [19], Air quality forecasting [20], Soil analysis

[21], water treatment application [22], Traffic and Vehicular pollution [23] and PM concentration prediction from the different sources in the opencast mines area [6]. Hence, the advantages of ANN over statistical model can be concluded as (i) It do not require detailed physical models; (ii) It is more compact than large experiment data; (iii) It requires few training points to accurately model the standards; (iv) It can be trained on only a few experiments data; (v) It can be much more accurate than statistical models, when limited experimental data are available. As ANN models are shown so advantageous some drawbacks are also there. For example (i) In order to create training sets to obtain ANN models valid for a large range; intensive measurements have to be done; (ii) These models are very poor outside the range of the training set. These drawbacks can be overcome by implementing prior information into the design of neural networks.

However, very few studies have shown the usefulness of ANN model in order to, investigate the concentration inside opencast mine and validation of experimental data set to predict PM concentration profile with meteorological input variable inside opencast mine. In this work, ANN models were developed and tested to predict PM concentrations profile at Malanjkhanda Copper Project (MCP). The results indicated that the ANN network was able to predict concentrations and shows significant agreement between the experimental results and the ANN model.

EXPERIMENTAL METHODOLOGY

STUDY SITE

The study was conducted in Malanjkhanda Copper Project (MCP) of Hindustan Copper Limited (HCL) of India. The detail description of study area is described in our previous published research article [24].

ANN model

ANN model is implemented through the data collected from the experimental results. The data are divided into three parts they are as follows: Training: These are presented to the network during training of the model, and the network is adjusted according to its error; Validation: These are used to measure network generalization and to halt training

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EFFECT OF ORGANIC MANURING ON CARBONSEQUESTRATION AND MICROBIAL DIVERSITY IN RICE SOIL

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ABSTRACT

The impact of organic amendments on the functional microbial activities, soil carbon (C) storage was investigated in a tropical rice soil. The treatments included unamended control, farmyard manure (FYM) and green manure (GM) (*Sesbania aculeata*). Our results suggest that the GM treatment has increased the global warming potential (GWP) by 110% as well decreased the C efficiency ratio (CER) by 24% in comparison to control. On contrary, under FYM treatment the soil organic C and total C contents were significantly higher to the tune of 34% and 53%, respectively. Our studies clearly reveal that the application of FYM could probably be the best soil amendment to sequester the soil organic C (SOC). Such amendments may not only have practical application value but also lead to higher yield capacity and minimize emission of GHG under flooded tropical rice soil systems.

Keywords GWP, Storage, Microbial Population, Rice Soil, Organic Amendments

INTRODUCTION

The research interest on global climate change is interlinked with C mineralization and deals with the C cycling of natural ecosystems. The SOC pool is the resultant of C input in the form of crop residues and biomass, and output including harvested biomass, carbon dioxide (CO₂), methane (CH₄) and other C losses (Mancinelli et al. 2010). The CO₂ emission from the soil to the atmosphere caused by the decomposition of organic matter may be affected by the changes in the quality of the substrate and microbial communities.

Soil enzyme activities and microbial populations are strongly influenced by the application of organic amendments. The dehydrogenase activity is considered as a sensitive indicator and a measure of soil quality and serves as a valid biomarker of alterations in total microbial activity (Roldan et al. 2007). Soil hydrolases provide an early indication of changes in soil fertility, as they are related to the mineralization of important nutrients like N, P and C (Garcia-Orenes et al. 2010). The use of organic amendments in rice agro ecosystems store higher soil organic C and increase the crop productivity. The main objectives of the present study are (a) to identify the most adoptable organic amendment that offers high carbon storage, (b) to measure soil C pools and microbial activities in relation under various organic manure treatments.

MATERIALS AND METHODS

TREATMENTS

The treatments were chosen in this study was

T₁ – Control (without any organic manure or inorganic fertilizer)

T₂ – FYM (60 kg N ha⁻¹)

T₃ – GM [*Sesbania aculeata*] (60 kg N ha⁻¹)

SOIL SAMPLING AND STORAGE

Soil samples were collected by a sample probe (at the depth of 0–15, 15–30, 30–45 and 45–60 cm; diameter of the probe was 8 cm) with three replications for each treatment. The fresh moistened soil samples (with native moisture content of fields) were kept in refrigerator at 4°C for biochemical and microbial analysis.

SOIL C FRACTIONS AND TOTAL N ANALYSIS

Soil microbial biomass-C (MBC) was measured by modified chloroform fumigation-extraction method with fumigation at atmospheric pressure (Witt et al. 2000). Readily

mineralizable C (RMC) content of the soil was estimated after extraction with 0.5M K₂SO₄ (Inubushi et al. 1991) followed by wet digestion of the soil extract with dichromate (Vance et al. 1987). Oxidizable organic C (OC) was estimated by dichromate digestion of soil (Walkley and Black, 1934). Acid hydrolyzable carbohydrate C (AHC) was measured by taking the equivalent weight of 2 g soil extracted with 20 ml of 1.5M H₂SO₄ (Angers and Mehuys, 1989) for 24 h with regular shaking and filtered through glass fiber filters (Whatman GF/C). The carbohydrate content of the extracts was determined using the anthrone method (Yoshida et al., 1976). The water soluble carbohydrate C (WSC) was estimated followed by the procedure of Haynes and Swift (1990).

SOIL ENZYMATIC ACTIVITIES AND MICROBIAL POPULATIONS

Dehydrogenase activity was determined by reduction of 2,3,5-Triphenyltetrazolium chloride (TTC) (Casida et al. 1964). Fluorescein diacetate (FDA) hydrolysis activity measurements were made following the method of Adam and Duncan (2001). The β-glucosidase activity was assayed by the procedure of Eivazi and Tabatabai (1988). The heterotrophic microbial populations were cultured by using the media of Rand et al. (1975). Populations of denitrifying bacteria were estimated following the protocol given by Abdel-Malek et al. (1974).

STATISTICAL ANALYSIS

Individual character data sets were analyzed for variance, and means were separated by Duncan's Multiple Range Test (DMRT) at the 0.05 level of probability using statistical software SPSS (Statistical package for social sciences) version 7.5. Pearson correlation (r) was applied to analyze the simple correlations between soil parameters and enzymatic activities.

RESULTS AND DISCUSSION

SOIL C POOLS

SOIL C FRACTIONS

The microbial biomass C (MBC) ranged from 155 to 235 mg kg⁻¹ and accounted for 3% of the total C in the soils under study (Table 1). The C fractions at the lower soil depths did not differ significantly among the treatments (below 15 cm; data not presented). Organic manure, either singly or in combination with inorganic fertilizer, enhanced SOC and its fractions due to the significant increase in C input and soil

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CLEANER PRODUCTION ASSESSMENT FOR A FISH PROCESSING INDUSTRY, GUJARAT – A CASE STUDY

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ABSTRACT

The rapid industrialization of India in the recent past has been the striking feature of Indian economic development. But the other angle of industrialization has been the serious damage to the surrounding environment due to the wastes and pollutants generated from the industries. Typically, there are two different types of environmental innovations that mitigate the environmental burden of production: cleaner production and end-of-pipe technologies. Cleaner production reduces resource use and/or pollution at the source by using cleaner products and production methods, whereas end-of-pipe technologies curb pollution emissions by implementing add-on measures. Gujarat state holds top position in fisheries contributing 25% of total marine production of India. The major steps involved in processing of shrimps include raw material receiving, beheading/gutting/deveining, washing, grading, weighing, freezing, packing, frozen storage and dispatch. Other minor steps which are also very important include glazing, chemical treatment, thawing wrapping and metal detection. During study, it has been found that due to bad housekeeping practice 30 kld water had been wasting. Cleaner production approach can result in finding some opportunity that can be beneficial for new useful product from waste including onsite reuse, recycle and recovery option for economic benefits.

Keywords Cleaner Production, Waste Minimization, Sustainability, Water Conservation, Energy Conservation

INTRODUCTION

The volume of water used by the seafood processing plants and the associated waste loading parameters reported by Islam (2004) shows that the processing plants possess high potential for polluting coast land near shore environments. To provide and check primary and secondary treatment with disinfection to seafood processing wastewater, Tay & Show (2006) studied parameters like pH, solid content, odour, temperature, TOC, BOD₅, COD and N & P and various biological processes were tested with the following observations as mentioned 85–95% of organic load removals can be achieved in activated sludge systems. It was reported to have removal efficiency of 90–95% of BOD₅ in seafood-processing wastewater treatment through aerated lagoons. Stabilization Ponds have been reported achieving 80–95% removal of BOD₅ and approximately 80% removal of suspended solids, with most of the effluent solids discharged as algal cells. In Trickling Filter, The BOD₅ removal efficiency varies with the organic load imposed but usually fluctuates between 45% and 70% for a single-stage filter. Removal efficiencies of up to 90% can be achieved in two stages. But all these treatment processes require continuous investments with no returns so, Dan et al., 2014 presented a case study on Cleaner Production (CP) potentials in seafood processing industry and various CP

Table 1: Process involved in Fishery Industry

Process Name	Process description	Types of waste generated and its amount
Raw Material Receiving	Fresh shrimps is received at receiving stations where they are washed and then weighed, mostly raw materials are brought in ice filled buckets to keep them fresh. It is visually inspected by skilled personnel for product specifications such as appearance, odour, texture, foreign matter, species homogeneity and physical characteristic such as size as per procurement order. [Figure 1(a)]	Waste type: Solid Some unwanted marine species came along with the desired raw material including defective pieces. Amount of waste generated = 0.5% of total raw material received. Waste type: Liquid Spillage of black ink on floors and weighing balance due to damage of ink-sacks. Wastewater discharge due to first washing and removal of ice in received containers. Amount of waste generated = 2kL
Beheading/Peeling/Deveining	This is a pre-processing step. Skilled workers remove the heads of shrimps and de-gut it. Depending on requirement of product, de-shelling may or may not be performed. During the entire process, the fish is covered with flake ice to maintain a temperature of 0°C to +4°C. The reason for using flake ice (instead of tube or block ice) is its higher surface area that would help in faster cooling of product.	Waste type: Solids Removed heads and/or skins/scales of shrimps. Defective pieces. Amount of waste generated = 30–32% of total raw material

options were thus identified. They suggested that up to 70% of water consumed for table and floor cleaning could be saved by using pressurized hoses, up to 10% of electricity bill could be reduced by suitably sizing and installing the capacitor banks. Simple CP options were also identified for waste minimization and better housekeeping. Cleaner production not only reduces waste at source and increase profitability, but it also enhances onsite recycle/reuse and creation of by-product opportunities. Fabbicino & Pontoni (2016) and Fabbicino & Gallo (2010) carried out test for Chromium removal from tannery wastewater using ground shrimp shells and use of non-treated shrimp-shells for textile dye removal from wastewater. And they observed Chromium removal from wastewater occurs quite rapidly after the addition of shrimp shells, and the detention time is not higher than for other low-cost adsorbents also it was observed that removal percentage up to 90% for the tested dyes are obtained in about 2 hours, using 2.1 mg/mL of shells, simply dried and grinded.

Waste Identification

Methodology for this study includes identification of various waste sources. During the walkthrough at the plant, following waste streams were identified and calculated the total quantity of the waste generated during the whole day and its cost was calculated accordingly.

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CARBON SEQUESTRATION POTENTIAL OF NOVEL COMPOSITE MATERIAL FOR MORTAR PREPARATION USING FLY ASH REINFORCED WITH PLANT FIBRES

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ABSTRACT

Increasing energy owing to urbanization and industrialization has led to high carbon dioxide (CO₂) emission into the environment and results into increase in earth temperature resulting in global warming. Therefore, there is urgent need to develop a cost effective methods and materials for the CO₂ sequestration from point source and reduce its impact on the environment. This paper discloses results of an investigation concerning the performance of fly ash/waste glass alkaline based mortars with recycled aggregates reinforced by jute and cotton fibres exposed to hasten CO₂ curing. The composite material used in this study were fly ash, cement, sodium hydroxide, milled glass, sand, jute fiber and water. The compressive strength increased significantly after CO₂ curing and the flexural strength reduced significantly in the composite material. The composite reinforced block without jute fibre result into CO₂ uptake by 32% and the composite material with jute fibre enhanced the efficiency to capture CO₂ by 16%. The use of jute fibre leads to reduction in C emissions of 25 kg CO₂ equivalent/m³. This means that accelerated carbonation of composites reinforced with natural fibres has not only carbon sequestration advantages but is also especially indicated for such composites. Therefore the jute fibre based composite blocks are exposed to accelerate CO₂ curing.

Keywords Global Warming, CO₂ Sequestration, Composite Reinforced Block, Accelerated Carbonation, Jute Fibre

Introduction

Climate change a major threat to the world in terms of greenhouse gases (GHGs) emission including carbon dioxide as a crucial emission point. Atmospheric CO₂ concentration as per the recent times has risen to 400ppm which increases the global CO₂ levels (Bretts. R. et al., 2016). These emissions in turn results into increasing global warming level. From past decade records, CO₂ levels never risen above 300ppm but since industrial era it has risen in steady manner. Due to these increasing levels of GHGs, international environmental treaty UNFCCC was formed under which few objectives were derived including carbon capture and storage.

According to IPCC reports, technological options were established for the CO₂ capturing and storing which emphasized carbon sequestration process (Hansen. J. et al., 2017). Furthermore terrestrial sequestration techniques were taken into consideration to increase afforestation/reforestation and to minimize CO₂ concentration. Presently carbon sequestration is mostly carried out through geologic CO₂ storage in saline aquifers (Zhang. Z. et al., 2017). However, this technique constitutes large risks and also very high in cost. Talking about Carbon capture and storage (CCS) from the stream of concentrated CO₂ at fossil fuel burning sites like power plants or steel plants is more efficient and can be less expensive than direct air capture (Hansen. J. et al., 2017). As per recent reports about increasing CO₂ levels; apart from natural sequestration processes, artificial processes are devised to increase carbon sequestration. Carbon sequestration altogether covers climate change mitigation, ecosystem sustainability and economic importance; that helps to confront global issue regarding global warming.

Currently researchers are focusing on product development to capture and store CO₂ for a longer duration of

time. Before few years, scientists were practicing over capturing CO₂ over natural ecosystem (various carbon pools). New advances triggers on the treatment of CO₂ at the generation point to minimizes longer process adaptation. Composite material, MOFs (metal-organic framework), nanosponges, hybrid membranes, nanofibres, etc are some of the products which are installed as a part of product/process modification. Modes of carbon sequestration comprise biological, chemical and physical processes also adapted by artificial techniques.

According to literature survey, biological processes sequester 320 billion metric tons of carbon compared to other sequestration processes. Few authors (Bertos. M. et al., 2004; Jang. J. et al., 2016) have studied the use of CO₂ as accelerated curing of cementitious constructions materials. Future consideration of this technology will prevent CO₂ to be released into the atmosphere but also to accelerate curing and strength development of such materials. Till now no studies were performed using alkali activated based materials. These materials have a particular ability for the reuse of several types of wastes (Bernal. S. et al., 2016; Paya. J. et al., 2014). Some wastes like fly ash deserve a special attention because they are generated in a very high amount and have a very low reuse rate. Waste glass is also a waste that is generated in relevant quantities and that merits increase recycling efforts. The high volume of construction and demolition wastes (CDW) also constitutes a serious problem. The reuse of CDW as recycled aggregates not only constitutes a way to give value to a waste but also prevents the use of river sand. According to this, the use of cementitious mortar materials reinforced with natural waste fibres could be a way to achieve a more sustainable construction. Natural waste fibres are renewable resource and are available almost all over the world. Vegetable fibres commonly available in



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Indoor Air Quality Assessment during Construction Activities in Rajkot City

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Abstract : *Due to a rapid increase in the population of India, there is hyper increase in the demand of residential areas resulting in a large number of constructional activities. Constructional activity also leads to an increase in the indoor air pollution for fixed area or for a specific location. Construction activities that contribute to indoor air pollution include land clearing, operation of diesel engines, demolition, burning, and working with toxic materials. All construction sites generate high levels of air pollutions (typically from concrete, cement, wood, stone, silica) and this can carry for very far distances over a long period of time. Due use of this raw materials in construction work there is release of the pollutant such as PM_{2.5}, PM₁₀, Humidity, Temperature, CO₂, AQI, TOC which leads to the harmful health effect to the workers and near living society peoples. Among this all pollutants the major amount of the pollutant which is generated is PM₁₀, with the size of less than 10 micron in diameter which is invisible with naked eye. In major cities there is between 20-150 micrograms of particulates (PM10 10 micron) per cubic meter of air.*

Keywords: Air Quality Index, Construction Activity, Indoor Pollution

I. Introduction

Air constitutes 80% of the man's daily intake of material by weight. We breathe about 22000 times a day on an average, inhaling 16kg of air/day. This suggests how important fresh unpolluted air is for human beings. But due to rapid industrialization, overpopulation many air pollutants are added into the atmosphere effecting human being, animals, plants and materials. We cannot control the flow of air as air pollutants after being emitted from the source travels to a considerable distance depending upon the atmospheric condition. Some of the effects of air pollution are global warming, ozone depletion and acid rain. The Minister for Environment, Forests & Climate Change, Shri Prakash Javadekar, launched The National Air Quality Index (NAQI), also known as IND-AQI, in New Delhi on 17th September 2014 under the Swachh Bharat Abhiyan. Due to a rapid increase in the population of India, there is hyper increase in the demand of residential areas resulting in a large number of constructional activities. With a demand of smart city, need of constructional activity will be at more pace as of today (Esplugues et. al 2010). Constructional activity also leads to

an increase in the indoor air pollution for fixed area or for a specific location. Construction activities that contribute to indoor air pollution include land clearing, operation of diesel engines, demolition, burning, and working with toxic materials. All construction sites generate high levels of air pollutions (typically from concrete, cement, wood, stone, silica) and this can carry for very far distances over a long period of time. Due use of this raw materials in construction work there is release of the pollutant such as PM_{2.5}, PM₁₀, Humidity, Temperature, CO₂, AQI, TOC which leads to the harmful health effect to the workers and near living society peoples. Among this all pollutants the major amount of the pollutant which is generated is PM₁₀, with the size of less than 10 micron in diameter which is invisible with naked eye. In major cities there is between 20-150 micrograms of particulates (PM₁₀ 10 micron) per cubic meter of air. The amount of the PM₁₀ over worldwide on the basis of year 2003-2010, as now there will big change in the countries as in the modern era (WHO 2000; WHO 2006). According to the World Health Organization (WHO) it is today the single biggest environmental health risk with around 3.7 million premature deaths worldwide per year because of the ambient air pollutions (WHO, 2010). Among the most serious indoor air quality health issues is the potential exposure to construction/renovation-generated pollutants in the society areas. The constructions sites or renovation sites provides many potential exposure opportunities to pollutants (Zhao et. al, 2008). As the use of the raw materials for the construction activities such as cement, fine sand, red bricks, soils which lead to the PM_{2.5} and PM₁₀. The application of tile adhesive, roofing materials, paints, and other products used during construction work provide point sources of volatile organic compounds (VOCs). There is also production of CO₂ by the use of the transport vehicles of supply of raw materials and used for the construction works like digging then filling the concrete trucks, and by the smoking of the workers working at the sites. Similar type of study was carried out by Mandarick et al, 2018 for a photocopying shop at different location within shop.

1.1 Monitoring Benefits

❖ Air quality monitoring helps in better understanding the various sources, levels of different air pollutants, effects of policies of air pollution control, and exposure of various substances in the air.



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Carbon Sequestration Potential of Select Natural Ecosystems of Tropical Regions in India

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Abstract : *The unprecedented increase in greenhouse gas emission in the atmosphere results into increase in atmospheric temperature and results into global warming, sea level rise and ocean acidification which is considered as one of the major problems that world community is facing today. Due to the increasing effects of global warming in several locations of the world, difficulties are faced to reduce the net emission of greenhouse gases. It is necessary to take actions to reduce greenhouse gas emissions by new strategies and appropriate laws. One of the ways to reduce atmospheric concentrations of greenhouse gases is carbon sequestration on agricultural lands. Carbon sequestration is an option for reducing carbon emissions in the form of carbon dioxide and methane from the atmosphere. By storing carbon as soil organic carbon, Carbon dioxide emission can be reduced by increasing storage of carbon dioxide in Agriculture area. Agricultural activities have profound short- and long-term influence on soil organic carbon (SOC).*

Keywords- C storage, C accumulation and sequestration rates, Greenhouse gases, Soil carbon, Soil enzymes.

Introduction

Carbon can be sequestered in oceans, soils, forests, geologic formation for a long time period. From all of them oceans store the highest amount of carbon followed by soil and then plants and animals. Soil performs a significant role in maintaining a balanced global carbon cycle. Soil is one of the vital sources and sinks for GHGs that reason a worldwide temperature alteration and environmental change (Janseens et al., 2003). Soil contributes about 20% to the all-out emanation of CO₂ through soil and root breath, 12% of CH₄ and 60% of anthropogenic N₂O discharges (IPCC, 2007). There are several effects of global warming like damaging the structure and functions of ecosystem. Concentration of organic matter in tropical soil is very low which could still decrease due to climate change. Soil science and microbial populaces are relied upon to change with changes in climatic conditions (Dough puncher, 2004). The best option to reduce global warming by decreasing the carbon emission is carbon sequestration. If the quality of substrate and microbial communities changes it may increase the decomposition of organic matter which can ultimately increase the carbon

dioxide emission. Climate change is linked with C cycling and C mineralization of ecosystems.

To improve soil quality and food production needs Soil carbon (C) sequestration is the best way. The governing factor for carbon sequestration is the soil structure formation. The core of soil structure is soil aggregates which can decide carbon stabilization or loss. Carbon Sequestration depends on the root nodules of the plant. Soil carbon dioxide flux is used to measure the atmospheric carbon. By capturing carbon from thermal power stations or other industries, carbon dioxide can be stored for a long time in the form of biomass by using plants.

Soil carbon is available in two structures: inorganic and natural. Soil inorganic carbon comprises of mineral types of C, either from enduring of parent material, or from response of soil minerals with barometrical CO₂. Soil natural carbon is available as soil natural issue. It incorporates moderately accessible C as crisp plant remains and generally idle C in materials got from plant remains. In the event that more carbon is put away in the dirt as natural carbon, it will lessen the sum present in the climate, and help decrease an unnatural weather change. The way toward putting away carbon in soil is called 'soil carbon sequestration'. The basic way to store carbon in soil system is as soil organic matter. Photosynthesis can fix Carbon dioxide present in atmosphere into plant. Soil organic carbon can be determined by plant roots. In rural frameworks, the sum and time allotment carbon is put away is resolved predominately by how the dirt asset is overseen. SOC levels result from the communications of a few biological system forms, of which photosynthesis, breath, and disintegration are vital. Soil carbon is found directly and indirectly, soil carbon is directly found from plant roots by the growth and death and indirectly it is found by transfer of carbon containing compounds from roots to soil microbes.

The measure of C in soil speaks to a considerable bit of the carbon found in earthbound biological systems of the planet. All out C in earthly environments is roughly 3170 gigatons (GT; 1 GT = 1 petagram = 1 billion metric tons). Of this sum, almost 80% (2500 GT) is found in soil (Lal 2008). Soil carbon can be either natural (1550 GT) or inorganic carbon (950 GT). The dirt carbon pool is around 3.1 occasions bigger than the climatic pool of 800 GT (Oelkers & Cole 2008). Just the sea

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EXTRACTION OF NICOTINE FROM TOBACCO

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ABSTRACT

The huge population of India is under the threat of certain social and lifestyle addictions. The top among those addictions include the usage of tobacco. The nicotine content in the tobacco proves to be very harmful to health. The lethal dose of nicotine is 50mg/kg for rats and 3mg/kg for mice. 40-60mg/kg can be lethal dosage for adult human beings. This makes it an extremely deadly poison. It is more toxic than many other alkaloids such as cocaine which has a lethal dose of 1000 mg. Thus in our study we have aimed at removing the nicotine content from the tobacco so that the dependency rate can be diminished. Our further focus is on finding the acceptable alternatives of nicotine in tobacco.

Keywords Tobacco; Nicotine; Alkaloids; Cocaine; Harmful to Health

Introduction

Nicotine is an alkaloid found in the nightshade family of plants (solanaceae) predominantly in tobacco and in lower quantities in tomato, eggplant and in green pepper. Nicotine alkaloids are also found in the leaves of the coca plant. Nicotine constituents 0.3% to 5% of the tobacco plant by dry weight with Biosynthesis taking place in the roots and accumulate in the leaves. It is potent neurotoxic and is included in many insecticides. In lower concentrations, the substance acts as a stimulant and is one of the main factors responsible for the Dependence-forming properties of tobacco addiction.

Nicotine Chemistry

Nicotine is hygroscopic, oily liquid that is miscible with water in its base form. As a nitrogenous base, nicotine forms salts with acids that are usually solid and water soluble. Nicotine easily penetrates the skin.

Toxicology for nicotine

The lethal dose of nicotine is 50mg/kg for rats and 3mg/kg for mice. 40-60mg/kg can be lethal dosage for adult human beings. This makes it an extremely deadly poison. It is more toxic than many other alkaloids such as cocaine which has a lethal dose of 1000 mg.

Principle

The extraction depends on isolation of base by dissolving the cigarettes in NaOH. Then extract nicotine from the filtrate by ether. After evaporation of ether you will get nicotine oil. The factories of tobacco remove large quantities of nicotine from cigarette leaves because of high toxicity. This is why the produced oil is very little. To get nicotine crystals, saturated solution of picric acid is added to form nicotine di picrate yellow crystals.

Materials required

- Tobacco
- Ether.
- NaOH solution (5%)
- Saturated picric acid solution in methanol.
- Mercury dichloride
- Beaker 250ml
- Separating funnel
- Conical flasks.
- Buchner glass wool.

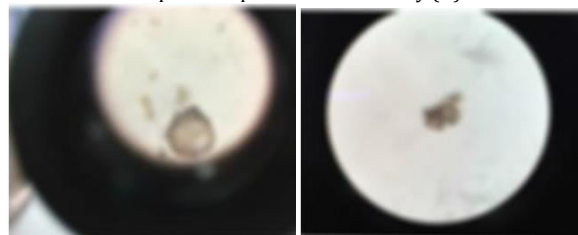
Procedure

Weigh 10 g of tobacco leaves in beaker.
Add 100ml NaOH solution and stir very well for 15 min.
Filter in Buchner using glass wool and press the tobacco very well by using other beaker.
Transfer the tobacco again to beaker.
Add 30ml distilled water and stir and filter again.
Collect the filtrate together. (If there is any impurities re-filter).
Transfer the filtrate to the SF and extract by 25ml ether.
Repeat the extraction 3 times.
Gather the 4 filtrates in conical flask.
Dry by using 1 teaspoon anhydrous potassium carbonate.
Filter
Evaporate ether on water bath. (Avoid extra heat because nicotine is hydrolysed by extreme heating).
After evaporation of ether add 4ml methanol to dissolve the resulted oil.
Add 10ml saturated picric acid solution
Cool in an ice bath to precipitate the nicotine di picrate crystals.
Filter; allow drying and weighing the product.

Microscopic observation

Nicotine + mercuric chloride $HgCl_2$ >>>>>> examine under microscope >>>>>> flowery-shape

The reason why we use mercury (II) chloride is that nicotine forms the complex compound with mercury (II).

**OBSERVATION**

Under the microscope, we can observe the shape of the nicotine extract.

We can observe the shape of the nicotine crystal easily. The shape is like flower.

PRECAUTIONS

The technique requires us to be careful because of several toxic materials including the ether, the saturated picric acid and mercury (II) di-chloride.

In this experiment, we need to wear safety gloves, face mask and goggles when working with toxic agent like ether, the saturated picric acid and mercury (II) dichloride.

Be careful with process ether evaporation and stringent precautions picric acid storing. Picric acid is a toxic substance, typically sold moisten with at least 30% water for safety purposes.

We caution when we drop the HgCl_2 into the slide because mercury is the hazardous metal. Under the microscope, we can observe the shape of the nicotine extract.

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<https://www.scientificamerican.com/article>

This book is intended for the under graduate students of chemistry. This book is written in simple language. Unique features of this book are separation of metal salt, balanced equations for chemical transformation, preparation of solutions and laboratory reagents as well as important viva questions with answers. We trust that this book will fulfill the void created for enhancement of practical knowledge for under graduate courses in science.



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For Under Graduate Students



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Science, Technology, and Management

HANDBOOK OF IoT and Big Data

edited by

Vijender Kumar Solanki

Vicente García Díaz

J. Paulo Davim



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14

Internet of Things: Inception and Its Expanding Horizon

Swagat Rameshchandra Barot, Subhanshu Goyal, and Anil Kumar

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14.1 Introduction

“Internet of Things” (IoT) is popularly defined as the grid of tangible devices including automobiles, household instruments, and other things equipped with software, electronics, sensing devices, and Internet connectivity, which empower these items to communicate and transfer information, giving rise to possibilities for more direct amalgamation of the real world into computing devices, leading to betterment in efficiency,

financial gain, and less human effort. It is also defined as a *network of various computing devices connected to internet and implanted in objects of routine usage to empower them to exchange information*. IoT is an abbreviation of Internet of things which is related to an ever-growing network of tangible objects possessing IP address for connectivity through internet, and the exchange of information taking place between these tangible objects and other items and/or systems capable of connecting through internet. In non-technical laymen's terms, any network of physical things with Internet and computing devices that produce, transfer, and occasionally even analyze the information leading to the ease of human life and jobs can be considered as an Internet of Things.

14.2 Historical View of IoT

Even though the buzz of IoT has been started showing up for quite a few years and we have been seeing this concept being taught in universities, the concept of the IoT is not that novel. The first noteworthy public discussion about the concept was heard from Nikola Tesla in 1926, when in an interview he very confidently predicted that in the very short future the concept of "wireless" would be widely and wisely applied, the that the earth would be an imitation of human brain on a giant basis. He justified the metaphor of the human brain by showing the similarity that everything on the earth was element of physical and periodic whole. He went further to predict that the machinery components of the mechanism would be extremely simple. Elaborating the simplicity of the machinery components, he said that it would be no more complex than the telephone of that time. He further foresaw that such mechanisms would be so common and tiny that almost every individual would have them in their trouser pockets. Similar thoughts were expressed by Alan Turing, the father of modern computing, in 1950, through one of his articles entitled "Computing Machinery and Intelligence" [1]. He forecasted that computing machines could be trained to imitate the human brain, provided they are well equipped with the best possible sensory mechanism and could be taught to understand and speak language. He found it very much possible that computing devices could be trained to learn new things like human children. In 1982, the world saw a first example of a smart machine when the research team of the computer science department of Carnegie Mellon University mounted micro-switches in the vending machine to keep a watch on the number of Coke bottles left unsold in the vending machine and the temperature of those bottles. In 1989, a project manager,

Chriet Titulaer, of the Netherlands attracted the attention of the entire world by presenting an example of a smart home, which had given rise to many technological inventions to enable effective interactions between human and home appliances. In fact, the concept of voice recognition was also a striking feature of the home. The beginning of connecting machines to the Internet nonetheless began in 1990, when Simon Hacket and John Romkey developed a toaster connected to the Internet (which they called Sunbeam Deluxe Automatic Radiant Control Toaster), which couldn't do much except get switched on and off automatically. The improved version of the toaster came in the next year, wherein the toaster could automatically take in the bread slice for toasting.

However, according to many references, official research pertaining to something very close to what is nowadays known as Internet of Things (IoT) started in 1999 [2]. A research team of a United Kingdom's technocrat Kelvin Ashton (who was later given the title of *the father of IoT*) comprised of two MIT professors, Sunny (Kai-Yeung) Siu and Indian origin professor Sanjay Sarma, started working in a laboratory of MIT. The team was researching to find ways to connect the Radio Frequency Identification (RFID) to the World Wide Web in the AutoID laboratory. Mainly involved in the research problem of the field of logistics and supply chain management, the team searched for the solution of the problem from technology, which ultimately gave rise to the field of IoT. Actually, Kelvin Ashton, an assistant brand manager in the multinational company Proctor & Gamble, once found that the inventory management handled by human intervention aided technology was not doing well, which led him to the research project conducted by the team [2]. Kelvin Ashton could see that the solution might come from the understanding of a similar problem in the nature; that is, the human sensory system. Working on the same theme, they could conclude that unlike the human sensory system, where the brain sees the world with the data provided by sensory organs, an intelligent system needs to get the capability of sensing in order to imitate the human sensory system. In 1999 speech, Kelvin explained how a majority of the data (worth 1024 terabytes) available on the entire World Wide Web by that time was created and posted on the Internet by humans, which required enumerable human hours [2]. If computers or computing systems were empowered to imitate humans and to know everything about the world on their own, without humans entering the information about it in any way, the wastage of human time could be saved. At the same time, information would be more accurate and cheaper. The nomenclature of the concept was stirred by the name of the book *When Things Start to Think*, written by Dr. Gershenfeld, a professor at the Massachusetts Institute of Technology. In his first presentation about the concept, Kelvin entitled his presentation as "Internet of Things (IoT)," which later on became the name of the concept [2].

14.3 Nontechnical Definition of Internet of Things (IoT)

In simple terms, when a number of daily life things are connected among one another via the Internet so that it can generate, transfer, and analyze data and use it for easing human life, they can be called smart machines or the Internet of Things. To be more technical, there are three main components of any IoT infrastructure: sensors and actuators, linkage, and people and process. We may find a number of examples of IoT around us:

- Mobile applications related to health and fitness are an embodiment of the Internet of Things. The applications use the Internet and GPS, monitor your activities using them, calculate the numbers of steps traveled, total running/walking time during the day, total calories burned during the day, and so on. It keeps track of all these data and accordingly gives dietary suggestions too.
- Smart air conditioners are also one type of IoT device. Based on the temperature outside the room, the season and many other factors, it modifies and maintains the temperature of the room. In fact, it also directs the swing fan in the direction of the individual present in the room.
- Smart lighting is a system that regulates the color and intensity of the light and can be controlled through mobile phones.
- A smart transportation system is a network of vehicles in which vehicles are GPS-enabled and interconnected so that locations of vehicles can be known by the other vehicles too.
- Smart lock is an intelligent locking system, which is a lock with sensors and doesn't require a key to open and lock it. In fact, the system has multiple features, for example, keeping track of entries and exits, allowing listed people to have free/restricted access, remote operation of the system through mobile phones, and more. The system can also provide reminders to the owners about several outdoor tasks.
- As mentioned earlier, the concept of the smart home turned into a reality long ago. However, due to continuous improvement and amendment in the mechanism, the recent smart homes include multiple features ranging from auto-cleaning to auto-cooking mechanisms. Self-regulatory safety mechanisms (similar to smart locks) and anti-fire systems are also features of smart homes of the current era.

14.3.1 Beneficiaries of Internet of Things

There are number of sectors that get benefited by IoT. In fact, one can say that there is no sector associated with human life that has remained untouched by IoT.

- **Health sector:** For regular monitoring of health, remote diagnosis and surgery, and dietary monitoring, IoT can play a vital role. In case of psychological and disabled patients, IoT can provide regular monitoring of health parameters, namely, blood sugar, blood pressure, and other health-related indices.
- **Transportation system:** IoT can play a crucial role in complete automation of automobiles, which can cut down the chances of accidents due to human error. Going one step beyond, IoT can change the entire transportation mechanism. Integration of GPS to automobiles can provide directions to vehicles about which is the shortest and most traffic-efficient route, seeing the real-time traffic situation. It may also be improved to maintain traffic situations and provide traffic instructions to each vehicle directly, which would eradicate the requirement of traffic police and traffic signals at all.
- **Manufacturing and production:** Several manufacturing and production operations like process control, regulation of safety parameters, and overall monitoring of the production unit could be automated by IoT infrastructure.
- **Agriculture and irrigation:** Through effective usage of the IoT, each plant can be provided individual care and treatment based on its requirement, depending on different parameters related to it; namely, amount of fertilizer and water required and the time of providing it, weeding, immediate pest control, and more. Accurate data related to plant can be furnished and processed through sensors connected to plants.
- **Optimization of energy consumption:** The majority of energy wastage can be regulated using the IoT, as it can sense the wastage at the initial stage and can take corrective actions automatically. As each component of the system sends data to the IoT, energy wastage at any juncture could be identified and regulated by the IoT.

14.4 Major Gains Due to IoT

- **Easy interchange of information among machines:** Due to the IoT, a variety of machines/devices can communicate with each other and can work more cohesively. For example, in case of accidents, a road CCTV camera and associated computer vision unit can immediately send a message to the ambulance and nearby medical team to be ready for appropriate actions. The visuals and current status of the patient could be constantly communicated to the team of doctors during the shifting of the patient to the hospital, so that they

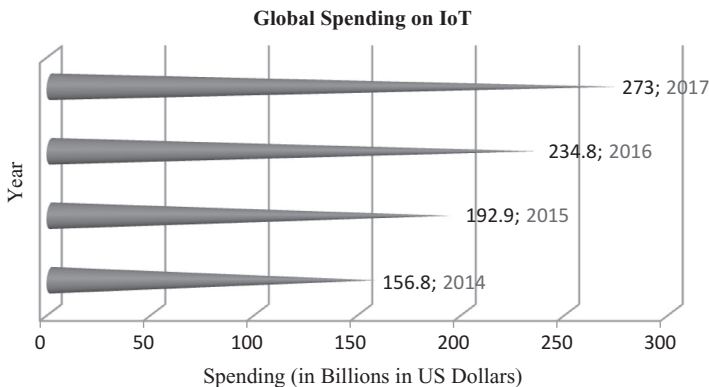
can immediately give appropriate treatment as soon as the patient arrives at the hospital. Automated wheelchairs and automatic inventory management of different medicines and oxygen cylinders resulting from intercommunications among devices can completely change the way hospitals and doctors work.

The devices can also be controlled from remote places: the IoT can enable devices to be effectively controlled from remote places. For example, an engineer can remotely give directions to the production unit in case of need. Even a smart locking system of the home can be regulated from the remote location by its owner.

- **Reduction in cost:** Due to automation, the IoT will reduce the chance of human error and will reduce the chance of loss of many kinds, be it human life or money. In production units, timely action in case of failure of the unit will quickly resolve the problem and can resume the production in no time, which may save the factory from potential financial loss. Due to smart transportation systems, automobiles will take short and traffic-free routes, which will save the fuel and hence the cost.

14.5 Rapid Growth of Internet of Things

The data shows that the notion of the Internet of Things is being adopted and applied to various fields worldwide. Graph 14.1 shows the rapid growth of it at global level by means of amount of dollars spent on it.



GRAPH 14.1

Global spending on the Internet of Things.

According to General Electric (GE), in the world's overall GDP, approximately 10^{13} to 1.5×10^{13} US dollars will be contributed by the ventures related to IoT by 2030. According to [3], global spending on the IoT is growing at the rate of 16.7% per year and has crossed 6×10^{13} in the year 2017. The growth is expected to boom in further years as private and public establishments and governments are spending in the IT sector, services, and connectivity enabling IoT.

According to the same survey, about 1.4×10^{12} US dollars are expected to get spent globally by 2021. Among these, with the spending of 4.55×10^{11} US dollars, the Asian Pacific region is likely to top the tally, leaving the US behind with the likely spending of 4.21×10^{11} US dollars. Western Europe is likely to spend 2.74×10^{11} US dollars.

In 2016, in the top IoT firms, spending on manufacturing and operations was 1.05×10^{11} US dollars out of the total spending of 1.75×10^{11} US dollars. Shockingly, the spending on manufacturing and operations was higher than that of production, asset management and field service.

14.6 Possible Future Applications and Directions

As discussed previously, each and every facet of human life has the potential of getting changed by the IoT, and our communication capability will not remain limited to only mobile devices. Rather, it will spread to each and every thing we deal with. The Internet of Things can affect each facet of human life by its applications. A number of applications are mentioned in the literature [4]. A few of these applications are as follows:

1. **Forecasting of natural calamities:** The blending of sensors and their independent coordination and simulation will help to give warnings against any natural calamities and to take proactive moves in advance.
2. **Applications to industry:** There are a number of industrial applications of the IoT; for example, management of all automobiles in the parking lots of an organization. The IoT is useful in evaluation of environmental performance of the industry and is also useful for data processing to identify those which need maintenance.
3. **Monitoring on water shortage:** The IoT may be useful in identifying water shortages at various places. A collection of sensors embedded in the network, along with the specific simulation activities, might not only keep an eye on long-term water interventions but also keep a close watch on accidental mixing of sewage water with the regular water stream/storage, which might otherwise lead to harmful results on the health of humans.

4. **Smart homes:** The concept of smart homes can be actualized by means of the IoT. The defining features of smart homes include optimization of energy consumption, intercommunication of home amenities, home safety features and automatic actions in case of emergencies [5,6].
5. **Medical applications:** The Internet of Things can play a vital role in the field of medicine, for example, determining various health-related measurements like BP, sugar levels, thyroid condition, monitoring bodily activities, support for independent living, regular alerts and help in medication consumption.
6. **Agriculture application:** Through a network of sensors installed in farms, data can be produced, processed, and analyzed and can yield inferences related to farming, which can be sent to the farmers; for example, the farmer can be alerted by the IoT infrastructure in case of the need for fertilizer in a particular region of a farm. Alerts for providing water to the crop can be provided to the farmer through moisture sensors installed in the drip irrigation system. IoT infrastructure can provide alerts for pest control too.
7. **Design of smart transportation:** The IoT can contribute to the design of effective and smart transportation systems [4]. By harnessing the power of the Internet, GPS, and sensors network, the smart transport system can give solutions to many existing problems of transportation, which includes traffic jams, road safety, traffic violations, pollution, and time accuracy and time management of public transport. The smart transportation system may guide vehicles to choose the least traffic-bearing routes to reach destinations in less time and in this way can help the spot with the traffic jam by getting rid of additional vehicles. In fact, the IoT-enabled transportation system can immediately inform the concerned authorities about the traffic jam so that corrective actions can be taken in minimum time. The system may solve the problem of traffic jams at the toll plaza by the integration of electronic toll payment systems in the vehicles. The system could closely monitor violation of traffic rules by CCTV cameras and could issue electronic traffic tickets too. By immediately informing an ambulance in case of an accident, the system can save precious human lives too [7].
8. **Embodiment of the concept of smart city:** The concept of a smart city can be actually implemented by taking the help of IoT infrastructure. Such smart cities will include smart transportation system, automatic streetlight regulation systems to save energy, energy-saving systems, smart communication systems, smart waste management systems, e-payment systems for various tasks, and so on [3,8]. The striking features of the smart cities are easing human lives by effective usage of technology that could be architected by the IoT.
9. **Smart billing system for utilities:** By the use of the IoT, utility distribution and billing can work intelligently. Such a smart system can

easily catch any power theft in the electricity distribution system by measuring the electric flow at various levels through sensors. The billing can also be automated, so that the accurate meter reading can take place and the bill can be issued through e-mails and SMSs at each month's end. Users can be provided online payment facilities, which can put a heavy cut on the cost borne by such organizations on physical bill payment centers. Such system can also bring reduction in wastage of water, electricity and gas during the distribution by preventing and effectively dealing with leakage in the distribution system.

10. **Security management system:** The IoT has a huge scope of contributing to the field of home security systems and surveillance of various public and private organizations. The IoT can provide features like identity verification system, regulated entry-exit system, alarm in case of unauthorized entry, and so on, which can strengthen the security of the organization.

In addition to the above-mentioned applications, the IoT has gained the attention of academia, industries, and governments at large. The world's top universities, a majority of which are funded by industries and governments, are involved in the research related to IoT. Many international organizations are engaged in specific IoT development. Many corporate giants are helping governments and societies at large by providing IoT infrastructures to effectively address water and air pollution problems. To name one, the Eye-on-Earth platform by Microsoft is focusing on water and air quality problems of many European countries. This program significantly helps ongoing worldwide research in the field of environment studies by providing accurate data of the field.

The IoT has attracted attention of the European Commission, yielding the project of CERP-IoT (Cluster of European Research Projects on the IoT). This project is one of the world's most active projects in the field of the Internet of Things. It focuses on applications of the Internet of Things in the field of industry and environment, and of society at large. One of the noteworthy projects of the field of IoT is IoT-A (The Internet of Things Architecture), funded by European EP7. Apart from IoT-A, the European EP7 also runs projects like IoT@Work and IoTi (Internet of Things Initiative), which both focus on development of new IoT infrastructure benefiting several areas of human lives. With the aim of letting the earth speak for itself, the Hewlett-Packard enterprise runs CeNSE (Central Nervous System for the Earth). The project aims to design an effective IoT system using billions of sensing devices and distributing them throughout the earth to achieve their goal. The secondary aim of the project is to develop smaller, cheaper, and more robust sensing devices which can detect minor vibrations and motions on the earth. This ambitious project aims to cover almost the whole earth with IoT infrastructure.

14.7 Significant Challenges

In contrast to many benefits of the Internet of Things, the concept has a few severe challenges to overcome. With the growing actualization of the IoT, the concerns related to such challenges have also gained the attentions of research communities and governments [4]. Following are a few of these challenges:

1. **Efficient identity management of IoT devices:** Due to the wide spread of the IoT in almost all facets of human life, there is fast growth in devices connected through the Internet. Current the IP address system cannot manage billions of devices effectively, and hence development of a new naming convention and system identity management system is badly needed. Such a system should be able to allocate exclusive identities to the rapidly growing number of Internet-connected devices.
2. **Standardization and interoperability:** Currently, different manufacturers use exclusive technologies and services in their devices that may not be accessible by devices of other manufacturers. For effective and global infrastructure of the IoT, interoperability among all objects and sensors is inevitable, which can be brought on only by standardization of IoT.
3. **Security and safety of objects:** As the IoT connects a large network of objects that might be spread over a large geographical area and enables them to exchange data, there is a very big threat to the IoT infrastructure to get targeted by impostors who may intend to get hold of that supposedly personal/confidential information or may corrupt the data being communicated or may cause damage to the objects physically. Thus, security and safety of the objects is of paramount importance.
4. **Privacy, encryption, and secure network capable of being programmed:** The majority of the IoT uses simple Radio Frequency Identification (RFID) and two-dimensional barcodes for identifying the objects involved in the IoT infrastructure. As these technologies are very common and hence vulnerable in terms of data privacy, measures have to be taken in order to ensure privacy and secured programming-enabled networks. Due to the interdependency of the data producing/collecting section and the data processing section of the IoT infrastructure, it is essential that sensors are equipped with adequate encryption systems to ensure the integrity of the data at the data processing section of IoT infrastructure.
5. **Optimization of energy usage by IoT:** As a large number of devices may share and process data at their end using electricity and the Internet, a large amount of energy will be used by the IoT infrastructure.

With the growing spread of the IoT concept, it will be inevitable to develop a cutting-edge technology to minimize the usage of the energy by the IoT. The option of green technology also needs to be well explored to yield energy-efficient IoT devices.

6. **Dedicated spectrums:** As the IoT infrastructure may connect billions of devices to communicate a wide range of data, a dedicated spectrum for safe and secured data transfer is essential. By growth of the IoT infrastructure at global and local level, this requirement will need primary attention.

14.8 Future of Internet of Things Network

In this section, the future of the Internet of Things network along with its details is presented. A vision of the future IoT network is described in [Figure 14.1](#). The details regarding each component will be elaborated in this section.

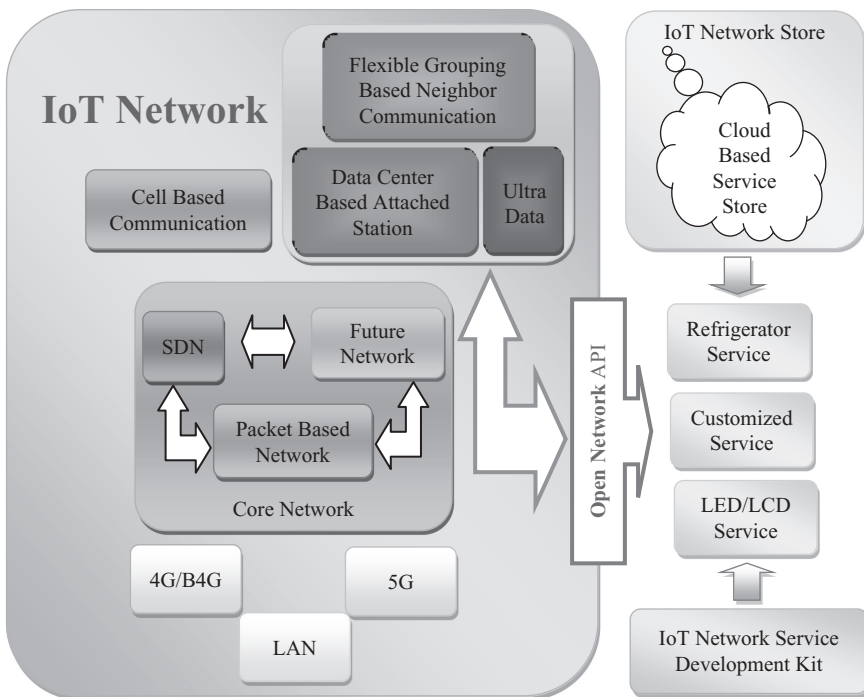


FIGURE 14.1
Outline of upcoming IoT network.

14.8.1 Software-Defined Network (SDN)

A software-defined network (SDN) empowers the users for programming the switch. SDN mainly empowers programming of network service devices. OpenFlow is a popular software-defined network. It enables users to design a switch through coding that can alter the protocol and can also check new protocols. For coding the switch to alter the protocol and for testing a new protocol, one may use this programmable network (PN).

14.8.2 IoT Device Management

For the devices connected to IoT infrastructure, ideally there should be support from the IoT network by a mechanism of plug-and-play for the IoT devices. Currently, devices are manually being connected to the network by their users. However, for effective IoT infrastructure, it is desirable that devices get automatically configured without user intervention. For this, a plug-and-play mechanism is essential for the IoT network.

Another important issue is efficient allocation of IP addresses, through which devices can connect to the IoT infrastructure and effectively communicate data. It seems that the present IP address assignment scheme doesn't work if the IoT involves a large number of devices. Looking to the growth of the concept at a global level and in every facet of human life, it is very much possible that almost all devices of daily use may get connected to one or the other IoT infrastructure. This could be a challenging task with reference to allocation of IP addresses to all these devices. For efficient handling of IoT-connected devices, an effective and mountable addressing scheme for connecting devices to the Internet is needed. An IPv6 address allocation scheme is one of the solutions to the problem. There are two scopes for unicast address, namely links local and global. The first one, local link, is used for auto-discovery and auto-configuration. It doesn't assure a unique address in the larger networks. Routers will not be able to forward it to other links too. For larger networks, global scope address is the solution. It ensures address uniqueness in the large networks.

14.8.3 Connection Management

Communication protocol possessed by different devices may not be the same. Hence, the connection management object may support different standards to nodes that belong to users. Different standards are managed by Access Point (AP) or IoT home gateway. However, there may be an issue when the node is not in the range of communication.

In case of mobile phones, which have a wide range of communication, they cannot be installed in small sensors, as that leads to a higher price and excessive battery usage. Grouping is the concept that can be helpful in the management of connectivity of the devices. Such devices are of two types: physical and logical.

[Figure 14.2](#) explains both types of groupings in the IoT infrastructure. Physical grouping connects devices that are physically close to each

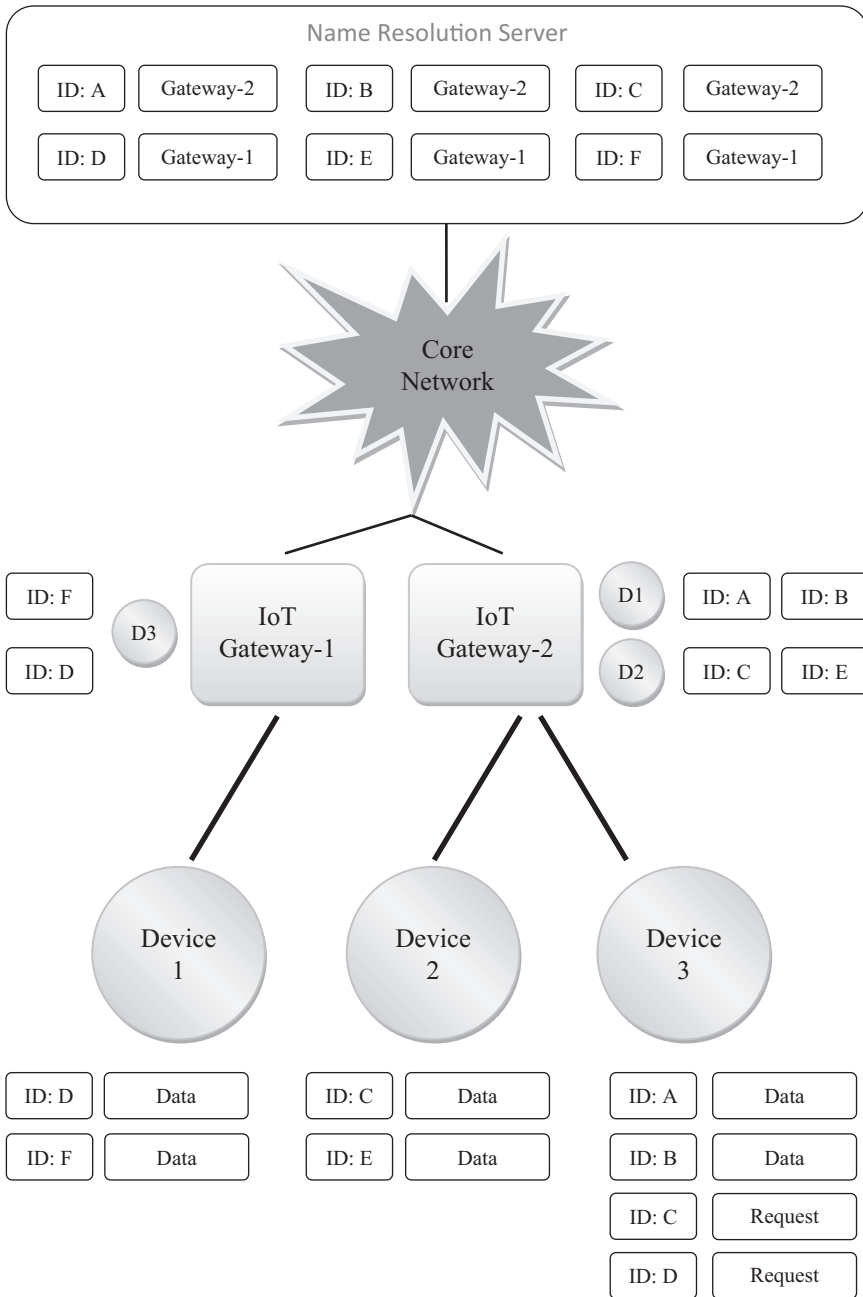


FIGURE 14.2
The concept of physical grouping and logical grouping.

other. Connection among equal IoT service devices is required to support service-oriented networks without generating direct connections with each other.

14.9 IoT Gateway

The IoT gateway is the core component in the future IoT network. [Figure 14.3](#) presents the overview of the IoT gateway.

The following subsection describes the key features to compose the IoT gateway.

14.9.1 Network-to-Network (N2N) Communication Support

In the composition of IoT gateways, the important part is the management of information provided by concerned nodes' analysis of contents and network properties available in the cluster of objects that utilize content specific network (CSN) or distributed information network (DSN). Moreover, these kinds of information need to be accessed by information management servers or peer network objects to facilitate information-based multi-connection or information-based routing strategy. A network object communicates with

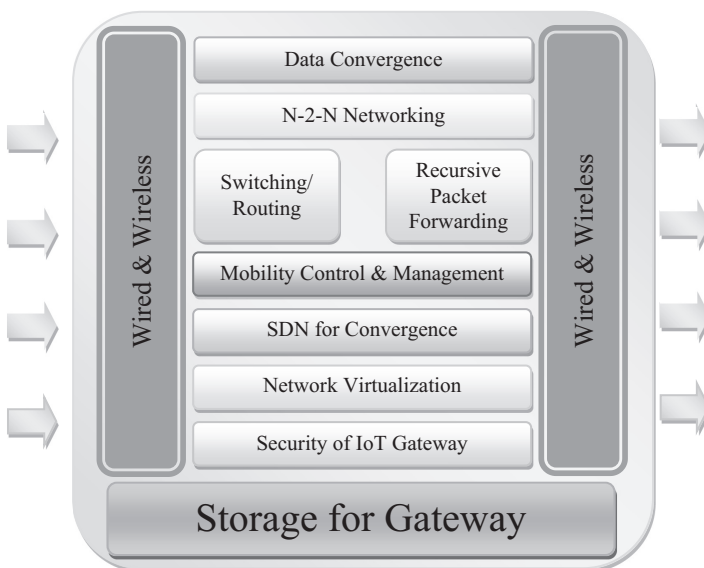


FIGURE 14.3

A glance at an IoT gateway.

other network objects through the core network for sharing information of the network. But the flip side is that sharing of information through newly designed connections of network objects may lead to problems of overhead, which might result in performance degradation in the core network. In this scenario, a technique is required to transmit the data without reconfiguring the new resulting networks among the network to solve this problem. Resultantly, protocol is required for network-to-network communication in an IoT gateway, which can act as an object for network management.

14.9.2 Routing Techniques

Routing algorithms play an important role not only in the routing for sub-networks of IoT infrastructure but also the routing of the related core network. A sensor kind of network that acts as a multi-hop network can be assigned the task of routing for the internal network that is the group of nodes or objects in the same subnet. This technique appears to be sufficient for primary IoT nodes comprised of sensors. However, there is still a problem of implementation in the IoT environment. First, there is an assumption in IoT architecture that there are chances of high mobility of sensors or nodes. Based on this assumption, the device pertaining to the user may be connected to the nearest object of the sub-network when the user is in a mobile state. Specifically, certain devices like sensors have a greater chance than other devices to connect to the nearest sub-network because of limited battery resources. Based on the limitation, a network group may break when a device tries to connect to a nearby network object, and then managing the network becomes chaotic. Thus, a routing algorithm is required for all the devices or objects to present them from connecting to different physical groups.

A possible remedy to tackle this challenge can be an algorithm that considers identification (ID) of things instead of an IP-based routing algorithm from the core network. A scenario depicting ID-based algorithm is shown in [Figure 14.4](#).

Assume that a device labeled as 1 requires contents whose identifiers are C and D. Device 1 posts a request to the IoT gateway No. 2 that the contents of C and D are needed. After this, Gateway No. 2 recognizes that device 2 maintains content labeled as D. There are three methods by which Gateway No. 2 can obtain the content of D.

The first solution is that network-to-network communication with IoT gateway No. 1 is performed by Gateway No. 2. So, it posts a request to Gateway No 1 for the content D. However, this solution will not work when two gateways are situated at too-far locations. Another solution is to request the name resolution server that maintains numerous identifications and locations of content. In this case, Gateway No 2 can fetch the information that Gateway No 1 has: the information about the location of content D. This method is easy to implement but overhead related to Gateway No 2 posts

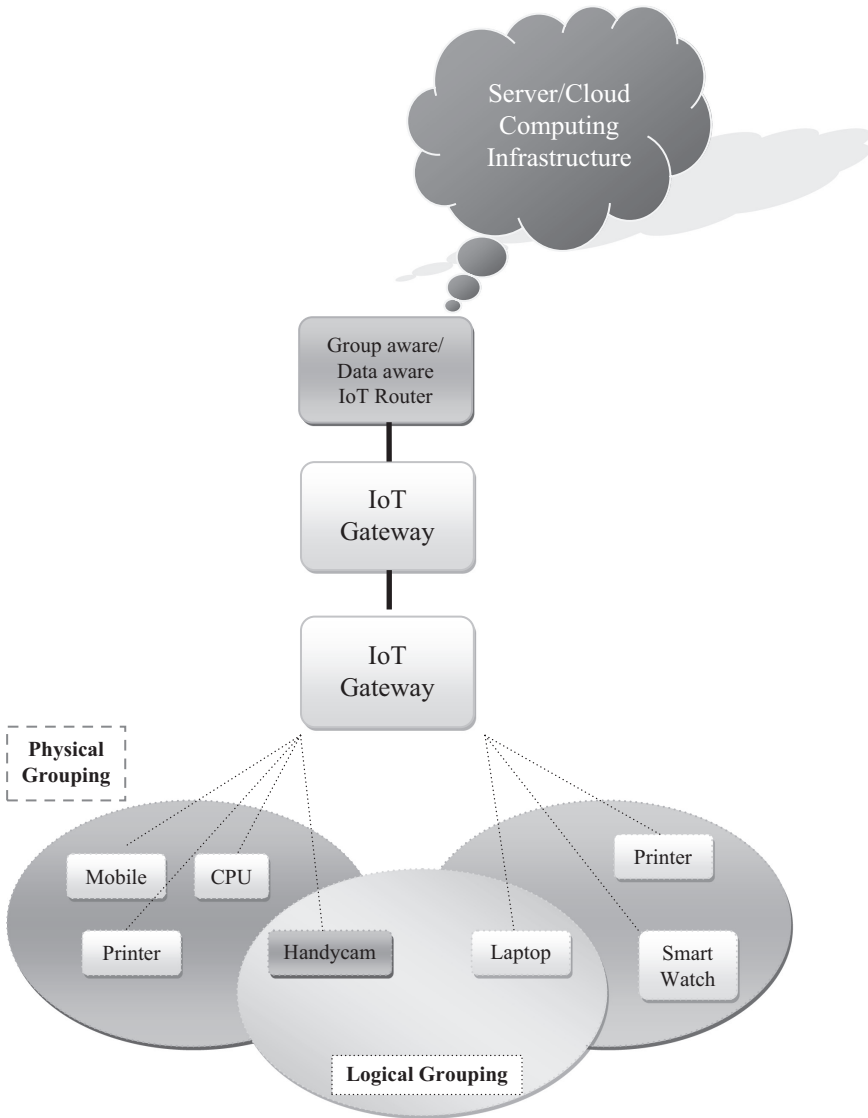


FIGURE 14.4
A scenario depicting an ID-based algorithm.

the request message to neighboring networks. On receiving the request message by Gateway No. 1, it replies along with content to Gateway No. 2 by applying backward technique. This illustration is simple for directly embedding in the core network, so a lot of new studies are requesting implementation of content-based routing techniques.

14.9.3 Mobility Support

Mobility is an important area of concern in contemporary networking and communication techniques. The various devices of communication have the property of mobility, and different studies have guided mobility support in IP networks and cellular networks. In the case of cellular networks, the issue of mobility is solved by a mobility management server that maintains the location of the network. However, this is feasible only with a large number of servers and infrastructure. Moreover, devices of cellular networks consume battery resources for connectivity.

In IP networking, mobility support is proposed by solutions like Mobile IP. But implementation of these solutions is challenging due to message authentication issues, delays in connection and the complex management of IP. Thus, mobility support in an IP network is required by the client when connection is lost. Even though it is an easy step, enormous switchover and connectivity are compromised. Moreover, performance and the quality of service (QoS) of the network seems to be degraded. Therefore, a new concept of mobility support is needed. Also, unlike cellular networks, IP networking can support mobility by network management objects in terms of robustness rather than creating new infrastructure and a large number of servers.

14.9.4 Packet Flow

In the IoT environment, lots of packets for communication are generated, since targetless connections are required to address the problem of delay. It is time-consuming to identify appropriate nodes for content and posting a connection request message; for example, to control the temperature of the room, each sensor must be able to read the temperature within the room. This information is to be sensed by the sensors, and messages are forwarded to the controlling server in the existing network. The controlling server analyses the received data and makes the connection established to send the temperature control order. So it takes numerous steps just to control the temperature of the room.

In the IoT environment, it is important to handle the issues of delay for a targetless connection. Moreover, multicasting or packet-forwarding techniques are suitable for this type of connection because these techniques facilitate sending of multiple packets to multiple parallel networks. But many packets for communication are generated, and techniques to improve network throughput are needed.

14.9.5 Software Defined Network

At the end level of the network in an IoT environment, there is a requirement of software-defined network, as every device requires a different network rate to fulfill the QoS, and guest devices demanding connection to the

IoT gateway need to be organized. The data generated by the server and actuators of the current network and data from different networks may be used by content. In this scenario, an IoT gateway must have the ability for convergence of data for speedy collection of data and remove the obsolete data or content. The processing of huge amounts of data and tailored data, as per user need, is the key for successful implementation of an IoT gateway. Therefore, data collection from different sources, converging it with the sensor network's information and converting it into transmittable data are important features of an IoT network.

14.9.6 Security Features in IoT Network

An IoT gateway provides an interface between a IoT network and an IoT device. All data pertaining to IoT devices is preserved by IoT gateways, and any kind of query can be solved by an IoT gateway as data of IoT devices is already with the IoT gateway. In this situation, confidentiality of data is not an issue for IoT devices. However, confidentiality of data is to be maintained during IoT gateway and IoT device communication. An IoT gateway has an algorithm; to ensure privacy, a novel security algorithm for privacy would go a long way toward implementing security in an IoT gateway [9].

Further wireless modes of communication between IoT gateways and IoT devices poses a problem of eavesdropping. Also, an IoT device is based on limited power—a battery—so implementation of a security algorithm may not be a viable idea. Rather, a lightweight security algorithm is required to secure the IoT data.

Registration of IoT nodes and their authenticity also needs to be address in the process of securing an IoT gateway. Depending on the type of node, like master node, member node or guest node, various kinds of registration types are required for communication with the gateway.

14.10 Conclusion

This chapter introduced the concept of the “Internet of Things,” which is a futuristic approach to connect all things in a single network. The sensor device provides intelligence to the IoT network for communication and transmission of data, and it supports intelligent decisions. The various types of communication, like between humans, between humans and devices, and between device and device, are automated through the IoT network. This chapter illustrates architecture for future IoT networks and techniques for this architecture to facilitate management of the IoT network and its various nodes as well as grouping and privacy.

This chapter also focused on different feasible future applications and various country-specific projects related to the IoT and challenges in implementing IoT techniques. The deployment of the IoT could be tough and demands active research efforts, but it can lead to significant impact in terms of professional and financial benefit in the coming years.

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My book is related to the Concept of Graph Theory. The last century has witnessed an upsurge growth in theory of graphs and its related concepts. The unprecedented rise of computer science and its applications is one of the reasons for recognition of graph theory as a subject of larger interest. It is believed that the well celebrated Königsberg bridge problem has been the origin of graph theory and the representation of the problem by means of vertices and edges initiated by Swiss Mathematician Leonhard Euler(1707-1783) was the first graph drawn ever in the history of graph theory. The Present book is aimed for Coloring and Domination Problems in Graph Theory with its applications in Real life problems and Computer sciences.



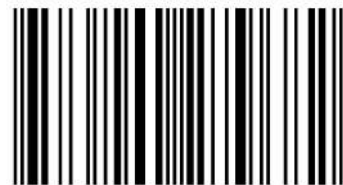
Minal Shukla



Dr. Minal Shukla is working as an Assistant Professor at Marwadi University. She has completed her Ph.D. from Saurashtra University, Rajkot in 2017. She has 4 years of research experience and 8 years of teaching experience.

Coloring and Domination Problems in Graphs - Some New Perspectives

Application to Computer Science



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Shukla



A science of vector is forgotten but it is the most important part to understand any reaction. Nowadays the computer does everything, but to understand the logic of the computer you need to check the direction. The science of direction is the vector. The vector analysis is a great tool for any analysis, whether its chemical, physical or biological. So the best thing to cover up the full understanding here is some glimpse in the book.



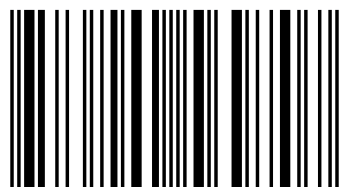
Hitaishi Bhatt
Minal Shukla



Dr. Minal Shukla and Dr. Hitaishi Bhatt are well-known faculties of Marwadi University. Both have experience of more than 7 years. They have written very extensive research articles as well as books.

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A Forgotten Part Of Science



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Introduction of Vector Analysis

A forgotten part of Science

By Dr. Minal Shukla & Dr. Hitaishi Bhatt

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Chapter 1

Vector Analysis

1.1 Elementary Approach

In science and engineering we frequently encounter quantities that have only magnitude: mass, time, and temperature. This magnitude remains the same no matter how we orient the coordinate axes that we may use. These quantities we label scalar quantities. In contrast, many interesting physical quantities have magnitude or length and, in addition, an associated direction. Quantities with magnitude and direction are called vectors. Their length and the angle between any vectors remain unaffected by the orientation of coordinates we choose. To distinguish vectors from scalars, we identify vector quantities with boldface type (i.e., \mathbf{V}). Vectors are useful in solving systems of linear equations (Chapter 3). They are not only helpful in Euclidean geometry but also indispensable in classical mechanics and engineering because force, velocity, acceleration, and angular momentum are vectors. Electrodynamics is unthinkable without vector fields such as electric and magnetic fields.

Practical problems of mechanics and geometry, such as searching for the shortest distance between straight lines or parameterizing the orbit of a particle, will lead us to the differentiation of vectors and to vector analysis. Vector analysis is a powerful tool to formulate equations of motions of particles and then solve them in mechanics and engineering, or field equations of electrodynamics.

In this section, we learn to add and subtract vectors geometrically and algebraically in terms of their rectangular components.

A vector may be geometrically represented by an arrow with length proportional to the magnitude. The direction of the arrow indicates the direction of the vector, the positive sense of direction being indicated by the point. In

Figure 1.1
Triangle Law of
Vector Addition

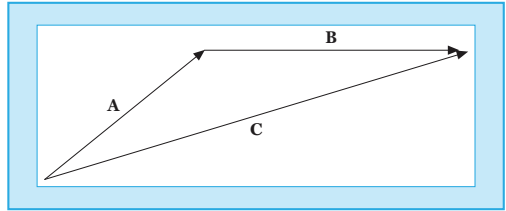
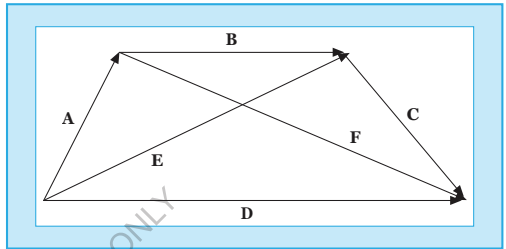


Figure 1.2
Vector Addition Is
Associative



this representation, vector addition

$$\mathbf{C} = \mathbf{A} + \mathbf{B} \quad (1.1)$$

consists of placing the rear end of vector \mathbf{B} at the point of vector \mathbf{A} (head to tail rule). Vector \mathbf{C} is then represented by an arrow drawn from the rear of \mathbf{A} to the point of \mathbf{B} . This procedure, the triangle law of addition, assigns meaning to Eq. (1.1) and is illustrated in Fig. 1.1. By completing the parallelogram (sketch it), we see that

$$\mathbf{C} = \mathbf{A} + \mathbf{B} = \mathbf{B} + \mathbf{A}. \quad (1.2)$$

In words, **vector addition is commutative**.

For the sum of three vectors

$$\mathbf{D} = \mathbf{A} + \mathbf{B} + \mathbf{C},$$

illustrated in Fig. 1.2, we first add \mathbf{A} and \mathbf{B} :

$$\mathbf{A} + \mathbf{B} = \mathbf{E}.$$

Then this sum is added to \mathbf{C} :

$$\mathbf{D} = \mathbf{E} + \mathbf{C}.$$

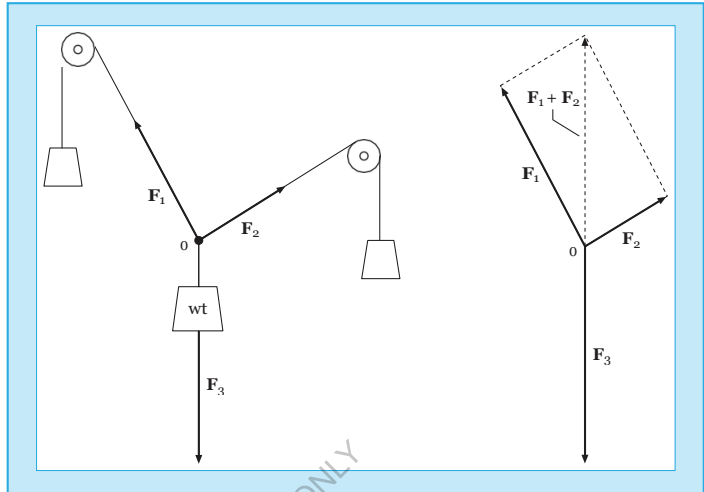
Alternatively, we may first add \mathbf{B} and \mathbf{C} :

$$\mathbf{B} + \mathbf{C} = \mathbf{F}.$$

Figure 1.3

Equilibrium of Forces:

$$\mathbf{F}_1 + \mathbf{F}_2 = -\mathbf{F}_3$$



Then

$$\mathbf{D} = \mathbf{A} + \mathbf{F}.$$

In terms of the original expression,

$$(\mathbf{A} + \mathbf{B}) + \mathbf{C} = \mathbf{A} + (\mathbf{B} + \mathbf{C})$$

so that these alternative ways of summing three vectors lead to the same vector, or **vector addition is associative**.

A direct physical example of the parallelogram addition law is provided by a weight suspended by two cords in Fig. 1.3. If the junction point is in equilibrium, the vector sum of the two forces \mathbf{F}_1 and \mathbf{F}_2 must cancel the downward force of gravity, \mathbf{F}_3 . Here, the parallelogram addition law is subject to immediate experimental verification.¹ Such a balance of forces is of immense importance for the stability of buildings, bridges, airplanes in flight, etc.

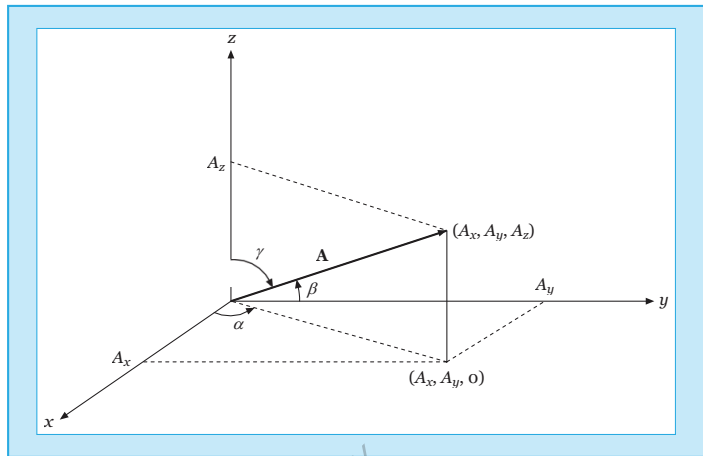
Subtraction is handled by defining the negative of a vector as a vector of the same magnitude but with reversed direction. Then

$$\mathbf{A} - \mathbf{B} = \mathbf{A} + (-\mathbf{B}).$$

The graphical representation of vector \mathbf{A} by an arrow suggests using coordinates as a second possibility. Arrow \mathbf{A} (Fig. 1.4), starting from the

¹Strictly speaking, the parallelogram addition was introduced as a definition. Experiments show that forces are vector quantities that are combined by parallelogram addition, as required by the equilibrium condition of zero resultant force.

Figure 1.4
Components and
Direction Cosines of A



origin,² terminates at the point (A_x, A_y, A_z) . Thus, if we agree that the vector is to start at the origin, the positive end may be specified by giving the **rectangular** or **Cartesian** coordinates (A_x, A_y, A_z) of the arrow head.

Although \mathbf{A} could have represented any vector quantity (momentum, electric field, etc.), one particularly important vector quantity, the distance from the origin to the point (x, y, z) , is denoted by the special symbol \mathbf{r} . We then have a choice of referring to the displacement as either the vector \mathbf{r} or the collection (x, y, z) , the coordinates of its end point:

$$\mathbf{r} \leftrightarrow (x, y, z). \quad (1.3)$$

Defining the magnitude r of vector \mathbf{r} as its geometrical length, we find that Fig. 1.4 shows that the end point coordinates and the magnitude are related by

$$x = r \cos \alpha, \quad y = r \cos \beta, \quad z = r \cos \gamma. \quad (1.4)$$

$\cos \alpha$, $\cos \beta$, and $\cos \gamma$ are called the **direction cosines**, where α is the angle between the given vector and the positive x -axis, and so on. The (Cartesian) components A_x , A_y , and A_z can also be viewed as the **projections** of \mathbf{A} on the respective axes.

Thus, any vector \mathbf{A} may be resolved into its components (or projected onto the coordinate axes) to yield $A_x = A \cos \alpha$, etc., as in Eq. (1.4). We refer to the vector as a single quantity \mathbf{A} or to its components (A_x, A_y, A_z) . Note that the subscript x in A_x denotes the x component and not a dependence on the variable x . The choice between using \mathbf{A} or its components (A_x, A_y, A_z) is

²We could start from any point; we choose the origin for simplicity. This freedom of shifting the origin of the coordinate system without affecting the geometry is called **translation invariance**.

essentially a choice between a **geometric or an algebraic representation**. The geometric “arrow in space” often aids in visualization. The algebraic set of components is usually more suitable for precise numerical or algebraic calculations. (This is illustrated in Examples 1.1.1–1.1.3 and also applies to Exercises 1.1.1, 1.1.3, 1.1.5, and 1.1.6.)

Vectors enter physics in two distinct forms:

- Vector \mathbf{A} may represent a single force acting at a single point. The force of gravity acting at the center of gravity illustrates this form.
- Vector \mathbf{A} may be defined over some extended region; that is, \mathbf{A} and its components may be functions of position: $A_x = A_x(x, y, z)$, and so on.

Imagine a vector \mathbf{A} attached to each point (x, y, z) , whose length and direction change with position. Examples include the velocity of air around the wing of a plane in flight varying from point to point and electric and magnetic fields (made visible by iron filings). Thus, vectors defined at each point of a region are usually characterized as a **vector field**. The concept of the vector defined over a region and being a function of position will be extremely important in Section 1.2 and in later sections in which we differentiate and integrate vectors.

A **unit vector** has length 1 and may point in any direction. Coordinate unit vectors are implicit in the projection of \mathbf{A} onto the coordinate axes to define its Cartesian components. Now, we define $\hat{\mathbf{x}}$ explicitly as a vector of unit magnitude pointing in the positive x -direction, $\hat{\mathbf{y}}$ as a vector of unit magnitude in the positive y -direction, and $\hat{\mathbf{z}}$ as a vector of unit magnitude in the positive z -direction. Then $\hat{\mathbf{x}}A_x$ is a vector with magnitude equal to A_x and in the positive x -direction; that is, the projection of \mathbf{A} onto the x -direction, etc. By vector addition

$$\mathbf{A} = \hat{\mathbf{x}}A_x + \hat{\mathbf{y}}A_y + \hat{\mathbf{z}}A_z, \quad (1.5)$$

which states that a vector equals the vector sum of its components or projections. Note that if \mathbf{A} vanishes, all of its components must vanish individually; that is, if

$$\mathbf{A} = \mathbf{0}, \quad \text{then } A_x = A_y = A_z = 0.$$

Finally, by the Pythagorean theorem, the length of vector \mathbf{A} is

$$A = \sqrt{A_x^2 + A_y^2 + A_z^2}. \quad (1.6)$$

This resolution of a vector into its components can be carried out in a variety of coordinate systems, as demonstrated in Chapter 2. Here, we restrict ourselves to Cartesian coordinates, where the unit vectors have the coordinates $\hat{\mathbf{x}} = (1, 0, 0)$, $\hat{\mathbf{y}} = (0, 1, 0)$, and $\hat{\mathbf{z}} = (0, 0, 1)$.

Equation (1.5) means that the three unit vectors $\hat{\mathbf{x}}$, $\hat{\mathbf{y}}$, and $\hat{\mathbf{z}}$ span the real three-dimensional space: Any constant vector may be written as a linear combination of $\hat{\mathbf{x}}$, $\hat{\mathbf{y}}$, and $\hat{\mathbf{z}}$. Since $\hat{\mathbf{x}}$, $\hat{\mathbf{y}}$, and $\hat{\mathbf{z}}$ are linearly independent (no one is a linear combination of the other two), they form a **basis** for the real three-dimensional space.

Complementary to the geometrical technique, algebraic addition and subtraction of vectors may now be carried out in terms of their components. For

$$\mathbf{A} = \hat{x}A_x + \hat{y}A_y + \hat{z}A_z \text{ and } \mathbf{B} = \hat{x}B_x + \hat{y}B_y + \hat{z}B_z,$$

$$\mathbf{A} \pm \mathbf{B} = \hat{x}(A_x \pm B_x) + \hat{y}(A_y \pm B_y) + \hat{z}(A_z \pm B_z). \quad (1.7)$$

Biographical Data

Descartes, René. Descartes, a French mathematician and philosopher, was born in La Haye, France, in 1596 and died in Stockholm, Sweden, in 1650. Cartesius is the latinized version of his name at a time when Latin was the language of sciences, although he mainly wrote in French. He discovered his love of mathematics in the army, when he had plenty of time for research. He introduced the concept of rectangular coordinates, thereby converting geometry to algebraic equations of the coordinates of points, now called analytic geometry. Thus, he paved the way for Newton's and Leibniz's calculus. He coined the phrase "Cogito, ergo sum," which translates to "I think, therefore I am."

EXAMPLE 1.1.1

Let

$$\begin{aligned} \mathbf{A} &= 6\hat{x} + 4\hat{y} + 3\hat{z} \\ &= 2\hat{x} - 3\hat{y} - 3\hat{z}. \end{aligned}$$

Then by Eq. (1.7)

$$\mathbf{A} + \mathbf{B} = (6 + 2)\hat{x} + (4 - 3)\hat{y} + (3 - 3)\hat{z} = 8\hat{x} + \hat{y},$$

$$\mathbf{A} - \mathbf{B} = (6 - 2)\hat{x} + (4 + 3)\hat{y} + (3 + 3)\hat{z} = 4\hat{x} + 7\hat{y} + 6\hat{z}. \quad \blacksquare$$

EXAMPLE 1.1.2

Parallelogram of Forces Find the sum of two forces \mathbf{a} and \mathbf{b} . To practice the geometric meaning of vector addition and subtraction, consider two forces

$$\mathbf{a} = (3, 0, 1), \quad \mathbf{b} = (4, 1, 2)$$

(in units of newtons, $1\text{ N} = 1\text{ kgm/s}^2$, in the Standard International system of units) that span a parallelogram with the diagonals forming the sum

$$\mathbf{a} + \mathbf{b} = (3 + 4, 1, 1 + 2) = (7, 1, 3) = \mathbf{b} + \mathbf{a},$$

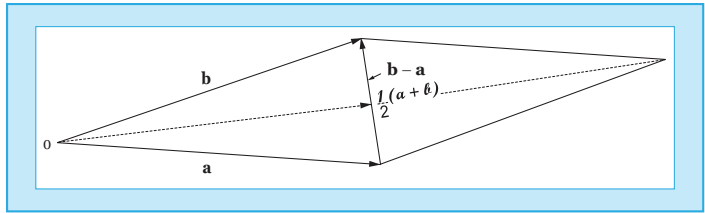
and the difference

$$\mathbf{b} - \mathbf{a} = (4 - 3, 1, 2 - 1) = (1, 1, 1),$$

as shown in Fig. 1.5. The midpoint \mathbf{c} is half the sum,

$$\mathbf{c} = \frac{1}{2}(\mathbf{a} + \mathbf{b}) = \frac{1}{2}(7, 1, 3)$$

Figure 1.5
Parallelogram of Forces
a and b



Alternately, to obtain the midpoint from **a**, add half of the second diagonal that points from **a** to **b**; that is,

$$\mathbf{a} + \frac{1}{2}(\mathbf{b} - \mathbf{a}) = \frac{1}{2}(\mathbf{a} + \mathbf{b}) = \mathbf{c} = \frac{7}{2}, \frac{3}{2}, \frac{1}{2} \quad \blacksquare$$

EXAMPLE 1.1.3

Center of Mass of Three Points at the Corners of a Triangle Consider each corner of a triangle to have a unit of mass and to be located \mathbf{a}_i from the origin, where

$$\mathbf{a}_1 = (2, 0, 0), \mathbf{a}_2 = (4, 1, 1), \mathbf{a}_3 = (3, 3, 2).$$

Then, the center of mass of the triangle is

$$\frac{1}{3}(\mathbf{a}_1 + \mathbf{a}_2 + \mathbf{a}_3) = \mathbf{c} = \frac{1}{3}(2+4+3, 1+3, 1+2) = \frac{4}{3}, \frac{7}{3}, \frac{1}{3}.$$

THEOREM 1.1

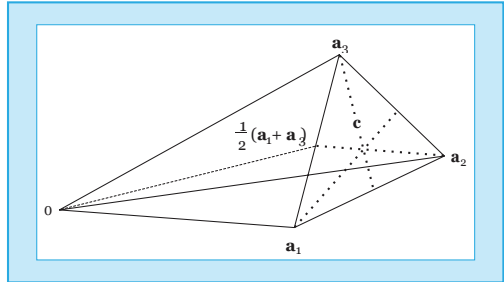
If we draw a straight line from each corner to the midpoint of the opposite side of the triangle in Fig. 1.6, these lines meet in the center, which is at a distance of two-thirds of the line length to the corner.

The three midpoints are located at the point of the vectors

$$\begin{aligned} \frac{1}{2}(\mathbf{a}_1 + \mathbf{a}_2) &= \frac{1}{2}(2+4, 1, 1) = (3, \frac{1}{2}, \frac{1}{2}) \\ \frac{1}{2}(\mathbf{a}_2 + \mathbf{a}_3) &= \frac{1}{2}(4+3, 1+3, 1+2) = (\frac{7}{2}, 2, \frac{3}{2}) \\ \frac{1}{2}(\mathbf{a}_3 + \mathbf{a}_1) &= \frac{1}{2}(3+2, 3, 2) = (\frac{5}{2}, \frac{3}{2}, 1) \end{aligned}$$

Figure 1.6

Center of a Triangle. The Dashed Line Goes from the Origin to the Midpoint of a Triangle Side, and the Dotted Lines Go from Each Corner to the Midpoint of the Opposite Triangle Side



To prove this theorem numerically or symbolically using general vectors, we start from each corner and end up in the center as follows:

$$\begin{aligned}
 (2, 0, 0) + \frac{2}{3} \left(\frac{a_2 + a_3}{2} - a_1 \right) &= \frac{2}{3} \left(\frac{a_1 + a_2 + a_3}{2} \right), \\
 (4, 1, 1) + \frac{2}{3} \left(\frac{a_1 + a_3}{2} - a_2 \right) &= \frac{2}{3} \left(\frac{a_1 + a_2 + a_3}{2} \right), \\
 (3, 3, 2) + \frac{2}{3} \left(\frac{a_1 + a_2}{2} - a_3 \right) &= \frac{2}{3} \left(\frac{a_1 + a_2 + a_3}{2} \right).
 \end{aligned}$$

This theorem is easy to establish using vector algebra, but it is much more tedious to prove working only with intersecting straight lines of Euclidean geometry. Thus, this example is not only useful practice but also lets us appreciate the power and versatility of the vector algebra. ■

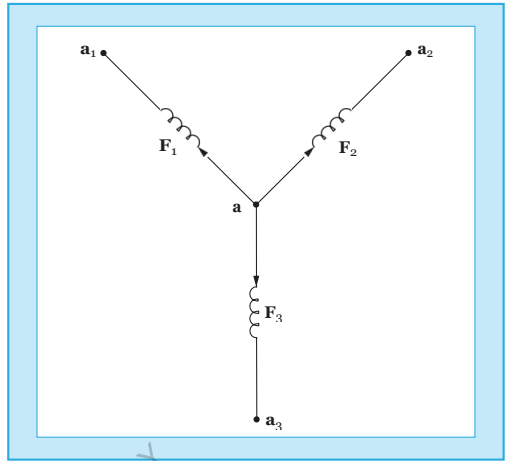
EXAMPLE 1.1.4

Elastic Forces A movable point \mathbf{a} is held elastically (denoted by springs in Fig. 1.7) by three fixed points \mathbf{a}_i , $i = 1, 2, 3$; that is, the force $\mathbf{F}_i = k_i(\mathbf{a}_i - \mathbf{a})$ for each i that \mathbf{a} experiences is pointed to \mathbf{a}_i and proportional to the distance. Let us show that the elastic forces to three points can be replaced by an elastic force to a single point.

This holds because the total force is given by

$$\mathbf{F} = \sum_i \mathbf{F}_i = \sum_i k_i \mathbf{a}_i - \mathbf{a} \sum_i k_i = \sum_i k_i \mathbf{a}_i - \mathbf{a} \sum_i k_i = k_0(\mathbf{a}_0 - \mathbf{a}),$$

Figure 1.7
The Point a Is Held
Elastically by Three
Points a_i



where $k_0 = \sum_i k_i$ and $\mathbf{a}_0 = \sum_i k_i \mathbf{a}_i / k_0$. This shows that the resulting force is equivalent to one with an effective spring constant k_0 acting from a point \mathbf{a}_0 . Note that if all k_i 's are the same, then $\mathbf{a}_0 = \frac{1}{3}(\mathbf{a}_1 + \mathbf{a}_2 + \mathbf{a}_3)$ is the center of mass.

Technical applications apply for bridges and buildings, for which the balance of forces is vital for stability. ■

Vectors and Vector Space Summary

An ordered triplet of real numbers (x_1, x_2, x_3) is labeled a **vector** \mathbf{x} . The number x_i is called the i th component of vector \mathbf{x} . The collection of all such vectors (obeying the properties that follow) forms a three-dimensional real **vector space**, or **linear space**. We ascribe five properties to our vectors: If $\mathbf{x} = (x_1, x_2, x_3)$ and $\mathbf{y} = (y_1, y_2, y_3)$,

1. Vector equality: $\mathbf{x} = \mathbf{y}$ means $x_i = y_i, i = 1, 2, 3$.
2. Vector addition: $\mathbf{x} + \mathbf{y} = \mathbf{z}$ means $x_i + y_i = z_i, i = 1, 2, 3$.
3. Scalar multiplication: $a\mathbf{x} = (ax_1, ax_2, ax_3)$.
4. Negative of a vector: $-\mathbf{x} = (-1)\mathbf{x} = (-x_1, -x_2, -x_3)$.
5. Null vector: There exists a null vector $\mathbf{o} = (0, 0, 0)$.

Since our vector components are numbers, the following properties also hold:

1. Addition of vectors is commutative: $\mathbf{x} + \mathbf{y} = \mathbf{y} + \mathbf{x}$.
2. Addition of vectors is associative: $(\mathbf{x} + \mathbf{y}) + \mathbf{z} = \mathbf{x} + (\mathbf{y} + \mathbf{z})$.

3. Scalar multiplication is distributive:

$$a(\mathbf{x} + \mathbf{y}) = a\mathbf{x} + a\mathbf{y}, \quad \text{also } (a + b)\mathbf{x} = a\mathbf{x} + b\mathbf{x}.$$

4. Scalar multiplication is associative: $(ab)\mathbf{x} = a(b\mathbf{x})$.

Furthermore, the null vector $\mathbf{0}$ is unique, as is the negative of a given vector \mathbf{x} .

With regard to the vectors, this approach merely formalizes the component discussion of Section 1.1. The importance lies in the extensions, which will be considered later. In Chapter 3, we show that vectors form a linear space, with the transformations in the linear space described by matrices. Finally, and perhaps most important, for advanced physics the concept of vectors presented here generalizes to (i) complex quantities,³ (ii) functions, and (iii) an infinite number of components. This leads to infinite dimensional function spaces, the Hilbert spaces, which are important in quantum mechanics. A brief introduction to function expansions and Hilbert space is provided in Chapter 9.

SUMMARY

So far, we have defined the operations of addition and subtraction of vectors guided by the use of elastic and gravitational forces in classical mechanics, set up mechanical and geometrical problems such as finding the center of mass of a system of mass points, and solved these problems using the tools of vector algebra.

Next, we address three varieties of multiplication defined on the basis of their applicability in geometry and mechanics: a scalar or inner product in Section 1.2; a vector product peculiar to three-dimensional space in Section 1.3, for which the angular momentum in mechanics is a prime example; and a direct or outer product yielding a second-rank tensor in Section 2.7. Division by a vector cannot be consistently defined.

EXERCISES

- 1.1.1** A jet plane is flying eastward from Kennedy Airport at a constant speed of 500 mph. There is a crosswind from the south at 50 mph. What is the resultant speed of the plane relative to the ground? Draw the velocities (using graphical software, if available).
- 1.1.2** A boat travels straight across a river at a speed of 5 mph when there is no current. You want to go straight across the river in that boat when there is a constant current flowing at 1 mph. At what angle do you have to steer the boat? Plot the velocities.
- 1.1.3** A sphere of radius a is centered at a point \mathbf{r}_1 .
 (a) Write out the algebraic equation for the sphere. Explain in words why you chose a particular form. Name theorems from geometry you may have used.

³The n -dimensional vector space of real n -tuples is often labeled \mathbf{R}^n , and the n -dimensional vector space of complex n -tuples is labeled \mathbf{C}^n .

- (b) Write out a **vector** equation for the sphere. Identify in words what you are doing.

$$\text{ANS. (a) } (x - x_1)^2 + (y - y_1)^2 + (z - z_1)^2 = a^2.$$

- (b) $\mathbf{r} = r\mathbf{a}$ (\mathbf{a} takes on all directions but has a fixed magnitude, a).

- 1.1.4** Show that the medians of a triangle intersect at a point. Show that this point is two-thirds of the way from any corner of the triangle to the mid-point of the opposite side. Compare a geometrical proof with one using vectors. If you use a Cartesian coordinate system, place your triangle so as to simplify the analysis as much as possible. Explain in words why you are allowed to do so.

- 1.1.5** The velocity of sailboat A relative to sailboat B , \mathbf{v}_{rel} , is defined by the equation $\mathbf{v}_{\text{rel}} = \mathbf{v}_A - \mathbf{v}_B$, where \mathbf{v}_A is the velocity of A and \mathbf{v}_B is the velocity of B . Determine the velocity of A relative to B if

$$\mathbf{v}_A = 30 \text{ km/hr east}$$

$$\mathbf{v}_B = 40 \text{ km/hr north.}$$

Plot the velocities (using graphical software, if available).

$$\text{ANS. } \mathbf{v}_{\text{rel}} = 50 \text{ km/hr, } 53.1^\circ \text{ south of east.}$$

- 1.1.6** A sailboat sails for 1 hr at 4 km/hr (relative to the water) on a steady compass heading of 40° east of north. The sailboat is simultaneously carried along by a current. At the end of the hour the boat is 6.12 km from its starting point. The line from its starting point to its location lies 60° east of north. Find the x (easterly) and y (northerly) components of the water's velocity. Plot all velocities.

$$\text{ANS. } v_{\text{east}} = 2.73 \text{ km/hr, } v_{\text{north}} \approx 0 \text{ km/hr.}$$

- 1.1.7** A triangle is defined by the vertices of three vectors, \mathbf{A} , \mathbf{B} , and \mathbf{C} , that extend from the origin. In terms of \mathbf{A} , \mathbf{B} , and \mathbf{C} , show that the **vector** sum of the successive sides of the triangle is zero. If software is available, plot a typical case.

- 1.1.8** Find the diagonal vectors of a unit cube with one corner at the origin and three adjacent sides lying along the three axes of a Cartesian coordinate system. Show that there are four diagonals with length $\sqrt{3}$. Representing these as vectors, what are their components? Show that the diagonals of the cube's surfaces have length $\sqrt{2}$. Determine their components.

- 1.1.9** Hubble's law: Hubble found that distant galaxies are receding with a velocity proportional to their distance (H_0 is the Hubble constant) from where we are on Earth. For the i th galaxy

$$\mathbf{v}_i = H_0 \mathbf{r}_i,$$

with our Milky Way galaxy at the origin. Show that this recession of the galaxies from us does **not** imply that we are at the center of the universe.

Specifically, take the galaxy at \mathbf{r}_1 as a new origin and show that Hubble's law is still obeyed.

1.2 Scalar or Dot Product

Having defined vectors, we now proceed to combine them in this section. The laws for combining vectors must be mathematically consistent. From the possibilities that are consistent we select two that are both mathematically and physically interesting. In this section, we start with the scalar product that is based on the geometric concept of projection that we used in Section 1.1 to define the Cartesian components of a vector. Also included here are some applications to particle orbits and analytic geometry that will prompt us to **differentiate vectors**, thus starting **vector analysis**.

The **projection of a vector \mathbf{A} onto a coordinate axis**, which defines its Cartesian components in Eq. (1.5), **is a special case of the scalar product of \mathbf{A} and the coordinate unit vectors**,

$$A_x = A \cos \alpha \equiv \mathbf{A} \cdot \hat{\mathbf{x}}, \quad A_y = A \cos \beta \equiv \mathbf{A} \cdot \hat{\mathbf{y}}, \quad A_z = A \cos \gamma \equiv \mathbf{A} \cdot \hat{\mathbf{z}} \quad (1.8)$$

and leads us to the general definition of the dot product. Just as the projection is linear in \mathbf{A} , we want the scalar product of two vectors to be linear in \mathbf{A} and \mathbf{B} —that is, to obey the distributive and associative laws

$$\mathbf{A} \cdot (\mathbf{B} + \mathbf{C}) = \mathbf{A} \cdot \mathbf{B} + \mathbf{A} \cdot \mathbf{C} \quad (1.9)$$

$$\mathbf{A} \cdot (y\mathbf{B}) = (y\mathbf{A}) \cdot \mathbf{B} = y\mathbf{A} \cdot \mathbf{B}, \quad (1.10)$$

where y is a real number. Now we can use the decomposition of \mathbf{B} into its Cartesian components according to Eq. (1.5), $\mathbf{B} = B_x\hat{\mathbf{x}} + B_y\hat{\mathbf{y}} + B_z\hat{\mathbf{z}}$, to construct the general scalar or dot product of the vectors \mathbf{A} and \mathbf{B} from the special case as

$$\begin{aligned} \mathbf{A} \cdot \mathbf{B} &= \mathbf{A} \cdot (B_x\hat{\mathbf{x}} + B_y\hat{\mathbf{y}} + B_z\hat{\mathbf{z}}), \\ &= B_x\mathbf{A} \cdot \hat{\mathbf{x}} + B_y\mathbf{A} \cdot \hat{\mathbf{y}} + B_z\mathbf{A} \cdot \hat{\mathbf{z}}, && \text{applying Eqs. (1.9) and (1.10)} \\ &= B_xA_x + B_yA_y + B_zA_z, && \text{upon substituting Eq. (1.8).} \end{aligned}$$

Hence,

$$\mathbf{A} \cdot \mathbf{B} \equiv \sum_i A_i B_i = \sum_i B_i A_i = \mathbf{B} \cdot \mathbf{A} \quad (1.11)$$

because we are dealing with components.

If $\mathbf{A} = \mathbf{B}$ in Eq. (1.11), we recover the magnitude $A = \left(\sum_i A_i^2 \right)^{1/2}$ of \mathbf{A} in Eq. (1.6) from Eq. (1.11).

It is obvious from Eq. (1.11) that the scalar product treats \mathbf{A} and \mathbf{B} alike, is symmetric in \mathbf{A} and \mathbf{B} , or is commutative. Based on this observation, we can generalize Eq. (1.8) to the projection of \mathbf{A} onto an arbitrary vector $\mathbf{B} \neq 0$

Figure 1.8

Scalar Product
 $\mathbf{A} \cdot \mathbf{B} = AB \cos \theta$

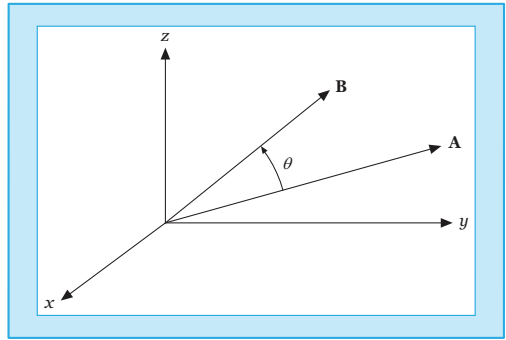
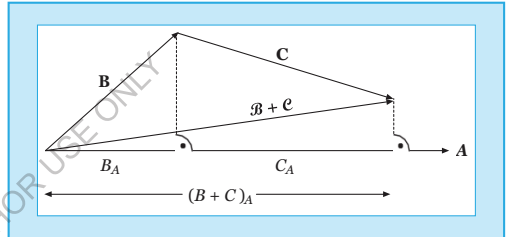


Figure 1.9

The Distributive Law
 $\mathbf{A} \cdot (\mathbf{B} + \mathbf{C}) = AB_A + AC_A = A(\mathbf{B} + \mathbf{C})_A$
 [Eq. (1.9)]



instead of the coordinate unit vectors. As a first step in this direction, we define A_B as $A_B \equiv A \cos \theta \equiv \mathbf{A} \cdot \hat{\mathbf{B}}$, where $\hat{\mathbf{B}} \equiv \mathbf{B}/B$ is the unit vector in the direction of \mathbf{B} and θ is the angle between \mathbf{A} and \mathbf{B} as shown in Fig. 1.8. Similarly, we project \mathbf{B} onto \mathbf{A} as $B_A = B \cos \theta \equiv \mathbf{B} \cdot \hat{\mathbf{A}}$. These projections are not symmetric in \mathbf{A} and \mathbf{B} . To make them symmetric in \mathbf{A} and \mathbf{B} , we define

$$\mathbf{A} \cdot \mathbf{B} \equiv A_B B = AB_A = AB \cos \theta. \tag{1.12}$$

The distributive law in Eq. (1.9) is illustrated in Fig. 1.9, which states that the sum of the projections of \mathbf{B} and \mathbf{C} onto \mathbf{A} , $B_A + C_A$, is equal to the projection of $\mathbf{B} + \mathbf{C}$ onto \mathbf{A} , $(\mathbf{B} + \mathbf{C})_A$.

From Eqs. (1.8), (1.11), and (1.12), we infer that the coordinate unit vectors satisfy the relations

$$\hat{\mathbf{x}} \cdot \hat{\mathbf{x}} = \hat{\mathbf{y}} \cdot \hat{\mathbf{y}} = \hat{\mathbf{z}} \cdot \hat{\mathbf{z}} = 1, \tag{1.13}$$

whereas

$$\hat{\mathbf{x}} \cdot \hat{\mathbf{y}} = \hat{\mathbf{x}} \cdot \hat{\mathbf{z}} = \hat{\mathbf{y}} \cdot \hat{\mathbf{z}} = 0. \tag{1.14}$$

If the component definition of the dot product, Eq. (1.11), is labeled an algebraic definition, then Eq. (1.12) is a geometric definition. One of the most common applications of the scalar product in physics is in the definition of work = force · displacement = $|\mathbf{F}| |\mathbf{s}| \cos \theta$, where θ is the angle between the force and the displacement. This expression is interpreted as displacement times the projection of the force along the displacement direction—that is, the scalar product of force and displacement, $W = \mathbf{F} \cdot \mathbf{s}$.

If $\mathbf{A} \cdot \mathbf{B} = 0$ and we know that $\mathbf{A} \neq 0$ and $\mathbf{B} \neq 0$, then from Eq. (1.12) $\cos \theta = 0$ or $\theta = 90^\circ, 270^\circ$, and so on. The vectors \mathbf{A} and \mathbf{B} must be **perpendicular**. Alternately, we may say \mathbf{A} and \mathbf{B} are **orthogonal**. The unit vectors \hat{x}, \hat{y} , and \hat{z} are mutually orthogonal.

Free Motion and Other Orbits

EXAMPLE 1.2.1

Free Particle Motion To apply this notion of orthogonality in two dimensions, let us first deal with the motion of a particle free of forces along a straight line

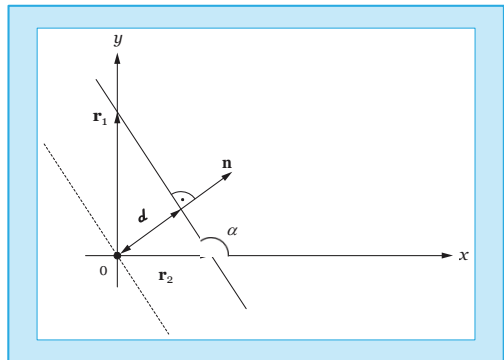
$$\mathbf{r}(t) = (x(t), y(t)) = (-3t, 4t)$$

through the origin (dashed line in Fig. 1.10). The particle travels with the velocity $v_x = -3$ in the x -direction and $v_y = 4$ in the y -direction (in meters per second; e.g., 1 m/sec = 3.6 km/hr). The constant velocity $\mathbf{v} = (-3, 4)$ is characteristic of free motion according to Newton's equations.

Eliminating the time t , we find the homogeneous linear equation $4x + 3y = 0$, whose coefficient vector $(4, 3)$ we normalize to unit length; that is, we write the linear equation as

$$\frac{4}{5}x + \frac{3}{5}y = 0 = \mathbf{n} \cdot \mathbf{r}.$$

Figure 1.10
The Dashed Line Is $\mathbf{n} \cdot \mathbf{r} = 0$ and the Solid Line Is $\mathbf{n} \cdot \mathbf{r} = d$



where $\mathbf{n} = (4/5, 3/5)$ is a constant unit vector and \mathbf{r} is the coordinate vector varying in the xy -plane; that is, $\mathbf{r} = \dot{x}\mathbf{i} + \dot{y}\mathbf{j}$. The scalar product

$$\mathbf{n} \cdot \mathbf{r} = 0 \quad (1.15)$$

means that the projection onto \mathbf{n} of the vector $\mathbf{r}(t)$ pointing from the origin (a point on the line) to the general point on the line is zero so that \mathbf{n} is the **normal of the straight line**. We verify that

$$(-3t, 4t) \cdot \frac{4}{5} \mathbf{i} + \frac{3}{5} \mathbf{j} = \frac{t}{5} (-3 \cdot 4 + 4 \cdot 3) = 0.$$

Because the particle's velocity is a tangent vector of the line, we can also write the scalar product as $\mathbf{v} \cdot \mathbf{n}$; omitting the normalization factor t/v .

If we throw the particle from the origin in an arbitrary direction with some velocity \mathbf{v} , it also will travel on a line through the origin. That is, upon varying the normal unit vector the linear Eq. (1.15) defines an arbitrary straight line through the origin in the xy -plane. Notice that in three dimensions Eq. (1.15) describes a plane through the origin, and a hyperplane ($(n-1)$ -dimensional subspace) in n -dimensional space.

Now we shift the line by some constant distance d along the normal direction \mathbf{n} so that it passes through the point $(3, 0)$ on the x -axis, for example. Because its tangent vector is \mathbf{v} , the line is parameterized as $x(t) = 3 - 3t$, $y(t) = 4t$. We can verify that it passes through the point $\mathbf{r}_1 = (3, 0)$ on the x -axis for $t = 0$ and $\mathbf{r}_2 = (0, 4)$ on the y -axis for $t = 1$. The particle has the same velocity and the path has the same normal. Eliminating the time as before, we find that the linear equation for the line becomes $4x + 3y = 12$, or

$$\mathbf{n} \cdot \mathbf{r} = d = \frac{12}{5} \quad (1.16)$$

The line no longer goes through the origin (solid line in Fig. 1.10) but has the shortest distance $d = 12/5$ from the origin. If $\mathbf{r}_1 = (0, 4)$, $\mathbf{r}_2 = (3, 0)$ are our different points on that line, then $\mathbf{T} = \mathbf{r}_1 - \mathbf{r}_2 = (-3, 4) = \mathbf{v}$ is a tangent vector of the line and therefore orthogonal to the normal \mathbf{n} because $\mathbf{n} \cdot \mathbf{T} = \mathbf{n} \cdot \mathbf{r}_1 - \mathbf{n} \cdot \mathbf{r}_2 = d - d = 0$ from Eq. (1.16). Then the general point on that line is parameterized by

$$\mathbf{r}(t) = \mathbf{r}_1 + t\mathbf{T} \quad (1.17)$$

because $\mathbf{n} \cdot \mathbf{r} = \mathbf{n} \cdot \mathbf{r}_1 + t\mathbf{n} \cdot \mathbf{T} = d + t \cdot 0 = d$.

Note that in general a straight line is defined by a linear relation, $\mathbf{n} \cdot \mathbf{r} = d$, and its points depend linearly on one variable t ; that is, in two dimensions Eq. (1.17) represents $x = x_1 + tT_x$, $y = y_1 + tT_y$, with $\mathbf{T} = (T_x, T_y)$. The geometry of Fig. 1.10 shows that the projection of the vectors \mathbf{r}_1 , \mathbf{r}_2 , \mathbf{r} on the normal \mathbf{n} is always d —that is, the shortest distance of our line from the origin, consistent with the algebraic definition $\mathbf{n} \cdot \mathbf{r} = d$ of our line, from which we started.

Equations (1.16) and (1.17) are consistent with the conventional definition of a straight line by its constant slope (or angle α with the x -axis)

$$\tan \alpha = \frac{y - y_1}{x - x_1} \leftrightarrow (x - x_1) \sin \alpha - (y - y_1) \cos \alpha = 0, \tag{1.18}$$

where the normal $\mathbf{n} = (\sin \alpha, \cos \alpha)$; upon comparing Eq. (1.18) with Eq. (1.16), $\mathbf{n} \cdot \mathbf{r} = d \leftrightarrow x_1 \sin \alpha + y_1 \cos \alpha = d$.

Generalizing to three-dimensional analytic geometry, $\mathbf{n} \cdot \mathbf{r} = d$ is linear in the variables $(x, y, z) = \mathbf{r}$; that is, it represents a plane, and the unit vector $\mathbf{n} = (n_1, n_2, n_3)$ is perpendicular to the plane—it is the constant normal of the plane. If we divide the plane equation by d , the coefficients n_i/d of the coordinates x_i of the plane give the inverse lengths of the segments from the origin to the intersection of the Cartesian axes with the plane. For example, the point of the plane $6x + 3y + 2z = 6$ in Fig. 1.11 on the x -axis defined by $y = z = 0$ is $(d/n_1, 0, 0)$ for $n_1 = 6/7, d = 6/7$, noting that $6^2 = 3^2 + 2^2 + 7^2$. The general point on the plane is parameterized as

$$\mathbf{r}(s, t) = \mathbf{r}_1 + s\mathbf{l}_1 + t\mathbf{l}_2,$$

where s and t are parameters, and \mathbf{r}_i is constructed from three of its points $\mathbf{r}_i, i = 1, 2, 3$, that is, $\mathbf{r}_1 = (1, 0, 0), \mathbf{r}_2 = (0, 2, 0), \mathbf{r}_3 = (0, 0, 3)$ for the plane in Fig. 1.11, so that the tangent vectors $\mathbf{l}_1 = \mathbf{r}_2 - \mathbf{r}_1, \mathbf{l}_2 = \mathbf{r}_3 - \mathbf{r}_1$ of the plane are not parallel. All this generalizes to higher dimensions.

Geometry also tells us that two nonparallel planes $\mathbf{a}_1 \cdot \mathbf{r} = d_1, \mathbf{a}_2 \cdot \mathbf{r} = d_2$ in three-dimensional space have a line in common and three nonparallel planes a single point in general. Finding them amounts to solving linear equations, which is addressed in Section 3.1 using determinants.

Figure 1.11
The Plane
 $6x + 3y + 2z = 6$

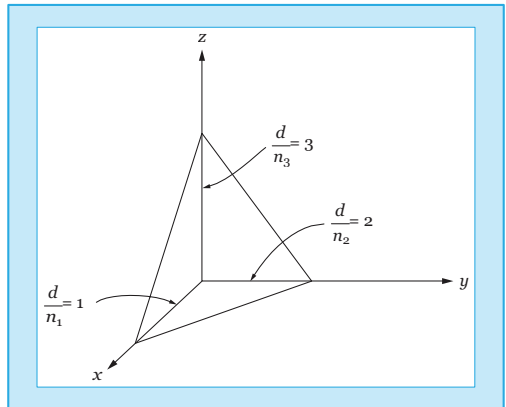
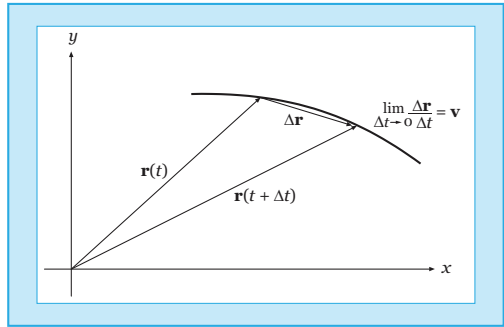


Figure 1.12
Differentiation of a Vector



More generally, the orbit of a particle or a curve in planar analytic geometry may be defined as $\mathbf{r}(t) = (x(t), y(t))$, where x and y are functions of the parameter t . In order to find the slope of a curve or the tangent to an orbit we need to differentiate vectors. Differentiating a vector function is a simple extension of differentiating scalar functions if we resolve $\mathbf{r}(t)$ into its Cartesian components. Then, for differentiation with respect to time, the linear velocity is given by

$$\frac{d\mathbf{r}(t)}{dt} = \lim_{\psi_t \rightarrow 0} \frac{\mathbf{r}(t + \psi_t) - \mathbf{r}(t)}{\psi_t} = \mathbf{v} = \left\langle \frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt} \right\rangle \equiv (\dot{x}, \dot{y}, \dot{z})$$

because the Cartesian unit vectors are constant. Thus, differentiation of a vector always reduces directly to a vector sum of not more than three (for three-dimensional space) scalar derivatives. In other coordinate systems (see Chapter 2), the situation is more complicated because the unit vectors are no longer constant in direction. Differentiation with respect to the space coordinates is handled in the same way as differentiation with respect to time. Graphically, we have the slope of a curve, orbit, or trajectory, as shown in Fig. 1.12. ■

EXAMPLE 1.2.2

Shortest Distance of a Rocket from an Observer What is the shortest distance of a rocket traveling at a constant velocity $\mathbf{v} = (1, 2, 3)$ from an observer at $\mathbf{r}_0 = (2, 1, 3)$? The rocket is launched at **time** $t = 0$ at the point $\mathbf{r}_1 = (1, 1, 1)$.

The path of the rocket is the straight line

$$\mathbf{r} = \mathbf{r}_1 + t\mathbf{v}, \quad (1.19)$$

or, in Cartesian coordinates,

$$x(t) = 1 + t, \quad y(t) = 1 + 2t, \quad z(t) = 1 + 3t.$$

We now minimize the distance $|\mathbf{r} - \mathbf{r}_0|$ of the observer at the point $\mathbf{r}_0 = (2, 1, 3)$ from $\mathbf{r}(t)$, or equivalently $(\mathbf{r} - \mathbf{r}_0)^2 = \min$. Differentiating Eq. (1.19) with respect to t yields $\dot{\mathbf{r}} = (\dot{x}, \dot{y}, \dot{z}) = \mathbf{v}$. Setting $\frac{d}{dt}(\mathbf{r}_t - \mathbf{r}_0)^2 = 0$, we obtain the condition

$$2(\mathbf{r} - \mathbf{r}_0) \cdot \mathbf{r}' = 2[\mathbf{r}_1 - \mathbf{r}_0 + t\mathbf{v}] \cdot \mathbf{v} = 0.$$

Because $\mathbf{r}' = \mathbf{v}$ is the tangent vector of the line, the geometric meaning of this condition is that the **shortest distance vector through \mathbf{r}_0 is perpendicular to the line**. Now solving for t yields the ratio of scalar products

$$t = - \frac{(\mathbf{r}_1 - \mathbf{r}_0) \cdot \mathbf{v}}{\mathbf{v}^2} = - \frac{(-1, 0, -2) \cdot (1, 2, 3)}{(1, 2, 3) \cdot (1, 2, 3)} = \frac{1+0+6}{1+4+9} = \frac{1}{2}.$$

Substituting this parameter value into Eq. (1.19) gives the point $\mathbf{r}_s = (3/2, 2, 5/2)$ on the line that is closest to \mathbf{r} . The shortest distance is $d = |\mathbf{r} - \mathbf{r}_s| = \sqrt{(-1/2, 1, -1/2)^2} = \sqrt{2/4 + 1} = \sqrt{3/2}$.

In two dimensions, $\mathbf{r}(t) = (x = a \cos t, y = b \sin t)$ describes an ellipse with half-axes a, b (so that $a=b$ gives a circle); for example, the orbit of a planet around the sun in a plane determined by the constant orbital angular momentum (the normal of the plane). If $\mathbf{r}_0 = (x(t_0), y(t_0)) = (x_0, y_0) = \mathbf{r}(t_0)$ is a point on our orbit, then the tangent at \mathbf{r}_0 has the slope \dot{y}_0/\dot{x}_0 , where the dots denote the derivatives with respect to the time t as usual. Returning to the slope formula, imagine inverting $x(t)$ to find $t(x)$, which is substituted into $y = y(t) = y(t(x)) = y(x)$ to produce the standard form of a curve in analytic geometry. Using the **chain rule of differentiation**, the slope of $f(x)$ at x is

$$\frac{df}{dx} = f'(x) = \frac{dy(t(x))}{dx} = \frac{dy}{dt} \frac{dt}{dx} = \frac{\dot{y}}{\dot{x}}.$$

The tangent is a straight line and therefore depends linearly on one variable u ,

$$\mathbf{r} = \mathbf{r}(t_0) + u\mathbf{t}(t_0), \quad (1.20)$$

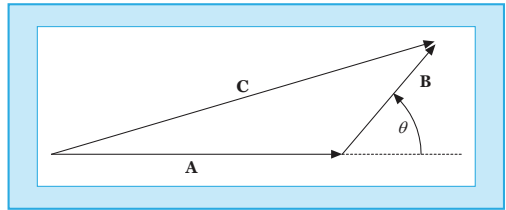
whereas the normal through the given point (x_0, y_0) obeys the linear equation

$$(x - x_0)\dot{x}_0 + (y - y_0)\dot{y}_0 = 0. \quad (1.21)$$

For the elliptical orbit mentioned previously, we check that the point $\mathbf{r}_0 = (0, b)$ for the parameter value $t = \pi/2$ lies on it. The slope at $t = \pi/2$ is zero, which we also know from geometry and because $y_0 = b \cos t = \pi/2 = 0$, whereas $x_0 = a \sin t = \pi/2 = a \neq 0$. The normal is the y -axis for which Eq. (1.21) yields $ax = 0$.

A curve can also be defined implicitly by a functional relation, $F(x, y) = 0$, of the coordinates. This common case will be addressed in Section 1.5 because it involves partial derivatives.

Figure 1.13
The Law of Cosines



Law of Cosines In a similar geometrical approach, we take $\mathbf{C} = \mathbf{A} + \mathbf{B}$ and dot it into itself:

$$\mathbf{C} \cdot \mathbf{C} = (\mathbf{A} + \mathbf{B}) \cdot (\mathbf{A} + \mathbf{B}) = \mathbf{A} \cdot \mathbf{A} + \mathbf{B} \cdot \mathbf{B} + 2\mathbf{A} \cdot \mathbf{B}. \quad (1.22)$$

Since

$$\mathbf{C} \cdot \mathbf{C} = C^2, \quad (1.23)$$

the square of the magnitude of vector \mathbf{C} is a scalar, we see that

$$\mathbf{A} \cdot \mathbf{B} = \frac{1}{2}(C^2 - A^2 - B^2) \quad (1.24)$$

is a scalar. Note that since the right-hand side of Eq. (1.24) is a scalar, the left-hand side $\mathbf{A} \cdot \mathbf{B}$ must also be a scalar, independent of the orientation of the coordinate system. We defer a proof that a scalar product is invariant under rotations to Section 2.6.

Equation (1.22) is another form of the **law of cosines**:

$$C^2 = A^2 + B^2 + 2AB \cos \theta. \quad (1.25)$$

Comparing Eqs. (1.22) and (1.25), we have another verification of Eq. (1.12) or, if preferred, a vector derivation of the law of cosines (Fig. 1.13). This law may also be derived from the triangle formed by the point of \mathbf{C} and its line of shortest distance from the line along \mathbf{A} , which has the length $B \sin \theta$, whereas the projection of \mathbf{B} onto \mathbf{A} has length $B \cos \theta$. Applying the Pythagorean theorem to this triangle with a right angle formed by the point of \mathbf{C} , $\mathbf{A} + \mathbf{B}$ and the shortest distance $B \sin \theta$ gives

$$C^2 = (A + \mathbf{B} \cdot \hat{\mathbf{A}})^2 + (B \sin \theta)^2 = A^2 + B^2(\cos^2 \theta + \sin^2 \theta) + 2AB \cos \theta.$$

SUMMARY

In this section, we defined the dot product as an algebraic generalization of the geometric concept of projection of vectors (their coordinates). We used it for geometrical purposes, such as finding the shortest distance of a point from a line or the cosine theorem for triangles. The geometrical meaning of the scalar product allowed us to go back and forth between the algebraic definition of a straight line as a linear equation and the parameterization of its general point $\mathbf{r}(t)$ as a linear function of time and similar steps for planes in three dimensions. We began differentiation of vectors as a tool for drawing tangents to orbits of particles, and this important step represents the start of vector analysis enlarging vector algebra.

The dot product, given by Eq. (1.11), may be generalized in two ways. The space need not be restricted to three dimensions. In n -dimensional space, Eq. (1.11) applies with the sum running from 1 to n ; n may be infinity, with the sum then a convergent infinite series (see Section 5.2). The other generalization extends the concept of vector to embrace functions. The function analog of a dot or inner product is discussed in Section 9.4.

EXERCISES

- 1.2.1** A car is moving northward with a constant speed of 50 mph for 5 min, and then makes a 45° turn to the east and continues at 55 mph for 1 min. What is the average acceleration of the car?
- 1.2.2** A particle in an orbit is located at the point \mathbf{r} (drawn from the origin) that terminates at and specifies the point in space (x, y, z) . Find the surface swept out by the tip of \mathbf{r} and draw it using graphical software if
- (a) $(\mathbf{r} - \mathbf{a}) \cdot \mathbf{a} = 0$,
 (b) $(\mathbf{r} - \mathbf{a}) \cdot \mathbf{r} = 0$.
- The vector \mathbf{a} is a constant (in magnitude and direction).
- 1.2.3** Develop a condition when two forces are parallel, with and without using their Cartesian coordinates.

- 1.2.4** The Newtonian equations of motion of two particles are

$$m_1 \dot{\mathbf{v}}_1 = \mathbf{F}_1^i + \mathbf{F}_1^e, \quad m_2 \dot{\mathbf{v}}_2 = \mathbf{F}_2^i + \mathbf{F}_2^e,$$

where m_i are their masses, \mathbf{v}_i are their velocities, and the superscripts on the forces denote internal and external forces. What is the total force and the total external force? Write Newton's third law for the forces. Define the center of mass and derive its equation of motion. Define the relative coordinate vector of the particles and derive the relevant equation of motion. Plot a typical case at some time instant using graphical software.

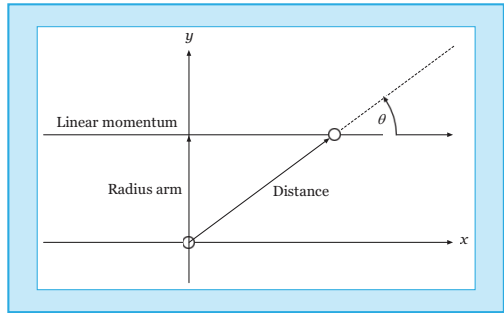
Note. The resultant of all forces acting on particle 1, whose origin lies outside the system, is called external force \mathbf{F}_1^e ; the force arising from the interaction of particle 2 with particle 1 is called the internal force \mathbf{F}_1^i so that $\mathbf{F}_1^i = -\mathbf{F}_2^i$.

- 1.2.5** If $|\mathbf{A}|$, $|\mathbf{B}|$ are the magnitudes of the vectors \mathbf{A} , \mathbf{B} , show that $-|\mathbf{A}||\mathbf{B}| \leq \mathbf{A} \cdot \mathbf{B} \leq |\mathbf{A}||\mathbf{B}|$.

1.3 Vector or Cross Product

A second form of vector multiplication employs the sine of the included angle (denoted by θ) instead of the cosine and is called cross product. The cross product generates a vector from two vectors, in contrast with the dot product, which produces a scalar. Applications of the cross product in analytic geometry and mechanics are also discussed in this section. For instance, the orbital

Figure 1.14
Angular Momentum



angular momentum of a particle shown at the point of the distance vector in Fig. 1.14 is defined as

$$\begin{aligned} \text{Angular momentum} &= \text{radius arm} \cdot \text{linear momentum} \\ &= \text{distance} \cdot \text{linear momentum} \cdot \sin \theta. \end{aligned} \quad (1.26)$$

For convenience in treating problems relating to quantities such as angular momentum, torque, angular velocity, and area, we define the vector or cross product as

$$\mathbf{C} = \mathbf{A} \times \mathbf{B}, \quad (1.27)$$

with the magnitude (but not necessarily the dimensions of length)

$$C = AB \sin \theta. \quad (1.28)$$

Unlike the preceding case of the scalar product, \mathbf{C} is now a vector, and we assign it a direction perpendicular to the plane of \mathbf{A} and \mathbf{B} such that \mathbf{A} , \mathbf{B} , and \mathbf{C} form a right-handed system. If we curl the fingers of the right hand from the point of \mathbf{A} to \mathbf{B} , then the extended thumb will point in the direction of $\mathbf{A} \times \mathbf{B}$, and these three vectors form a right-handed system. With this choice of direction, we have

$$\mathbf{A} \times \mathbf{B} = -\mathbf{B} \times \mathbf{A}, \quad \text{anticommutation.} \quad (1.29)$$

In general, the cross product of two collinear vectors is zero so that

$$\hat{x} \times \hat{x} = \hat{y} \times \hat{y} = \hat{z} \times \hat{z} = 0, \quad (1.30)$$

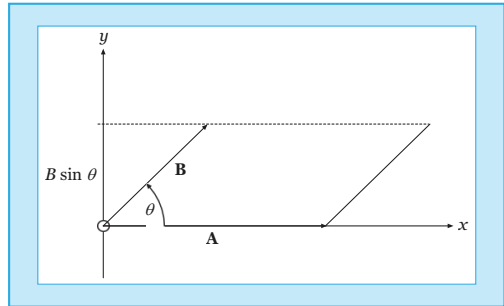
whereas

$$\begin{aligned} \hat{x} \times \hat{y} = \hat{z}, \quad \hat{y} \times \hat{z} = \hat{x}, \quad \hat{z} \times \hat{x} = \hat{y}, \\ \hat{y} \times \hat{x} = -\hat{z}, \quad \hat{z} \times \hat{y} = -\hat{x}, \quad \hat{x} \times \hat{z} = -\hat{y}. \end{aligned} \quad (1.31)$$

Among the examples of the cross product in mathematical physics are the relation between linear momentum \mathbf{p} and angular momentum \mathbf{L} (defining angular momentum),

$$\mathbf{L} = \mathbf{r} \times \mathbf{p} \quad (1.32)$$

Figure 1.15
Parallelogram
Representation
of the Vector Product



and the relation between linear velocity \mathbf{v} and angular velocity $\boldsymbol{\omega}$,

$$\mathbf{v} = \boldsymbol{\omega} \times \mathbf{r}. \quad (1.33)$$

Vectors \mathbf{v} and \mathbf{p} describe properties of the particle or physical system. However, the position vector \mathbf{r} is determined by the choice of the origin of the coordinates. This means that $\boldsymbol{\omega}$ and \mathbf{L} depend on the choice of the origin.

The familiar magnetic induction \mathbf{B} occurs in the vector product force equation called Lorentz force

$$\mathbf{F}_M = q\mathbf{v} \times \mathbf{B} \quad (\text{SI units}), \quad (1.34)$$

where \mathbf{v} is the velocity of the electric charge q , and \mathbf{F}_M is the resulting magnetic force on the moving charge. The cross product has an important geometrical interpretation that we shall use in subsequent sections. In the parallelogram (Fig. 1.15) defined by \mathbf{A} and \mathbf{B} , $B \sin \theta$ is the height if A is taken as the length of the base. Then $|\mathbf{A} \times \mathbf{B}| = AB \sin \theta$ is the **area of the parallelogram**. As a vector, $\mathbf{A} \times \mathbf{B}$ is the area of the parallelogram defined by \mathbf{A} and \mathbf{B} , with the area vector normal to the plane of the parallelogram. This means that area (with its orientation in space) is treated as a vector.

An alternate definition of the vector product can be derived from the special case of the coordinate unit vectors in Eqs. (1.30) and (1.31) in conjunction with the linearity of the cross product in both vector arguments, in analogy with Eqs. (1.9) and (1.10) for the dot product,

$$\mathbf{A} \times (\mathbf{B} + \mathbf{C}) = \mathbf{A} \times \mathbf{B} + \mathbf{A} \times \mathbf{C}, \quad (1.35)$$

$$(\mathbf{A} + \mathbf{B}) \times \mathbf{C} = \mathbf{A} \times \mathbf{C} + \mathbf{B} \times \mathbf{C}, \quad (1.36)$$

$$\mathbf{A} \times (y\mathbf{B}) = y\mathbf{A} \times \mathbf{B} = (y\mathbf{A}) \times \mathbf{B}, \quad (1.37)$$

where y is a number, a scalar. Using the decomposition of \mathbf{A} and \mathbf{B} into their Cartesian components according to Eq. (1.5), we find

$$\begin{aligned}\mathbf{A} \times \mathbf{B} \equiv \mathbf{C} &= (C_x, C_y, C_z) = (A_x\hat{\mathbf{x}} + A_y\hat{\mathbf{y}} + A_z\hat{\mathbf{z}}) \times (B_x\hat{\mathbf{x}} + B_y\hat{\mathbf{y}} + B_z\hat{\mathbf{z}}) \\ &= (A_xB_y - A_yB_x)\hat{\mathbf{x}} \times \hat{\mathbf{y}} + (A_xB_z - A_zB_x)\hat{\mathbf{x}} \times \hat{\mathbf{z}} \\ &\quad + (A_yB_z - A_zB_y)\hat{\mathbf{y}} \times \hat{\mathbf{z}},\end{aligned}$$

upon applying Eqs. (1.35) and (1.37) and substituting Eqs. (1.30) and (1.31) so that the Cartesian components of $\mathbf{A} \times \mathbf{B}$ become

$$C_x = A_yB_z - A_zB_y, \quad C_y = A_zB_x - A_xB_z, \quad C_z = A_xB_y - A_yB_x, \quad (1.38)$$

or

$$C_i = A_j B_k - A_k B_j, \quad i, j, k \text{ all different}, \quad (1.39)$$

and with cyclic permutation of the indices i, j , and k or $x \rightarrow y \rightarrow z \rightarrow x$ in Eq. (1.38). The vector product \mathbf{C} may be represented by a determinant

$$\mathbf{C} \equiv \begin{vmatrix} \hat{\mathbf{x}} & \hat{\mathbf{y}} & \hat{\mathbf{z}} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}. \quad (1.40)$$

which, according to the expansion Eq. (3.11) of the determinant along the top row, is a shorthand form of the vector product

$$\mathbf{C} = \hat{\mathbf{x}}(A_yB_z - A_zB_y) + \hat{\mathbf{y}}(A_zB_x - A_xB_z) + \hat{\mathbf{z}}(A_xB_y - A_yB_x).$$

If Eqs. (1.27) and (1.28) are called a geometric definition of the vector product, then Eq. (1.38) is an algebraic definition.

To show the equivalence of Eqs. (1.27) and (1.28) and the component definition Eq. (1.38), let us form $\mathbf{A} \cdot \mathbf{C}$ and $\mathbf{B} \cdot \mathbf{C}$ using Eq. (1.38). We have

$$\begin{aligned}\mathbf{A} \cdot \mathbf{C} &= \mathbf{A} \cdot (\mathbf{A} \times \mathbf{B}) \\ &= A_x(A_yB_z - A_zB_y) + A_y(A_zB_x - A_xB_z) + A_z(A_xB_y - A_yB_x) \\ &= 0.\end{aligned} \quad (1.41)$$

Similarly,

$$\mathbf{B} \cdot \mathbf{C} = \mathbf{B} \cdot (\mathbf{A} \times \mathbf{B}) = 0. \quad (1.42)$$

Equations (1.41) and (1.42) show that \mathbf{C} is perpendicular to both \mathbf{A} and \mathbf{B} and therefore perpendicular to the plane they determine. The positive direction is determined by considering special cases, such as the unit vectors $\hat{\mathbf{x}} \times \hat{\mathbf{y}} = \hat{\mathbf{z}}$.

⁴Determinants are discussed in detail in Section 3.1.

The magnitude is obtained from

$$\begin{aligned}(\mathbf{A} \times \mathbf{B}) \cdot (\mathbf{A} \times \mathbf{B}) &= A^2 B^2 - (\mathbf{A} \cdot \mathbf{B})^2 \\ &= A^2 B^2 - A^2 B^2 \cos^2 \theta \\ &= A^2 B^2 \sin^2 \theta,\end{aligned}\quad (1.43)$$

which implies Eq. (1.28). The first step in Eq. (1.43) may be verified by expanding out in component form using Eq. (1.38) for $\mathbf{A} \times \mathbf{B}$ and Eq. (1.11) for the dot product. From Eqs. (1.41)–(1.43), we see the equivalence of Eqs. (1.28) and (1.38), the two definitions of vector product.

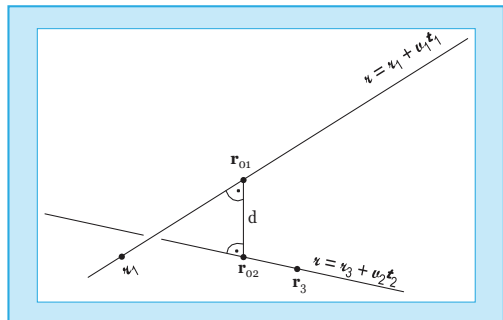
EXAMPLE 1.3.1

Shortest Distance between Two Rockets in Free Flight Considering Example 1.2.2 as a similar but simpler case, we remember that the shortest distance between a point and a line is measured along the normal from the line through the point. Therefore, we expect that the shortest distance between two lines is normal to both tangent vectors of the straight lines. Establishing this fact will be our first and most important step. The second step involves the projection of a vector between two points, one on each line, onto that normal to both lines. However, we also need to locate the points where the normal starts and ends. This problem we address first.

Let us take the first line from Example 1.2.2, namely $\mathbf{r} = \mathbf{r}_1 + t_1 \mathbf{v}_1$ with time variable t_1 and tangent vector $\mathbf{v}_1 = \mathbf{r}_2 - \mathbf{r}_1 = (1, 2, 3)$ that goes through the points $\mathbf{r}_1 = (1, 1, 1)$ and $\mathbf{r}_2 = (2, 3, 4)$ and is shown in Fig. 1.16, along with the second line $\mathbf{r} = \mathbf{r}_3 + t_2 \mathbf{v}_2$ with time variable t_2 that goes through the points $\mathbf{r}_3 = (5, 2, 1)$ and $\mathbf{r}_4 = (4, 1, 2)$, and so has the tangent vector $\mathbf{r}_4 - \mathbf{r}_3 = (-1, -1, 1) = \mathbf{v}_2$ and the parameterization

$$x = 5 - t_2, \quad y = 2 - t_2, \quad z = 1 + t_2.$$

Figure 1.16
Shortest Distance
Between Two
Straight Lines That
Do Not Intersect



In order to find the end points \mathbf{r}_{ok} of this shortest distance we minimize the distances squared $(\mathbf{r} - \mathbf{r}_{ok})^2$ to obtain the conditions

$$0 = \frac{d}{dt_1} (\mathbf{r} - \mathbf{r}_{o2})^2 = \frac{d}{dt_1} (\mathbf{r}_1 - \mathbf{r}_{o2} + t_1 \mathbf{v}_1)^2 = 2\mathbf{v}_1 \cdot (\mathbf{r}_1 - \mathbf{r}_{o2} + t_1 \mathbf{v}_1),$$

$$0 = \frac{d}{dt_2} (\mathbf{r} - \mathbf{r}_{o1})^2 = 2\mathbf{v}_2 \cdot (\mathbf{r}_3 - \mathbf{r}_{o1} + t_2 \mathbf{v}_2). \tag{1.44}$$

We can solve for $t_1 = -\mathbf{v}_1 \cdot (\mathbf{r}_1 - \mathbf{r}_{o2})/v_1^2$ and $t_2 = -\mathbf{v}_2 \cdot (\mathbf{r}_3 - \mathbf{r}_{o1})/v_2^2$ and then plug these parameter values into the line coordinates to find the points \mathbf{r}_{ok} and $d = |\mathbf{r}_{o1} - \mathbf{r}_{o2}|$. [This is straightforward but tedious. Alternatively, we can exploit the geometric meaning of Eq. (1.44) that the distance vector $\mathbf{d} = \mathbf{r}_1 + t_1 \mathbf{v}_1 - \mathbf{r}_{o2} = (\mathbf{r}_3 - t_2 \mathbf{v}_2 - \mathbf{r}_{o1})$ is perpendicular to both tangent vectors \mathbf{v}_k as shown in Fig. 1.16. Thus, the distance vector \mathbf{d} is along the normal unit vector

$$\mathbf{n} = \frac{\mathbf{v}_1 \times \mathbf{v}_2}{|\mathbf{v}_1 \times \mathbf{v}_2|} = \frac{\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ 3 & -1 & 4 \\ 1 & -2 & 3 \end{vmatrix}}{\sqrt{3^2 + 1^2 + 4^2} \sqrt{1^2 + 2^2 + 3^2}} = \frac{1}{\sqrt{42}} (5\hat{x} - 4\hat{y} + \hat{z}) = \frac{1}{\sqrt{42}} (5, -4, 1),$$

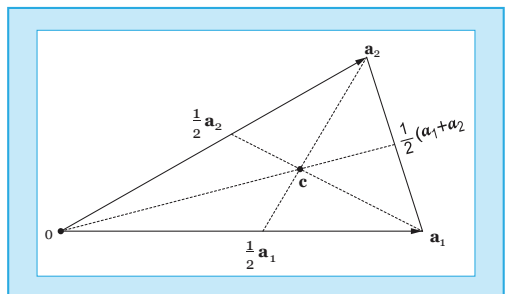
the **cross product** of both tangent vectors. We get the distance d by projecting the distance vector between two points $\mathbf{r}_1, \mathbf{r}_3$, one on each line, onto that normal \mathbf{n} —that is, $d = (\mathbf{r}_3 - \mathbf{r}_1) \cdot \mathbf{n} = \sqrt{42} (4, 1, 0) \cdot (5, -4, 1) = \frac{20 - 4 + 0}{\sqrt{42}} = \frac{16}{\sqrt{42}}$.

This example generalizes to the shortest distance between two orbits by examining the shortest distance between their tangent lines. In this form, there are many applications in mechanics, space travel, and satellite orbits. ■

EXAMPLE 1.3.2

Medians of a Triangle Meet in the Center Let us consider Example 1.1.3 and Fig. 1.6 again, but now without using the 2:1 ratio of the segments from the center to the end points of each median. We put the origin of the coordinate system in one corner of the triangle, as shown in Fig. 1.17, so that the median from the origin will be given by the vector $\mathbf{m}_3 = (\mathbf{a}_1 + \mathbf{a}_2)/2$. The medians

Figure 1.17
Medians of a Triangle Meet in the Center



from the triangle corners \mathbf{a}_1 and \mathbf{a}_2 intersect at a point we call the center that is given by the vector \mathbf{c} from the origin. We want to show that \mathbf{m}_3 and \mathbf{c} are parallel (and therefore collinear), indicating that the center will also lie on the median from the origin.

From Fig. 1.17, we see that the vector $\mathbf{c} - \mathbf{a}_1$ from the corner \mathbf{a}_1 to the center will be parallel to $\frac{1}{2}\mathbf{a}_2 - \mathbf{a}_1$; similarly, $\mathbf{c} - \mathbf{a}_2$ will be collinear with $\frac{1}{2}\mathbf{a}_1 - \mathbf{a}_2$. We write these conditions as follows:

$$(\mathbf{c} - \mathbf{a}_1) \times \frac{1}{2}\mathbf{a}_2 - \mathbf{a}_1 = 0, \quad (\mathbf{c} - \mathbf{a}_2) \times \frac{1}{2}\mathbf{a}_1 - \mathbf{a}_2 = 0.$$

Expanding, and using the fact that $\mathbf{a}_1 \times \mathbf{a}_1 = 0 = \mathbf{a}_2 \times \mathbf{a}_2$, we find

$$\mathbf{c} \times \frac{1}{2}\mathbf{a}_2 - \mathbf{c} \times \mathbf{a}_1 - \frac{1}{2}(\mathbf{a}_1 \times \mathbf{a}_2) = 0, \quad \mathbf{c} \times \frac{1}{2}\mathbf{a}_1 - \mathbf{c} \times \mathbf{a}_2 - \frac{1}{2}(\mathbf{a}_2 \times \mathbf{a}_1) = 0.$$

Adding these equations, the last terms on the left-hand sides cancel, and the other terms combine to yield

$$-\frac{1}{2}\mathbf{c} \times (\mathbf{a}_1 + \mathbf{a}_2) = 0,$$

proving that \mathbf{c} and \mathbf{m}_3 are parallel.

The center of mass (see Example 1.1.3) will be at the point $\frac{1}{3}(\mathbf{a}_1 + \mathbf{a}_2)$ and is therefore on the median from the origin. By symmetry it must be on the other medians as well, confirming both that they meet at a point and that the distance from the triangle corner to the intersection is two-thirds of the total length of the median. ■

SUMMARY

If we define a vector as an ordered triplet of numbers (or functions) as in Section 1.2, then there is no problem identifying the cross product as a vector. The cross product operation maps the two triples \mathbf{A} and \mathbf{B} into a third triple \mathbf{C} , which by definition is a vector. In Section 2.6, we shall see that the cross product also transforms like a vector.

The cross product combines two vectors antisymmetrically and involves the sine of the angle between the vectors, in contrast to their symmetric combination in the scalar product involving the cosine of their angle, and it unites the angular momentum and velocity of mechanics with the area concept of geometry. The vector nature of the cross product is peculiar to three-dimensional space, but it can naturally be generalized to higher dimensions. The cross product occurs in many applications such as conditions for parallel forces or other vectors and the shortest distance between lines or curves more generally.

We now have two ways of multiplying vectors; a third form is discussed in Chapter 2. However, what about division by a vector? The ratio \mathbf{B}/\mathbf{A} is not uniquely specified (see Exercise 3.2.21) unless \mathbf{A} and \mathbf{B} are also required to be parallel. Hence, division of one vector by another is meaningless.

EXERCISES

1.3.1 Prove the law of cosines starting from $A^2 = (\mathbf{B} - \mathbf{C})^2$, where \mathbf{A} , \mathbf{B} , and \mathbf{C} are the vectors collinear with the sides of a triangle. Plot the triangle and describe the theorem in words. State the analog of the law of cosines on the unit sphere (Fig. 1.18), if \mathbf{A} , \mathbf{B} , and \mathbf{C} go from the origin to the corners of the triangle.

1.3.2 A coin with a mass of 2 g rolls on a horizontal plane at a constant velocity of 5 cm/sec. What is its kinetic energy?

Hint. Show that the radius of the coin drops out.

1.3.3 Starting with $\mathbf{C} = \mathbf{A} + \mathbf{B}$, show that $\mathbf{C} \times \mathbf{C} = \mathbf{0}$ leads to

$$\mathbf{A} \times \mathbf{B} = -\mathbf{B} \times \mathbf{A}.$$

1.3.4 Show that

(a) $(\mathbf{A} - \mathbf{B}) \cdot (\mathbf{A} + \mathbf{B}) = A^2 - B^2$,

(b) $(\mathbf{A} - \mathbf{B}) \times (\mathbf{A} + \mathbf{B}) = 2\mathbf{A} \times \mathbf{B}$.

The distributive laws needed here,

$$\mathbf{A} \cdot (\mathbf{B} + \mathbf{C}) = \mathbf{A} \cdot \mathbf{B} + \mathbf{A} \cdot \mathbf{C}$$

and

$$\mathbf{A} \times (\mathbf{B} + \mathbf{C}) = \mathbf{A} \times \mathbf{B} + \mathbf{A} \times \mathbf{C},$$

may be verified by expansion in Cartesian components.

1.3.5 If $\mathbf{P} = \hat{x}P_x + \hat{y}P_y$ and $\mathbf{Q} = \hat{x}Q_x + \hat{y}Q_y$ are any two nonparallel (also non-antiparallel) vectors in the xy -plane, show that $\mathbf{P} \times \mathbf{Q}$ is in the z -direction.

Figure 1.18
Spherical Triangle

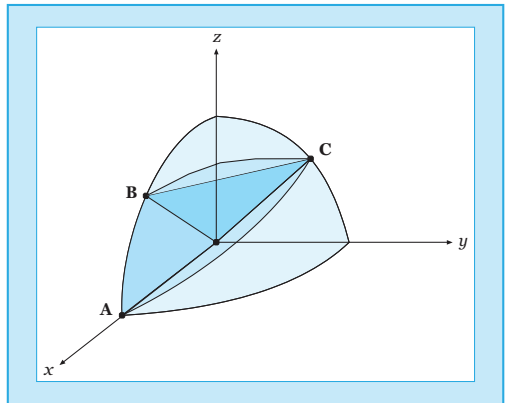
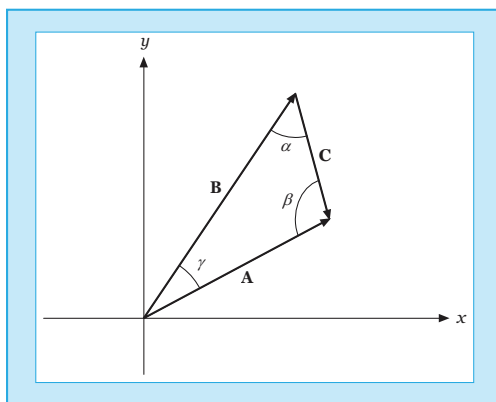


Figure 1.19
Law of Sines



1.3.6 Prove that $(\mathbf{A} \cdot \mathbf{B}) \cdot (\mathbf{A} \times \mathbf{B}) = \mathbf{A}^2 \mathbf{B}^2 \sin^2(\alpha)$. Write the identity appropriately and describe it in geometric language. Make a plot for a typical case using graphical software.

1.3.7 Using the vectors

$$\mathbf{P} = \hat{x} \cos \theta + \hat{y} \sin \theta,$$

$$\mathbf{Q} = \hat{x} \cos \phi - \hat{y} \sin \phi,$$

$$\mathbf{R} = \hat{x} \cos \phi + \hat{y} \sin \phi,$$

prove the familiar trigonometric identities

$$\sin(\theta + \phi) = \sin \theta \cos \phi + \cos \theta \sin \phi,$$

$$\cos(\theta + \phi) = \cos \theta \cos \phi - \sin \theta \sin \phi.$$

1.3.8 If four vectors \mathbf{a} , \mathbf{b} , \mathbf{c} , and \mathbf{d} all lie in the same plane, show that

$$(\mathbf{a} \times \mathbf{b}) \times (\mathbf{c} \times \mathbf{d}) = \mathbf{0}.$$

If graphical software is available, plot all vectors for a specific numerical case.

Hint. Consider the directions of the cross product vectors.

1.3.9 Derive the law of sines (Fig. 1.19):

$$\frac{\sin \alpha}{|\mathbf{A}|} = \frac{\sin \beta}{|\mathbf{B}|} = \frac{\sin \gamma}{|\mathbf{C}|}.$$

1.3.10 A proton of mass m , charge $+e$, and (asymptotic) momentum $p = mv$ is incident on a nucleus of charge $+Ze$ at an impact parameter b . Determine its distance of closest approach.

Hint. Consider only the Coulomb repulsion and classical mechanics, not the strong interaction and quantum mechanics.

- 1.3.11** Expand a vector \mathbf{x} in components parallel to three linearly independent vectors \mathbf{a} , \mathbf{b} , \mathbf{c} .

$$\text{ANS. } (\mathbf{a} \times \mathbf{b} \cdot \mathbf{c})\mathbf{x} = (\mathbf{x} \times \mathbf{b} \cdot \mathbf{c})\mathbf{a} + (\mathbf{a} \times \mathbf{x} \cdot \mathbf{c})\mathbf{b} + (\mathbf{a} \times \mathbf{b} \cdot \mathbf{x})\mathbf{c}.$$

- 1.3.12** Let \mathbf{F} be a force vector drawn from the coordinate vector \mathbf{r} . If \mathbf{r}' goes from the origin to another point on the line through the point of \mathbf{r} with tangent vector given by the force, show that the torque $\mathbf{r}' \times \mathbf{F} = \mathbf{r} \times \mathbf{F}$ —that is, the torque about the origin due to the force stays the same.

- 1.3.13** A car drives in a horizontal circular track of radius R (to its center of mass). Find the speed at which it will overturn, if h is the height of its center of mass and d the distance between its left and right wheels.

Hint. Find the speed at which there is no vertical force on the inner wheels. (The mass of the car drops out.)

- 1.3.14** A force $\mathbf{F} \in \mathbb{R}^3$ acts at the point $(1, 4, 2)$. Find the torque about the origin. Plot the vectors using graphical software.

- 1.3.15** Generalize the cross product to n -dimensional space ($n \geq 2, 4, 5, \dots$) and give a geometrical interpretation of your construction. Give realistic examples in four- and higher dimensional spaces.

- 1.3.16** A jet plane flies due south over the north pole with a constant speed of 500 mph. Determine the angle between a plumb line hanging freely in the plane and the radius vector from the center of the earth to the plane above the north pole.

Hint. Assume that the earth's angular velocity is 2π radians in 24 hr, which is a good approximation. Why?

1.4 Triple Scalar Product and Triple Vector Product

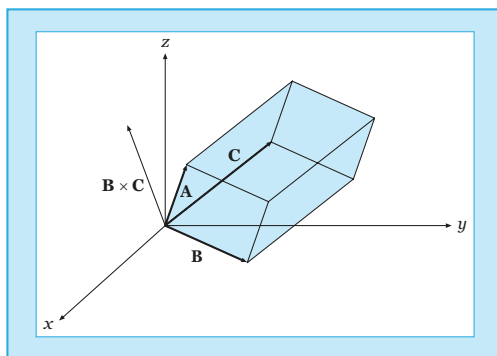
Triple Scalar Product

Sections 1.2 and 1.3 discussed the two types of vector multiplication. However, there are combinations of three vectors, $\mathbf{A} \cdot (\mathbf{B} \times \mathbf{C})$ and $\mathbf{A} \times (\mathbf{B} \times \mathbf{C})$, that occur with sufficient frequency in mechanics, electrodynamics, and analytic geometry to deserve further attention. The combination

$$\mathbf{A} \cdot (\mathbf{B} \times \mathbf{C}) \tag{1.45}$$

is known as the **triple scalar product**. $\mathbf{B} \times \mathbf{C}$ yields a vector that, dotted into \mathbf{A} , gives a scalar. We note that $(\mathbf{A} \cdot \mathbf{B}) \times \mathbf{C}$ represents a scalar crossed into a vector, an operation that is not defined. Hence, if we agree to exclude this undefined interpretation, the parentheses may be omitted and the triple scalar product written as $\mathbf{A} \cdot \mathbf{B} \times \mathbf{C}$.

Figure 1.20
Parallelepiped
Representation
of
Triple Scalar
Product



Using Eq. (1.38) for the cross product and Eq. (1.11) for the dot product, we obtain

$$\begin{aligned} \mathbf{A} \cdot \mathbf{B} \times \mathbf{C} &= A_x(B_y C_z - B_z C_y) + A_y(B_z C_x - B_x C_z) + A_z(B_x C_y - B_y C_x) \\ &= \mathbf{B} \cdot \mathbf{C} \times \mathbf{A} = \mathbf{C} \cdot \mathbf{A} \times \mathbf{B} = -\mathbf{A} \cdot \mathbf{C} \times \mathbf{B} \\ &= -\mathbf{C} \cdot \mathbf{B} \times \mathbf{A} = -\mathbf{B} \cdot \mathbf{A} \times \mathbf{C}. \end{aligned} \quad (1.46)$$

The high degree of symmetry present in the component expansion should be noted. Every term contains the factors A_i , B_j , and C_k . If i , j , and k are in cyclic order (x , y , z), the sign is positive. If the order is anticyclic, the sign is negative. Furthermore, the dot and the cross may be interchanged:

$$\mathbf{A} \cdot \mathbf{B} \times \mathbf{C} = \mathbf{A} \times \mathbf{B} \cdot \mathbf{C}. \quad (1.47)$$

A convenient representation of the component expansion of Eq. (1.46) is provided by the determinant

$$\mathbf{A} \cdot \mathbf{B} \times \mathbf{C} = \begin{vmatrix} A_x & A_y & A_z \\ B_x & B_y & B_z \\ C_x & C_y & C_z \end{vmatrix}, \quad (1.48)$$

which follows from Eq. (1.38) by dotting $\mathbf{B} \times \mathbf{C}$ into \mathbf{A} . The rules for interchanging rows and columns of a determinant⁵ provide an immediate verification of the permutations listed in Eq. (1.46), whereas the symmetry of \mathbf{A} , \mathbf{B} , and \mathbf{C} in the determinant form suggests the relation given in Eq. (1.46). The triple products discussed in Section 1.3, which showed that $\mathbf{A} \times \mathbf{B}$ was perpendicular to both \mathbf{A} and \mathbf{B} , were special cases of the general result [Eq. (1.46)].

The triple scalar product has a direct **geometrical interpretation** in which the three vectors \mathbf{A} , \mathbf{B} , and \mathbf{C} are interpreted as defining a **parallelepiped** (Fig. 1.20):

$$|\mathbf{B} \times \mathbf{C}| = BC \sin \theta = \text{area of parallelogram base}. \quad (1.49)$$

⁵See Section 3.1 for a detailed discussion of the properties of determinants.

The direction, of course, is normal to the base. Dotting \mathbf{A} into this means multiplying the base area by the projection of \mathbf{A} onto the normal, or base times height. Therefore,

$$\mathbf{A} \cdot \mathbf{B} \times \mathbf{C} = \text{volume of parallelepiped defined by } \mathbf{A}, \mathbf{B}, \text{ and } \mathbf{C}. \quad (1.50)$$

Note that $\mathbf{A} \cdot \mathbf{B} \times \mathbf{C}$ may sometimes be negative. This is not a problem, and its proper interpretation is provided in Chapter 2.

EXAMPLE 1.4.1

A Parallelepiped For

$$\mathbf{A} = \hat{x} + 2\hat{y} - \hat{z}, \quad \mathbf{B} = \hat{y} + \hat{z}, \quad \mathbf{C} = \hat{x} - \hat{y},$$

$$\mathbf{A} \cdot \mathbf{B} \times \mathbf{C} = \begin{vmatrix} 1 & 2 & -1 \\ 0 & 1 & 1 \\ -1 & -1 & 0 \end{vmatrix} = 4.$$

This is the volume of the parallelepiped defined by \mathbf{A} , \mathbf{B} , and \mathbf{C} . ■

Recall that we already encountered a triple scalar product, namely the distance $d \sim (\mathbf{r}_3 - \mathbf{r}_1) \cdot (\mathbf{v}_1 \times \mathbf{v}_2)$ between two straight lines in Example 1.3.1.

Triple Vector Product

The second triple product of interest is $\mathbf{A} \times (\mathbf{B} \times \mathbf{C})$, which is a vector. Here, the parentheses must be retained, as is seen from a special case $(\hat{x} \times \hat{x}) \times \hat{y} = 0$, whereas $\hat{x} \times (\hat{x} \times \hat{y}) = \hat{x} \times \hat{z} = -\hat{y}$. Let us start with an example that illustrates a key property of the triple product.

EXAMPLE 1.4.2

A Triple Vector Product By using the three vectors given in Example 1.4.1, we obtain

$$\mathbf{B} \times \mathbf{C} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ 0 & 1 & 1 \\ 1 & -1 & 0 \end{vmatrix} = \hat{x} + \hat{y} - \hat{z}$$

and

$$\mathbf{A} \times (\mathbf{B} \times \mathbf{C}) = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ 1 & 2 & -1 \\ 1 & 1 & -1 \end{vmatrix} = -\hat{x} - \hat{z} = -(\hat{y} + \hat{z}) - (\hat{x} - \hat{y}). \quad \blacksquare$$

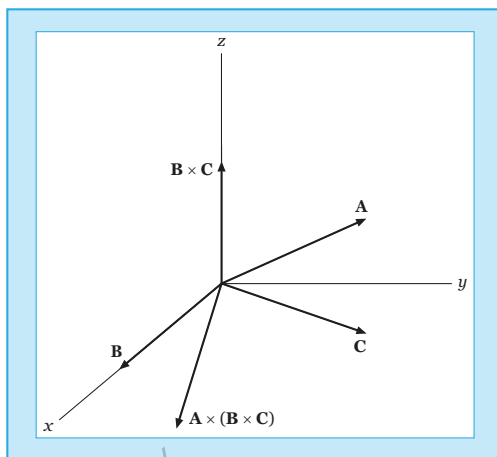
By rewriting the result in the last line as a linear combination of \mathbf{B} and \mathbf{C} , we notice that, taking a geometric approach, the triple product vector is perpendicular to \mathbf{A} and to $\mathbf{B} \times \mathbf{C}$. The plane spanned by \mathbf{B} and \mathbf{C} is perpendicular to $\mathbf{B} \times \mathbf{C}$, so the triple product lies in this plane (Fig. 1.21):

$$\mathbf{A} \times (\mathbf{B} \times \mathbf{C}) = u\mathbf{B} + v\mathbf{C}, \quad (1.51)$$

where u and v are numbers. Multiplying Eq. (1.51) by \mathbf{A} gives zero for the left-hand side so that $u\mathbf{A} \cdot \mathbf{B} + v\mathbf{A} \cdot \mathbf{C} = 0$. Hence, $u = w\mathbf{A} \cdot \mathbf{C}$ and $v = -w\mathbf{A} \cdot \mathbf{B}$ for

Figure 1.21

B and **C** are in the xy -Plane. $\mathbf{B} \times \mathbf{C}$ is perpendicular to the xy -Plane and is shown here along the z -Axis. Then $\mathbf{A} \times (\mathbf{B} \times \mathbf{C})$ is perpendicular to the z -Axis and therefore is back in the xy -Plane



a suitable number w . Substituting these values into Eq. (1.50) gives

$$\mathbf{A} \times (\mathbf{B} \times \mathbf{C}) = w[\mathbf{B}(\mathbf{A} \cdot \mathbf{C}) - \mathbf{C}(\mathbf{A} \cdot \mathbf{B})]. \quad (1.52)$$

Equation (1.51), with $w = 1$, which we now prove, is known as the **BAC–CAB rule**. Since Eq. (1.52) is linear in \mathbf{A} , \mathbf{B} , and \mathbf{C} , w is independent of these magnitudes. That is, we only need to show that $w = 1$ for unit vectors $\hat{\mathbf{A}}$, $\hat{\mathbf{B}}$, $\hat{\mathbf{C}}$. Let us denote $\hat{\mathbf{B}} \cdot \hat{\mathbf{C}} = \cos \alpha$, $\hat{\mathbf{C}} \cdot \hat{\mathbf{A}} = \cos \beta$, $\hat{\mathbf{A}} \cdot \hat{\mathbf{B}} = \cos \gamma$, and square Eq. (1.52) to obtain

$$\begin{aligned} [\hat{\mathbf{A}} \times (\hat{\mathbf{B}} \times \hat{\mathbf{C}})]^2 &= \hat{\mathbf{A}}^2 (\hat{\mathbf{B}} \times \hat{\mathbf{C}})^2 - [\hat{\mathbf{A}} \cdot (\hat{\mathbf{B}} \times \hat{\mathbf{C}})]^2 \\ &= 1 - \cos^2 \alpha - [\hat{\mathbf{A}} \cdot (\hat{\mathbf{B}} \times \hat{\mathbf{C}})]^2 \\ &= w^2 [(\hat{\mathbf{A}} \cdot \hat{\mathbf{C}})^2 + (\hat{\mathbf{A}} \cdot \hat{\mathbf{B}})^2 - 2 \hat{\mathbf{A}} \cdot \hat{\mathbf{B}} \hat{\mathbf{A}} \cdot \hat{\mathbf{C}} \hat{\mathbf{B}} \cdot \hat{\mathbf{C}}] \\ &= w^2 (\cos^2 \beta + \cos^2 \gamma - 2 \cos \alpha \cos \beta \cos \gamma), \end{aligned} \quad (1.53)$$

using $(\hat{\mathbf{A}} \times \hat{\mathbf{B}})^2 = \hat{\mathbf{A}}^2 \hat{\mathbf{B}}^2 - (\hat{\mathbf{A}} \cdot \hat{\mathbf{B}})^2$ repeatedly. Consequently, the (squared) volume spanned by $\hat{\mathbf{A}}$, $\hat{\mathbf{B}}$, $\hat{\mathbf{C}}$ that occurs in Eq. (1.53) can be written as

$$[\hat{\mathbf{A}} \cdot (\hat{\mathbf{B}} \times \hat{\mathbf{C}})]^2 = 1 - \cos^2 \alpha - w^2 (\cos^2 \beta + \cos^2 \gamma - 2 \cos \alpha \cos \beta \cos \gamma).$$

Here, we must have $w^2 = 1$ because this volume is symmetric in α , β , γ . That is, $w = \pm 1$ and is independent of $\hat{\mathbf{A}}$, $\hat{\mathbf{B}}$, $\hat{\mathbf{C}}$. Again using the special case $\hat{\mathbf{x}} \times (\hat{\mathbf{x}} \times \hat{\mathbf{y}}) = -\hat{\mathbf{y}}$ in Eq. (1.51) finally gives $w = 1$.

An alternate and easier algebraic derivation using the Levi-Civita ϵ_{ijk} of Chapter 2 is the topic of Exercise 2.9.8.

Note that because vectors are independent of the coordinates, a vector equation is independent of the particular coordinate system. The coordinate system only determines the components. If the vector equation can be established in Cartesian coordinates, it is established and valid in any of the coordinate systems, as will be shown in Chapter 2. Thus, Eq. (1.52) may be verified by a direct though not very elegant method of expanding into Cartesian components (see Exercise 1.4.1).

Other, more complicated, products may be simplified by using these forms of the triple scalar and triple vector products.

SUMMARY

We have developed the geometric meaning of the triple scalar product as a volume spanned by three vectors and exhibited its component form that is directly related to a determinant whose entries are the Cartesian components of the vectors.

The main property of the triple vector product is its decomposition expressed in the *BAC-CAB* rule. It plays a role in electrodynamics, a vector field theory in which cross products abound.

EXERCISES

1.4.1 Verify the expansion of the triple vector product

$$\mathbf{A} \times (\mathbf{B} \times \mathbf{C}) = \mathbf{B}(\mathbf{A} \cdot \mathbf{C}) - \mathbf{C}(\mathbf{A} \cdot \mathbf{B})$$

by direct expansion in Cartesian coordinates.

1.4.2 Show that the first step in Eq. (1.43),

$$(\mathbf{A} \times \mathbf{B}) \cdot (\mathbf{A} \times \mathbf{B}) = A^2 B^2 - (\mathbf{A} \cdot \mathbf{B})^2,$$

is consistent with the *BAC-CAB* rule for a triple vector product.

1.4.3 The orbital angular momentum \mathbf{L} of a particle is given by $\mathbf{L} = \mathbf{r} \times \mathbf{p} = m\mathbf{r} \times \mathbf{v}$, where \mathbf{p} is the linear momentum. With linear and angular velocity related by $\mathbf{v} = \boldsymbol{\omega} \times \mathbf{r}$, show that

$$\mathbf{L} = mr^2[\boldsymbol{\omega} - \hat{\mathbf{r}}(\hat{\mathbf{r}} \cdot \boldsymbol{\omega})],$$

where $\hat{\mathbf{r}}$ is a unit vector in the \mathbf{r} direction. For $\mathbf{r} \cdot \boldsymbol{\omega} = 0$, this reduces to $\mathbf{L} = I\boldsymbol{\omega}$, with the moment of inertia I given by mr^2 .

1.4.4 The kinetic energy of a single particle is given by $T = \frac{1}{2}m\mathbf{v}^2$. For rota-

tional motion this becomes $\frac{1}{2}m(\boldsymbol{\omega} \times \mathbf{r})^2$. Show that

$$T = \frac{1}{2}m[r^2\omega^2 - (\mathbf{r} \cdot \boldsymbol{\omega})^2].$$

For $\mathbf{r} \cdot \boldsymbol{\omega} = 0$, this reduces to $T = \frac{1}{2}I\omega^2$, with the moment of inertia I given by mr^2 .

1.4.5 Show that

$$\mathbf{a} \times (\mathbf{b} \times \mathbf{c}) + \mathbf{b} \times (\mathbf{c} \times \mathbf{a}) + \mathbf{c} \times (\mathbf{a} \times \mathbf{b}) = \mathbf{0}.^6$$

1.4.6 A vector \mathbf{A} is decomposed into a radial vector \mathbf{A}_r and a tangential vector \mathbf{A}_t . If $\hat{\mathbf{r}}$ is a unit vector in the radial direction, show that

- (a) $\mathbf{A}_r = \hat{\mathbf{r}}(\mathbf{A} \cdot \hat{\mathbf{r}})$ and
 (b) $\mathbf{A}_t = -\hat{\mathbf{r}} \times (\hat{\mathbf{r}} \times \mathbf{A})$.

1.4.7 Prove that a necessary and sufficient condition for the three (nonvanishing) vectors \mathbf{A} , \mathbf{B} , and \mathbf{C} to be coplanar is the vanishing of the triple scalar product

$$\mathbf{A} \cdot \mathbf{B} \times \mathbf{C} = 0.$$

1.4.8 Vector \mathbf{D} is a linear combination of three noncoplanar (and nonorthogonal) vectors:

$$\mathbf{D} = a\mathbf{A} + b\mathbf{B} + c\mathbf{C}.$$

Show that the coefficients are given by a ratio of triple scalar products,

$$a = \frac{\mathbf{D} \cdot \mathbf{B} \times \mathbf{C}}{\mathbf{A} \cdot \mathbf{B} \times \mathbf{C}}, \quad \text{and so on.}$$

If symbolic software is available, evaluate numerically the triple scalar products and coefficients for a typical case.

1.4.9 Show that

$$(\mathbf{A} \times \mathbf{B}) \cdot (\mathbf{C} \times \mathbf{D}) = (\mathbf{A} \cdot \mathbf{C})(\mathbf{B} \cdot \mathbf{D}) - (\mathbf{A} \cdot \mathbf{D})(\mathbf{B} \cdot \mathbf{C}).$$

1.4.10 Show that

$$(\mathbf{A} \times \mathbf{B}) \times (\mathbf{C} \times \mathbf{D}) = (\mathbf{A} \cdot \mathbf{B} \times \mathbf{D})\mathbf{C} - (\mathbf{A} \cdot \mathbf{B} \times \mathbf{C})\mathbf{D}.$$

1.4.11 Given

$$\mathbf{a}^i = \frac{\mathbf{b} \times \mathbf{c}}{\mathbf{a} \cdot \mathbf{b} \times \mathbf{c}}, \quad \mathbf{b}^i = \frac{\mathbf{c} \times \mathbf{a}}{\mathbf{a} \cdot \mathbf{b} \times \mathbf{c}}, \quad \mathbf{c}^i = \frac{\mathbf{a} \times \mathbf{b}}{\mathbf{a} \cdot \mathbf{b} \times \mathbf{c}},$$

and $\mathbf{a} \cdot \mathbf{b} \times \mathbf{c} \neq 0$, show that

- (a) $\mathbf{x}^i \cdot \mathbf{y}^i = \delta_{ij}$ (if $\mathbf{x} = \mathbf{y}$) and $\mathbf{x}^i \cdot \mathbf{y}^j = 0$ (if $\mathbf{x} \neq \mathbf{y}$), for $(\mathbf{x}, \mathbf{y} = \mathbf{a}, \mathbf{b}, \mathbf{c})$,
 (b) $\mathbf{a}^i \mathbf{b}^j \mathbf{c}^k (\mathbf{a} \cdot \mathbf{b} \times \mathbf{c})^{-1}$,
 (c) $\mathbf{a} = \frac{\mathbf{b} \times \mathbf{c}}{\mathbf{a} \cdot \mathbf{b} \times \mathbf{c}}$.

1.4.12 If $\mathbf{x}^i \cdot \mathbf{y}^i = 0$ if $\mathbf{x} \neq \mathbf{y}$ and $\mathbf{x}^i \cdot \mathbf{y}^i = 1$ if $\mathbf{x} = \mathbf{y}$, for $(\mathbf{x}, \mathbf{y} = \mathbf{a}, \mathbf{b}, \mathbf{c})$, prove that

$$\mathbf{a}^i = \frac{\mathbf{b} \times \mathbf{c}}{\mathbf{a} \cdot \mathbf{b} \times \mathbf{c}}.$$

(This is the converse of Problem 1.4.11.)

⁶This is Jacobi's identity for vector products.

1.4.13 Show that any vector \mathbf{V} may be expressed in terms of the reciprocal vectors $\mathbf{a}^i, \mathbf{b}^i, \mathbf{c}^i$ (of Problem 1.4.11) by

$$\mathbf{V} = (\mathbf{V} \cdot \mathbf{a}) \mathbf{a}^i + (\mathbf{V} \cdot \mathbf{b}) \mathbf{b}^i + (\mathbf{V} \cdot \mathbf{c}) \mathbf{c}^i.$$

1.4.14 An electric charge q_1 moving with velocity \mathbf{v}_1 produces a magnetic induction \mathbf{B} given by

$$\mathbf{B} = \frac{\mu_0}{4\pi} q_1 \frac{\mathbf{v}_1 \times \hat{\mathbf{r}}}{r^2} \quad (\text{SI units}),$$

where $\hat{\mathbf{r}}$ points from q_1 to the point at which \mathbf{B} is measured (Biot and Savart's law).

(a) Show that the magnetic force on a second charge q_2 , velocity \mathbf{v}_2 , is given by the triple vector product

$$\mathbf{F}_2 = \frac{\mu_0}{4\pi} q_1 q_2 \mathbf{v}_2 \times (\mathbf{v}_1 \times \hat{\mathbf{r}}).$$

(b) Write out the corresponding magnetic force \mathbf{F}_1 that q_2 exerts on q_1 . Define your unit radial vector. How do \mathbf{F}_1 and \mathbf{F}_2 compare?

(c) Calculate \mathbf{F}_1 and \mathbf{F}_2 for the case of q_1 and q_2 moving along parallel trajectories side by side.

ANS.

$$(b) \mathbf{F}_1 = -\frac{\mu_0}{4\pi} q_1 q_2 \mathbf{v}_1 \times (\mathbf{v}_2 \times \hat{\mathbf{r}}).$$

$$(c) \mathbf{F}_1 = \frac{\mu_0}{4\pi} q_1 q_2 v_2^2 \hat{\mathbf{r}} = -\mathbf{F}_2.$$

1.5 Gradient, ∇

Partial Derivatives

In this section, we deal with derivatives of functions of several variables that will lead us to the concept of directional derivative or gradient operator, which is of central importance in mechanics, electrodynamics, and engineering.

We can view a function $z = \phi(x, y)$ of two variables geometrically as a surface over the xy -plane in three-dimensional Euclidean space because for each point (x, y) we find the z value from ϕ . For a fixed value y then, $z = \phi(x, y) \equiv f(x)$ is a function of x only, viz. a curve on the intersection of the surface with the xz -plane going through y . The slope of this curve,

$$\frac{df}{dx} \equiv \frac{\partial \phi(x, y)}{\partial x} = \lim_{h \rightarrow 0} \frac{\phi(x+h, y) - \phi(x, y)}{h}, \quad (1.54)$$

is the **partial derivative** of ϕ with respect to x defined with the understanding that the other variable y is held fixed. It is useful for drawing tangents and locating a maximum or minimum on the curve where the slope is zero. The partial derivative $\partial \phi / \partial y$ is similarly defined holding x fixed (i.e., it is the slope of the surface in the y -direction), and so on for the higher partial derivatives.

EXAMPLE 1.5.1

Error Estimate Error estimates usually involve many partial derivatives. Let us calculate the moment of inertia of a rectangular slab of metal of length $a = 10 \pm 1$ cm, width $b = 15 \pm 2$ cm, and height $c = 5 \pm 1$ cm about an axis through its center of gravity and perpendicular to the area ab and estimate the error. The uniform density is $\rho = 9.1$ g/cm³. The moment of inertia is given by

$$\begin{aligned}
 I &= \rho \int_0^a \int_{-b/2}^{b/2} (x^2 + y^2) dy dx = \rho c \int_0^a x^2 dx \int_{-b/2}^{b/2} dy + \rho c \int_0^a dx \int_{-b/2}^{b/2} y^2 dy \\
 &= \rho c \left[\frac{a^3}{3} \cdot b + a \cdot \frac{b^3}{12} \right] = \frac{\rho abc}{12} (a^2 + b^2) \tag{1.55} \\
 &= \frac{1}{2} \rho b^2 \left(\frac{a}{3} + \frac{b}{6} \right) = 1.15625 \times 10^{-3} \text{ kg m}^2,
 \end{aligned}$$

where $d\tau = c dx dy$ has been used.

The corresponding error in I derives from the errors in all variables, each being weighted by the corresponding partial derivative,

$$(\Psi I)^2 = \left(\frac{\partial I^2}{\partial \rho} (\Psi \rho)^2 + \frac{\partial I^2}{\partial a} (\Psi a)^2 + \frac{\partial I^2}{\partial b} (\Psi b)^2 + \frac{\partial I^2}{\partial c} (\Psi c)^2 \right),$$

where Ψx is the error in the variable x , that is, $\Psi a = 1$ cm, etc. The partial derivatives

$$\begin{aligned}
 \frac{\partial I}{\partial \rho} &= \frac{abc}{12} (a^2 + b^2), & \frac{\partial I}{\partial a} &= \frac{\rho bc}{12} (3a^2 + b^2), \\
 \frac{\partial I}{\partial b} &= \frac{\rho ac}{12} (a^2 + 3b^2), & \frac{\partial I}{\partial c} &= \frac{\rho ab}{12} (a^2 + b^2)
 \end{aligned} \tag{1.56}$$

are obtained from Eq. (1.55). Substituting the numerical values of all parameters, we get

$$\begin{aligned}
 \frac{\partial I}{\partial \rho} \Psi \rho &= 0.203125 \times 10^{-3} \text{ kg m}^2, & \frac{\partial I}{\partial a} \Psi a &= 1.640625 \times 10^{-3} \text{ kg m}^2, \\
 \frac{\partial I}{\partial b} \Psi b &= 3.2291667 \times 10^{-3} \text{ kg m}^2, & \frac{\partial I}{\partial c} \Psi c &= 2.03125 \times 10^{-3} \text{ kg m}^2.
 \end{aligned}$$

Squaring and summing up, we find $\Psi I = 1.1577 \times 10^{-3}$ kg m². This error of more than 40% of the value I is much higher than the largest error Ψc 20% of the variables on which I depends and shows how errors in several variables can add up. Thus, all decimals except the first one can be dropped safely. ■

EXAMPLE 1.5.2

Partials of a Plane Let us now take a plane $F(\mathbf{r}) = \mathbf{n} \cdot \mathbf{r} - d = 0$ that cuts the coordinate axes at $x = 1, y = 2, z = 3$ so that $n_x = d, 2n_y = d, 3n_z = d$. Because the normal $\mathbf{n}^2 = 1$, we have the constraint $d^2(1 + \frac{1}{4} + \frac{1}{9}) = 1$ so that

$d = 6/7$. Hence, the partial derivatives

$$\frac{\partial F}{\partial x} = n_x = 6/7, \quad \frac{\partial F}{\partial y} = n_y = 3/7, \quad \frac{\partial F}{\partial z} = n_z = 2/7$$

are the components of a vector \mathbf{n} (the normal) for our plane $6x + 3y + 2z = 6$. This suggests the partial derivatives of any function F are a vector. ■

To provide more motivation for the vector nature of the partial derivatives, we now introduce the **total variation of a function** $F(x, y)$,

$$dF = \frac{\partial F}{\partial x} dx + \frac{\partial F}{\partial y} dy. \quad (1.57)$$

It consists of independent variations in the x - and y -directions. We write dF as a sum of two increments, one purely in the x - and the other in the y -direction,

$$\begin{aligned} dF(x, y) &\equiv F(x + dx, y + dy) - F(x, y) = [F(x + dx, y + dy) - F(x, y + dy)] \\ &\quad + [F(x, y + dy) - F(x, y)] = \frac{\partial F}{\partial x} dx + \frac{\partial F}{\partial y} dy, \end{aligned}$$

by adding and subtracting $F(x, y + dy)$. The mean value theorem (i.e., continuity of F) tells us that here $\partial F/\partial x$, $\partial F/\partial y$ are evaluated at some point ξ , η between x and $x + dx$, y and $y + dy$, respectively. As $dx \rightarrow 0$ and $dy \rightarrow 0$, $\xi \rightarrow x$ and $\eta \rightarrow y$. This result generalizes to three and higher dimensions. For example, for a function ϕ of three variables,

$$\begin{aligned} d\phi(x, y, z) &\equiv [\phi(x + dx, y + dy, z + dz) - \phi(x, y + dy, z + dz)] \\ &\quad + [\phi(x, y + dy, z + dz) - \phi(x, y, z + dz)] \\ &\quad + [\phi(x, y, z + dz) - \phi(x, y, z)] \\ &= \frac{\partial \phi}{\partial x} dx + \frac{\partial \phi}{\partial y} dy + \frac{\partial \phi}{\partial z} dz. \end{aligned} \quad (1.58)$$

Note that if F is a scalar function, dF is also a scalar and the form of Eq. (1.57) suggests an interpretation as a scalar product of the coordinate displacement vector $d\mathbf{r} = (dx, dy)$ with the partial derivatives of F ; the same holds for $d\phi$ in three dimensions. These observations pave the way for the gradient in the next section.

As an application of the total variation, we consider the slope of an implicitly defined curve $F(x, y) = 0$, a general theorem that we postponed in Section 1.3. Because also $dF = 0$ on the curve, we find the slope of the curve

$$\frac{dy}{dx} = -\frac{\frac{\partial F}{\partial x}}{\frac{\partial F}{\partial y}} \quad (1.59)$$

from Eq. (1.57). Compare this result with y/x for the slope of a curve defined in terms of two functions $x(t)$, $y(t)$ of time t in Section 1.2.

Often, we are confronted with more difficult problems of finding a slope given some constraint. A case in point is the next example.

EXAMPLE 1.5.3

Extremum under a Constraint Find the points of shortest (or longest) distance from the origin on the curve $G(x, y) \equiv x^2 + xy + y^2 - 1 = 0$.

From analytic geometry we know that the points on such a quadratic form with center at the origin (there are no terms linear in x or y that would shift the center) represent a conic section. But which kind? To answer this question, note that $(x - y)^2 = x^2 - 2xy + y^2 \geq 0$ implies that $xy \leq (x^2 + y^2)/2$ so that the quadratic form is positive definite, that is, $G(x, y) \geq 0$, and G must therefore be an ellipse (Fig. 1.22). Hence, our problem is equivalent to finding the orientation of its principal axes (see Section 3.5 for the alternative matrix diagonalization method). The square of the distance from the origin is defined by the function $F(x, y) = x^2 + y^2$, subject to the constraint that the point (x, y) lie on the ellipse defined by G . The constraint G defines $y = y(x)$. Therefore, we look for the solutions of

$$0 = \frac{dF(x, y(x))}{dx} = 2x + 2y \frac{dy}{dx}$$

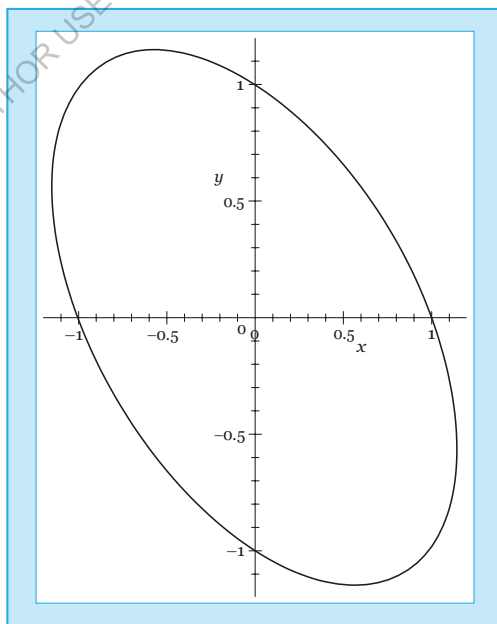
Differentiating G , we find

$$y' = -\frac{2x + y}{2y + x} \quad \text{from } 2x + y + xy' + 2yy' = 0,$$

Figure 1.22

The Ellipse

$$x^2 + xy + y^2 = 1$$



which we substitute into our min/max condition $dF/dx = 0$. This yields

$$x(2y + x) = y(2x + y), \text{ or } y = \pm x.$$

Substituting $x = y$ into G gives the solutions $x = \pm 1/\sqrt{3}$, while $x = -y$ yields the points $x = \pm 1$ on the ellipse. Substituting $x = 1$ into G gives $y = 0$ and $y = -1$, while $x = -1$ yields $y = 0$ and $y = 1$. Although the points $(x, y) = (1, 0)$, $(-1, 0)$ lie on the ellipse, their distance ($= 1$) from the origin is neither shortest nor longest. However, the points $(1, -1)$, $(-1, 1)$ have the longest distance ($= \sqrt{2}$) and define the line $x + y = 0$ through the origin (at 135°) as a principal axis. The points $(1/\sqrt{3}, 1/\sqrt{3})$, $(-1/\sqrt{3}, -1/\sqrt{3})$ define the line at 45° through the origin as the second principal axis that is orthogonal to the first axis.

It is also instructive to apply the slope formula (1.59) at the intersection points of the principal axes and the ellipse, that is, $(\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}})$, $(\frac{-1}{\sqrt{3}}, \frac{-1}{\sqrt{3}})$. The partial derivatives there are given by $G_x = \frac{\partial G}{\partial x} = 2x + y = \frac{2}{\sqrt{3}} + \frac{1}{\sqrt{3}} = \frac{3}{\sqrt{3}} = \sqrt{3}$ and $G_y = \frac{\partial G}{\partial y} = 2y + x = \frac{2}{\sqrt{3}} + \frac{1}{\sqrt{3}} = \sqrt{3}$, so that respectively, $G_x/G_y = \frac{\sqrt{3}}{\sqrt{3}} = 1$, so that the slopes become $-G_x/G_y = -1 = -1$ equal to that of the principal axis $x + y = 0$, and $-1/(-1) = 1$ equal to that of the other principal axis $x - y = 0$. ■

Although this problem was straightforward to solve, there is the more elegant **Lagrange multiplier method** for finding a maximum or minimum of a function $F(x, y)$ subject to a constraint $G(x, y) = 0$.

Introducing a Lagrange multiplier λ helps us avoid the direct (and often messy algebraic) solution for x and y as follows. Because we look for the solution of

$$dF = \frac{\partial F}{\partial x} dx + \frac{\partial F}{\partial y} dy = 0, \quad dG = \frac{\partial G}{\partial x} dx + \frac{\partial G}{\partial y} dy = 0, \quad (1.60)$$

we can solve for the slope dy/dx from one equation and substitute that solution into the other one. Equivalently, we use the function $F + \lambda G$ of three variables x, y, λ , and solve

$$d(F + \lambda G) = \frac{\partial F}{\partial x} dx + \frac{\partial G}{\partial x} dx + \frac{\partial F}{\partial y} dy + \frac{\partial G}{\partial y} dy + \frac{\partial(F + \lambda G)}{\partial \lambda} d\lambda = 0$$

by choosing λ to satisfy $\frac{\partial F}{\partial x} + \lambda \frac{\partial G}{\partial x} = 0$, $\frac{\partial F}{\partial y} + \lambda \frac{\partial G}{\partial y} = 0$, for example, and then eliminating the last term by the constraint $G = 0$ (note that F does not depend on λ) so that $\frac{\partial F}{\partial x} + \lambda \frac{\partial G}{\partial x} = 0$ follows. Including the constraint, we now have three equations for three unknowns x, y, λ , where the slope λ is not usually needed.

EXAMPLE 1.5.4

Lagrange Multiplier Method Let us illustrate the method by solving Example 1.5.3 again, this time using the Lagrange multiplier method. The x

and y partial derivative equations of the Lagrange multiplier method are given by

$$\begin{aligned}\frac{\partial F}{\partial x} + \lambda \frac{\partial G}{\partial x} &\equiv 2x + \lambda(2x + y) = 0, \\ \frac{\partial F}{\partial y} + \lambda \frac{\partial G}{\partial y} &\equiv 2y + \lambda(2y + x) = 0.\end{aligned}$$

We find for the ratio $\xi \equiv y/x = -2(\lambda + 1)/\lambda$ and $\xi = -\lambda/2(1 + \lambda)$, that is, $\xi = 1/\xi$, or $\xi = \pm 1$, so that the principal axes are along the lines $x + y = 0$ and $x - y = 0$ through the origin. Substituting these solutions into the conic section G yields $x = 1/\sqrt{3} = y$ and $x = 1 = -y$, respectively. Contrast this simple, yet sophisticated approach with our previous lengthy solution. ■

Biographical Data

Lagrange, Joseph Louis comte de. Lagrange, a French mathematician and physicist, was born in Torino to a wealthy French-Italian family in 1736 and died in Paris in 1813. While in school, an essay on calculus by the English astronomer Halley sparked his enthusiasm for mathematics. In 1755, he became a professor in Torino. In 1766, he succeeded L. Euler (who moved to St. Petersburg to serve Catherine the Great) as director of the mathematics–physics section of the Prussian Academy of Sciences in Berlin. In 1786, he left Berlin for Paris after the death of king Frederick the Great. He was the founder of analytical mechanics. His famous book, *Mécanique Analytique*, contains not a single

Gradient as a Vector Operator

The **total variation** $dF(x, y)$ in Eq. (1.57) looks like a scalar product of the incremental length vector $d\mathbf{r} = (dx, dy)$ with a vector $(\frac{\partial F}{\partial x}, \frac{\partial F}{\partial y})$ of partial derivatives in two dimensions, that is, the change of F depends on the direction in which we go. For example, F could be a wave function in quantum mechanics or describe a temperature distribution in space. When we are at the peak value, the height will fall off at different rates in different directions, just like a ski slope: One side might be for beginners, whereas another has only expert runs. When we generalize this to a function $\phi(x, y, z)$ of three variables, we obtain Eq. (1.58),

$$d\phi = \frac{\partial \phi}{\partial x} dx + \frac{\partial \phi}{\partial y} dy + \frac{\partial \phi}{\partial z} dz, \quad (1.61)$$

for the total change in the scalar function ϕ consisting of additive contributions of each coordinate change corresponding to a change in position

$$d\mathbf{r} = \hat{x} dx + \hat{y} dy + \hat{z} dz, \quad (1.62)$$

the increment of length $d\mathbf{r}$. Algebraically, $d\phi$ in Eq. (1.58) is a scalar product of the change in position $d\mathbf{r}$ and the **directional** change of ϕ . Now we are ready to recognize the three-dimensional partial derivative as a vector, which leads

us to the concept of gradient. A convenient notation is

$$\nabla \equiv \frac{\partial}{\partial x} \hat{\mathbf{x}} + \frac{\partial}{\partial y} \hat{\mathbf{y}} + \frac{\partial}{\partial z} \hat{\mathbf{z}} \quad (1.63)$$

$$\nabla \phi = \hat{\mathbf{x}} \frac{\partial \phi}{\partial x} + \hat{\mathbf{y}} \frac{\partial \phi}{\partial y} + \hat{\mathbf{z}} \frac{\partial \phi}{\partial z} \quad (1.64)$$

so that ∇ (del) is a vector that differentiates (scalar) functions. As such, it is a **vector operator**. All the relations for ∇ can be derived from the hybrid nature of del in terms of both the partial derivatives and its vector nature.

The gradient of a scalar is extremely important in physics and engineering in expressing the relation between a force field and a potential field

$$\text{force } \mathbf{F} = -\nabla(\text{potential } V), \quad (1.65)$$

which holds for both gravitational and electrostatic fields, among others. Note that the minus sign in Eq. (1.65) results in water flowing downhill rather than uphill. If a force can be described as in Eq. (1.65) by a single function $V(\mathbf{r})$ everywhere, we call the scalar function V its **potential**. Because the force is the directional derivative of the potential, we can find the potential, if it exists, by integrating the force along a suitable path. Because the total variation $dV = \nabla V \cdot d\mathbf{r} = \mathbf{F} \cdot d\mathbf{r}$ is the work done against the force along the path $d\mathbf{r}$, we recognize the physical meaning of the potential (difference) as work and energy. Moreover, in a sum of path increments the intermediate points cancel,

$$\begin{aligned} & [V(\mathbf{r} + d\mathbf{r}_1 + d\mathbf{r}_2) - V(\mathbf{r} + d\mathbf{r}_1)] + [V(\mathbf{r} + d\mathbf{r}_1) - V(\mathbf{r})] \\ & = V(\mathbf{r} + d\mathbf{r}_2 + d\mathbf{r}_1) - V(\mathbf{r}), \end{aligned}$$

so that the integrated work along some path from an initial point \mathbf{r}_i to a final point \mathbf{r}_f is given by the potential difference $V(\mathbf{r}_f) - V(\mathbf{r}_i)$ at the end points of the path. Therefore, such forces are especially simple and well behaved: They are called **conservative**. When there is loss of energy due to friction along the path or some other dissipation, the work will depend on the path and such forces cannot be conservative: No potential exists. We discuss conservative forces in more detail in Section 1.12.

EXAMPLE 1.5.5

The Gradient of a Function of r Because we often deal with **central forces** in physics and engineering, we start with the gradient of the radial

$$\text{distance } r = \sqrt{x^2 + y^2 + z^2}. \quad \text{From } r \text{ as a function of } x, y, z, \quad \frac{\partial r}{\partial x} = \frac{x}{(x^2 + y^2 + z^2)^{1/2}} = \frac{x}{r},$$

etc. Now we can calculate the more general gradient of a spherically symmetric potential $f(r)$ of a central force law so that

$$\nabla f(r) = \hat{\mathbf{x}} \frac{\partial f(r)}{\partial x} + \hat{\mathbf{y}} \frac{\partial f(r)}{\partial y} + \hat{\mathbf{z}} \frac{\partial f(r)}{\partial z} \quad (1.66)$$

where $f(r)$ depends on x through the dependence of r on x . Therefore⁷,

$$\frac{\partial f(r)}{\partial x} = \frac{df(r)}{dr} \cdot \frac{\partial r}{\partial x}.$$

Therefore,

$$\frac{\partial f(r)}{\partial x} = \frac{df(r)}{dr} \cdot \frac{x}{r}. \tag{1.67}$$

Permuting coordinates ($x \rightarrow y, y \rightarrow z, z \rightarrow x$) to obtain the y and z derivatives, we get

$$\nabla f(r) = (\hat{x}x + \hat{y}y + \hat{z}z) \frac{1}{r} \frac{df}{dr} = \frac{\mathbf{r}}{r} \frac{df}{dr} = \hat{\mathbf{r}} \frac{df}{dr}, \tag{1.68}$$

where $\hat{\mathbf{r}}$ is a unit vector (\mathbf{r}/r) in the **positive** radial direction. The gradient of a function of r is a vector in the (positive or negative) radial direction. ■

A Geometrical Interpretation

Example 1.5.2 illustrates the geometric meaning of the gradient of a plane: It is its normal vector. This is a special case of the general geometric meaning of the gradient of an implicitly defined surface $\phi(\mathbf{r}) = \text{const}$. Consider P and Q to be two points on a surface $\phi(x, y, z) = C$, a constant. If ϕ is a potential, the surface is an **equipotential surface**. These points are chosen so that Q is a distance $d\mathbf{r}$ from P . Then, moving from P to Q , the change in $\phi(x, y, z)$, given by Eq. (1.58) that is now written in vector notation, must be

$$d\phi = (\nabla\phi) \cdot d\mathbf{r} = 0 \tag{1.69}$$

since we stay on the surface $\phi(x, y, z) = C$. This shows that $\nabla\phi$ is perpendicular to $d\mathbf{r}$. Since $d\mathbf{r}$ may have any direction from P as long as it stays in the surface $\phi = \text{const}$, the point Q being restricted to the surface but having arbitrary direction, $\nabla\phi$ is seen as **normal to the surface** $\phi = \text{const}$. (Fig. 1.23).

If we now permit $d\mathbf{r}$ to take us from one surface $\phi = C_1$ to an adjacent surface $\phi = C_2$ (Fig. 1.24),

$$d\phi = C_1 - C_2 = \psi C = (\nabla\phi) \cdot d\mathbf{r}. \tag{1.70}$$

For a given $d\phi$, $d\mathbf{r}$ is a minimum when it is chosen parallel to $\nabla\phi$ ($\cos\theta = 1$); for a given $|d\mathbf{r}|$, the change in the scalar function ϕ is maximized by choosing $d\mathbf{r}$ parallel to $\nabla\phi$. **This identifies $\nabla\phi$ as a vector having the direction of the maximum space rate of change of ϕ** , an identification that will be useful in Chapter 2 when we consider non-Cartesian coordinate systems.

⁷This is a special case of the **chain rule** generalized to partial derivatives:

$$\frac{\partial f(r, \theta, \phi)}{\partial x} = \frac{\partial f}{\partial r} \frac{\partial r}{\partial x} + \frac{\partial f}{\partial \theta} \frac{\partial \theta}{\partial x} + \frac{\partial f}{\partial \phi} \frac{\partial \phi}{\partial x},$$

where $\partial f/\partial \theta = \partial f/\partial \phi = 0, \partial f/\partial r \rightarrow df/dr$.

Figure 1.23
The Length
Increment dr is
Required to Stay on
the Surface $\phi = C$

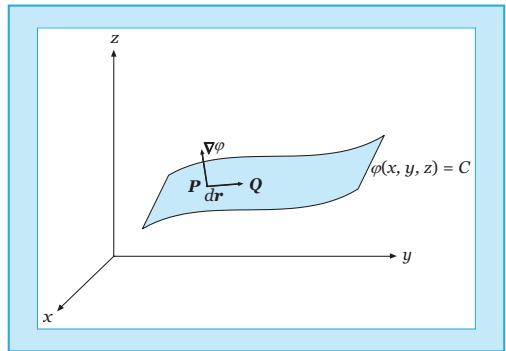
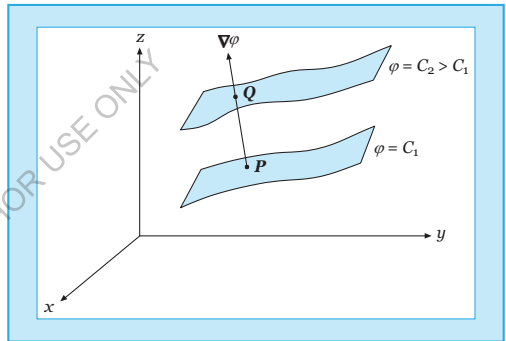


Figure 1.24
Gradient



SUMMARY

We have constructed the gradient operator as a vector of derivatives. The total variation of a function is the dot product of its gradient with the coordinate displacement vector. A conservative force is the (negative) gradient of a scalar called its potential.

EXERCISES

- 1.5.1** The dependence of the free fall acceleration g on geographical latitude ϕ at sea level is given by $g = g_0(1 + 0.0053 \sin^2 \phi)$. What is the southward displacement near $\phi = 30^\circ$ that changes g by 1 part in 10^8 ?
- 1.5.2** Given a vector $\mathbf{r}_{12} = \hat{\mathbf{x}}(x_1 - x_2) + \hat{\mathbf{y}}(y_1 - y_2) + \hat{\mathbf{z}}(z_1 - z_2)$, show that $\nabla_{\mathbf{r}_{12}}$ (gradient with respect to x_i , y_i , and z_i , of the magnitude r_{12}) is a unit vector in the direction of \mathbf{r}_{12} . Note that a central force and a potential may depend on r_{12} .

1.5.3 If a vector function \mathbf{F} depends on both space coordinates (x, y, z) and time t , show that

$$d\mathbf{F} = (d\mathbf{r} \cdot \nabla)\mathbf{F} + \frac{\partial \mathbf{F}}{\partial t} dt.$$

1.5.4 Show that $\nabla(uv) = \nabla u \cdot \nabla v$, where u and v are differentiable scalar functions of $x, y,$ and z (product rule).

- (a) Show that a necessary and sufficient condition that $u(x, y, z)$ and $v(x, y, z)$ are related by some function $f(u, v) = 0$ is that $(\nabla u) \times (\nabla v) = 0$. Describe this geometrically. If graphical software is available, plot a typical case.
- (b) If $u = u(x, y)$ and $v = v(x, y)$, show that the condition $(\nabla u) \times (\nabla v) = 0$ leads to the two-dimensional Jacobian

$$J = \begin{vmatrix} \frac{\partial u}{\partial x} & \frac{\partial u}{\partial y} \\ \frac{\partial v}{\partial x} & \frac{\partial v}{\partial y} \end{vmatrix} = \frac{\partial u}{\partial x} \frac{\partial v}{\partial y} - \frac{\partial u}{\partial y} \frac{\partial v}{\partial x} = 0.$$

The functions u and v are assumed differentiable.

1.6 Divergence, ∇

In Section 1.5, ∇ was defined as a vector operator. Now, paying careful attention to both its vector and its differential properties, we let it operate on a vector. First, as a vector we dot it into a second vector to obtain

$$\nabla \cdot \mathbf{V} = \frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} + \frac{\partial V_z}{\partial z}, \tag{1.71}$$

known as the divergence of \mathbf{V} , which we expect to be a scalar.

EXAMPLE 1.6.1

Divergence of a Central Force Field From Eq. (1.71) we obtain for the coordinate vector with radial outward flow

$$\nabla \cdot \mathbf{r} = \frac{\partial x}{\partial x} + \frac{\partial y}{\partial y} + \frac{\partial z}{\partial z} = 3. \tag{1.72}$$

Because the gravitational (or electric) force of a mass (or charge) at the origin is proportional to \mathbf{r} with a radial $1/r^3$ dependence, we also consider the more general and important case of the divergence of a central force field

$$\begin{aligned} \nabla \cdot \mathbf{r} f(r) &= \frac{\partial}{\partial x} [x f(r)] + \frac{\partial}{\partial y} [y f(r)] + \frac{\partial}{\partial z} [z f(r)] \\ &= f(r) \nabla \cdot \mathbf{r} + x \frac{\partial f}{\partial x} + y \frac{\partial f}{\partial y} + z \frac{\partial f}{\partial z} = 3f(r) + r \frac{df}{dr} \\ &= 3f(r) + \frac{x^2 df}{r dr} + \frac{y^2 df}{r dr} + \frac{z^2 df}{r dr} = 3f(r) + r \frac{df}{dr}. \end{aligned} \tag{1.73}$$

using the product and chain rules of differentiation in conjunction with Example 1.5.5 and Eq. (1.71). In particular, if $f(r) = r^{n-1}$,

$$\nabla \cdot \mathbf{r}r^{n-1} = \nabla \cdot (\mathbf{r}r^n) = 3r^{n-1} + (n-1)r^{n-1} = (n+2)r^{n-1}. \quad (1.74)$$

This divergence vanishes for $n = -2$, except at $r = 0$ (where \mathbf{r}/r^2 is singular). This is relevant for the Coulomb potential

$$V(r) = A = \frac{q}{4\pi\epsilon_0 r}$$

with the electric field

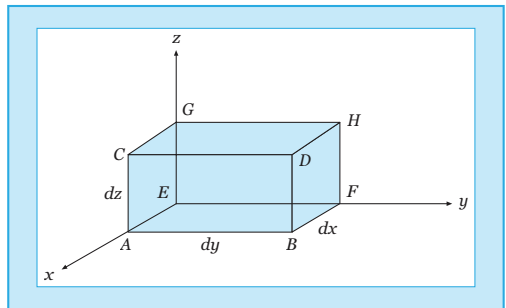
$$\mathbf{E} = -\nabla V = \frac{q\mathbf{r}}{4\pi\epsilon_0 r^2}.$$

Using Eq. (1.74) we obtain the divergence $\nabla \cdot \mathbf{E} = 0$ (except at $r = 0$, where the derivatives are undefined). ■

A Physical Interpretation

To develop an understanding of the physical significance of the divergence, consider $\nabla(\rho\mathbf{v})$, with $\mathbf{v}(x, y, z)$, the velocity of a compressible fluid, and $\rho(x, y, z)$, its density at point (x, y, z) . If we consider a small volume $dx dy dz$ (Fig. 1.25), the fluid flowing into this volume per unit time (positive x -direction) through the face $EFGH$ is (rate of flow in) $_{EFGH} = \rho v_x|_{x+dx} dy dz$. The components of the flow ρv_y and ρv_z tangential to this face contribute nothing to the flow through this face. The rate of flow out (still positive x -direction) through face $ABCD$ is $\rho v_x|_{x-dx} dy dz$. To compare these flows and to find the net flow out, we add the change of ρv_x in the x -direction for an increment dx that

Figure 1.25
Differential Rectangular Parallelepiped (in the First or Positive Octant)



is given by its partial derivative (i.e., expand this last result in a Maclaurin series).⁸ This yields

$$\begin{aligned} \text{(rate of flow out)}_{ABCD} &= \rho v_x|_{x=dx} dydz \\ &= \rho v_x + \frac{\partial}{\partial x} (\rho v_x) dx \int_{x=0}^{\Sigma} dydz. \end{aligned}$$

Here, the derivative term is a first correction term allowing for the possibility of nonuniform density or velocity or both.⁹ The zero-order term $\rho v_x|_{x=0}$ (corresponding to uniform flow) cancels out:

$$\text{Net rate of flow out}|_x = \frac{\partial}{\partial x} (\rho v_x) dx dy dz.$$

Equivalently, we can arrive at this result by

$$\lim_{\psi \rightarrow 0} \frac{\rho v_x(\psi, 0, 0) - \rho v_x(0, 0, 0)}{\psi} = \frac{\partial [\rho v_x(x, y, z)]}{\partial x} \Big|_{(0,0,0)}$$

Now the x -axis is not entitled to any preferred treatment. The preceding result for the two faces perpendicular to the x -axis must hold for the two faces perpendicular to the y -axis, with x replaced by y and the corresponding changes for y and z : $y \rightarrow z, z \rightarrow x$. This is a cyclic permutation of the coordinates. A further cyclic permutation yields the result for the remaining two faces of our parallelepiped. Adding the net rate of flow out for all three pairs of surfaces of our volume element, we have

$$\begin{aligned} \text{Net flow out} &= \sum \frac{\partial}{\partial x} (\rho v_x) + \frac{\partial}{\partial y} (\rho v_y) + \frac{\partial}{\partial z} (\rho v_z) dx dy dz \\ \text{(per unit time)} &= \nabla \cdot (\rho \mathbf{v}) dx dy dz. \end{aligned} \tag{1.75}$$

Therefore, the net flow of our compressible fluid out of the volume element $dx dy dz$ per unit volume per unit time is $\nabla \cdot (\rho \mathbf{v})$. Hence the name **divergence**. A direct application is in the **continuity equation**

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0, \tag{1.76}$$

which states that a net flow out of the volume results in a decreased density inside the volume. Note that in Eq. (1.76), ρ is considered to be a possible function of time as well as of space: $\rho(x, y, z, t)$. The divergence appears in a wide variety of physical problems, ranging from a probability current density in quantum mechanics to neutron leakage in a nuclear reactor.

⁸A Maclaurin expansion for a single variable is given by Eq. (5.75) in Section 5.6. Here, we have the increment x of Eq. (5.75) replaced by dx . We show a partial derivative with respect to x because ρv_x may also depend on y and z .

⁹Strictly speaking, ρv_x is averaged over face $EFGH$ and the expression $\rho v_x (\partial/\partial x)(\rho v_x) dx$ is similarly averaged over face $ABCD$. Using an arbitrarily small differential volume, we find that the averages reduce to the values employed here.

The combination $\nabla \cdot (f\mathbf{V})$, in which f is a scalar function and \mathbf{V} a vector function, may be written as

$$\begin{aligned}\nabla \cdot (f\mathbf{V}) &= \frac{\partial}{\partial x}(fV_x) + \frac{\partial}{\partial y}(fV_y) + \frac{\partial}{\partial z}(fV_z) \\ &= \frac{\partial f}{\partial x}V_x + f\frac{\partial V_x}{\partial x} + \frac{\partial f}{\partial y}V_y + f\frac{\partial V_y}{\partial y} + \frac{\partial f}{\partial z}V_z + f\frac{\partial V_z}{\partial z} \\ &= (\nabla f) \cdot \mathbf{V} + f\nabla \cdot \mathbf{V},\end{aligned}\quad (1.77)$$

which is what we would expect for the derivative of a product. Notice that ∇ as a differential operator differentiates both f and \mathbf{V} ; as a vector it is dotted into \mathbf{V} (in each term).

SUMMARY

The divergence of a vector field is constructed as the dot product of the gradient with the vector field, and it locally measures its spatial outflow. In this sense, the continuity equation captures the essence of the divergence: the temporal change of the density balances the spatial outflow of the current density.

EXERCISES

1.6.1 For a particle moving in a circular orbit $\mathbf{r} = \hat{x}r \cos \omega t + \hat{y}r \sin \omega t$,

- (a) evaluate $\mathbf{r} \times \dot{\mathbf{r}}$
 (b) Show that $\mathbf{r} \times \ddot{\mathbf{r}} = \mathbf{0}$.

The radius r and the angular velocity ω are constant.

$$\text{ANS. (a) } \dot{\omega}r^2. \quad \text{Note: } \dot{\mathbf{r}} = d\mathbf{r}/dt, \ddot{\mathbf{r}} = d^2\mathbf{r}/dt^2.$$

1.6.2 Show, by differentiating components, that

- (a) $\frac{d}{dt}(\mathbf{A} \cdot \mathbf{B}) = \frac{d\mathbf{A}}{dt} \cdot \mathbf{B} + \mathbf{A} \cdot \frac{d\mathbf{B}}{dt}$
 (b) $\frac{d}{dt}(\mathbf{A} \times \mathbf{B}) = \frac{d\mathbf{A}}{dt} \times \mathbf{B} + \mathbf{A} \times \frac{d\mathbf{B}}{dt}$,
 in the same way as the derivative of the product of two scalar functions.

1.7 Curl, $\nabla \times$

Another possible application of the vector ∇ is to cross it into a vector field called its curl, which we discuss in this section along with its physical interpretation and applications. We obtain

$$\begin{aligned}\nabla \times \mathbf{V} &= \hat{x} \left(\frac{\partial V_z}{\partial y} - \frac{\partial V_y}{\partial z} \right) + \hat{y} \left(\frac{\partial V_x}{\partial z} - \frac{\partial V_z}{\partial x} \right) + \hat{z} \left(\frac{\partial V_y}{\partial x} - \frac{\partial V_x}{\partial y} \right) \\ &= \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ V_x & V_y & V_z \end{vmatrix},\end{aligned}\quad (1.78)$$

which is called the **curl** of \mathbf{V} . In expanding this determinant we must consider the derivative nature of ∇ . Specifically, $\nabla \nabla$ is meaningless unless it acts on a function or a vector. Then it is certainly not equal, in general, to $-\nabla \times \nabla$.¹⁰ In the case of Eq. (1.78), the determinant must be expanded **from the top down** so that we get the derivatives as shown in the middle of Eq. (1.78). If ∇ is crossed into the product of a scalar and a vector, we can show

$$\begin{aligned} \nabla \times (f\mathbf{V})|_x &= \sum \frac{\partial}{\partial y} (fV_z) - \sum \frac{\partial}{\partial z} (fV_y) \\ &= f \frac{\partial V_z}{\partial y} + \frac{\partial f}{\partial y} V_z - f \frac{\partial V_y}{\partial z} - \frac{\partial f}{\partial z} V_y \\ &= f \nabla \times \mathbf{V}|_x + (\nabla f) \times \mathbf{V}|_x. \end{aligned} \quad (1.79)$$

If we permute the coordinates $x \rightarrow y, y \rightarrow z, z \rightarrow x$ to pick up the y -component and then permute them a second time to pick up the z -component,

$$\nabla \times (f\mathbf{V}) = f \nabla \times \mathbf{V} + (\nabla f) \times \mathbf{V}, \quad (1.80)$$

which is the vector product analog of Eq. (1.77). Again, as a differential operator, ∇ differentiates both f and \mathbf{V} . As a vector, it is crossed into \mathbf{V} (in each term).

EXAMPLE 1.7.1

Vector Potential of a Constant B Field From electrodynamics we know that $\nabla \cdot \mathbf{B} = 0$, which has the general solution $\mathbf{B} = \nabla \times \mathbf{A}$, where $\mathbf{A}(\mathbf{r})$ is called the vector potential (of the magnetic induction) because $\nabla \cdot (\nabla \times \mathbf{A}) = (\nabla \times \nabla) \cdot \mathbf{A} = 0$ as a triple scalar product with two identical vectors. This last identity will not change if we add the gradient of some scalar function to the vector potential, which is therefore not unique.

In our case, we want to show that a vector potential is $\mathbf{A} = \frac{1}{2}(\mathbf{B} \times \mathbf{r})$.

Using the *BAC-CAB* rule in conjunction with Eq. (1.72), we find that

$$2\nabla \times \mathbf{A} = \nabla \times (\mathbf{B} \times \mathbf{r}) = (\nabla \cdot \mathbf{r})\mathbf{B} - (\mathbf{B} \cdot \nabla)\mathbf{r} = 3\mathbf{B} - \mathbf{B} = 2\mathbf{B},$$

where we indicate by the ordering of the scalar product of the second term that the gradient still acts on the coordinate vector. ■

EXAMPLE 1.7.2

Curl of a Central Force As in Example 1.6.1, let us start with the curl of the coordinate vector

$$\nabla \times \mathbf{r} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x & y & z \end{vmatrix} = \mathbf{0}. \quad (1.81)$$

¹⁰Note that for the quantum mechanical angular momentum operator, $\mathbf{L} = -i(\mathbf{r} \times \nabla)$, we find that $\mathbf{L} \times \mathbf{L} = i\mathbf{L}$. See Sections 4.3 and 4.4 for more details.

Algebraically, this comes about because each Cartesian coordinate is independent of the other two.

Now we are ready to calculate the curl of a central force $\mathbf{F} = -\nabla f(r)$, where we expect zero for the same reason. By Eq. (1.80),

$$\nabla \times \mathbf{r}f(r) = f(r)\nabla \times \mathbf{r} + [\nabla f(r)] \times \mathbf{r}. \quad (1.82)$$

Second, using $\nabla f(r) = \hat{\mathbf{r}}(df/dr)$ (Example 1.5.5), we obtain

$$\nabla \times \mathbf{r}f(r) = \frac{df}{dr} \hat{\mathbf{r}} \times \mathbf{r} = 0. \quad (1.83)$$

This vector product vanishes because $\mathbf{r} = \hat{\mathbf{r}}r$ and $\hat{\mathbf{r}} \times \hat{\mathbf{r}} = 0$.

This central force case is important in potential theory of classical mechanics and engineering (see Section 1.12). ■

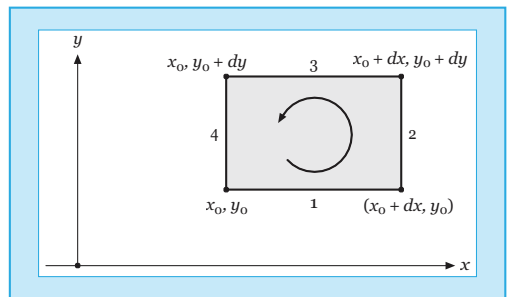
To develop a better understanding of the physical significance of the curl, we consider the circulation of fluid around a differential loop in the xy -plane (Fig. 1.26).

Although the circulation is technically given by a vector line integral $\oint \mathbf{V} \cdot d\boldsymbol{\lambda}$, we can set up the equivalent scalar integrals here. Let us take the circulation to be

$$\begin{aligned} \text{Circulation}_{1234} &= \int_1^2 V_x(x, y) d\lambda_x + \int_2^3 V_y(x, y) d\lambda_y \\ &+ \int_3^4 V_x(x, y) d\lambda_x + \int_4^1 V_y(x, y) d\lambda_y. \end{aligned} \quad (1.84)$$

The numbers 1–4 refer to the numbered line segments in Fig. 1.26. In the first integral $d\lambda_x = +dx$ but in the third integral $d\lambda_x = -dx$ because the third line segment is traversed in the negative x -direction. Similarly, $d\lambda_y = +dy$ for the

Figure 1.26
Circulation Around
a Differential Loop



second integral and $-dy$ for the fourth. Next, the integrands are referred to the point (x_0, y_0) with a Taylor expansion,¹¹ taking into account the displacement of line segment 3 from 1 and 2 from 4. For our differential line segments, this leads to

$$\begin{aligned} \text{Circulation}_{1234} &= \int_{\Sigma} V_x(x_0, y_0) dx + \int_{\Sigma} V_y(x_0, y_0) + \frac{\partial V_y}{\partial x} dx dy \\ &\quad + \int_{\Sigma} V_x(x_0, y_0) + \frac{\partial V_x}{\partial y} dy (-dx) + \int_{\Sigma} V_y(x_0, y_0) (-dy) \\ &= \int_{\Sigma} \left(\frac{\partial V_y}{\partial x} - \frac{\partial V_x}{\partial y} \right) dx dy. \end{aligned} \quad (1.85)$$

Dividing by $dxdy$, we have

$$\text{Circulation per unit area} = \nabla \times \mathbf{V}|_z. \quad (1.86)$$

This is an infinitesimal case of Stokes's theorem in Section 1.11. The circulation¹² about our differential area in the xy -plane is given by the z -component of $\nabla \times \mathbf{V}$. In principle, the curl $\nabla \times \mathbf{V}$ at (x_0, y_0) could be determined by inserting a (differential) paddle wheel into the moving fluid at point (x_0, y_0) . The rotation of the little paddle wheel would be a measure of the curl and its axis along the direction of $\nabla \times \mathbf{V}$, which is perpendicular to the plane of circulation.

In light of this connection of the curl with the concept of circulation, we now understand intuitively the vanishing curl of a central force in Example 1.7.2 because \mathbf{r} flows radially outward from the origin with no rotation, and any scalar $f(r)$ will not affect this situation. When

$$\nabla \times \mathbf{V} = \mathbf{0}, \quad (1.87)$$

\mathbf{V} is labeled **irrotational**. The most important physical examples of irrotational vectors are the gravitational and electrostatic forces. In each case,

$$\mathbf{V} = C \frac{\mathbf{r}}{r^2} = C \frac{\mathbf{r}}{r^3}, \quad (1.88)$$

where C is a constant and \mathbf{r} is the unit vector in the outward radial direction. For the gravitational case, we have $C = -Gm_1m_2$, given by Newton's law of universal gravitation. If $C = q_1q_2/(4\pi\epsilon_0)$, we have Coulomb's law of electrostatics (SI units). The force \mathbf{V} given in Eq. (1.88) may be shown to be irrotational by direct expansion into Cartesian components as we did in Example 1.7.2 [Eq. (1.83)].

In Section 1.15 of Arfken and Weber's *Mathematical Methods for Physicists* (5th ed.), it is shown that a vector field may be resolved into an irrotational part and a solenoidal part (subject to conditions at infinity).

¹¹ $V_y(x_0 + dx, y_0) = V_y(x_0, y_0) + \left(\frac{\partial V_y}{\partial x}\right)_{x_0} dx + \dots$. The higher order terms will drop out in the limit as $dx \rightarrow 0$.

¹²In fluid dynamics, $\nabla \times \mathbf{V}$ is called the vorticity.

For waves in an elastic medium, if the displacement \mathbf{u} is irrotational, $\nabla \times \mathbf{u} = 0$, plane waves (or spherical waves at large distances) become longitudinal. If \mathbf{u} is solenoidal, $\nabla \cdot \mathbf{u} = 0$, then the waves become transverse. A seismic disturbance will produce a displacement that may be resolved into a solenoidal part and an irrotational part. The irrotational part yields the longitudinal P (primary) earthquake waves. The solenoidal part gives rise to the slower transverse S (secondary) waves.

Using the gradient, divergence, curl, and the $BAC-CAB$ rule, we may construct or verify a large number of useful vector identities. For verification, complete expansion into Cartesian components is always a possibility. Sometimes if we use insight instead of routine shuffling of Cartesian components, the verification process can be shortened drastically.

Remember that ∇ is a vector operator, a hybrid object satisfying two sets of rules: vector rules and partial differentiation rules, including differentiation of a product.

EXAMPLE 1.7.3

Gradient of a Dot Product Verify that

$$\nabla(\mathbf{A} \cdot \mathbf{B}) = (\mathbf{B} \cdot \nabla)\mathbf{A} + (\mathbf{A} \cdot \nabla)\mathbf{B} + \mathbf{B} \times (\nabla \times \mathbf{A}) + \mathbf{A} \times (\nabla \times \mathbf{B}). \quad (1.89)$$

This particular example hinges on the recognition that $\nabla(\mathbf{A} \cdot \mathbf{B})$ is the type of term that appears in the $BAC-CAB$ expansion of a triple vector product [Eq. (1.52)]. For instance,

$$\mathbf{A} \times (\nabla \times \mathbf{B}) = \nabla(\mathbf{A} \cdot \mathbf{B}) - (\mathbf{A} \cdot \nabla)\mathbf{B},$$

with the ∇ differentiating only \mathbf{B} , not \mathbf{A} . From the commutativity of factors in a scalar product we may interchange \mathbf{A} and \mathbf{B} and write

$$\mathbf{B} \times (\nabla \times \mathbf{A}) = \nabla(\mathbf{A} \cdot \mathbf{B}) - (\mathbf{B} \cdot \nabla)\mathbf{A},$$

now with ∇ differentiating only \mathbf{A} , not \mathbf{B} . Adding these two equations, we obtain ∇ differentiating the product $\mathbf{A} \cdot \mathbf{B}$ and the identity [Eq. (1.89)]. This identity is used frequently in electromagnetic theory. Exercise 1.7.9 is an illustration. ■

SUMMARY

The curl is constructed as the cross product of the gradient and a vector field, and it measures the local rotational flow or circulation of the vector field. When the curl of a force field is zero, then the force is labeled conservative and derives from the gradient of a scalar, its potential. In Chapter 6, we shall see that an analytic function of a complex variable describes a two-dimensional irrotational fluid flow.

EXERCISES

- 1.7.1** Show that $\mathbf{u} \times \mathbf{v}$ is solenoidal if \mathbf{u} and \mathbf{v} are each irrotational. Start by formulating the problem in terms of mathematical equations.
- 1.7.2** If \mathbf{A} is irrotational, show that $\mathbf{A} \times \mathbf{r}$ is solenoidal.

1.7.3 A rigid body is rotating with constant angular velocity $\boldsymbol{\omega}$. Show that the linear velocity \mathbf{v} is solenoidal.

1.7.4 If a vector function $\mathbf{f}(x, y, z)$ is not irrotational but the product of f and a scalar function $g(x, y, z)$ is irrotational, show that

$$\mathbf{f} \cdot \nabla \times \mathbf{f} = 0.$$

1.7.5 Verify the vector identity

$$\nabla \times (\mathbf{A} \times \mathbf{B}) = (\mathbf{B} \cdot \nabla)\mathbf{A} - (\mathbf{A} \cdot \nabla)\mathbf{B} - \mathbf{B}(\nabla \cdot \mathbf{A}) + \mathbf{A}(\nabla \cdot \mathbf{B}).$$

Describe in words what causes the last two terms to appear in the identity beyond the $BAC-CAB$ rule. If symbolic software is available, test the Cartesian components for a typical case, such as $\mathbf{A} = \mathbf{L}$, $\mathbf{B} = \mathbf{r}/r^3$.

1.7.6 As an alternative to the vector identity of Example 1.7.5, show that

$$\nabla(\mathbf{A} \cdot \mathbf{B}) = (\mathbf{A} \times \nabla) \times \mathbf{B} + (\mathbf{B} \times \nabla) \times \mathbf{A} + \mathbf{A}(\nabla \cdot \mathbf{B}) + \mathbf{B}(\nabla \cdot \mathbf{A}).$$

1.7.7 Verify the identity

$$\mathbf{A} \times (\nabla \times \mathbf{A}) = \frac{1}{2} \nabla(A^2) - (\mathbf{A} \cdot \nabla)\mathbf{A}.$$

Test this identity for a typical vector field, such as $\mathbf{A} \sim \mathbf{r}$ or \mathbf{r}/r^3 .

1.7.8 If \mathbf{A} and \mathbf{B} are constant vectors, show that

$$\nabla(\mathbf{A} \cdot \mathbf{B} \times \mathbf{r}) = \mathbf{A} \times \mathbf{B}.$$

1.7.9 A distribution of electric currents creates a constant magnetic moment \mathbf{m} . The force on \mathbf{m} in an external magnetic induction \mathbf{B} is given by

$$\mathbf{F} = \nabla \times (\mathbf{B} \times \mathbf{m}).$$

Show that

$$\mathbf{F} = \nabla(\mathbf{m} \cdot \mathbf{B}).$$

Note. Assuming no time dependence of the fields, Maxwell's equations yield $\nabla \times \mathbf{B} = 0$. Also, $\nabla \cdot \mathbf{B} = 0$.

1.7.10 An electric dipole of moment \mathbf{p} is located at the origin. The dipole creates an electric potential at \mathbf{r} given by

$$\psi(\mathbf{r}) = \frac{\mathbf{p} \cdot \mathbf{r}}{4\pi\epsilon_0 r^3}.$$

Find the electric field $\mathbf{E} = -\nabla\psi$ at \mathbf{r} .

1.7.11 The vector potential \mathbf{A} of a magnetic dipole, dipole moment \mathbf{m} , is given by $\mathbf{A}(\mathbf{r}) = (\mu_0/4\pi)(\mathbf{m} \times \mathbf{r}/r^3)$. Show that the magnetic induction $\mathbf{B} = \nabla \times \mathbf{A}$ is given by

$$\mathbf{B} = \frac{\mu_0}{4} \frac{3\hat{\mathbf{r}}(\hat{\mathbf{r}} \cdot \mathbf{m}) - \mathbf{m}}{r^3}.$$

- 1.7.12** Classically, orbital angular momentum is given by $\mathbf{L} = \mathbf{r} \times \mathbf{p}$, where \mathbf{p} is the linear momentum. To go from classical mechanics to quantum mechanics, replace \mathbf{p} by the operator $-i\hbar\nabla$ (Section 14.6). Show that the quantum mechanical angular momentum operator has Cartesian components

$$L_x = -i\hbar \left(y \frac{\partial}{\partial z} - z \frac{\partial}{\partial y} \right)$$

$$L_y = -i\hbar \left(z \frac{\partial}{\partial x} - x \frac{\partial}{\partial z} \right)$$

$$L_z = -i\hbar \left(x \frac{\partial}{\partial y} - y \frac{\partial}{\partial x} \right)$$

(in units of \hbar).

- 1.7.13** Using the angular momentum operators previously given, show that they satisfy commutation relations of the form

$$[L_x, L_y] = i\hbar L_z$$

and, hence,

$$\mathbf{L} \times \mathbf{L} = i\hbar \mathbf{L}.$$

These commutation relations will be taken later as the defining relations of an angular momentum operator—see Exercise 3.2.15 and the following one and Chapter 4.

- 1.7.14** With the commutator bracket notation $[L_x, L_y] = i\hbar L_z$, the angular momentum vector \mathbf{L} satisfies $[L_x, L_y] = i\hbar L_z$, etc., or $\mathbf{L} \times \mathbf{L} = i\hbar \mathbf{L}$. If two other vectors \mathbf{a} and \mathbf{b} commute with each other and with \mathbf{L} , that is, $[\mathbf{a}, \mathbf{b}] = [\mathbf{a}, \mathbf{L}] = [\mathbf{b}, \mathbf{L}] = \mathbf{0}$, show that

$$[\mathbf{a} \cdot \mathbf{L}, \mathbf{b} \cdot \mathbf{L}] = i\hbar (\mathbf{a} \times \mathbf{b}) \cdot \mathbf{L}.$$

This vector version of the angular momentum commutation relations is an alternative to that given in Exercise 1.7.13.

- 1.7.15** Prove $\nabla \cdot (\mathbf{a} \times \mathbf{b}) = \mathbf{b} \cdot (\nabla \times \mathbf{a}) - \mathbf{a} \cdot (\nabla \times \mathbf{b})$. Explain in words why the identity is valid.

Hint. Treat as a triple scalar product.

1.8 Successive Applications of ∇

We have now defined gradient, divergence, and curl to obtain vector, scalar, and vector quantities, respectively. Letting ∇ operate on each of these quantities, we obtain

$$(a) \nabla \cdot \nabla \phi \quad (b) \nabla \times \nabla \phi \quad (c) \nabla \nabla \cdot \mathbf{V}$$

$$(d) \nabla \cdot \nabla \times \mathbf{V} \quad (e) \nabla \times (\nabla \times \mathbf{V}).$$

All five expressions involve second derivatives and all five appear in the second-order differential equations of mathematical physics, particularly in electro-magnetic theory.

The first expression, $\nabla \cdot \nabla \phi$, the divergence of the gradient, is called the Laplacian of ϕ . We have

$$\begin{aligned} \nabla \cdot \nabla \phi &= \frac{\partial}{\partial x} \left(\frac{\partial \phi}{\partial x} \right) + \frac{\partial}{\partial y} \left(\frac{\partial \phi}{\partial y} \right) + \frac{\partial}{\partial z} \left(\frac{\partial \phi}{\partial z} \right) \\ &= \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} + \frac{\partial^2 \phi}{\partial z^2} \end{aligned} \quad (1.90)$$

When ϕ is the electrostatic potential, in a charge-free region we have

$$\nabla \cdot \nabla \phi = 0, \quad (1.91)$$

which is Laplace's equation of electrostatics. Often, the combination $\nabla \cdot \nabla$ is written ∇^2 , or Ψ in the European literature.

Biographical Data

Laplace, Pierre Simon. Laplace, a French mathematician, physicist, and astronomer, was born in Beaumont-en-Auge in 1749 and died in Paris in 1827. He developed perturbation theory for the solar system, published a monumental treatise *Celestial Mechanics*, and applied mathematics to artillery. He made contributions of fundamental importance to hydrodynamics, differential equations and probability, the propagation of sound, and surface tension in liquids. To Napoleon's remark missing "God" in his treatise, he replied "I had no need for that hypothesis." He generally disliked giving credit to others.

EXAMPLE 1.8.1

Laplacian of a Radial Function Calculate $\nabla \cdot \nabla g(r)$. Referring to Examples 1.5.5 and 1.6.1,

$$\nabla \cdot \nabla g(r) = \nabla \cdot \mathbf{r} \frac{dg}{dr} = \frac{2}{r} \frac{dg}{dr} + \frac{d^2g}{dr^2}$$

replacing $f(r)$ in Example 1.6.1 by $1/r \cdot dg/dr$. If $g(r) = r^n$, this reduces to

$$\nabla \cdot \nabla r^n = n(n+1)r^{n-2}.$$

This vanishes for $n = 0$ [$g(r) = \text{constant}$] and for $n = -1$; that is, $g(r) = 1/r$ is a solution of Laplace's equation $\nabla^2 g(r) = 0$. This is for $r \neq 0$. At the origin there is a singularity. ■

Expression (b) may be written as

$$\nabla \times \nabla \phi = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ \frac{\partial \phi}{\partial x} & \frac{\partial \phi}{\partial y} & \frac{\partial \phi}{\partial z} \end{vmatrix}$$

By expanding the determinant, we obtain

$$\nabla \times \nabla \phi = \hat{x} \begin{vmatrix} \frac{\partial^2 \phi}{\partial y^2} & \frac{\partial^2 \phi}{\partial z^2} \\ \frac{\partial^2 \phi}{\partial y \partial z} & \frac{\partial^2 \phi}{\partial z \partial y} \end{vmatrix} - \hat{y} \begin{vmatrix} \frac{\partial^2 \phi}{\partial x^2} & \frac{\partial^2 \phi}{\partial z^2} \\ \frac{\partial^2 \phi}{\partial x \partial z} & \frac{\partial^2 \phi}{\partial z \partial x} \end{vmatrix} + \hat{z} \begin{vmatrix} \frac{\partial^2 \phi}{\partial x^2} & \frac{\partial^2 \phi}{\partial y^2} \\ \frac{\partial^2 \phi}{\partial x \partial y} & \frac{\partial^2 \phi}{\partial y \partial x} \end{vmatrix} = 0, \tag{1.92}$$

assuming that the order of partial differentiation may be interchanged. This is true as long as these second partial derivatives of ϕ are continuous functions. Then, from Eq. (1.92), the curl of a gradient is identically zero. All gradients, therefore, are irrotational. Note that the zero in Eq. (1.92) comes as a mathematical identity, independent of any physics. The zero in Eq. (1.91) is a consequence of physics.

Expression (d) is a triple scalar product that may be written as

$$\nabla \cdot \nabla \times \mathbf{V} = \begin{vmatrix} \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ V_x & V_y & V_z \end{vmatrix} = 0. \tag{1.93}$$

Again, assuming continuity so that the order of differentiation is immaterial, we obtain

$$\nabla \cdot \nabla \times \mathbf{V} = 0. \tag{1.94}$$

The divergence of a curl vanishes or all curls are solenoidal.

One of the most important cases of a vanishing divergence of a vector is

$$\nabla \cdot \mathbf{B} = 0, \tag{1.95}$$

where \mathbf{B} is the magnetic induction, and Eq. (1.95) appears as one of Maxwell's equations. When a vector is solenoidal, it may be written as the curl of another vector known as its vector potential, $\mathbf{B} = \nabla \times \mathbf{A}$. This form solves one of the four vector equations that make up Maxwell's field equations of electrodynamics. Because a vector field may be determined from its curl and divergence (Helmholtz's theorem), solving Maxwell's (often called Oersted's) equation involving the curl of \mathbf{B} determines \mathbf{A} and thereby \mathbf{B} . Similar considerations apply to the other pair of Maxwell's equations involving the divergence and curl of \mathbf{E} and make plausible the fact that there are precisely four vector equations as part of Maxwell's equations.

The two remaining expressions satisfy a relation

$$\nabla \times (\nabla \times \mathbf{V}) = \nabla (\nabla \cdot \mathbf{V}) - (\nabla \cdot \nabla) \mathbf{V}. \tag{1.96}$$

This decomposition of the Laplacian $\nabla \cdot \nabla$ into a longitudinal part (the gradient) and a transverse part (the curl term) follows from Eq. (1.52), the *BAC-CAB* rule, which we rewrite so that \mathbf{C} appears at the extreme right of each term. The term $(\nabla \cdot \nabla) \mathbf{V}$ was not included in our list, but it appears in the Navier-Stokes's equation and may be **defined** by Eq. (1.96). In words, this is the Laplacian (a scalar operator) acting on a vector, so it is a vector with three components in three-dimensional space. ■

EXAMPLE 1.8.2

Electromagnetic Wave Equations One important application of this vector relation [Eq. (1.96)] is in the derivation of the electromagnetic wave equation. In vacuum Maxwell's equations become

$$\nabla \cdot \mathbf{B} = 0, \quad (1.97a)$$

$$\nabla \cdot \mathbf{E} = 0, \quad (1.97b)$$

$$\nabla \times \mathbf{B} = \epsilon_0 \mu_0 \frac{\partial \mathbf{E}}{\partial t} = \frac{1}{c^2} \frac{\partial \mathbf{E}}{\partial t}, \quad (1.97c)$$

$$\nabla \times \mathbf{E} = - \frac{\partial \mathbf{B}}{\partial t}, \quad (1.97d)$$

where \mathbf{E} is the electric field, \mathbf{B} the magnetic induction, ϵ_0 the electric permittivity, and μ_0 the magnetic permeability (SI units), so that $\epsilon_0 \mu_0 = 1/c^2$, where c is the velocity of light. This relation has important consequences. Because ϵ_0 , μ_0 can be measured in any frame, the velocity of light is the same in any frame.

Suppose we eliminate \mathbf{B} from Eqs. (1.97c) and (1.97d). We may do this by taking the curl of both sides of Eq. (1.97d) and the time derivative of both sides of Eq. (1.97c). Since the space and time derivatives commute,

$$\frac{\partial}{\partial t} \nabla \times \mathbf{B} = \nabla \times \frac{\partial \mathbf{B}}{\partial t},$$

and we obtain

$$\nabla \times (\nabla \times \mathbf{E}) = - \frac{1}{c^2} \frac{\partial^2 \mathbf{E}}{\partial t^2}.$$

Application of Eqs. (1.96) and (1.97b) yields

$$(\nabla \cdot \nabla) \mathbf{E} = \frac{1}{c^2} \frac{\partial^2 \mathbf{E}}{\partial t^2}, \quad (1.98)$$

the electromagnetic vector wave equation. Again, if \mathbf{E} is expressed in Cartesian coordinates, Eq. (1.98) separates into three scalar wave equations, each involving a scalar Laplacian.

When external electric charge and current densities are kept as driving terms in Maxwell's equations, similar wave equations are valid for the electric potential and the vector potential. To show this, we solve Eq. (1.97a) by writing $\mathbf{B} = \nabla \times \mathbf{A}$ as a curl of the vector potential. This expression is substituted into Faraday's induction law in differential form [Eq. (1.97d)] to yield $\nabla \times (\mathbf{E} - \frac{\partial \mathbf{A}}{\partial t}) = 0$. The vanishing curl implies that $\mathbf{E} - \frac{\partial \mathbf{A}}{\partial t}$ is a gradient and therefore can be written as $-\nabla \phi$ where $\phi(\mathbf{r}, t)$ is defined as the (nonstatic) electric potential. These results

$$\mathbf{B} = \nabla \times \mathbf{A}, \quad \mathbf{E} = -\nabla \phi - \frac{\partial \mathbf{A}}{\partial t} \quad (1.99)$$

for the \mathbf{B} and \mathbf{E} fields solve the homogeneous Maxwell's equations.

We now show that the inhomogeneous Maxwell's equations,

$$\begin{aligned} \text{Gauss's law: } \nabla \cdot \mathbf{E} &= \rho/\epsilon_0; \\ \text{Oersted's law: } \nabla \times \mathbf{B} - \frac{1}{c^2} \frac{\partial \mathbf{E}}{\partial t} &= \mu_0 \mathbf{J} \end{aligned} \quad (1.100)$$

in differential form lead to wave equations for the potentials ϕ and \mathbf{A} , provided that $\nabla \cdot \mathbf{A}$ is determined by the constraint $\frac{1}{c^2} \frac{\partial \phi}{\partial t} + \nabla \cdot \mathbf{A} = 0$. This choice of fixing the divergence of the vector potential is called the **Lorentz gauge** and serves to uncouple the partial differential equations of both potentials. This gauge constraint is not a restriction; it has no physical effect.

Substituting our electric field solution into Gauss's law yields

$$\frac{\rho}{\epsilon_0} = \nabla \cdot \mathbf{E} = -\nabla \cdot \nabla \phi - \frac{\partial}{\partial t} \nabla \cdot \mathbf{A} = -\nabla^2 \phi + \frac{1}{c^2} \frac{\partial^2 \phi}{\partial t^2},$$

the wave equation for the electric potential. In the last step, we used the Lorentz gauge to replace the divergence of the vector potential by the time derivative of the electric potential and thus decouple ϕ from \mathbf{A} .

Finally, we substitute $\mathbf{B} = \nabla \times \mathbf{A}$ into Oersted's law and use Eq. (1.96), which expands $\nabla \cdot (\nabla \times \mathbf{A})$ in terms of a longitudinal (the gradient term) and a transverse component (the curl term). This yields

$$\mu_0 \mathbf{J} + \frac{1}{c^2} \frac{\partial \mathbf{E}}{\partial t} = \nabla \times (\nabla \times \mathbf{A}) = \nabla (\nabla \cdot \mathbf{A}) - \nabla^2 \mathbf{A} = \mu_0 \mathbf{J} - \frac{1}{c^2} \nabla \frac{\partial \phi}{\partial t} + \frac{\partial^2 \mathbf{A}}{\partial t^2},$$

where we have used the electric field solution [Eq. (1.99)] in the last step. Now we see that the Lorentz gauge condition eliminates the gradient terms so that the wave equation

$$\frac{1}{c^2} \frac{\partial^2 \mathbf{A}}{\partial t^2} - \nabla^2 \mathbf{A} = \mu_0 \mathbf{J}$$

for the vector potential remains.

Finally, looking back at Oersted's law, taking the divergence of Eq. (1.100), dropping $\nabla \cdot (\nabla \times \mathbf{B}) = 0$ and substituting Gauss's law for $\nabla \cdot \mathbf{E} = \rho/\epsilon_0$, we find $\mu_0 \nabla \cdot \mathbf{J} = -\frac{1}{\epsilon_0 c^2} \frac{\partial \rho}{\partial t}$, where $\epsilon_0 \mu_0 = 1/c^2$, that is, the continuity equation for the current density. This step justifies the inclusion of Maxwell's displacement current in the generalization of Oersted's law to nonstationary situations. ■

EXERCISES

1.8.1 Verify Eq. (1.96)

$$\nabla \times (\nabla \times \mathbf{V}) = \nabla (\nabla \cdot \mathbf{V}) - (\nabla \cdot \nabla) \mathbf{V}$$

by direct expansion in Cartesian coordinates. If symbolic software is available, check the identity for typical fields, such as $\mathbf{V} = \mathbf{r}/r^3$, $\mathbf{a} = \mathbf{r}\mathbf{b}$, $\mathbf{a} \times \mathbf{r}$.

1.8.2 Show that the identity

$$\nabla \times (\nabla \times \mathbf{V}) = \nabla (\nabla \cdot \mathbf{V}) - (\nabla \cdot \nabla) \mathbf{V}$$

follows from the *BAC-CAB* rule for a triple vector product. Justify any alteration of the order of factors in the *BAC* and *CAB* terms.

1.8.3 Prove that $\nabla \times (\phi \nabla \phi) = 0$.

1.8.4 Prove that $\nabla(u) \times \nabla(v)$ is solenoidal, where u and v are differentiable scalar functions. Start by formulating the problem as a mathematical equation.

1.8.5 ϕ is a scalar satisfying Laplace's equation, $\nabla^2 \phi = 0$. Show that $\nabla \phi$ is **both** solenoidal and irrotational.

1.8.6 With ψ a scalar function, show that

$$(\mathbf{r} \times \nabla) \cdot (\mathbf{r} \times \nabla) \psi = r \nabla^2 \psi - r \frac{\partial^2 \psi}{\partial r^2} - 2r \frac{\partial \psi}{\partial r}.$$

(This can actually be shown more easily in spherical polar coordinates; see Section 2.5.)

1.8.7 In the Pauli theory of the electron one encounters the expression

$$(\mathbf{p} - e\mathbf{A}) \times (\mathbf{p} - e\mathbf{A})\psi,$$

where ψ is a scalar function. \mathbf{A} is the magnetic vector potential related to the magnetic induction \mathbf{B} by $\mathbf{B} = \nabla \times \mathbf{A}$. Given that $\mathbf{p} = -i\nabla$, show that this expression reduces to $ie\mathbf{B}\psi$. Show that this leads to the orbital g -factor $g_L = 1$ upon writing the magnetic moment as $\boldsymbol{\mu} = g_L \mathbf{L}$ in units of Bohr magnetons. See also Example 1.7.1.

1.8.8 Show that any solution of the equation

$$\nabla \times \nabla \times \mathbf{A} - k^2 \mathbf{A} = 0$$

automatically satisfies the vector Helmholtz equation

$$\nabla^2 \mathbf{A} + k^2 \mathbf{A} = 0$$

and the solenoidal condition

$$\nabla \cdot \mathbf{A} = 0.$$

Hint. Let $\nabla \cdot$ operate on the first equation.

1.9 Vector Integration

The next step after differentiating vectors is to integrate them. Let us start with line integrals and then proceed to surface and volume integrals. In each case, the method of attack will be to reduce the vector integral to one-dimensional integrals over a coordinate interval.

Line Integrals

Using an increment of length $d\mathbf{r} = \hat{x} dx + \hat{y} dy + \hat{z} dz$, we often encounter the line integral

$$\int_C \mathbf{V} \cdot d\mathbf{r}, \tag{1.101}$$

in which the integral is over some contour C that may be open (with starting point and ending point separated) or closed (forming a loop) instead of an interval of the x -axis. The Riemann integral is defined by subdividing the curve into ever smaller segments whose number grows indefinitely. The form [Eq. (1.101)] is exactly the same as that encountered when we calculate the work done by a force that varies along the path

$$W = \int \mathbf{F} \cdot d\mathbf{r} = \int F_x(x, y, z) dx + \int F_y(x, y, z) dy + \int F_z(x, y, z) dz, \tag{1.102}$$

that is, a sum of conventional integrals over intervals of one variable each. In this expression, \mathbf{F} is the force exerted on a particle. In general, such integrals depend on the path except for conservative forces, whose treatment we postpone to Section 1.12.

EXAMPLE 1.9.1

Path-Dependent Work The force exerted on a body is $\mathbf{F} = -\hat{x}y + \hat{y}x$. The problem is to calculate the work done going from the origin to the point (1, 1),

$$W = \int_{0,0}^{1,1} \mathbf{F} \cdot d\mathbf{r} = \int_{0,0}^{1,1} (-y dx + x dy). \tag{1.103}$$

Separating the two integrals, we obtain

$$W = - \int_0^1 y dx + \int_0^1 x dy. \tag{1.104}$$

The first integral cannot be evaluated until we specify the values of y as x ranges from 0 to 1. Likewise, the second integral requires x as a function of y . Consider first the path shown in Fig. 1.27. Then

$$W = - \int_0^1 0 dx + \int_0^1 1 dy = 1 \tag{1.105}$$

because $y = 0$ along the first segment of the path and $x = 1$ along the second. If we select the path [$x = 0, 0 \leq y \leq 1$] and [$0 \leq x \leq 1, y = 1$], then Eq. (1.103) gives $W = 1$. For this force, the work done depends on the choice of path. ■

EXAMPLE 1.9.2

Line Integral for Work Find the work done going around a unit circle clockwise from 0 to π shown in Fig. 1.28 in the xy -plane doing work against a force field given by

$$\mathbf{F} = \frac{-\hat{x}y}{x^2 + y^2} + \frac{\hat{y}x}{x^2 + y^2}.$$

Figure 1.27

A Path of Integration

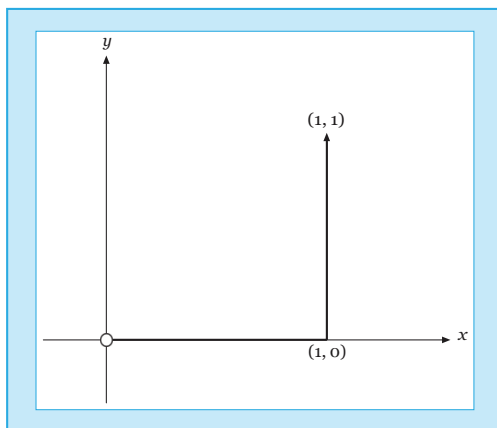
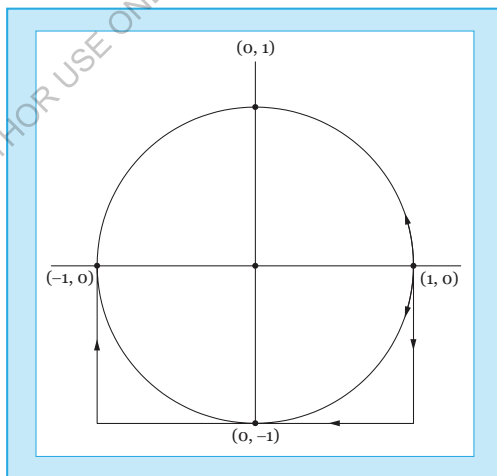


Figure 1.28

Circular and Square Integration Paths



Let us parameterize the circle C as $x = \cos \phi$, $y = \sin \phi$ with the polar angle ϕ so that $dx = -\sin \phi d\phi$, $dy = \cos \phi d\phi$. Then the force can be written as $\mathbf{F} = -\hat{x} \sin \phi + \hat{y} \cos \phi$. The work becomes

$$\int_C \frac{xdy - ydx}{x^2 + y^2} = \int_0^{-\pi} (-\sin^2 \phi - \cos^2 \phi) d\phi = \pi.$$

Here we spend energy. If we integrate anticlockwise from $\phi = 0$ to π we find the value $-\pi$ because we are riding with the force. The work is path dependent, which is consistent with the physical interpretation that $\mathbf{F} \cdot d\mathbf{r} \sim xdy - ydx = L_z$ is proportional to the z -component of orbital angular momentum (involving circulation, as discussed in Section 1.7).

If we integrate along the square through the points $(1, 0)$, $(0, 1)$ surrounding the circle, we find for the clockwise lower half square path of Fig. 1.28

$$\begin{aligned} \int \mathbf{F} \cdot d\mathbf{r} &= - \int_0^{-1} F_y dy|_{x=1} - \int_1^{-1} F_x dx|_{y=-1} - \int_{-1}^0 F_y dy|_{x=-1} \\ &= \int_0^1 dy \int_1^{-1} dx \int_0^1 dy \\ &= \arctan(1) + \arctan(1) - \arctan(-1) - \arctan(-1) \\ &= 4 \cdot \frac{\pi}{4} = \pi, \end{aligned}$$

which is consistent with the circular path.

For the circular paths we used the $x = \cos \phi$, $y = \sin \phi$ parameterization, whereas for the square shape we used the standard definitions $y = f(x)$ or $x = g(y)$ of a curve, that is, $y = -1 = \text{const.}$ and $x = \pm 1 = \text{const.}$ We could have used the implicit definition $F(x, y) = x^2 + y^2 = 1$ of the circle. Then the total variation

$$dF = \frac{\partial F}{\partial x} dx + \frac{\partial F}{\partial y} dy = 2x dx + 2y dy \equiv 0$$

so that

$$dy = -x dx/y \text{ with } y = -\sqrt{1-x^2}$$

on our half circle. The work becomes

$$\begin{aligned} \int_C \frac{x dy - y dx}{x^2 + y^2} &= \int_1^{-1} \frac{-x}{y} dx = \int_1^{-1} \frac{dx}{-y} = \int_1^{-1} \frac{dx}{-\sqrt{1-x^2}} \\ &= \arcsin 1 - \arcsin(-1) = 2 \cdot \frac{\pi}{2} = \pi, \text{ in} \end{aligned}$$

agreement with our previous results. ■

EXAMPLE 1.9.3

Gravitational Potential If a force can be described by a scalar function V_G as $\mathbf{F} = -\nabla V_G(\mathbf{r})$ [Eq. (1.65)], everywhere we call V_G its potential in mechanics and engineering. Because the total variation $dV_G = \nabla V_G \cdot d\mathbf{r} = -\mathbf{F}_G \cdot d\mathbf{r}$ is the work done against the force along the path $d\mathbf{r}$, the integrated work along any path from the initial point \mathbf{r}_0 to the final point \mathbf{r} is given by a line integral $\int_{\mathbf{r}_0}^{\mathbf{r}} dV_G = V_G(\mathbf{r}) - V_G(\mathbf{r}_0)$, the potential difference between the end points of

the path. Thus, to find the scalar potential for the gravitational force on a unit mass m_1 ,

$$\mathbf{F}_G = -\frac{Gm_1m_2\hat{\mathbf{r}}}{r^2} = -\frac{k\hat{\mathbf{r}}}{r^2}, \quad \text{radially inward} \quad (1.106)$$

we integrate from infinity, where V_G is zero into position \mathbf{r} . We obtain

$$V_G(r) - V_G(\infty) = -\int_{\infty}^{\mathbf{r}} \mathbf{F}_G \cdot d\mathbf{r} = +\int_{\infty}^{\mathbf{r}} \mathbf{F}_G \cdot d\mathbf{r}. \quad (1.107)$$

By use of $\mathbf{F}_G = \mathbf{F}_{\text{applied}}$, the potential is the work done in bringing the unit mass in from infinity. (We can define only the potential difference. Here, we arbitrarily assign infinity to be a zero of potential.) Since \mathbf{F}_G is radial, we obtain a contribution to V_G only when $d\mathbf{r}$ is radial or

$$V_G(r) = -\int_{\infty}^r \frac{k dr}{r^2} = -\frac{k}{r} = -\frac{Gm_1m_2}{r}. \quad (1.108)$$

The negative sign reflects the attractive nature of gravity. ■

Surface Integrals

Surface integrals appear in the same forms as line integrals, the element of area also being a vector, $d\boldsymbol{\sigma}$.¹³ Often this area element is written $\mathbf{n} dA$, where \mathbf{n} is a unit (normal) vector to indicate the positive direction.¹⁴ There are two conventions for choosing the positive direction. First, if the surface is a closed surface, we agree to take the outward normal as positive. Second, if the surface is an open surface, the positive normal depends on the direction in which the perimeter of the open surface is traversed. If the right-hand fingers are curled in the direction of travel around the perimeter, the positive normal is indicated by the thumb of the right hand. As an illustration, a circle in the xy -plane (Fig. 1.29) mapped out from x to y to x to $-y$ and back to x will have its positive normal parallel to the positive z -axis (for the right-handed coordinate system).

Analogous to the line integrals, Eq. (1.101), surface integrals may appear in the form

$$\int \mathbf{V} \cdot d\boldsymbol{\sigma}. \quad (1.109)$$

This surface integral, $\int \mathbf{V} \cdot d\boldsymbol{\sigma}$ may be interpreted as a flow or flux through

the given surface. This is really what we did in Section 1.6 to understand the significance of the concept of divergence. Note that both physically and from the dot product the tangential components of the velocity contribute nothing to the flow through the surface.

¹³Recall that in Section 1.3 the area (of a parallelogram) is represented by a cross product vector. ¹⁴Although \mathbf{n} always has unit length, its direction may well be a function of position.

Figure 1.29
Right-Hand Rule for the Positive Normal

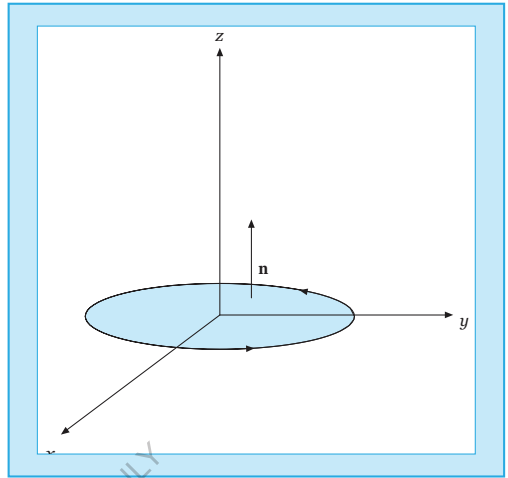
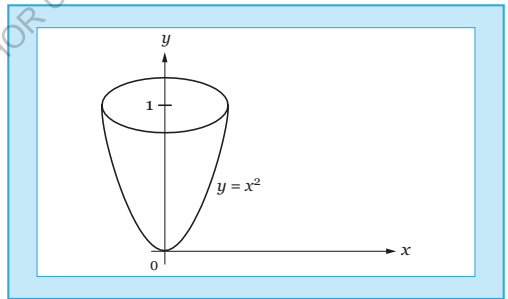


Figure 1.30
The Parabola $y = x^2$ for $0 \leq y \leq 1$ Rotated About the y -Axis



EXAMPLE 1.9.4

Moment of Inertia Let us determine the moment of inertia I_y of a segment of the parabola $y = x^2$ cut off by the line $y = 1$ and rotated about the y -axis (Fig. 1.30). We find

$$I_y = 2\mu \int_0^1 \int_{-x}^x x^2 dx dy = 2\mu \int_0^1 (1 - x^2)x^2 dx = 2\mu \left[\frac{x^3}{3} - \frac{x^5}{5} \right]_0^1 = \frac{4\mu}{15}$$

The factor of 2 originates in the reflection symmetry of $x \rightarrow -x$, and μ is the constant mass density. ■

A surface in three-dimensional space may be explicitly given as $z = f(x, y)$ or by the coordinate functions of its points

$$x = x(u, v), \quad y = y(u, v), \quad z = z(u, v)$$

in terms of two parameters u, v or in implicit form $F(x, y, z) = 0$. The explicit form is a special case

$$F(x, y, z) \equiv z - f(x, y)$$

of the general implicit definition of a surface. We find the area $dA = dx dy / n_z$ over the projection $dx dy$ of the surface onto the xy -plane for the latter case. Here, $n_z \cos \gamma$ is the z -component of the normal unit vector \mathbf{n} at \mathbf{r} on the surface so that γ is the angle of dA with the xy -plane. Thus, when we project dA to the xy -plane, we get $dA \cos \gamma = dx dy$, which proves this useful formula for measuring the **area of a curved surface**. From the gradient properties

we also know that $\mathbf{n} = \nabla f / |\nabla f|$.

EXAMPLE 1.9.5

A Surface Integral Here we apply the general formula for surface integrals to find the area on xy -plane cut out by the unit circle in the xy -plane shown in Fig. 1.31. We start from

$$\frac{\partial f}{\partial x} = \frac{\partial z}{\partial x} = y, \quad \frac{\partial f}{\partial y} = \frac{\partial z}{\partial y} = x, \quad \frac{\partial f}{\partial z} = \frac{\partial z}{\partial z} = 1,$$

which we substitute into

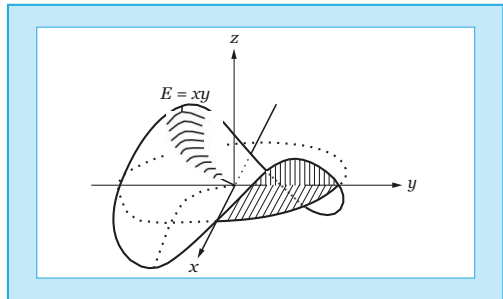
$$n_z = \frac{1}{\sqrt{1 + \left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2}}$$

for the normal to yield the area

$$A = \int_{x=-1}^1 \int_{y=-\sqrt{1-x^2}}^{\sqrt{1-x^2}} \sqrt{1 + x^2 + y^2} dx dy.$$

Figure 1.31

**The Surface $z = xy$
Above and Below the
Unit Circle
 $x^2 + y^2 = 1$**



For the circular geometry plane polar coordinates r, ϕ are more appropriate, where the radial integral is evaluated by substituting $u = 1 + r^2$ in

$$A = \int_0^1 \int_0^{2\pi} \sqrt{1+r^2} r dr d\phi = \pi \int_1^2 \sqrt{u} du = \frac{2\pi}{3} \cdot (1+r^2)^{3/2} \Big|_0^1 = \frac{2\pi}{3} (2\sqrt{2}-1).$$

More examples of line and surface integrals are provided in Chapter 2.

Volume Integrals

Volume integrals are simpler because the volume element $d\tau$ is a scalar quantity.¹⁵ We have

$$\int_V \mathbf{V} d\tau = \hat{x} \int_V V_x d\tau + \hat{y} \int_V V_y d\tau + \hat{z} \int_V V_z d\tau, \tag{1.110}$$

again reducing the vector integral to a vector sum of scalar integrals.

If the vector

$$\mathbf{V} = V_\rho(\rho, \phi, z)\hat{\rho} + V_\phi(\rho, \phi, z)\hat{\phi} + V_z(\rho, \phi, z)\hat{z}$$

and its components are given in cylindrical coordinates $x = \rho \cos \phi, y = \rho \sin \phi$ with volume element $d\tau = \rho d\rho d\phi dz$, the volume integral

$$\int_V \mathbf{V} d\tau = \hat{z} \int_V V_z d\tau + (V_\rho \hat{\rho} + V_\phi \hat{\phi}) \int_V \rho d\rho d\phi dz$$

involves integrals over the varying unit vectors of the polar coordinates. To reduce them to scalar integrals, we need to expand the polar coordinate unit vectors in Cartesian unit vectors as follows. Dividing the plane coordinates by ρ , we find

$$\hat{\rho} = \frac{1}{\rho}(x, y) = (\cos \phi, \sin \phi) = \hat{x} \cos \phi + \hat{y} \sin \phi.$$

Differentiating $\hat{\rho}^2 = 1$, we see from $0 = \frac{d\hat{\rho}^2}{d\phi} = 2\hat{\rho} \cdot \frac{d\hat{\rho}}{d\phi}$ that

$$\frac{d\hat{\rho}}{d\phi} = -\hat{x} \sin \phi + \hat{y} \cos \phi = \hat{\phi}$$

is perpendicular to $\hat{\rho}$ and a unit vector; therefore, it is equal to $\hat{\phi}$. Substituting these expressions into the second integral yields the final result

$$\int_V \mathbf{V} d\tau = \hat{z} \int_V V_z d\tau + \hat{x} \int_V [V_\rho \cos \phi - V_\phi \sin \phi] \rho d\rho d\phi dz + \hat{y} \int_V [V_\rho \sin \phi + V_\phi \cos \phi] \rho d\rho d\phi dz. \tag{1.111}$$

The terms in brackets are the Cartesian components V_x, V_y expressed in plane polar coordinates.

¹⁵Frequently, the symbols d^3r and d^3x are used to denote a volume element in coordinate (xyz) or $(x_1x_2x_3)$ space.

In spherical polar coordinates, all of the unit vectors depend on the coordinates, none can be pulled out of the integrals, and all have to be expanded in Cartesian unit vectors. This task of rewriting Eq. (1.110) is left as an exercise.

EXAMPLE 1.9.6

Volume of Rotated Gaussian Rotate the Gaussian $\exp(-x^2)$ about the z -axis leading to $\exp(-x^2 - y^2)$. Then the volume in the polar (cylindrical) coordinates appropriate for the geometry is given by

$$V = \int_{\phi=0}^{\infty} \int_{\phi=0}^{2\pi} \int_{z=0}^{\infty} r \, dr \, d\phi \, dz = 2\pi \int_0^{\infty} r e^{-r^2} \, dr = \pi \int_0^{\infty} e^{-u} \, du = \pi,$$

upon substituting $\exp(-x^2 - y^2) = \exp(-r^2)$, $dx \, dy = r \, dr \, d\phi$, $u = r^2$, and $du = 2r \, dr$. ■

Integral Definitions of Gradient, Divergence, and Curl

One interesting and significant application of our surface and volume integrals is their use in developing alternate definitions of our differential relations. We find

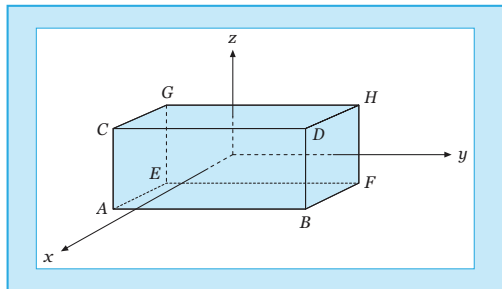
$$\nabla \phi = \lim_{\delta \tau \rightarrow 0} \frac{\oint_{\delta \tau} \phi \, d\sigma}{\delta \tau}, \tag{1.112}$$

$$\nabla \cdot \mathbf{V} = \lim_{\delta \tau \rightarrow 0} \frac{\int_{\delta \tau} \mathbf{V} \cdot d\sigma}{\delta \tau}, \tag{1.113}$$

$$\nabla \times \mathbf{V} = \lim_{\delta \tau \rightarrow 0} \frac{\oint_{\delta \tau} d\sigma \times \mathbf{V}}{\delta \tau}. \tag{1.114}$$

In these three equations, $\delta \tau$ is the volume of a small region of space and $d\sigma$ is the vector area element of this volume. The identification of Eq. (1.113) as the divergence of \mathbf{V} was carried out in Section 1.6. Here, we show that Eq. (1.112) is consistent with our earlier definition of $\nabla \phi$ [Eq. (1.64)]. For simplicity, we choose $\delta \tau$ to be the differential volume $dx \, dy \, dz$ (Fig. 1.32). This

Figure 1.32
Differential Rectangular Parallelepiped (Origin at Center)



time, we place the origin at the geometric center of our volume element. The area integral leads to six integrals, one for each of the six faces. Remembering that $d\sigma$ is outward, $d\sigma = \hat{x} |d\sigma|$ for surface $EFHG$, and $d\sigma = -\hat{x} |d\sigma|$ for surface $ABDC$, we have

$$\begin{aligned} \oint \phi d\sigma = & \int_{EFHG} -\hat{x} \left(\phi - \frac{\partial \phi}{\partial x} dx \right) dy dz + \int_{ABDC} \hat{x} \left(\phi + \frac{\partial \phi}{\partial x} dx \right) dy dz \\ & + \int_{AEGC} \hat{y} \left(\phi - \frac{\partial \phi}{\partial y} dy \right) dx dz + \int_{BFHD} -\hat{y} \left(\phi + \frac{\partial \phi}{\partial y} dy \right) dx dz \\ & + \int_{ABFE} \hat{z} \left(\phi - \frac{\partial \phi}{\partial z} dz \right) dx dy + \int_{CDHG} -\hat{z} \left(\phi + \frac{\partial \phi}{\partial z} dz \right) dx dy. \end{aligned}$$

Using the first two terms of a Maclaurin expansion, we evaluate each integrand at the origin with a correction included to correct for the displacement (dx/2, etc.) of the center of the face from the origin. Having chosen the total volume to be of differential size $d\tau = dx dy dz$, we drop the integral signs on the right and obtain

$$\oint \phi d\sigma = \hat{x} \frac{\partial \phi}{\partial x} + \hat{y} \frac{\partial \phi}{\partial y} + \hat{z} \frac{\partial \phi}{\partial z} dx dy dz. \tag{1.115}$$

Dividing by

$$\int d\tau = dx dy dz,$$

we verify Eq. (1.112).

This verification has been oversimplified in ignoring other correction terms beyond the first derivatives. These additional terms, which are introduced in Section 5.6 when the Taylor expansion is developed, vanish in the limit

$$d\tau \rightarrow 0 \quad (dx \rightarrow 0, dy \rightarrow 0, dz \rightarrow 0).$$

This, of course, is the reason for specifying in Eqs. (1.112)–(1.114) that this limit be taken. Verification of Eq. (1.114) follows these same lines, using a differential volume $d\tau = dx dy dz$.

EXERCISES

- 1.9.1 Find the potential for the electric field generated by a charge q at the origin. Normalize the potential to zero at spatial infinity.
- 1.9.2 Determine the gravitational field of the earth taken to be spherical and of uniform mass density. Punch out a concentric spherical cavity and show that the field is zero inside it. Show that the field is constant if the cavity is not concentric.

1.9.3 Evaluate

$$\frac{1}{3} \int_S \mathbf{r} \cdot d\boldsymbol{\sigma}$$

over the unit cube defined by the point (0, 0, 0) and the unit intercepts on the positive x -, y -, and z -axes. Note that (a) $\mathbf{r} \cdot d\boldsymbol{\sigma}$ is zero for three of the surfaces, and (b) each of the three remaining surfaces contributes the same amount to the integral.

1.9.4 Show by expansion of the surface integral that

$$\lim_{\Delta t \rightarrow 0} \frac{d\boldsymbol{\sigma} \cdot \mathbf{V}}{d\mathbf{r}} = \nabla \times \mathbf{V}.$$

Hint. Choose the volume to be a differential volume, $dx dy dz$.

1.10 Gauss's Theorem

Here, we derive a useful relation between a surface integral of a vector and the volume integral of the divergence of that vector. Let us assume that the vector \mathbf{V} and its first derivatives are continuous over the simply connected region (without holes) of interest. Then, **Gauss's theorem** states that

$$\int_S \mathbf{V} \cdot d\boldsymbol{\sigma} = \int_V \nabla \cdot \mathbf{V} d\tau. \quad (1.116a)$$

In words, the surface integral of a vector over a closed surface equals the volume integral of the divergence of that vector integrated over the volume enclosed by the surface.

Imagine that volume V is subdivided into an arbitrarily large number of tiny (differential) parallelepipeds. For each parallelepiped,

$$\int_{\text{six surfaces}} \mathbf{V} \cdot d\boldsymbol{\sigma} = \int_V \nabla \cdot \mathbf{V} d\tau \quad (1.116b)$$

from the analysis of Section 1.6, Eq. (1.75), with $\rho\mathbf{v}$ replaced by \mathbf{V} . The summation is over the six faces of the parallelepiped. Summing over all parallelepipeds, we find that the $\mathbf{V} \cdot d\boldsymbol{\sigma}$ terms cancel (pairwise) for all **interior** faces; only the contributions of the **exterior** surfaces survive (Fig. 1.33). Analogous to the definition of a Riemann integral as the limit of a sum, we take the limit as the number of parallelepipeds approaches infinity ($\rightarrow \infty$) and the dimensions of each approach zero ($\rightarrow 0$):

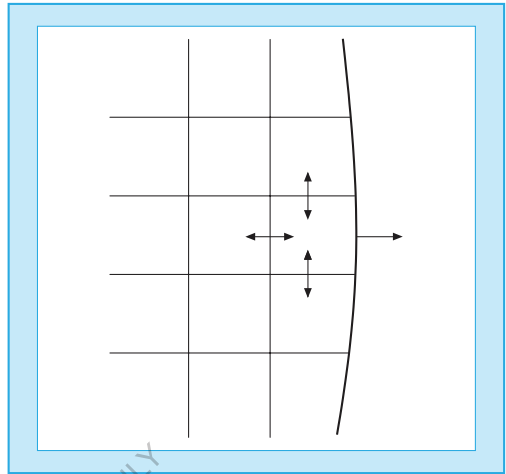
$$\int_{\text{exterior surfaces}} \mathbf{V} \cdot d\boldsymbol{\sigma} = \int_{\text{volumes}} \nabla \cdot \mathbf{V} d\tau$$

$$\int_S \mathbf{V} \cdot d\boldsymbol{\sigma} = \int_V \nabla \cdot \mathbf{V} d\tau.$$

The result is Eq. (1.116a), Gauss's theorem.

Figure 1.33

**Exact Cancellation
of $\mathbf{V} \cdot d\boldsymbol{\sigma}$'s on
Interior Surfaces.
No Cancellation on
the Exterior Surface**



From a physical standpoint, Eq. (1.75) has established $\nabla \cdot \mathbf{V}$ as the net outflow of field per unit volume. The volume integral then gives the total net outflow. However, the surface integral $\mathbf{V} \cdot d\boldsymbol{\sigma}$ is just another way of expressing this same quantity, which is the equality, Gauss's theorem.

Biographical Data

Gauss, Carl Friedrich. Gauss, a German mathematician, physicist, and astronomer, was born in Brunswick in 1777 and died in Göttingen in 1855. He was an infant prodigy in mathematics whose education was directed and financed by the Duke of Brunswick. As a teenager, he proved that regular n -polygons can be constructed in Euclidean geometry provided n is a Fermat prime number such as 3, 5, 17, and 257, a major advance in geometry since antiquity. This feat convinced him to stay in mathematics and give up the study of foreign languages. For his Ph.D., he proved the fundamental theorem of algebra, avoiding the then controversial complex numbers he had used to discover it. In his famous treatise *Disquisitiones Arithmetica* on number theory, he first proved the quadratic reciprocity theorem and originated the terse style and rigor of mathematical proofs as a series of logical steps, discarding any trace of the original heuristic ideas used in the discovery and checks of examples. Not surprisingly, he hated teaching. He is considered by many as the greatest mathematician of all times and was the last to provide major contributions to all then existing branches of mathematics. As the founder of differential geometry, he developed the intrinsic properties of surfaces, such as curvature, which later motivated B. Riemann to develop the

of Einstein's General Relativity. In astronomy (for the orbit of the asteroid Ceres), he developed the method of least squares for fitting curves to data. In physics, he developed potential theory, and the unit of the magnetic induction is named after him in honor of his measurements and development of units in physics.

Green's Theorem

A frequently useful corollary of Gauss's theorem is a relation known as Green's theorem. If u and v are two scalar functions, we have the identities

$$\nabla \cdot (u \nabla v) = u \nabla^2 v + (\nabla u) \cdot (\nabla v), \quad (1.117)$$

$$\nabla \cdot (v \nabla u) = v \nabla^2 u + (\nabla v) \cdot (\nabla u), \quad (1.118)$$

which follow from the product rule of differentiation. Subtracting Eq. (1.118) from Eq. (1.117), integrating over a volume (u , v , and their derivatives, assumed continuous), and applying Eq. (1.116a) (Gauss's theorem), we obtain

$$\int_V (u \nabla^2 v - v \nabla^2 u) d\tau = - \int_S (u \nabla v - v \nabla u) \cdot d\boldsymbol{\sigma}. \quad (1.119)$$

This is **Green's theorem**, which states that the antisymmetric Laplacian of a pair of functions integrated over a simply connected volume (no holes) is equivalent to the antisymmetric gradient of the pair integrated over the bounding surface. An alternate form of Green's theorem derived from Eq. (1.117) alone is

$$\int_V u \nabla^2 v \, d\tau = \int_S u \nabla v \cdot d\boldsymbol{\sigma} + \int_V \nabla u \cdot \nabla v \, d\tau. \quad (1.120)$$

Finally, Gauss's theorem may also be extended to tensors (see Section 2.11).

Biographical Data

Green, George. Green, an English mathematician, was born in Nottingham in 1793 and died near Nottingham in 1841. He studied Laplace's papers in Cambridge and developed potential theory in

EXERCISES

1.10.1 If $\mathbf{B} = \nabla \times \mathbf{A}$, show that

$$\int_S \mathbf{B} \cdot d\boldsymbol{\sigma} = 0$$

for any closed surface S . State this in words. If symbolic software is available, check this for a typical vector potential and specific surfaces, such as a sphere or cube.

1.10.2 Over some volume V , let ψ be a solution of Laplace's equation (with the derivatives appearing there continuous). Prove that the integral over

any closed surface in V of the normal derivative of ψ ($\partial\psi/\partial n$, or $\nabla\psi \cdot \mathbf{n}$) will be zero.

- 1.10.3** In analogy to the integral definition of gradient, divergence, and curl of Section 1.10, show that

$$\nabla^2 \phi = \lim_{d\tau \rightarrow 0} \frac{\int \nabla \phi \cdot d\boldsymbol{\sigma}}{d\tau}.$$

- 1.10.4** The electric displacement vector \mathbf{D} satisfies the Maxwell equation $\nabla \cdot \mathbf{D} = \rho$, where ρ is the charge density (per unit volume). At the boundary between two media there is a surface charge density σ (per unit area). Show that a boundary condition for \mathbf{D} is

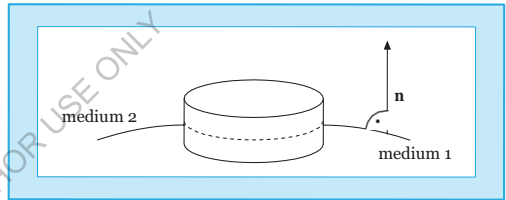
$$(\mathbf{D}_2 - \mathbf{D}_1) \cdot \mathbf{n} = \sigma,$$

where \mathbf{n} is a unit vector normal to the surface and out of medium 1.

Hint. Consider a thin pillbox as shown in Fig. 1.34.

Figure 1.34

Pillbox



- 1.10.5** From Eq. (1.77) and Example 1.6.1, with \mathbf{V} the electric field \mathbf{E} and f the electrostatic potential ϕ , show that

$$\rho \phi \, d\tau = \epsilon_0 \int E^2 \, d\tau.$$

This corresponds to a three-dimensional integration by parts.

Hint. $\mathbf{E} = -\nabla \phi$, $\nabla \cdot \mathbf{E} = \rho/\epsilon_0$. You may assume that ϕ vanishes at large r at least as fast as r^{-1} .

- 1.10.6** The creation of a **localized** system of steady electric currents (current density \mathbf{J}) and magnetic fields may be shown to require an amount of work

$$W = \frac{1}{2} \int \mathbf{H} \cdot \mathbf{B} \, d\tau.$$

Transform this into

$$W = \frac{1}{2} \int \mathbf{J} \cdot \mathbf{A} \, d\tau,$$

where \mathbf{A} is the magnetic vector potential, $\nabla \times \mathbf{A} = \mathbf{B}$.

Hint. In Maxwell's equations, take the displacement current term $\partial \mathbf{D} / \partial t$ and explain why using Ohm's law. If the fields and currents are localized, a bounding surface may be taken far enough out so that the integrals of the fields and currents over the surface yield zero.

1.11 Stokes's Theorem

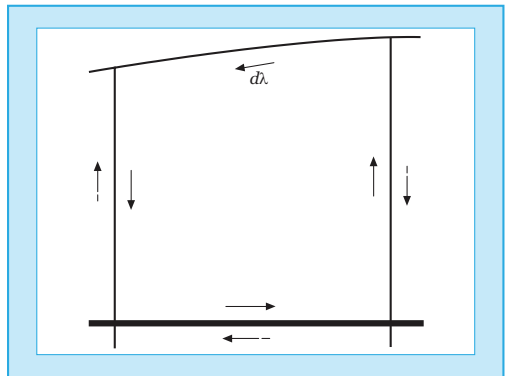
Gauss's theorem relates the volume integral of a derivative of a function to an integral of the function over the closed surface bounding the volume. Here, we consider an analogous relation between the surface integral of a derivative of a function and the line integral of the function, the path of integration being the perimeter bounding the surface.

Let us take the surface and subdivide it into a network of arbitrarily small rectangles. In Section 1.7, we showed that the circulation about such a differential rectangle (in the xy -plane) is $\oint \mathbf{V} \cdot d\boldsymbol{\lambda} = \iint \nabla \times \mathbf{V} \cdot d\boldsymbol{\sigma}$. From Eq. (1.85) applied to **one** differential rectangle,

$$\oint_{\text{four sides}} \mathbf{V} \cdot d\boldsymbol{\lambda} = \nabla \times \mathbf{V} \cdot d\boldsymbol{\sigma}. \tag{1.121}$$

We sum over all the little rectangles as in the definition of a Riemann integral. The surface contributions [right-hand side of Eq. (1.121)] are added together. The line integrals [left-hand side of Eq. (1.121)] of all **interior** line segments cancel identically. Only the line integral around the perimeter survives (Fig. 1.35). Taking the usual limit as the number of rectangles approaches

Figure 1.35
Exact Cancellation on Interior Paths; No Cancellation on the Exterior Path



infinitely while $dx \rightarrow 0, dy \rightarrow 0$, we have

$$\int_{\text{exterior line segments}} \mathbf{V} \cdot d\mathbf{\lambda} = \int_S \nabla \times \mathbf{V} \cdot d\boldsymbol{\sigma} \tag{1.122}$$

This is Stokes's theorem. The surface integral on the right is over the surface bounded by the perimeter or contour for the line integral on the left. The direction of the vector representing the area is out of the paper plane toward the reader if the direction of traversal around the contour for the line integral is in the positive mathematical sense as shown in Fig. 1.35.

This demonstration of Stokes's theorem is limited by the fact that we used a Maclaurin expansion of $\mathbf{V}(x, y, z)$ in establishing Eq. (1.85) in Section 1.7. Actually, we need only demand that the curl of $\mathbf{V}(x, y, z)$ exists and that it be integrable over the surface. Stokes's theorem obviously applies to an open, simply connected surface. It is possible to consider a closed surface as a limiting case of an open surface with the opening (and therefore the perimeter) shrinking to zero. This is the point of Exercise 1.11.4.

As a special case of Stokes's theorem, consider the curl of a two-dimensional vector field $\mathbf{V} = (V_1(x, y), V_2(x, y), 0)$. The curl $\nabla \times \mathbf{V} = (0, 0, \frac{\partial V_2}{\partial x} - \frac{\partial V_1}{\partial y})$ so

$$\int_S \nabla \times \mathbf{V} \cdot \hat{\mathbf{z}} \, dx \, dy = \int_S \left(\frac{\partial V_2}{\partial x} - \frac{\partial V_1}{\partial y} \right) dx \, dy = \int_C \mathbf{V} \cdot d\mathbf{r} = \int_C (V_1 dx + V_2 dy),$$

where the curve C is the boundary of the simply connected surface S that is integrated in the positive mathematical sense (anticlockwise). This relation is sometimes also called Green's theorem. In Chapter 6, we shall use it to prove Cauchy's theorem for analytic functions.

EXAMPLE 1.11.1

Area as a Line Integral For the two-dimensional Stokes's theorem, we first choose $\mathbf{V} = x\hat{\mathbf{y}}$, which gives the area $S = \int_C x \, dy = \int_C y \, dx$, and for $\mathbf{V} = (y\hat{\mathbf{x}})$

we get similarly $S = \int_C x \, dy = - \int_C y \, dx$. Adding both results gives the area

$$S = \frac{1}{2} \int_C (x \, dy - y \, dx). \quad \blacksquare$$

We can use Stokes's theorem to derive Oersted's and Faraday's laws from two of Maxwell's equations and vice versa, thus recognizing that the former are an integrated form of the latter.

EXAMPLE 1.11.2

Oersted's and Faraday's Laws Consider the magnetic field generated by a long wire that carries a stationary current I (Fig. 1.36). Starting from Maxwell's differential law $\nabla \times \mathbf{H} = \mathbf{J}$ [Eq. (1.97c); with Maxwell's displacement current $\partial \mathbf{D} / \partial t \rightarrow \mathbf{J}$ for a stationary current case by Ohm's law], we integrate over a closed area S perpendicular to and surrounding the wire and apply Stokes's

Figure 1.36
Oersted's Law for a Long Wire Carrying a Current

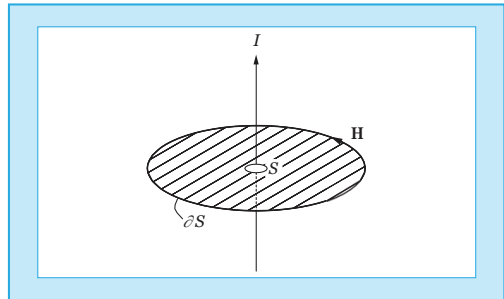
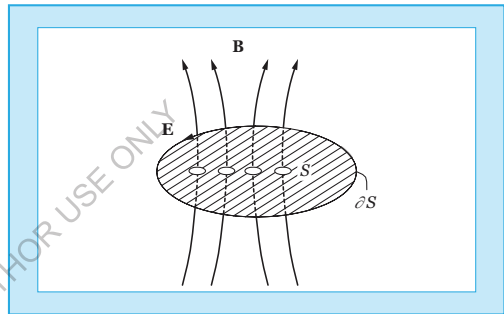


Figure 1.37
Faraday's Induction Law Across a Magnetic Induction Field



theorem to get

$$I = \int_S \mathbf{J} \cdot d\boldsymbol{\sigma} = \int_S (\nabla \times \mathbf{H}) \cdot d\boldsymbol{\sigma} = \int_{\partial S} \mathbf{H} \cdot d\mathbf{r},$$

which is Oersted's law. Here, the line integral is along ∂S , the closed curve surrounding the cross section area S .

Similarly, we can integrate Maxwell's equation $\nabla \times \mathbf{E} = -\dot{\mathbf{B}}$ [Eq. (1.97d)] to yield Faraday's induction law. Imagine moving a closed loop (∂S) of wire (of area S) across a magnetic induction field \mathbf{B} (Fig. 1.37). At a fixed moment of time we integrate Maxwell's equation and use Stokes's theorem, yielding

$$\int_{\partial S} \mathbf{E} \cdot d\mathbf{r} = - \int_S (\nabla \times \mathbf{E}) \cdot d\boldsymbol{\sigma} = \int_S \dot{\mathbf{B}} \cdot d\boldsymbol{\sigma} = \frac{d}{dt} \int_S \mathbf{B} \cdot d\boldsymbol{\sigma} = - \frac{d\rho}{dt},$$

which is Faraday's law. The line integral on the left-hand side represents the voltage induced in the wire loop, whereas the right-hand side is the change with time of the magnetic flux ρ through the moving surface S of the wire. ■

SUMMARY

Both Stokes's and Gauss's theorems are of tremendous importance in a wide variety of problems involving vector calculus in electrodynamics, where they

allow us to derive the local form of Maxwell's differential equations from the global (integral) form of the experimental laws. An indication of their power and versatility may be obtained from the exercises in Sections 1.10 and 1.11 and the development of potential theory in Section 1.12.

Biographical Data

Stokes, Sir George Gabriel. Stokes, a British mathematician and physicist, was born in Skreen, Ireland, in 1819 and died in Cambridge in 1903. Son of a clergyman, his talent for mathematics was already evident in school. In 1849, he became Lucasian professor at Cambridge, the chair Isaac Newton once held and currently held by S. Hawking. In 1885, he became president of the Royal Society. He is known for the theory of viscous fluids, with practical applications to the motion of ships in water. He demonstrated his vision by hailing Joule's work early on and recognizing X-rays as electromagnetic radiation. He received the Rumford and Copley medals of the Royal Society and served as a member of Parliament for

EXERCISES

1.11.1 The calculation of the magnetic moment of a current loop leads to the line integral

$$\mathbf{r} \times d\mathbf{r}.$$

- (a) Integrate around the perimeter of a current loop (in the xy -plane) and show that the scalar magnitude of this line integral is twice the area of the enclosed surface.
- (b) The perimeter of an ellipse is described by $\mathbf{r} = \hat{x}a \cos \theta + \hat{y}b \sin \theta$. From part (a), show that the area of the ellipse is πab .

1.11.2 In steady state, the magnetic field \mathbf{H} satisfies the Maxwell equation $\nabla \times \mathbf{H} = \mathbf{J}$, where \mathbf{J} is the current density (per square meter). At the boundary between two media there is a surface current density \mathbf{K} (perimeter). Show that a boundary condition on \mathbf{H} is

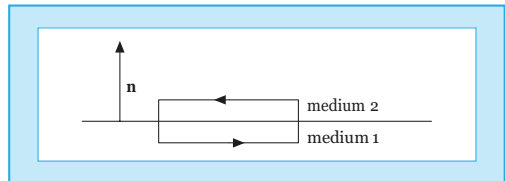
$$\mathbf{n} \times (\mathbf{H}_2 - \mathbf{H}_1) = \mathbf{K},$$

where \mathbf{n} is a unit vector normal to the surface and out of medium 1.

Hint. Consider a narrow loop perpendicular to the interface as shown in Fig. 1.38.

Figure 1.38

Loop Contour



1.11.3 A magnetic induction \mathbf{B} is generated by electric current in a ring of radius R . Show that the **magnitude** of the vector potential \mathbf{A} ($\mathbf{B} = \nabla \times \mathbf{A}$) at the ring is

$$|\mathbf{A}| = \frac{\rho}{2\pi R},$$

where ρ is the total magnetic flux passing through the ring.

Note. \mathbf{A} is tangential to the ring.

1.11.4 Prove that

$$\int_S \nabla \times \mathbf{V} \cdot d\boldsymbol{\sigma} = 0$$

if S is a closed surface.

1.11.5 Prove that

$$u \nabla \mathbf{v} \cdot d\boldsymbol{\lambda} = - \mathbf{v} \nabla u \cdot d\boldsymbol{\lambda}.$$

1.11.6 Prove that

$$u \nabla \mathbf{v} \cdot d\boldsymbol{\lambda} = \int_S (\nabla u) \times (\nabla \mathbf{v}) \cdot d\boldsymbol{\sigma}.$$

1.12 Potential Theory

Scalar Potential

This section formulates the conditions under which a force field \mathbf{F} is conservative. From a mathematical standpoint, it is a practice session of typical applications of Gauss's and Stokes's theorems in physics.

If a force in a given **simply connected region** of space V (i.e., no holes in it) can be expressed as the negative gradient of a scalar function ϕ ,

$$\mathbf{F} = -\nabla \phi, \quad (1.123)$$

we call ϕ a scalar potential that describes the force by one function instead of three, which is a significant simplification. A scalar potential is only determined up to an additive constant, which can be used to adjust its value at infinity (usually zero) or at some other point. The force \mathbf{F} appearing as the negative gradient of a single-valued scalar potential is labeled a **conservative** force. We want to know when a scalar potential function exists. To answer this question, we establish two other relations as equivalent to Eq. (1.123):

$$\nabla \times \mathbf{F} = 0 \quad (1.124)$$

and

$$\mathbf{F} \cdot d\mathbf{r} = 0, \quad (1.125)$$

for every closed path in our simply connected region V . We proceed to show that each of these three equations implies the other two. Let us start with

$$\mathbf{F} = -\nabla\phi. \quad (1.126)$$

Then

$$\nabla \times \mathbf{F} = -\nabla \times \nabla\phi = 0 \quad (1.127)$$

by Eq. (1.92), or Eq. (1.123) implies Eq. (1.124). Turning to the line integral, we have

$$\mathbf{F} \cdot d\mathbf{r} = -\nabla\phi \cdot d\mathbf{r} = -d\phi \quad (1.128)$$

using Eq. (1.58). Now $d\phi$ integrates to give ϕ . Because we have specified a closed loop, the end points coincide and we get zero for every closed path in our region S for which Eq. (1.123) holds. It is important to note the restriction that the potential be single-valued and that Eq. (1.123) hold for **all** points in S . This derivation may also apply to a scalar magnetic potential as long as no net current is encircled. As soon as we choose a path in space that encircles a net current, the scalar magnetic potential ceases to be single-valued and our analysis no longer applies because V is no longer simply connected.

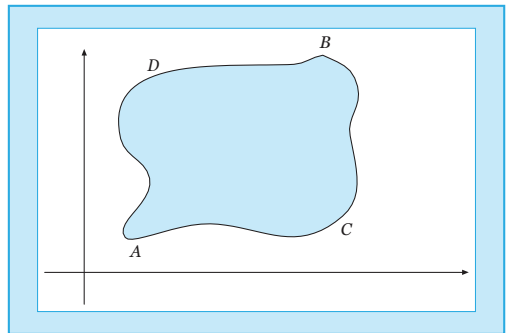
Continuing this demonstration of equivalence, let us assume that Eq. (1.125) holds. If $\mathbf{F} \cdot d\mathbf{r} = 0$ for all paths in S , the value of the integral joining two distinct points A and B is independent of the path (Fig. 1.39). Our premise is that

$$\int_{ACBDA} \mathbf{F} \cdot d\mathbf{r} = 0. \quad (1.129)$$

Therefore,

$$\int_{ACB} \mathbf{F} \cdot d\mathbf{r} - \int_{BDA} \mathbf{F} \cdot d\mathbf{r} + \int_{ADB} \mathbf{F} \cdot d\mathbf{r} = 0, \quad (1.130)$$

Figure 1.39
Possible Paths for
Doing Work



reversing the sign by reversing the direction of integration. Physically, this means that the work done in going from A to B is independent of the path and that the work done in going around a closed path is zero. This is the reason for labeling such a force conservative: Energy is conserved.

With the result shown in Eq. (1.130), we have the work done dependent only on the end points A and B . That is,

$$\text{Work done by force} = \int_A^B \mathbf{F} \cdot d\mathbf{r} = \phi(A) - \phi(B). \quad (1.131)$$

Equation (1.131) defines a scalar potential (strictly speaking, the difference in potential between points A and B) and provides a means of calculating the potential. If point B is taken as a variable such as (x, y, z) , then differentiation with respect to $x, y,$ and z will recover Eq. (1.123).

The choice of sign on the right-hand side is arbitrary. The choice here is made to achieve agreement with Eq. (1.123) and to ensure that water will run downhill rather than uphill. For points A and B separated by a length $d\mathbf{r}$, Eq. (1.131) becomes

$$\mathbf{F} \cdot d\mathbf{r} = -d\phi = -\nabla\phi \cdot d\mathbf{r}. \quad (1.132)$$

This may be rewritten

$$(\mathbf{F} + \nabla\phi) \cdot d\mathbf{r} = 0, \quad (1.133)$$

and since $d\mathbf{r} \neq 0$ is arbitrary, Eq. (1.126) must follow. If

$$\mathbf{F} \cdot d\mathbf{r} = 0, \quad (1.134)$$

we may obtain Eq. (1.123) by using Stokes's theorem [Eq. (1.122)]:

$$\mathbf{F} \cdot d\mathbf{r} = \nabla \times \mathbf{F} \cdot d\boldsymbol{\sigma}. \quad (1.135)$$

If we take the path of integration to be the perimeter of an arbitrary differential area $d\boldsymbol{\sigma}$, the integrand in the surface integral must vanish. Hence, Eq. (1.125) implies Eq. (1.123).

Finally, if $\nabla \times \mathbf{F} = \mathbf{0}$, we need only reverse our statement of Stokes's theorem [Eq. (1.135)] to derive Eq. (1.125). Then, by Eqs. (1.131)–(1.133) the initial statement $\mathbf{F} = -\nabla\phi$ is derived. The triple equivalence is illustrated in Fig. 1.40.

SUMMARY

A single-valued scalar potential function ϕ exists if and only if \mathbf{F} is irrotational so that the work done around every closed loop is zero. The gravitational and electrostatic force fields given by Eq. (1.88) are irrotational and therefore conservative. Gravitational and electrostatic scalar potentials exist. Now, by calculating the work done [Eq. (1.131)], we proceed to determine three potentials (Fig. 1.41).

Figure 1.40
Equivalent Formulations of a Conservative Force

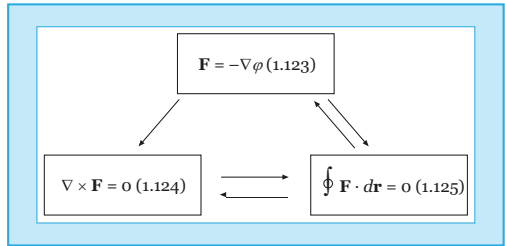
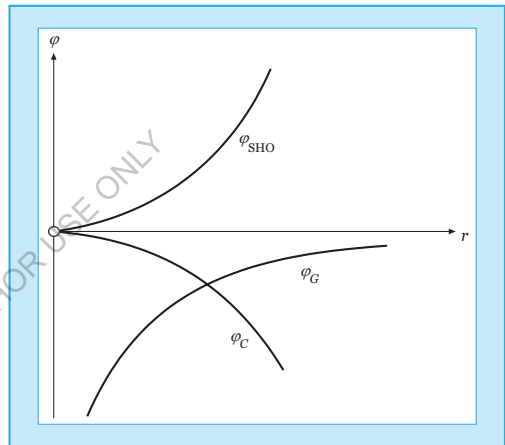


Figure 1.41
Potential Energy Versus Distance (Gravitational, Centrifugal, and Simple Harmonic Oscillator)



EXAMPLE 1.12.1

Centrifugal Potential Calculate the scalar potential for the **centrifugal** force per unit mass, $\mathbf{F}_C = \omega^2 \mathbf{r}$, radially **outward**. Physically, the centrifugal force is what you feel when on a merry-go-round. Proceeding as in Example 1.9.3, but integrating from the origin outward and taking $\phi_C(0) = 0$, we have

$$\phi_C(r) = - \int_0^r \omega^2 r^2 \cdot dr = - \frac{\omega^2 r^3}{3}$$

If we reverse signs, taking $\mathbf{F}_{SHO} = -k\mathbf{r}$, we obtain $\phi_{SHO} = \frac{1}{2}kr^2$ —the simple harmonic oscillator potential.

The gravitational, centrifugal, and simple harmonic oscillator potentials are shown in Fig. 1.41. Clearly, the simple harmonic oscillator yields stability and describes a restoring force. The centrifugal potential describes an unstable situation. ■

SUMMARY

When a vector \mathbf{B} is solenoidal, a vector potential \mathbf{A} exists such that $\mathbf{B} = \nabla \times \mathbf{A}$. \mathbf{A} is undetermined to within an additive gradient of a scalar function. This is similar to the arbitrary zero of a potential, due to an additive constant of the scalar potential.

In many problems, the magnetic vector potential \mathbf{A} will be obtained from the current distribution that produces the magnetic induction \mathbf{B} . This means solving Poisson's (vector) equation (see Exercise 1.13.4).

EXERCISES

1.12.1 The usual problem in classical mechanics is to calculate the motion of a particle given the potential. For a uniform density (ρ_0), nonrotating massive sphere, Gauss's law (Section 1.10) leads to a gravitational force on a unit mass m_0 at a point r_0 produced by the attraction of the mass at $r < r_0$. The mass at $r > r_0$ contributes nothing to the force.

- Show that $\mathbf{F}/m_0 = -(4\pi G\rho_0/3)\mathbf{r}$, $0 \leq r \leq a$, where a is the radius of the sphere.
- Find the corresponding gravitational potential, $0 \leq r \leq a$.
- Imagine a vertical hole running completely through the center of the earth and out to the far side. Neglecting the rotation of the earth and assuming a uniform density $\rho = 5.5 \text{ g/cm}^3$, calculate the nature of the motion of a particle dropped into the hole. What is its period? *Note.* $\mathbf{F} \propto \mathbf{r}$ is actually a very poor approximation. Because of varying density, the approximation $\mathbf{F} = \text{constant}$, along the outer half of a radial line, and $\mathbf{F} \propto \mathbf{r}$, along the inner half, is much closer.

1.12.2 The origin of the Cartesian coordinates is at the earth's center. The moon is on the z -axis, a fixed distance R away (center-to-center distance). The tidal force exerted by the moon on a particle at the earth's surface (point x, y, z) is given by

$$F_x = -GMm \frac{x}{R^3}, \quad F_y = -GMm \frac{y}{R^3}, \quad F_z = +2GMm \frac{z}{R^3}$$

Find the potential that yields this tidal force.

$$\text{ANS. } -\frac{GMm}{R^3} \left[z^2 - \frac{1}{2}x^2 - \frac{1}{2}y^2 \right]$$

In terms of the Legendre polynomials of Chapter 11, this becomes

$$-\frac{GMm}{R^3} r^2 P_2(\cos \theta).$$

1.12.3 Vector \mathbf{B} is formed by the product of two gradients

$$\mathbf{B} = (\nabla u) \times (\nabla v),$$

where u and v are scalar functions.

- (a) Show that \mathbf{B} is solenoidal.
 (b) Show that

$$\mathbf{A} = \frac{1}{2}(u \nabla \mathbf{v} - \mathbf{v} \nabla u)$$
 is

a vector potential for \mathbf{B} in that

$$\mathbf{B} = \nabla \times \mathbf{A}.$$

- 1.12.4** The magnetic induction \mathbf{B} is related to the magnetic vector potential \mathbf{A} by $\mathbf{B} = \nabla \times \mathbf{A}$. By Stokes's theorem,

$$\int \mathbf{B} \cdot d\boldsymbol{\sigma} = \int \mathbf{A} \cdot d\mathbf{r}.$$

Show that each side of this equation is invariant under the **gauge transformation**, $\mathbf{A} \rightarrow \mathbf{A} + \nabla \tau$, where τ is an arbitrary scalar function.
Note. Take the function τ to be single-valued.

- 1.12.5** With \mathbf{E} as the electric field and \mathbf{A} as the magnetic vector potential, show that $[\mathbf{E} + \partial\mathbf{A}/\partial t]$ is irrotational and that we may therefore write

$$\mathbf{E} = -\nabla\phi - \frac{\partial\mathbf{A}}{\partial t}$$

- 1.12.6** The total force on a charge q moving with velocity \mathbf{v} is

$$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}).$$

Using the scalar and vector potentials, show that

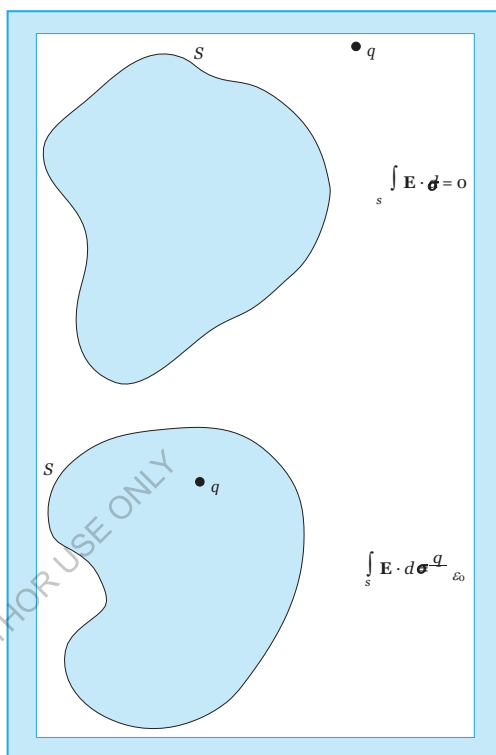
$$\mathbf{F} = q \left[-\nabla\phi - \frac{d\mathbf{A}}{dt} + \nabla(\mathbf{A} \cdot \mathbf{v}) \right].$$

Note that we now have a total time derivative of \mathbf{A} in place of the partial derivative of Exercise 1.12.5.

- 1.12.7** A planet of mass m moves on a circular orbit of radius r around a star in an attractive gravitational potential $\phi = kr^n$. Find the conditions on the exponent n for the orbit to be stable.

Note. You can set $k = GmM$, where M is the mass of the star, and use classical mechanics. Einstein's General Relativity gives $n = 1$, whereas in Newton's gravitation the Kepler laws are needed in addition to determining that $n = -1$.

Figure 1.42
Gauss's Law



1.13 Gauss's Law and Poisson's Equation

Gauss's Law

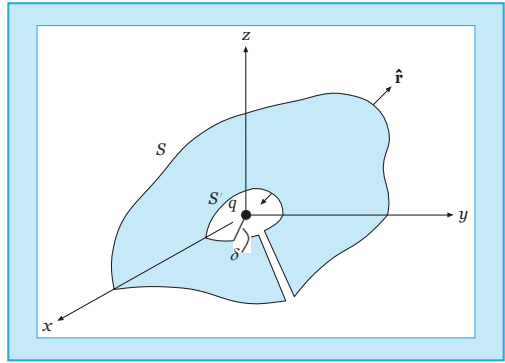
Consider a point electric charge q at the origin of our coordinate system. This produces an electric field \mathbf{E} ¹⁶ given by

$$\mathbf{E} = \frac{q\hat{\mathbf{r}}}{4\pi\epsilon_0 r^2}. \quad (1.136)$$

We now derive Gauss's law, which states that the surface integral in Fig. 1.42 is q/ϵ_0 if the closed surface S includes the origin (where q is located) and zero

¹⁶The electric field \mathbf{E} is defined as the force per unit charge on a small stationary test charge q_t : $\mathbf{E} = \mathbf{F}/q_t$. From Coulomb's law, the force on q_t due to q is $\mathbf{F} = (qq_t/4\pi\epsilon_0)(\hat{\mathbf{r}}/r^2)$. When we divide by q_t , Eq. (1.136) follows.

Figure 1.43
Exclusion of the
Origin



if the surface does not include the origin. The surface S is any closed surface; it need not be spherical.

Using Gauss's theorem [Eq. (1.116a)] (and neglecting the scale factor $q/4\pi\epsilon_0$), we obtain

$$\int_S \frac{\mathbf{r} \cdot d\boldsymbol{\sigma}}{r^2} = \int_V \nabla \cdot \frac{\mathbf{r}}{r^2} dt = 0 \quad (1.137)$$

by Example 1.6.1, provided the surface S does not include the origin, where the integrands are not defined. This proves the second part of Gauss's law.

The first part, in which the surface S must include the origin, may be handled by surrounding the origin with a small sphere S^δ of radius δ (Fig. 1.43). So that there will be no question as to what is inside and what is outside, imagine the volume outside the outer surface S and the volume inside surface S^δ ($r < \delta$) connected by a small hole. This joins surfaces S and S^δ , combining them into one **single, simply connected closed surface**. Because the radius of the imaginary hole may be made vanishingly small, there is no additional contribution to the surface integral. The inner surface is deliberately chosen to be spherical so that we will be able to integrate over it. Gauss's theorem now applies to the volume between S and S^δ without any difficulty. We have

$$\int_S \frac{\mathbf{r} \cdot d\boldsymbol{\sigma}}{r^2} + \int_{S^\delta} \frac{\hat{\mathbf{r}} \cdot d\boldsymbol{\sigma}^i}{S^\delta} = 0. \quad (1.138)$$

We may evaluate the second integral for $d\boldsymbol{\sigma}^i = -\hat{\mathbf{r}}\delta^2 d\chi$, in which $d\chi$ is an element of solid angle. The minus sign appears because we agreed in Section 1.9 to have the positive normal $\hat{\mathbf{r}}$ **outward** from the volume. In this case, the outward $\hat{\mathbf{r}}^i$ is in the negative radial direction, $\hat{\mathbf{r}}^i = -\hat{\mathbf{r}}$. By integrating over all angles, we have

$$\int_{S^\delta} \frac{\hat{\mathbf{r}} \cdot d\boldsymbol{\sigma}^i}{\delta^2} = - \int_{S^\delta} \frac{\hat{\mathbf{r}} \cdot \hat{\mathbf{r}}\delta^2 d\chi}{\delta^2} = -4\pi, \quad (1.139)$$

independent of the radius δ . With the constants from Eq. (1.136), this results in

$$\int_S \mathbf{E} \cdot d\boldsymbol{\sigma} = \frac{q}{4\pi\epsilon_0} = \frac{q}{\epsilon_0}, \quad (1.140)$$

completing the proof of Gauss's law. Notice that although the surface S may be spherical, it **need not** be spherical.

Going a bit further, we consider a distributed charge so that

$$q = \int_V \rho \, d\tau. \quad (1.141)$$

Equation (1.140) still applies, with q now interpreted as the total distributed charge enclosed by surface S :

$$\int_S \mathbf{E} \cdot d\boldsymbol{\sigma} = \frac{1}{\epsilon_0} \int_V \rho \, d\tau. \quad (1.142)$$

Using Gauss's theorem, we have

$$\int_V \nabla \cdot \mathbf{E} \, d\tau = \int_V \frac{\rho}{\epsilon_0} \, d\tau. \quad (1.143)$$

Since our volume is completely arbitrary, the integrands must be equal or

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}, \quad (1.144)$$

one of Maxwell's equations. If we reverse the argument, Gauss's law follows immediately from Maxwell's equation by integration.

Poisson's Equation

Replacing \mathbf{E} by $-\nabla\phi$, Eq. (1.144) becomes

$$\nabla \cdot \nabla\phi = -\frac{\rho}{\epsilon_0}, \quad (1.145)$$

which is Poisson's equation. We know a solution,

$$\phi(\mathbf{r}) = \frac{1}{4\pi\epsilon_0} \int \frac{\rho(\mathbf{r}') \, d\tau'}{|\mathbf{r} - \mathbf{r}'|^2}$$

from generalizing a sum of Coulomb potentials for discrete charges in electrostatics to a continuous charge distribution.

For the condition $\rho = 0$ this reduces to an even more famous equation, the **Laplace equation**.

$$\nabla \cdot \nabla\phi = 0. \quad (1.146)$$

We encounter Laplace's equation frequently in discussing various curved coordinate systems (Chapter 2) and the special functions of mathematical physics that appear as its solutions in Chapter 11.

From direct comparison of the Coulomb electrostatic force law and Newton's law of universal gravitation,

$$\mathbf{F}_E = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \hat{\mathbf{r}}, \quad \mathbf{F}_G = -G \frac{m_1 m_2}{r^2} \hat{\mathbf{r}}.$$

All of the potential theory of this section therefore applies equally well to gravitational potentials. For example, the gravitational Poisson equation is

$$\nabla \cdot \nabla \phi = +4\pi G\rho, \quad (1.147)$$

with ρ now a mass density.

Biographical Data

Poisson, Siméon Denis. Poisson, a French mathematician, was born in Pithiviers, France in 1781 and died in Paris in 1840. He studied mathematics at the Ecole Polytechnique under Laplace and Lagrange, whom he so impressed with his talent that he became professor there in 1802. He contributed to their celestial mechanics, Fourier's heat theory, and probability theory, among others.

EXERCISES

1.13.1 Develop Gauss's law for the two-dimensional case in which

$$\phi = -q \frac{\ln \rho}{2\pi\epsilon_0}, \quad \mathbf{E} = -\nabla \phi = q \frac{\hat{\rho}}{2\pi\epsilon_0 \rho},$$

where q is the charge at the origin or the line charge per unit length if the two-dimensional system is a unit thickness slice of a three-dimensional (circular cylindrical) system. The variable ρ is measured radially outward from the line charge. $\hat{\rho}$ is the corresponding unit vector (see Section 2.2). If graphical software is available, draw the potential and field for the $q/2\pi\epsilon_0 = 1$ case.

1.13.2 (a) Show that Gauss's law follows from Maxwell's equation

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$$

by integrating over a closed surface. Here, ρ is the charge density.

(b) Assuming that the electric field of a point charge q is spherically symmetric, show that Gauss's law implies the Coulomb inverse square expression

$$\mathbf{E} = \frac{q\hat{r}}{4\pi\epsilon_0 r^2}.$$

1.13.3 Show that the value of the electrostatic potential ϕ at any point P is equal to the average of the potential over any spherical surface centered on P . There are no electric charges on or within the sphere.

Hint. Use Green's theorem [Eq. (1.119)], with $u^{-1} = r$, the distance from P , and $v = \phi$.

1.13.4 Using Maxwell's equations, show that for a system (steady current) the magnetic vector potential \mathbf{A} satisfies a vector Poisson equation

$$\nabla^2 \mathbf{A} = -\mu \mathbf{J},$$

provided we require $\nabla \cdot \mathbf{A} = 0$ in Coulomb gauge.

1.14 Dirac Delta Function

From Example 1.6.1 and the development of Gauss's law in Section 1.13,

$$\int_V \nabla \cdot \frac{\mathbf{r}}{r^3} d\tau = -\int_V \nabla \cdot \frac{\mathbf{r}}{r^2} d\tau = 0, \quad (1.148)$$

depending on whether the integration includes the origin $\mathbf{r} = 0$ or not. This result may be conveniently expressed by introducing the Dirac delta function,

$$\int_V \frac{\mathbf{r}}{r} d\tau = 4\pi\delta(\mathbf{r}) = 4\pi\delta(x)\delta(y)\delta(z). \quad (1.149)$$

This Dirac delta function is **defined** by its assigned properties

$$\delta(x) = 0, \quad x \neq 0 \quad (1.150)$$

$$f(0) = \int_{-\infty}^{\infty} f(x)\delta(x)dx, \quad (1.151)$$

where $f(x)$ is any well-behaved function and the integration includes the origin. As a special case of Eq. (1.151),

$$\int_{-\infty}^{\infty} \delta(x)dx = 1. \quad (1.152)$$

From Eq. (1.151), $\delta(x)$ must be an infinitely high, infinitely thin spike at $x = 0$, as in the description of an impulsive force or the charge density for a point charge.¹⁷ The problem is that **no such function exists** in the usual sense of function. However, the crucial property in Eq. (1.151) can be developed rigorously as the limit of a **sequence** of functions, a distribution. For example, the delta function may be approximated by the sequences of functions in n for $n \rightarrow \infty$ [Eqs. (1.153)–(1.156) and Figs. 1.44–1.47]:

$$\delta_n(x) = \begin{cases} \frac{1}{n}, & -\frac{1}{2n} < x < \frac{1}{2n} \\ 0, & x > \frac{1}{2n} \end{cases} \quad (1.153)$$

$$\delta_n(x) = \frac{n}{\sqrt{\pi}} \exp(-n^2x^2) \quad (1.154)$$

$$\delta_n(x) = \frac{n}{\pi} \frac{1}{1+n^2x^2} \quad (1.155)$$

$$\delta_n(x) = \frac{\sin nx}{\pi x} = \frac{1}{2\pi} \int_{-n}^n e^{ixt} dt. \quad (1.156)$$

¹⁷The delta function is frequently invoked to describe very short-range forces such as nuclear forces. It also appears in the normalization of continuum wave functions of quantum mechanics.

Figure 1.44
 δ Sequence Function
 Eq. (1.153)

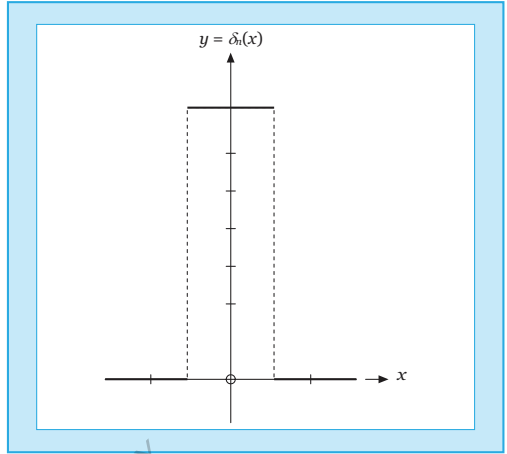
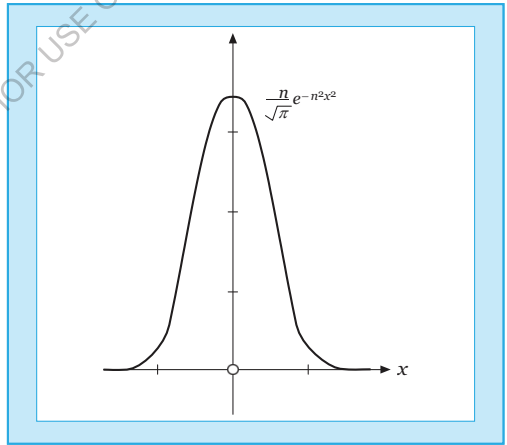


Figure 1.45
 δ Sequence Function
 Eq. (1.154)



EXAMPLE 1.14.1

Let us evaluate $\int_{-\pi}^{\pi} \cos x \delta(x) dx = \cos 0 = 1$ using the sequence of Eq. (1.153). We find

$$\begin{aligned} \int_{-1/2n}^{1/2n} n \cos x dx &= n \sin x \Big|_{-1/2n}^{1/2n} = n \left(\sin \frac{1}{2n} - \sin \left(-\frac{1}{2n}\right) \right) \\ &= 2n \sin \frac{1}{2n} = 2n \left(\frac{1}{2n} + O\left(\frac{1}{n^3}\right) \right) \rightarrow 1 \text{ for } n \rightarrow \infty. \end{aligned}$$

Figure 1.46
δ Sequence Function
Eq. (1.155)

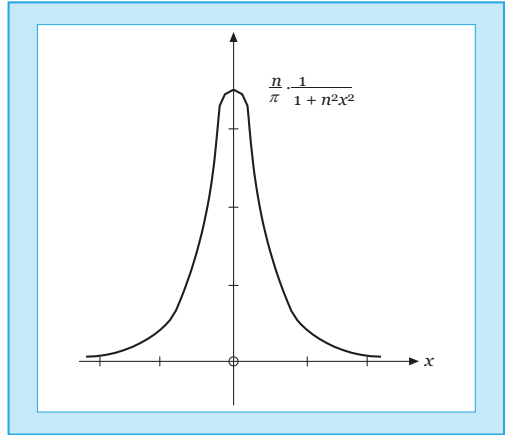
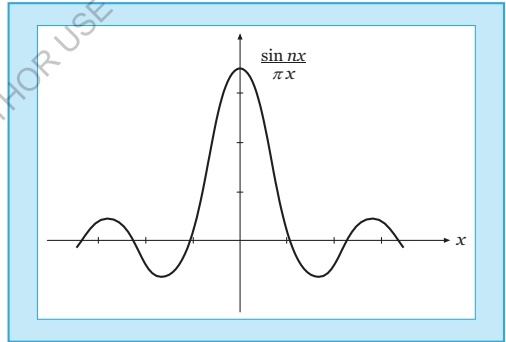


Figure 1.47
δ Sequence Function
Eq. (1.156)



Notice how the integration limits change in the first step. Similarly,

$$\int_{-\pi}^{\pi} \sin x \delta(x) \cdot dx = \sin 0 = 0. \text{ We could have used Eq. (1.155) instead,}$$

$$\int_{-\pi}^{\pi} \cos x dx = \int_{-\pi}^{\pi} \frac{1}{1+x^2/2+\dots} \frac{n}{\pi} \frac{1}{1+n^2x^2} dx = \frac{n}{\pi} \int_{-\pi}^{\pi} \frac{1}{1+n^2x^2}$$

$$= \frac{1}{\pi} \int_{-\pi/n}^{\pi/n} \frac{1}{1+y^2} dy = \frac{1}{\pi} [\arctan(n\pi) - \arctan(-n\pi)]$$

$$= \frac{2}{\pi} \arctan(n\pi) \rightarrow \frac{2}{\pi} \frac{\pi}{2} = 1, \text{ for } n \rightarrow \infty,$$

by keeping just the first term of the power expansion of $\cos x$. Again, we could have changed the integration limits to $\pm\pi/n$ in the first step for all terms with positive powers of x because the denominator is so large, except close to $x = 0$ for large n . This explains why the higher order terms of the $\cos x$ power series do not contribute. ■

These approximations have varying degrees of usefulness. Equation (1.153) is useful in providing a simple derivation of the integral property [Eq. (1.151)]. Equation (1.154) is convenient to differentiate. Its derivatives lead to the Hermite polynomials. Equation (1.156) is particularly useful in Fourier analysis and in its applications to quantum mechanics. In the theory of Fourier series, Eq. (1.156) often appears (modified) as the Dirichlet kernel:

$$\delta_n(x) = \frac{1 \sin[(n + \frac{1}{2})x]}{2\pi \sin(\frac{x}{2})}. \tag{1.157}$$

In using these approximations in Eq. (1.151) and later, we assume that $f(x)$ is integrable—it offers no problems at large x .

For most physical purposes such approximations are quite adequate. From a mathematical standpoint, the situation is still unsatisfactory: The limits

$$\lim_{n \rightarrow \infty} \delta_n(x)$$

do not exist.

A way out of this difficulty is provided by the theory of distributions. Recognizing that Eq. (1.151) is the fundamental property, we focus our attention on it rather than on $\delta(x)$. Equations (1.153)–(1.156), with $n = 1, 2, 3, \dots$, may be interpreted as **sequences** of normalized functions:

$$\int_{-\infty}^{\infty} \delta_n(x) dx = 1. \tag{1.158}$$

The sequence of integrals has the limit

$$\lim_{n \rightarrow \infty} \int_{-\infty}^{\infty} \delta_n(x) f(x) dx = f(0). \tag{1.159}$$

Note that Eq. (1.158) is the limit of a sequence of integrals. Again, the limit of $\delta_n(x)$, $n \rightarrow \infty$, does not exist. [The limits for all four forms of $\delta_n(x)$ diverge at $x = 0$.]

We may treat $\delta(x)$ consistently in the form

$$\int_{-\infty}^{\infty} \delta(x) f(x) dx = \lim_{n \rightarrow \infty} \int_{-\infty}^{\infty} \delta_n(x) f(x) dx. \tag{1.160}$$

$\delta(x)$ is labeled a distribution (not a function) defined by the sequences $\delta_n(x)$ as indicated in Eq. (1.158). We might emphasize that the integral on the left-hand side of Eq. (1.160) is not a Riemann integral.¹⁸ It is a limit.

¹⁸It can be treated as a Stieltjes integral if desired. $\delta(x) dx$ is replaced by $du(x)$, where $u(x)$ is the Heaviside step function.

This distribution $\delta(x)$ is only one of an infinity of possible distributions, but it is the one we are interested in because of Eq. (1.151).

From these sequences of functions, we see that Dirac's delta function must be even in x , $\delta(-x) = \delta(x)$.

Let us now consider a detailed application of the Dirac delta function to a single charge and illustrate the singularity of the electric field at the origin.

EXAMPLE 1.14.2

Total Charge inside a Sphere Consider the total electric flux $\mathbf{E} \cdot d\boldsymbol{\sigma}$ out of a sphere of radius R around the origin surrounding n charges e_j located at the points \mathbf{r}_j with $r_j < R$ (i.e., inside the sphere). The electric field strength $\mathbf{E} = -\nabla\phi(\mathbf{r})$, where the potential

$$\phi = \sum_{j=1}^n \frac{e_j}{|\mathbf{r} - \mathbf{r}_j|} = \int \frac{\rho(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} d^3r'$$

is the sum of the Coulomb potentials generated by each charge and the total charge density is $\rho(\mathbf{r}) = \sum_j e_j \delta(\mathbf{r} - \mathbf{r}_j)$. The delta function is used here as an abbreviation of a pointlike density. Now we use Gauss's theorem for

$$\mathbf{E} \cdot d\boldsymbol{\sigma} = -\nabla\phi \cdot d\boldsymbol{\sigma} = -\nabla^2\phi d\tau = \int \frac{\rho(\mathbf{r}')}{\epsilon_0} d^3r' = \sum_j e_j \int \delta(\mathbf{r} - \mathbf{r}_j) d^3r$$

in conjunction with the differential form of Gauss's law $\nabla \cdot \mathbf{E} = -\rho/\epsilon_0$ and $\int \delta(\mathbf{r} - \mathbf{r}_j) d^3r = e_j$.

The integral property [Eq. (1.151)] is useful in cases in which the argument of the delta function is a function $g(x)$ with **simple zeros** on the real axis, which leads to the rules

$$\delta(ax) = \frac{1}{|a|} \delta(x), \quad a > 0, \tag{1.161}$$

$$\delta(g(x)) = \sum_{g^i(a)=0} \frac{\delta(x-a)}{|g^i(a)|}, \tag{1.162}$$

To obtain Eq. (1.161) we change the integration variable in

$$\int_{-\infty}^{\infty} f(x)\delta(ax)dx = \frac{1}{|a|} \int_{-\infty}^{\infty} f\left(\frac{y}{a}\right)\delta(y)dy = \frac{1}{|a|} f(0)$$

and apply Eq. (1.151). To prove Eq. (1.162), we decompose the integral

$$\int_{-\infty}^{\infty} f(x)\delta(g(x))dx = \sum_{a^i} \int_{a^i-\epsilon}^{a^i+\epsilon} f(x)\delta((x-a^i)g^i(a^i))dx \tag{1.163}$$

into a sum of integrals over small intervals containing the first-order zeros of $g(x)$. In these intervals, $g(x) \approx g(a) + (x - a)g^i(a) = (x - a)g^i(a)$. Using Eq. (1.161) on the right-hand side of Eq. (1.163), we obtain the integral of Eq. (1.162).

EXAMPLE 1.14.3

Evaluate $I \equiv \int_{-\infty}^{\infty} f(x)\delta(x^2 - 2)dx$. Because the zeros of the argument of the delta function, $x^2 = 2$, are $x = \pm \sqrt{2}$, we can write the integral as a sum of two contributions:

$$\begin{aligned} I &= \int_{-\sqrt{2}}^{\sqrt{2}} \delta(x - \sqrt{2}) \frac{f(x)dx}{\frac{d(x^2-2)}{dx} \Big|_{x=\sqrt{2}}} + \int_{-\sqrt{2}}^{-\sqrt{2}} \delta(x + \sqrt{2}) \frac{f(x)dx}{\frac{d(x^2-2)}{dx} \Big|_{x=-\sqrt{2}}} \\ &= \int_{-\sqrt{2}}^{\sqrt{2}} \delta(x - \sqrt{2}) \frac{f(x)dx}{2\sqrt{2}} + \int_{-\sqrt{2}}^{-\sqrt{2}} \delta(x + \sqrt{2}) \frac{f(x)dx}{-2\sqrt{2}} \\ &= \frac{f(\sqrt{2})}{2\sqrt{2}} + \frac{f(-\sqrt{2})}{-2\sqrt{2}} \quad \blacksquare \end{aligned}$$

This example is good training for the following one.

EXAMPLE 1.14.4

Phase Space In the scattering theory of relativistic particles using Feynman diagrams, we encounter the following integral over energy of the scattered particle (we set the velocity of light $c = 1$):

$$\begin{aligned} \int d^4p \delta(p^2 - m^2) f(p) &\equiv \int \int d^3p \delta(p^2 - \mathbf{p}^2 - m^2) f(p) \\ &= \int_{E>0} \frac{d^3p f(E, \mathbf{p})}{2\sqrt{m^2 + \mathbf{p}^2}} + \int_{E<0} \frac{d^3p f(E, \mathbf{p})}{2\sqrt{m^2 + \mathbf{p}^2}}, \end{aligned}$$

where we have used Eq. (1.162) at the zeros $E = \pm \sqrt{m^2 + \mathbf{p}^2}$ of the argument of the delta function. The physical meaning of $\delta(p^2 - m^2)$ is that the particle of mass m and four-momentum $p^\mu = (p_0, \mathbf{p})$ is on its mass shell because $p^2 - m^2$ is equivalent to $E^2 - m^2 - \mathbf{p}^2$. Thus, the on-mass-shell volume element in momentum space is the Lorentz invariant $\frac{d^3p}{2E}$, in contrast to the nonrelativistic d^3p of momentum space. The fact that a negative energy occurs is a peculiarity of relativistic kinematics that is related to the antiparticle. \blacksquare

Using integration by parts we can also define the derivative $\delta'(x)$ of the Dirac delta function by the relation

$$\int_{-\infty}^{\infty} f(x)\delta'(x - x^i) dx = - \int_{-\infty}^{\infty} f'(x)\delta(x - x^i) dx = -f'(x^i). \quad (1.164)$$

It should be understood that our Dirac delta function has significance only as part of an integrand. Thus, the Dirac delta function is often regarded as a linear operator: $\delta(x - x_0)$ operates on $f(x)$ and yields $f(x_0)$:

$$L(x_0)f(x) \equiv \int_{-\infty}^{\infty} \delta(x - x_0)f(x) dx = f(x_0). \quad (1.165)$$

It may also be classified as a linear mapping or simply as a generalized function. Shifting our singularity to the point $x = x^i$, we write the Dirac delta function as $\delta(x - x^i)$. Equation (1.151) becomes

$$\int_{-\infty}^{\infty} f(x)\delta(x - x^i) dx = f(x^i). \tag{1.166}$$

As a description of a singularity at $x = x^i$, the Dirac delta function may be written as $\delta(x - x^i)$ or as $\delta(x^i - x)$. Expanding to three dimensions and using spherical polar coordinates, we obtain

$$\begin{aligned} f(\mathbf{0}) &= \int_0^{\infty} \int_0^{\pi} \int_0^{2\pi} f(\mathbf{r})\delta(\mathbf{r}) r^2 dr \sin \theta d\theta d\phi \\ &= \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x, y, z)\delta(x)\delta(y)\delta(z) dx dy dz, \\ &= \int_0^{\infty} \delta(r) r^2 dr \int_{-1}^1 \delta(\cos \theta) d\cos \theta \int_0^{2\pi} \delta(\phi) d\phi = 1, \end{aligned} \tag{1.167}$$

where each one-dimensional integral is equal to unity. This corresponds to a singularity (or source) at the origin. Again, if our source is at $\mathbf{r} = \mathbf{r}_1$, Eq. (1.167) generalizes to

$$\int f(\mathbf{r}_2)\delta(\mathbf{r}_2 - \mathbf{r}_1) r_2^2 dr_2 \sin \theta_2 d\theta_2 d\phi_2 = f(\mathbf{r}_1), \tag{1.168}$$

where

$$\int_0^{\infty} \delta(r_2 - r_1) r_2^2 dr_2 \int_{-1}^1 \delta(\cos \theta_2 - \cos \theta_1) d\cos \theta_2 \int_0^{2\pi} \delta(\phi_2 - \phi_1) d\phi_2 = 1.$$

SUMMARY

We use $\delta(x)$ frequently and call it the Dirac delta function—for historical reasons.¹⁹ Remember that it is not really a function. It is essentially a shorthand notation, defined implicitly as the limit of integrals in a sequence, $\delta_n(x)$, according to Eq. (1.160).

Biographical Data

Dirac, Paul Adrien Maurice. Dirac, an English physicist, was born in Bristol in 1902 and died in Bristol in 1984. He obtained a degree in electrical engineering at Bristol and obtained his Ph.D. in mathematical physics in 1926 at Cambridge. By 1932, he was Lucasian professor, like Stokes, the chair Newton once held. In the 1920s, he advanced quantum mechanics, became one of the founders of quantum field theory, and, in 1928, discovered his relativistic equation for the electron that predicted antiparticles for which he was awarded the Nobel prize in 1933.

¹⁹Dirac introduced the delta function to quantum mechanics. Actually, the delta function can be traced back to Kirchoff, 1882. For further details, see M. Jammer (1966). *The Conceptual Development of Quantum Mechanics*, p. 301. McGraw-Hill, New York.

EXERCISES

1.14.1 Let

$$\delta_n(x) = \begin{cases} 0, & x < -\frac{1}{2n} \\ n, & -\frac{1}{2n} < x < \frac{1}{2n} \\ 0, & \frac{1}{2n} < x \end{cases}$$

Show that

$$\lim_{n \rightarrow \infty} \int_{-\infty}^{\infty} f(x) \delta_n(x) dx = f(0),$$

assuming that $f(x)$ is continuous at $x = 0$.1.14.2 Verify that the sequence $\delta_n(x)$, based on the function

$$\delta_n(x) = \begin{cases} 0, & x < 0, \\ \frac{1}{n} e^{-nx}, & x > 0, \end{cases}$$

is a delta sequence [satisfying Eq. (1.159)]. Note that the singularity is at $+0$, the positive side of the origin.*Hint.* Replace the upper limit (∞) by c/n , where c is large but finite, and use the mean value theorem of integral calculus.

1.14.3 For

$$\delta_n(x) = \frac{n}{\pi} \frac{1}{1 + n^2 x^2}$$

[Eq. (1.155)], show that

$$\int_{-\infty}^{\infty} \delta_n(x) dx = 1.$$

1.14.4 Demonstrate that $\delta_n = \frac{\sin nx}{\pi x}$ is a delta distribution by showing that

$$\lim_{n \rightarrow \infty} \int_{-\infty}^{\infty} f(x) \frac{\sin nx}{\pi x} dx = f(0).$$

Assume that $f(x)$ is continuous at $x = 0$ and vanishes as $x \rightarrow \pm\infty$.*Hint.* Replace x by y/n and take $\lim_{n \rightarrow \infty}$ **before** integrating.

1.14.5 Fejer's method of summing series is associated with the function

$$\frac{1}{\sum_{k=0}^n \cos^2 \frac{kt}{2}}$$

$$\delta_n(t) = \frac{1}{2\pi n} \frac{\sin^2(t/2)}{\sin(t/2)}$$

Show that $\delta_n(t)$ is a delta distribution in the sense that

$$\lim_{n \rightarrow \infty} \frac{1}{2\pi n} \int_{-\infty}^{\infty} f(t) \frac{\sin^2(nt/2)}{\sin(t/2)} dt = f(0).$$

1.14.6 Using the Gaussian delta sequence (δ_n), Eq. (1.154), show that

$$x \frac{d}{dx} \delta(x) = -\delta(x),$$

treating $\delta(x)$ and its derivative as in Eq. (1.151).

1.14.7 Show that

$$\int_{-\infty}^{\infty} \delta^i(x) f(x) dx = -f^i(0).$$

Assume that $f^i(x)$ is continuous at $x = 0$.

1.14.8 Prove that

$$\delta(f(x)) = \frac{df(x)^{-1}}{dx} \delta(x - x_0),$$

where x_0 is chosen so that $f(x_0) = 0$ with $df/dx \neq 0$ that is, $f(x)$ has a simple zero at x_0 .

Hint. Use $\delta(f) df = \delta(x) dx$ after explaining why this holds.

1.14.9 Show that in spherical polar coordinates $(r, \cos \theta, \phi)$ the delta function $\delta(\mathbf{r}_1 - \mathbf{r}_2)$ becomes

$$\frac{1}{r_1^2} \delta(r_1 - r_2) \delta(\cos \theta_1 - \cos \theta_2) \delta(\phi_1 - \phi_2).$$

1.14.10 For the finite interval $[-\pi, \pi]$ expand the Dirac delta function $\delta(x)$ in a series of sines and cosines: $\sin nx, \cos nx, n = 0, 1, 2, \dots$. Note that although these functions are orthogonal, they are not normalized to unity.

1.14.11 In the interval $(-\pi, \pi)$, $\delta_n(x) = \frac{\sqrt{n}}{\pi} \exp(-n^2 x^2)$.

(a) Expand $\delta_n(x)$ as a Fourier cosine series.

(b) Show that your Fourier series agrees with a Fourier expansion of $\delta(x)$ in the limit as $n \rightarrow \infty$.

(c) Confirm the delta function nature of your Fourier series by showing that for any $f(x)$ that is finite in the interval $[-\pi, \pi]$ and continuous at $x = 0$,

$$\int_{-\pi}^{\pi} f(x) [\text{Fourier expansion of } \delta_n(x)] dx = f(0).$$

1.14.12 (a) Expand $\delta_n(x) = \frac{\sqrt{n}}{\pi} \exp(-n^2 x^2)$ in the interval $(-\infty, \infty)$ as a Fourier integral.

(b) Expand $\delta_n(x) = n \exp(-nx)$ as a Laplace transform.

1.14.13 We may define a sequence

$$\delta_n(x) = \begin{cases} n, & |x| < 1/2n, \\ 0, & |x| > 1/2n. \end{cases}$$

[Eq. (1.153)]. Express $\delta_n(x)$ as a Fourier integral (via the Fourier integral theorem, inverse transform, etc.). Finally, show that we may write

$$\delta(x) = \lim_{n \rightarrow \infty} \delta_n(x) = \frac{1}{2} \int_{-\infty}^{\infty} e^{-ikx} dk.$$

1.14.14 Using the sequence

$$\delta_n(x) = \sqrt{\frac{n}{\pi}} \exp(-n^2 x^2),$$

show that

$$\delta(x) = \frac{1}{\pi} \int_{-\infty}^{\infty} e^{-ikx} dk.$$

Note. Remember that $\delta(x)$ is defined in terms of its behavior as part of an integrand, especially Eq. (1.159).

1.14.15 Derive sine and cosine representations of $\delta(t - x)$.

$$\text{ANS. } \frac{2}{\pi} \int_0^{\infty} \sin \omega t \sin \omega x d\omega, \frac{2}{\pi} \int_0^{\infty} \cos \omega t \cos \omega x d\omega.$$

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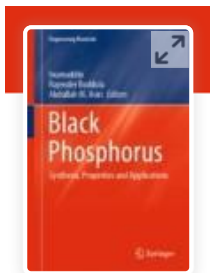
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Black Phosphorus pp 117–138

Biomedical Applications of Black Phosphorus

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Abstract

Two dimensional (2D) materials have attracted extravagant eminence in the area of biomedical applications due to their distinctive structure, biocompatibility, and physicochemical properties. Mono-layered black phosphorus (BP), also known as phosphorene, is a thermodynamically stable allotrope of phosphorous and is the very recent member of the 2D family has lured tremendous scientific interest since its rediscovery in 2014. The exceptional properties of BP including high carrier mobility, large specific surface area, tunable band gap, intrinsic anisotropy, and inherent in vivo biocompatibility and biodegradability make it an

ideal alternative to other 2D materials in biomedical applications. This chapter summarizes various biomedical applications of BP including drug delivery, bio-imaging, bio-sensing, photothermal/photodynamic therapy, and theranostics. The main focus of this chapter is to emphasize the efficacy of BP nanosheets (NSs) and quantum dots (QDs) as robust and tunable diagnostic and therapeutic platforms. Finally, the current challenges and future perspectives in biomedical applications of BP have also been addressed.

Keywords

Black phosphorous

Biomedical

Theranostics

Drug delivery

Bio-sensing

Imaging

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Chapter 5

Energy-Saving Synthesis of $Mg_2SiO_4:RE^{3+}$ Nanophosphors for Solid-State Lighting Applications



Ramachandra Naik, Ramyakrishna Pothu, Prashantha S. C,
Nagabhushana H, Aditya Saran, Harisekhar Mitta, and Rajender Boddula

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Abstract Magnesium silicate (Mg_2SiO_4) doped with rare earth (RE^{3+}) ions can be prepared using different methods. The combustion method is the most widely used technique because it saves time and energy compared with conventional solid-state reactions. Preparation of nanophosphors via the combustion method can be carried out using different fuels such as urea, oxalyldihydrazide (ODH), diformylhydrazine, and plant extracts. In this study, $Mg_2SiO_4:RE^{3+}$ nanophosphors are prepared using the combustion method with ODH fuel, which is an energy-saving synthesis because the products are formed at a low temperature (350 °C). Photoluminescence analysis is carried out with the prepared nanophosphors for solid-state lighting applications.

5.1 Introduction

5.1.1 Nanophosphors

The word phosphor means “light bearer” in Greek; it appears in Greek myths in reference to the personification of the morning superstar Venus (Cao 2004). Phosphors are prepared by introducing an activator into a host material; the activator acts as a luminescent center, and the host can be any compound. Usually, lanthanide ions are used to act as the luminescent centers. Lanthanide ions cause discrete energy levels within the host; they are the center from which luminescence emanates. The energy states are situated within the band gap, such that the electrons are de-excited from the higher to the lower states radiatively. The phosphors may be in the form of either powder or a thin film. The phosphor substances are doped intentionally with exact impurities to obtain the favored wavelength. These phosphor powders and thin films are extremely important in the development and improvement of display technologies. Smaller-sized particles are essential for high-resolution images. Hence, there is a need for the construction and development of phosphor nanoparticles (NPs) with enhanced emission intensities. Phosphor particles that are of submicrometric size, with narrow particle distribution and spherical morphology, provide greater particle packing densities than commercial products (3–5 μm) and are therefore effective in the enhancement of luminescence efficiency (Noto 2011).

Phosphors with enhanced properties are required for the development of new types of high-efficiency and high-resolution displays. Monodispersed crystalline fine

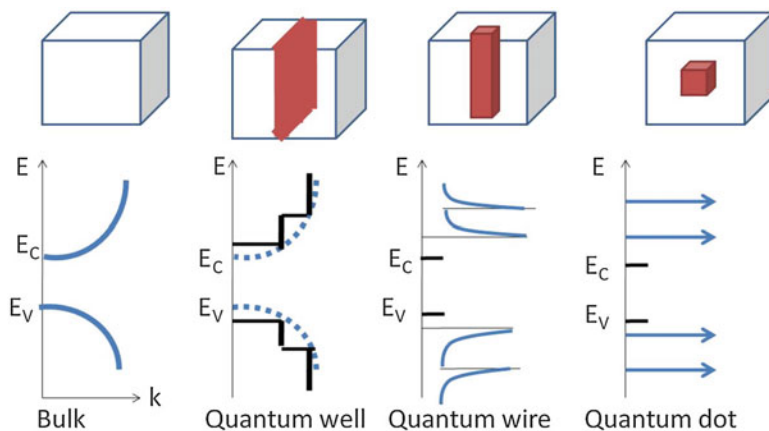


Fig. 5.1 Schematic diagram of the comparison of energy levels in different materials

particles of high-efficiency phosphor materials are the key to the development of these devices. Phosphors must have narrow size distribution, fine size, spherical morphology, and non-aggregation to exhibit good luminescent characteristics (Rao 1994). Nanosized phosphors exhibit fascinating properties, such as extremely fast recombination time, an increase in the band gap because of the smaller particle size, and high quantum efficiency for photoluminescence (PL) (Hagenmuller 1992).

Owing to their potential quantum confinement effect and low dimensionality, inorganic nanocrystals exhibit fascinating size- and shape-dependent properties. In general, the intrinsic properties of nanoscale materials are determined by their composition, structure, crystallinity, size, and morphology. Over the past few years, the synthesis of inorganic nanoscale materials with specific morphologies has been the focus of extensive studies in materials science. In particular, the development of nanostructured luminescent materials has also made a very positive contribution to systematic fundamental studies of synthesis and possible new applications (Fendler and Meldrum 1995; Lakshmi et al. 1997; Sun and Xia 2002; Cushing et al. 2004; Fernández-García et al. 2004; Wang et al. 2009).

Figure 5.1 represents the schematic diagram of the comparison of energy levels in different materials, such as bulk, quantum wells, wires, and dots (NPs). It can be seen from the diagram that energy levels of bulk material are parabolic, a step model for quantum wells, a spike model for quantum wires, and discrete energy levels for quantum dots. Figure 5.2 shows a schematic diagram of the comparison of the bandgap of bulk and quantum dots. It is observed that bulk material has a lower band gap value and that energy levels are continuous. Nanoparticles have larger band gaps and more discrete energy levels owing to the various quantum confinement effects within it, which can be as small as only a few dozen atoms wide (a couple of nanometers). Quantum confinement is defined as confinement of the movement of the particles in one or more dimensions. When these dimensions are comparable with the de Broglie wavelength of the particle, quantum confinement effects take place and cause the band gap of the particle to increase.

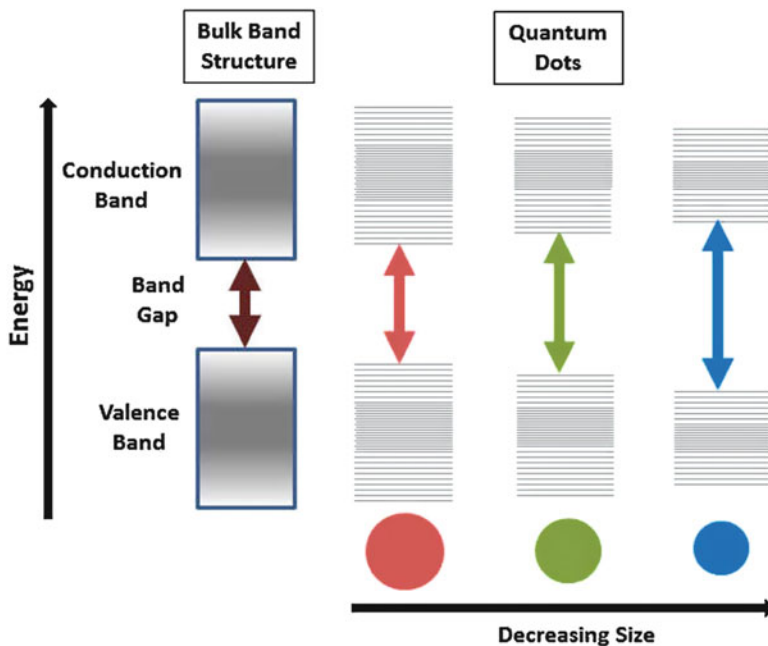


Fig. 5.2 Schematic diagram of the comparison of the bandgap of bulk and quantum dots (nanoparticles)

5.1.2 Magnesium Silicate

The silicate family is an attractive class of materials among inorganic phosphors and is used for a wide range of applications owing to its special properties, such as water and chemical resistance, and visible light transparency. In particular, inorganic nanophosphors with the incorporation of trivalent rare earth (RE) cations reveal major luminescence effects. Further, various vacancies and defects present in the host matrix result in different luminescence features (Prashantha et al. 2011). Enhanced electrical, luminescent, and optical properties of nanophosphors are caused by the quantum size effect, which is generated by an increase in the bandgap due to a decrease in the quantum allowed state and the high surface-to-volume ratio (Cho et al. 2010). Among the silicate family, the Mg_2SiO_4 (forsterite) host doped with RE ions exhibits some interesting applications, such as long-lasting phosphor, X-ray imaging, light-emitting display, and environmental monitoring.

Forsterite, an important material in the magnesia–silica system and a member of the olivine family of crystals, has an orthorhombic crystalline structure in which Mg^{2+} occupies two non-equivalent octahedral sites: one (M1) with inversion symmetry (CI) and the other (M2) with mirror symmetry (CS). The material has some essential properties, such as a high melting point, chemical stability even at high temperatures, vast electrical and refractory characteristics, in addition to good mechanical

properties, bioactivity, and biocompatibility (Mostafavi et al. 2013). Therefore, it has commercial applications in many industrial areas, e.g., electronics as insulators working at high frequencies (Sanosh et al. 2010), the refractory industry (Bos 2001), advanced technologies such as solid oxide fuel cells (Kosanović et al. 2005), biomedicine (Kharaziha and Fathi 2009), and luminescent technology (Lin et al. 2008).

5.1.3 Rare Earth Ions Doping

Rare earth (RE) ions have attracted much attention owing to the distinct electronic and optical characteristics arising from their 4f electrons. When RE ions are introduced into a suitable host, an efficient luminescent phosphor with a high quantum yield, narrow bandwidth, large Stokes shifts, converting unusable UV to useful visible light, and ligand-dependent luminescence sensitization (Wong et al. 2013; Krishna et al. 2014). In particular, the RE-doped luminescent materials are particularly attractive because of the increasing interest of the lighting industry, and as a result, the materials are quite useful in the solid state lighting (SSL) applications (Dorman et al. 2012; Han et al. 2012; Krishna et al. 2013).

From an application point of view, it is obvious that a size reduction of NPs can significantly enhance the surface phenomena. For this reason, the study of optical properties of RE-doped nanophosphors synthesized at low temperatures compared with their bulk counterparts has encouraged this research more intensely. Highly luminescent nanophosphors with greater brightness can be prepared with the addition of alkali metal ions such as Li^+ as co-dopants. Alkali metal ions remove the charge imbalance problem, increase the crystallinity, and enhance the emission intensity of nanophosphors because of having low oxidation states and distinct ionic radii (Su et al. 2008; Balakrishnaiah et al. 2011). This technique is employed in several systems, such as $\text{ZnB}_2\text{O}_4\text{:Eu}^{3+}$, $\text{CaWO}_4\text{:Eu}^{3+}$, $\text{YBO}_3\text{:Eu}^{3+}$, $\text{YVO}_4\text{:Eu}^{3+}$, $\text{GdVO}_4\text{:Yb,HO}$, and $\text{GdVO}_4\text{:Yb,Er}$, to achieve impressive luminescence properties (Su et al. 2008; Yang et al. 2010; Balakrishnaiah et al. 2011; Mu et al. 2011; Chen et al. 2012; Gavrilović et al. 2015).

5.1.4 Synthesis

The efficiency of a nanophosphor depends on the host material and on improved synthetic routes. Pure and doped Mg_2SiO_4 NPs are synthesized via different chemical routes. Forsterite is preferably prepared using solution-based methods to obtain high chemical homogeneity and small crystallite size compared with the conventional solid-state reaction, which needs higher calcination temperatures to obtain phase-pure crystals. However, the synthesis of the pure and doped nanocrystalline forsterite with controlled particle size remains challenging. Therefore, many

alternative synthesis techniques have been reported for the synthesis of forsterite, including the citrate–nitrate method (Gavrilović et al. 2014), the molten salt approach (Saber et al. 2009), combined mechanical activation (Sun et al. 2009), the polymer precursor method (Tavangarian and Emadi 2010), flame spray pyrolysis (Martin et al. 1992), mechano-thermal synthesis (Tani et al. 2007), combustion synthesis (Kharaziha and Fathi 2009), mechano-chemical synthesis (Fathi and Kharaziha 2008), and sol–gel techniques (Fathi and Kharaziha 2009; Mostafavi et al. 2013).

Forsterite can be synthesized at high temperatures for an extensive time period via a solid-state reaction process. This process generally produces powders with large grain sizes, and the final product is not homogeneous and has an unwanted MgSiO_3 phase (Saber et al. 2007). Therefore, synthesizing single-phase Mg_2SiO_4 NPs without an MgSiO_3 and MgO (periclase) phase remains a challenging task for material scientists (Lin et al. 2006).

5.1.5 Combustion Synthesis

Combustion synthesis is also known as self-propagating high-temperature synthesis. To generate combustion, an oxidizer, a fuel, and the right temperature are required. The process makes use of highly exothermic redox chemical reactions between an oxidizer and a fuel. A redox reaction involves simultaneous oxidation and reduction processes. The term combustion covers flaming (gas-phase), smoldering (solid-gas), and explosive reactions. The preparation of forsterite via solid-state reactions usually requires a high temperature and long reaction time, whereas the solution combustion process with the proper selection of fuel is a rapid and precise process for achieving nano-sized compounds. It also reduces the crystallization temperature and prevents phase segregation during heating because it is not only implemented in minutes at a relatively low temperature, it also allows molecular-level mixing, a high degree of homogeneity, and uniform doping of trace amounts of RE and transition metal ions in a single step (Kosanović et al. 2005).

5.1.6 Photoluminescence

Luminescence was first observed in an extract of *Ligrium nephiticium* by Monardes in 1565, but Sir G.G. Stokes in 1852 fully described the theoretical basis for the mechanism of absorption (excitation) and emission. Today, luminescence, in its various forms, is one of the fastest growing and most useful analytical techniques in science. Applications can be found in areas as diverse as materials science, environmental science, microelectronics, physics, chemistry, biology, biochemistry, medicine, toxicology, pharmaceuticals, and clinical chemistry. This rapid growth has only occurred in the past couple of decades and has been principally driven by the

unique needs of the life sciences. The tremendous interdisciplinary appeal of luminescence techniques has resulted in a growing number of researchers desiring to quickly employ new and emerging luminescence techniques without the time-consuming effort of becoming an expert in physical spectroscopy.

Luminescence provides some of the most sensitive and specific analytical techniques, with the possible exception of radioactive labeling procedures. The advantages of emission techniques include high sensitivity, good selectivity, qualitative environmental information, a large linear quantitative range, and multidimensional information.

The general term luminescence includes a wide variety of light-emitting processes that derive their names from the various sources of energy that power them. Photoluminescence, which includes fluorescence and phosphorescence, is one of many categories of luminescence. To illustrate the diversity of luminescence emissions, the following are some of the more commonly observed types of luminescence:

- (i) **Electroluminescence** is an **optical phenomenon** and **electrical phenomenon** in which a material emits light in response to the passage of an **electric current** or a strong **electric field**. Electroluminescence is the result of the **radiative recombination** of **electrons** and **holes** in a material. Example: A gas-discharge lamp.
- (ii) **Radioluminescence** is the phenomenon by which **light is produced in a material** by bombardment with **ionizing radiation** such as **beta particles**.
Example: A luminous radium watch; a mixture of **radium** and **copper-doped zinc sulfide** is used to paint the instrument's dials, giving a greenish glow.
- (iii) **Triboluminescence** is an **optical phenomenon** in which **light** is generated through the breaking of chemical bonds of a material when it is pulled apart, ripped, scratched, crushed, or rubbed. The word *tribo* is derived from the Greek language meaning “to rub.”
Examples: A **diamond** may begin to glow while being rubbed (Mostafavi et al. 2013), certain types of sugar crystals.
- (iv) **Sonoluminescence** is the emission of short bursts of **light** from **imploding bubbles** in a **liquid** when excited by **sound**.
- (v) **Chemiluminescence** is the generation of electromagnetic radiation as light by the release of energy from a chemical reaction. Although the light can, in principle, be emitted in the ultraviolet, visible or infrared regions, those emitting visible light are the most common. It is the breaking of the chemical bonds that supplies the energy.
- (vi) **Bioluminescence** is the production and emission of **light** by a living **organism**. Its name is a **hybrid word**, originating from the **Greek** *bios* meaning “living” and the **Latin** *lumen* meaning “light.” Bioluminescence is a naturally occurring form of **chemiluminescence**. **Fireflies**, **anglerfish**, and other creatures produce the chemicals **luciferin** (a **pigment**) and **luciferase** (an **enzyme**). The luciferin reacts with **oxygen** to create light. The luciferase acts as a catalyst to

speed up the reaction, which is sometimes mediated by cofactors such as calcium ions or adenosine triphosphate (ATP) (Naik et al. 2014a).

Example: Light emitted by fireflies and glow-worms.

- (vii) **Cathodoluminescence (ChL)** is an optical and electromagnetic phenomenon in which electrons that have an impact on a luminescent material, such as a phosphor, cause the emission of photons that may have wavelengths in the visible spectrum. A familiar example is the generation of light by an electron beam scanning the phosphor-coated inner surface of the screen of a television that uses a cathode ray tube. ChL is the inverse of the photoelectric effect, in which electron emission is induced by irradiation with photons.
- (viii) **Photoluminescence (PL)** derives energy from the absorption of light energy (most commonly within the wavelength ranges of infrared, ultraviolet, or visible light). Photoluminescence is further divided into the categories of fluorescence, delayed fluorescence, and phosphorescence. Today, they are defined via the emission-based quantum mechanical mechanism for the orbital angular momentum multiplicity of the emitted electron (i.e., the singlet or triplet excited state). However, before the advent of quantum theory, PL was defined solely on the basis of empirical evaluation of the duration of an emission lifetime.

A photoluminescent emission arises from the singlet electronic state. To the human eye, fluorescence is observed only when the exciting light source shines on the radiator.

Phosphorescence Phosphorescence is defined as a photoluminescent process that originates from the triplet electronic state. Emissions from the triplet state are 10 to 10,000 times longer than those from fluorescence; therefore, to the naked eye, these radiators appear to emit after the excitation radiation is removed.

Delayed Fluorescence Delayed fluorescence is a rare phenomenon whereby the electron responsible for the emission starts out in the singlet state, crosses over to the triplet state, but eventually returns to the singlet state before emission. The result is a singlet state emission with a much longer lifetime than normal.

Photoluminescence is the emission of light that follows the absorption of photons by nanomaterials. Generally speaking, it is possible to distinguish between two forms of PL, namely fluorescence (spin-allowed emission of light from an electronically excited state) and phosphorescence (spin-forbidden emission of light from an electronically excited state). These two emission mechanisms can be schematically illustrated by the Jablonski diagram (Fig. 5.3), in which the excitation and the relaxation pathways are shown.

Luminescent materials can be divided into different families, according to their chemical nature (Kirkwood 2005). Organic and coordination compound-based dyes are among the most popular classes of luminescent compounds. More recently, semiconductor NPs (quantum dots) and lanthanide-doped NPs have received great attention because of their remarkable luminescent properties.



Measurement, Analysis and Remediation of Environmental Pollutants pp 199–209

Spatial Variation of Airborne Allergenic Fungal Spores in the Ambient PM_{2.5}—A Study in Rajkot City, Western Part of India

[Charmi Humbal](#), [Sneha Gautam](#) , [Suneel Kumar Joshi](#) & [Mahendrapal Singh Rajput](#)

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Abstract

Fungal spores in the fine particle is an emerging pollutant of the technological age, which can create adversely effect on human health and their surrounding environment. Probably the first time in the western part of India, an investigation was organized to assess the spatial distribution of PM_{2.5} associated fungal spore concentration levels in an urban city. Five urban locations selected to cover probably all major areas of a city to conduct the study by using fine particulate sampler with 24 hours' interval. Highest ($101.79 \pm 8.09 \mu\text{g m}^{-3}$)

concentrations of PM_{2.5} have been observed in the industrial area only. The highest (8.0×10^{13} Colony-forming unit (CFU) m⁻³) in industrial area and lowest (2.0×10^8 CFU m⁻³) fungal concentrations were found in the residential area. Spores of seven fungal species (i.e., *Aspergillus*, *Candida*, *Fusarium*, *Penicillium*, *Alternaria*, *Cephalosporium* and *Mucor*) were significantly predominant in all selected locations in the urban area. In these views, *Aspergillus*, *Candida* and *Penicillium*, and *Fusarium* species were the dominant fungi in Industrial, slaughter house and dump site, respectively. The highest concentration of fungal spores was reported in industrial area and poultry farm as compared to other locations. Outcomes of the current work suggested that fungal spores were observed in the respirable fraction (<2.5 μm) and so had the potential to penetrate the deeper part of the lungs. In addition, the meteorological parameters i.e., temperature and relative humidity, were recorded to understand the relationship between meteorology and enhanced viability of fungal spores.

Keywords

PM_{2.5}

Bioaerosols

Fungal spores

Health issues

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Chapter 8

Nanopesticides and Nanosensors in Agriculture



Rajender Boddula, Ujwalkumar Trivedi, Ramykrishna Pothu,
Mahendrapal Singh Rajput, and Aditya Saran

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8.1 Introduction

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Pesticides are used for different purpose and in different places like agricultural field, veterinary, domestic, etc. They are available in different formulations such as gel, paste, chalk, powder, granules, pellets and many other from concentration 2% to 80% of active ingredient (Laborde 2008).

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Nanoparticles have high surface to volume ratio, and they are able to linked with other compounds and be used as carrier. Hence, they can be used as nanocarriers or as an active ingredient or as both. Nanoformulations usually consist of several surfactants, polymers or inorganic (e.g. metal) NPs in the nanometre size range and therefore cannot be considered as a single entity (Perlatti et al. 2013). Nanoparticles can be inorganic, organic or a combination of both. As per the need such as biodegradability, long-term stability, water solubility, etc., the nanocarriers are selected. Nanoparticle-derived or nanoparticle-associated pesticides show higher performance in terms of effectiveness, targeted delivery and action with reduced management costs. This brings acceptability towards nanopesticides (Anwunobi and Emeje 2011; Bhattacharyya et al. 2016).

A nanocarrier enables the controlled release of an active compound stored at the core, so that the adequate concentration of this active compound could be preserved during the whole period of insect growth (Jampílek and Kráľová 2017). Bang et al. (2011) prepared a sustainable nanocarrier through coating of liposomes of etofenprox or alpha-cypermethrin by multiple layers of chitosan. Because of this thick multiple layers of coating and intrinsic the release time of the stored active compound increased (Bang et al. 2011).

Insect pests not only destroy crops, it also infests stored food and food products. The deterioration of food quality and transmission of plant disease due to pests are also considered as loss (Neethirajan and Jayas 2011; Ragaei and Sabry 2014). Chemical insecticides are broad range and also cause harm to nontarget species and increase soil toxicity. Nano-insecticides can be delivered specifically to target, for example an encapsulated pesticide can act as a gut buster if it gets breaks up only when it comes in contact with alkaline environment like the gut of the insect. Hence this type of target-specific delivery system will cause minimum damage to the ecosystem and nontarget species (Prasad et al. 2014, 2017). Some effects of nanonematocides are shown in Tables 8.1, 8.2, 8.3, and 8.4.

A target-specific herbicide molecule, which can inhibit glycolysis, can be encapsulated in NP for targeted delivery and translocation to the site of action specifically. This will ultimately make the specific weed to starve for food and get killed (Ali

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Chapter 8

Nanopesticides and Nanosensors in Agriculture



Rajender Boddula, Ujwalkumar Trivedi, Ramykrishna Pothu,
Mahendrapal Singh Rajput, and Aditya Saran

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Pesticides are used for different purpose and in different places like agricultural field, veterinary, domestic, etc. They are available in different formulations such as gel, paste, chalk, powder, granules, pellets and many other from concentration 2% to 80% of active ingredient (Laborde 2008).

8.2 Pesticide Toxicity

Pesticides are beneficial in terms of crop protection, disease control, food and material protection. But at the same time, it is toxic to human, animals and nontarget species. Additionally they negatively impact on environment and ecosystem (Laborde 2008). Pesticides are widely used in the prevention of malaria, dengue and other vector-borne diseases, but the same cause negative effect by killing up to one million children per year as per the data of National Research Council of 1993 (Council 1993). One can imagine the situation of current scenario. In agricultural fields pesticides are applied via spray, seed treatment and other required roots which ultimately pollute air, soil and groundwater. Pesticide in surface water may go to aquatic organism or to other organism which remains in sediments. The persistence of pesticides depends upon its stability. Persistent organic pollutants (POPs) are lipophilic and have low water solubility. They can accumulate in the food chain, concentrate there and cause toxic effects. Many persistent pesticides are banned in developed and in some developing countries, for example, DDT. There is concern about potential endocrine and development effects of persistence chemicals in children. Highest concentration of persistence chemicals is found in marine animals. Persistent chemicals are controlled under the Stockholm Convention (Laborde 2008). Dermal, ocular and inhalation are the most common routes of absorption of pesticides. They can easily cross the epithelium and mucous membrane. Children have high surface area in terms of the skin and also their metabolic rate is high. So children are more prone to pesticides. Fat-soluble pesticides get stored at adipose tissue. Biotransformation of pesticides inside an organism involves many chemical reactions such as oxidoreduction, hydrolysis, etc. These biotransformed products may be more or less toxic than its precursor. The excretory routes are urinary, faecal and milk excretion. Here the milk containing pesticide can cause severe damage to new born baby and children. Residues of pesticides have been detected in breast milk which includes DDT, HCB and HCH isomers. Pesticide can also cross the placenta. (Krieger 2010; Pronczuk et al. 2002) The pesticide toxicity can give rise to

irritation, allergic sensitization (e.g. fungicides), enzyme inhibition (e.g. cholinesterases and OPs and carbamates), oxidative damage (e.g. paraquat), inhibition of neurotransmission (e.g. organochlorines), uncoupling of oxidative phosphorylation (e.g. glyphosate) and many other effects (Laborde 2008).

An organochloride is an insecticide containing a minimum of one covalently bonded chlorine atom. Their utilization isn't prescribed in food animals inasmuch as their persistence in animal tissues conducts to their contribution to the human food chain. Such pesticides are still commercially applied, and in spite of the fact that they have a nonanimal use, the intoxication of animals can be exhibited. Amongst the effects delivered by their inebriation are nervous excitement, tremor, convulsions and death. They can restrain diverse enzymes being acetylcholinesterase one of them. An organophosphate is a natural ester of phosphoric acid, which is the premise of numerous insecticides, herbicides and nerve gases. As per the U.S. Ecological Protection Agency (EPA), these pesticides are exceptionally lethal to honey bees, untamed life, and humans due that they are organophosphorus mixes extremely pervasive. A carbamate is any organic ester derived of carbamic acid, which is used as insecticide to kill insects. These have been used in specific medications and insecticides. They are poisonous and may cause convulsions and death through ingestion or skin contact. Such pesticides can cause reversible hindrance of acetylcholinesterase and cholinesterase. A pyrethroid is a manufactured substance utilized as commercial household bug spray. They are generally harmless to human beings in low doses but can harm sensitive individuals. Be that as it may, such pesticides are lethal to oceanic life forms. Albeit few investigations have been acknowledged, enzymes, for example, acetylcholinesterase (AChE) are repressed by these pesticides (Vargas-Bernal et al. 2012).

8.3 Nanopesticides

Around 50–70% of the chemicals used in agricultural fields in forms of fertilizer or pesticides remain unused by leaching, mineralization and bioconversion (Bollag et al. 1992). Chemical pesticides not only do harmful effects on humans, but it also destabilizes the ecosystem. Hence for the sustainable agriculture use of nanopesticides is required.

Nanoparticles have high surface to volume ratio, and they are able to linked with other compounds and be used as carrier. Hence, they can be used as nanocarriers or as an active ingredient or as both. Nanoformulations usually consist of several surfactants, polymers or inorganic (e.g. metal) NPs in the nanometre size range and therefore cannot be considered as a single entity (Perlatti et al. 2013). Nanoparticles can be inorganic, organic or a combination of both. As per the need such as biodegradability, long-term stability, water solubility, etc., the nanocarriers are selected. Nanoparticle-derived or nanoparticle-associated pesticides show higher performance in terms of effectiveness, targeted delivery and action with reduced management costs. This brings acceptability towards nanopesticides (Anwunobi and Emeje 2011; Bhattacharyya et al. 2016).

A nanocarrier enables the controlled release of an active compound stored at the core, so that the adequate concentration of this active compound could be preserved during the whole period of insect growth (Jampílek and Kráľová 2017). Bang et al. (2011) prepared a sustainable nanocarrier through coating of liposomes of etofenprox or alpha-cypermethrin by multiple layers of chitosan. Because of this thick multiple layers of coating and intrinsic the release time of the stored active compound increased (Bang et al. 2011).

Insect pests not only destroy crops, it also infests stored food and food products. The deterioration of food quality and transmission of plant disease due to pests are also considered as loss (Neethirajan and Jayas 2011; Ragaei and Sabry 2014). Chemical insecticides are broad range and also cause harm to nontarget species and increase soil toxicity. Nano-insecticides can be delivered specifically to target, for example an encapsulated pesticide can act as a gut buster if it gets breaks up only when it comes in contact with alkaline environment like the gut of the insect. Hence this type of target-specific delivery system will cause minimum damage to the ecosystem and nontarget species (Prasad et al. 2014, 2017). Some effects of nanonematocides are shown in Tables 8.1, 8.2, 8.3, and 8.4.

A target-specific herbicide molecule, which can inhibit glycolysis, can be encapsulated in NP for targeted delivery and translocation to the site of action specifically. This will ultimately make the specific weed to starve for food and get killed (Ali

Table 8.1 Effect of nanonematocides

S. no.	Nanonematocides	Target species	Effect	References
1.	Uniform spherical nanocapsules of lansiumamide B with the mean particle size of 38.5 nm	<i>Bursaphelenchus xylophilus</i> and second-stage juveniles (J2) of <i>Meloidogyne incognita</i> with the LC50 values of 2.14 and 19.36 mg/L, respectively, at 24 h after treatment	Moreover, treatment with lansiumamide B nanocapsules, lansiumamide B and ethoprophos led to a decrease in the disease progression by 68.42%, 36.84% and 26.32%, respectively, and a decline in the average number of root knots of <i>Ipomoea Aquatica</i> by 83.94%, 78.03% and 63.66%, respectively, indicating that the nematocide nanoformulation performed more efficient and longer effective maintenance against plant parasitic nematodes	Yin et al. (2012)
2.	AgNPs stabilized by a starch	<i>M. incognita</i>	AgNPs inactivated the root-knot nematode <i>M. incognita</i> in 6 h by >99% in vitro	Cromwell et al. (2014)

Chapter 77

Effect of Microstructure on Electrical Properties of $\text{Cu}_2\text{ZnSnS}_4$ Films Deposited from Inks



Prashant R. Ghediya and Tapas K. Chaudhuri

Abstract Electrical properties of $\text{Cu}_2\text{ZnSnS}_4$ (CZTS), potential absorber materials for low-cost solar cells, are significantly affected by its microstructure. In this paper, effect of microstructure on electrical properties of CZTS films have been studied from 77 to 300 K. Temperature variation of electrical conductivity of structurally different films revealed that transport of holes is by either hopping in defect states or activated band conduction depending on the temperature range. The electrical conductivity and activation energy changes significantly with the structure of the films.

77.1 Introduction

Microstructures significantly affect the transport and photovoltaic properties of semiconductor films [1]. $\text{Cu}_2\text{ZnSnS}_4$ (CZTS), an earth-abundant and non-toxic semiconductor, has the potential to deliver low-cost thin film solar cells and has already attained about 9% efficiency. Even though there have been vigorous efforts in development of solar cells, there has been no study on the electrical conductivity of films especially with respect to microstructures. It has been shown by us [2–5] that microstructure of CZTS films deposited from inks depend on type of ink such as, molecular or nanoparticle suspension. The microstructures of CZTS films range from continuous nanocrystalline to interconnected grains with voids. In this paper, we report the electrical properties of ink-deposited CZTS films [2–5] having different microstructures. It was found that microstructure of films have significant effect on the mode of conduction as does the temperature.

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77.2 Experimental

CZTS films were coated on glass using different types of inks by doctor blading, drop-casting and dip-coating [2–5]. CZTS nanoparticle ink (NPI) was prepared by one-step and rapid microwave process [3]. Molecular solution inks were synthesized with ethylene glycol (MGI) and methanol (MMI) as solvents [2, 4, 5]. The electrical conductivity (σ) and thermoelectric power (TEP) of films were measured at room temperature (300 K) in dark to determine carrier concentration and mobility. The temperature variation of σ of different films was recorded in vacuum from 77 to 300 K. Microstructure of films was determined by observing cross-sections with Scanning Electron Microscope (SEM).

77.3 Results and Discussion

Structural and compositional analysis of the films confirms deposition of pure kesterite CZTS [2–5]. Figure 77.1 depicts the cross-sectional SEM of the films deposited from (a) MMI, (b), NPI (b) and (c) MGI. Films deposited from MMI are nanocrystalline (crystallite ~ 5 nm), non-granular and continuous without voids. However, NPI and MGI resulted in films with interconnected grains and voids with grain sizes of 0.2–0.4 μm and 0.4–0.5 μm , respectively. The grain size is increasing as $\text{MGI} > \text{NPI} > \text{MMI}$.

The electrical properties of these films at 300 K in dark are presented in Table 77.1. All the films are p-type with hole concentration of $\sim 10^{19} \text{ cm}^{-3}$. MMI films have highest σ and μ because of compactness and continuity of the films while granular structure of the films results in low σ and μ in case of NPI and MGI films.

Figure 77.2 shows the temperature variation of σ of different CZTS films in dark from 77 to 300 K. In general, σ of films increases exponentially with inverse of temperature. The overall conductivity of CZTS films can be expressed as

$$\sigma_D = \sigma_{01M} \exp\left(\left(-\frac{T_{MD}}{T}\right)^{\frac{1}{4}}\right) + \sigma_{02} \exp\left(-\frac{E_{NNHD}}{k_b T}\right) + \sigma_{03} \exp\left(-\frac{E_{TACD}}{k_b T}\right) + \frac{\sigma_{04}}{T^{\frac{1}{2}}} \exp\left(-\frac{E_{BD}}{K_b T}\right)$$

where, first, second, third and fourth terms represents conductivity due to Mott-Variable Range Hopping (M-VRH), Nearest Neighbour Hopping (NNH), Thermally Activated Conduction (TAC) and Thermionic Emission over Grain Boundary Barriers (TE over GB), respectively.

The data of Fig. 77.2 were analyzed to determine the appropriate mode of conduction for each type of film. In all the films, hopping conduction is dominant

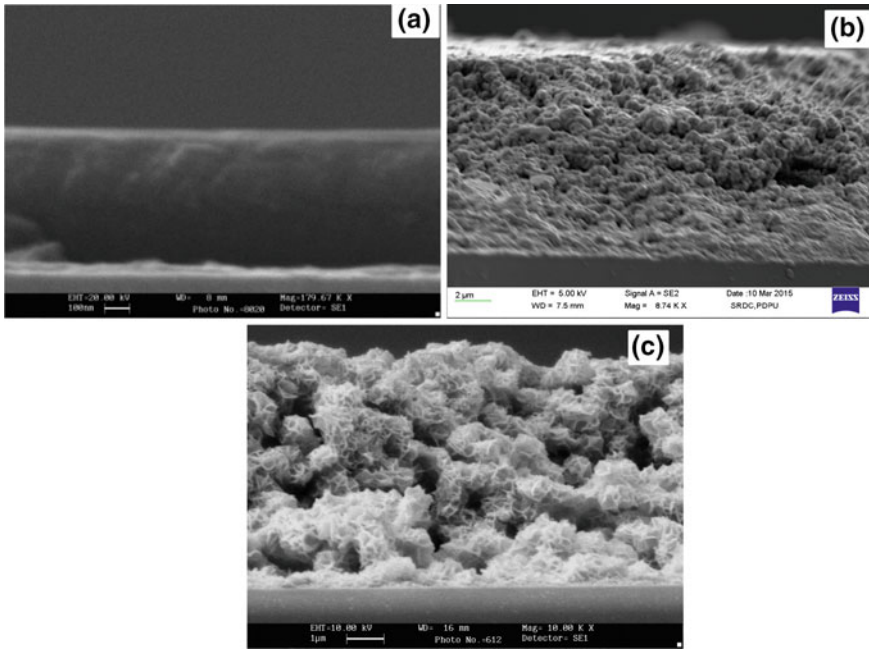


Fig. 77.1 Cross-sectional SEM of films deposited from **a** molecular methanolic ink **b** nanoparticle ink and **c** molecular glycolic ink

Table 77.1 Electrical properties of different types of CZTS films in dark at 300 K

CZTS film	Grain size (μm)	σ (S/cm)	TEP (μV/K)	p (cm ⁻³)	μ (cm ² /Vs)
MMI	None	0.34	+40	3.3×10^{19}	0.10
NPI	0.2–0.4	3.5×10^{-4}	+350	1.3×10^{18}	0.003
MGI	0.4–0.5	1.2×10^{-2}	+79	2×10^{19}	0.05

below 200 K through either Mott-Variable Range and/or Nearest Neighbour. Figure 77.3 shows the validation of hopping conduction in films made from MMI, NPI and MGI.

It can be seen from Fig. 77.3a, b that in case both MMI and NPI films, the conduction is by M-VRH through interband energy levels situated above valence band. These levels are spatially separated and arise due to disorder and defects. Since, MMI films are nanocrystalline there would be large number such states for M-VRH conduction. In case of NPI films, the grain sizes are small and such states are also available in the intergranular boundaries and in the grains. However, films deposited from MGI shows comparatively larger grains. The existence of NNH in such samples was shown in Fig. 77.3c. In NNH the available energy states are separated by very small energy difference. The origin of these states is defects and is situated in bulk and mostly at inter-granular boundaries. To conduct through

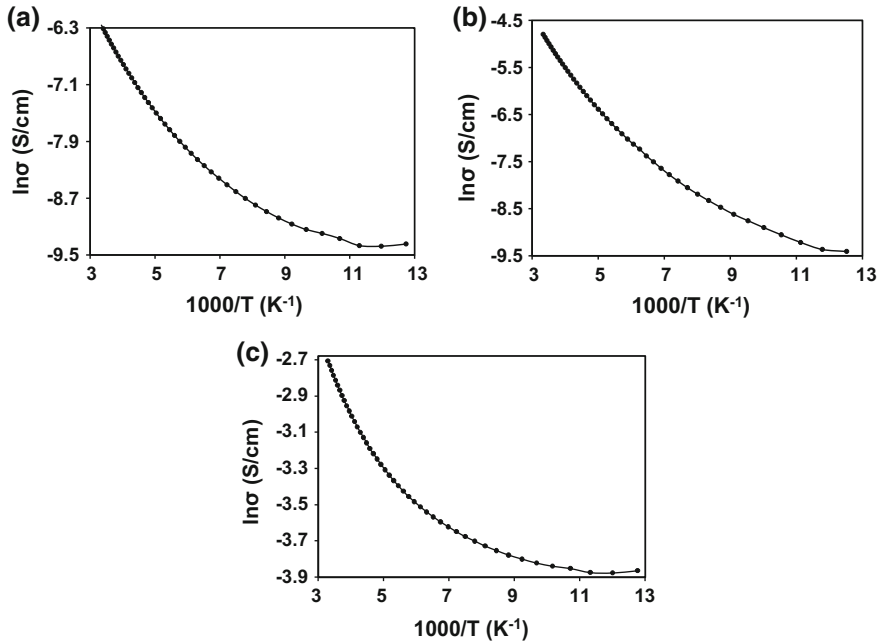


Fig. 77.2 Temperature variation of electrical conductivity of CZTS films deposited from **a** molecular methanolic ink, **b** Nanoparticle ink and **c** molecular glycolic ink

these states require some thermal activation energy. Figure 77.3 suggests that there seems to be a cross-over from M-VRH to NNH after a critical grain size of around $0.4 \mu\text{m}$.

Above 200 K, the entire CZTS films exhibit thermally activated band conduction either because of thermally activation (TAC) or thermionic emission over grain boundary barriers (TE over GBB). CZTS films deposited from MMI and NPI showed conduction due to TAC from 200 to 300 K. At these temperatures holes are ejected from energy levels above valence band. Deep level defects and impurities are responsible for such energy levels. The TAC activation energies for MMI and MPI films are 90 and 120 meV, respectively. However, the CZTS films prepared from MGI reveal TE over GBB conduction obeying Seto's model [6]. This is probably because sizes of grains in MGI films are larger than the depletion width and hence gives rise to barriers at the grain boundaries. The conduction modes in CZTS films produced from MMI, NPI and GMI from 77 to 300 K are summarized in Table 77.2.

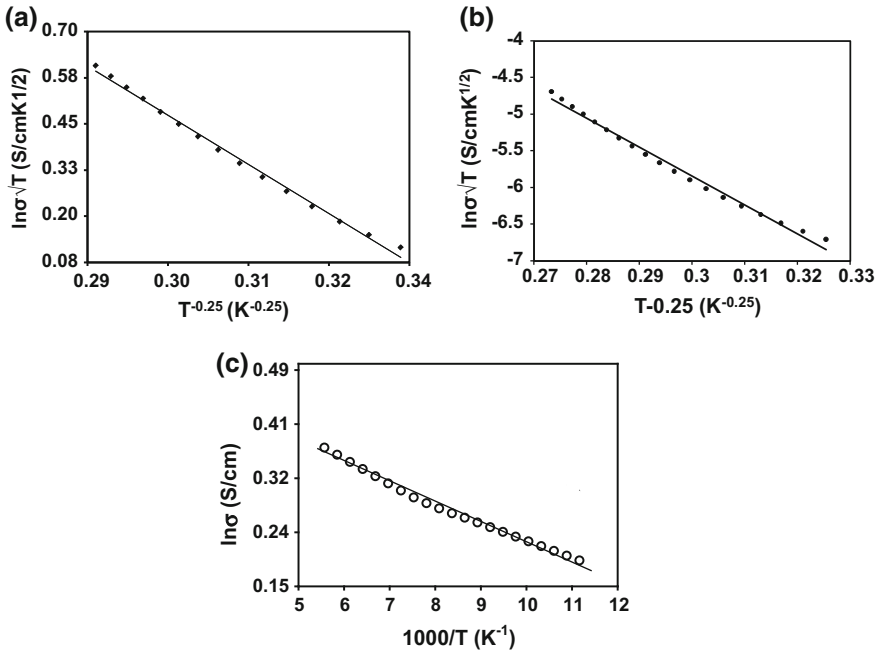


Fig. 77.3 Validation of hopping conduction in CZTS films deposited from **a** molecular methanolic ink: M-VRH, **b** nanoparticle ink: M-VRH and **c** molecular glycolic ink: NNH

Table 77.2 Modes of electronic transport in CZTS films from 77 to 300 K

CZTS films	Grain size (μm)	Conduction modes in temperature range (K)			
		Hopping (E _H meV)		Band conduction (E _A meV)	
		M-VRH	NNH	TAC	TEGB
MMI	None	77–150	–	200–300 (90)	–
NPI	0.2–0.4	77–180	–	200–300 (120)	–
MGI	0.4–0.5	–	85–180 (32)	–	200–300 (95)

Bold denotes the value of activation energy

77.4 Conclusions

Electrical properties of ink-deposited p-type CZTS films with different microstructures have been investigated from 77 to 300 K. The transport of holes is by either hopping in defect states or thermally activated band conduction depending on the temperature range and microstructure of film.

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Vadodra Chapter

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in COVID World

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Chapter 18

Sustainable Product Development: A Tool to Manage People, Planet and Profit in Covid World.

Dr. Rhuta Mehta¹ Ms. Nirali Karia²

Abstract

Sustainable products can be defining as those products that are offering an environmental, social and economic profits while caring for the public health and environment over their whole life cycle, from the mining and getting of the raw materials until the final disposal of the products developed.

Sustainable product development has marked its importance and presence during the pandemic time where, Covid-19 has created massive destruction and disturbance at an international level that has changed the entire socio-economic system that results in the de-globalization of almost all economic activities. Economies of all over the world have been impacted due to Covid-19 in the almost all the business including production, retail, hospitality, entertainment, aviation etc.

The purpose of this research topic is to comprehend and draw the attention towards the importance of sustainable product development, and its role as a tool to manage the 3P's i.e. People, Planet and Profit in Covid world even to identify the loopholes.

Conversation with all those founders of such products and the organizations, it has been observed that such entrepreneurs, even after working hard, are facing the resistance while putting their sustainable products in market. The issue is not related to the

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development or manufacturing of sustainable products, but it is about the lack of awareness among people about such products.

Introduction

In the perspective of the preface provided by the Charter of the United Nations, development is defined as the endorsement of social progress and enhanced quality standards of living in the larger autonomy. This extensive explanation of development is convoluted by adding the adjective "sustainable". The earliest meaning of sustain is to support, or to uphold the course of or to keep into being. Where the one more meaning is to provide with food and drink, or the necessities of life. Still another definition is to endure without giving way or yielding. The point to emphasize here is that the term 'sustainability' has ideological and political content as well as ecological and economic content. There is a struggle, worldwide, to determine how 'sustainable development' or 'sustainable capitalism' will be defined in the discourse on the wealth of nations (ibid., p. 153).

Popular mythology suggests that there is mostly one environmental movement, that it began with Earth Day in 1970, and that it is mainly concerned with preserving extra-urban nature (wilderness). Improved environmental performance of products and services has lately become one of the major tactical and operational targets of producers. This is because of the influences from different stakeholders including government, consumers, societies and the business partners. Markedly, diverged producers differently executed their environmental practices for sustainable product development depending on various driving factors such as customer awareness about it, legislation, economical reimbursement and competitive strategies, etc.

During the time of covid, we have lately realized that few practices of living the life followed by our ancestors were something important which were directly and indirectly affecting and was

playing a role in maintaining our health as well as the environment. The practices that were so normal and regular in the early days have now turned into something called innovation and or maybe we can call it the trend of living life today. Sustainable product development in that case is now becoming a tool to manage the people, planet and profit in the times of covid. Like there were lot many people who lost their jobs during covid and then there were the other few whose business came to an end due to covid. In such a time, the products that were made out of certain things which aren't harmful to the society and were under the head of sustainable products; played its role and such organizations grew pretty in these times. Like it was quite a normal thing to use the cow dung as a "dhup" (incense stick) in the earlier times, but covid now taught our generation to use it as one of the best ways to improve your breathing and maintain immunity.

Literature review:

One of the most recent developments in the emergence of the concept of "sustainable product development" which deals with elementary demands, essential product functions, and the system in which product function, the nature, availability, and selection of resources, and the distribution of those resources among nations and generation. In the last ten years, many companies all over the world have become aware of the fact that both economically and ecologically, proactive policies and preventive measures are far more attractive than after-the-event and end-of-pipe technologies. As a result, the 'pollution prevention' concept became increasingly popular (J.C. Van Weenen, 1995)

Waste is generally meant for discarding because it acts as a source of pollution (Pongracz & Pohjola 2004). However, if it is used in any other process such as feedstock it may be considered as a co-product (Brown 2003). For example; In India, 69.9% population resides in rural areas (The Hindu 2011), where a cow is major cattle

and generates 9 – 15 kg dung/day (Werner, et al. 1989; Brown 2013).

The need for introducing environmental requirements into the design and development of new products has already been discussed for more than a decade (Pezzoli K., 1997). Environmental requirements are mainly considered as an unavoidable "must", which generates additional design constraints and increases the cost (Bhamra TA 1999, Borland 1998, Fiksel J. 1996)

Current practices of product development in manufacturing companies are still predominately based on traditional cost/profit models (Asiedu Y, 1996) aiming at the high quality of product at a low cost and high profit. Users learn about products, their environmental, societal, and economic impacts and their use, and environmental aspects of changes in consumer behavior, and they develop ideas on how to influence corporate strategies. It is argued that too close a link to customers may hinder innovations as the company may only pay attention to current customers (Christensen and Bower, 1996, Danneels 2003) resulting in a strong niche orientation. (Brockhoff, 1997,1998)

Objectives of the study

1. To understand the significance of sustainable products and their' design development for people, the planet, and profit.
2. To understand the purpose and process adopted by the various companies for sustainable product development.

Research methodology

Qualitative research has been carried out to fulfill the stated objectives. Through telephonic interviews of ten entrepreneurs engaged in sustainable product development and production, the required data has been collected. Interpretation is based on researchers' own perception and understating.

Analysis

Research Analysis included the details collected from those companies, which included their product line, financial support, and source, inception idea about the start-up and their customer pool.

1. **Gaukriti** is the inventor of India's first handmade recyclable paper out of cow dung. These papers consist of seeds of vegetation that will grow in plants of Tulsi, Gander, Cumin, and such plants after being dumped.

Product line by Gaukriti: This company has come up with innovations in more than 70 products which include bags, bangle box, calendars, diaries, envelopes, and wedding cards and so on. During the hard times of covid, they also came up with masks made out of cow dung papers including the vegetation seeds too. Before the festival of Raksha Bandhan arrives, they also start manufacturing the rakhis made out of cow dung which are plantable too.

Interview Gist:

In our conversation with Mr. Bhimrao Sharma, we analyzed that the production of such an innovative product as cow dung paper was not an easy task. The idea behind coming up with such a product was protecting the cows from not being taken care by the owners while she is not giving milk and the second was protecting the environment. We came to know that there are times when cows stop giving the milk or give the least milk than its average capacity, during such times the cow owners either leave the cow or stop feeding the cow in the same amount that it needs on its daily basis. This is why, there were lot many cows found on the road who were not getting proper food and shelter. By coming up with a concept of making papers from cow dung, cow now became a monetary source even when she is not giving milk. Hence, the least owners now let their cows run on the road.

Talking about the manufacturing of paper; along with cow dung, cotton waste is also the other raw material that is used. Out of 40

Kgs of cow dung and the basic raw material, 100 Kgs of paper is manufactured at the unit of Gaukriti. While in the normal papers, 24 trees are cut down to manufacture at least 1000 kgs of paper. At the same time, the paper made at Gaukriti has 12 types of different seeds including fruits and vegetables which are suitable to grow in every different weather and soil condition.

The main reason Mr. Bhimrao highlights about least acceptance and sale of such products in our market is the lack of awareness among people about such products. There could be various ways that he suggests to push such products in the market and the government can play a big role in it, but we haven't reached there yet and so, most of the products that are manufactured are exported to other countries.

Resources: The main raw material for manufacturing these papers is cow dung which is bought by Gaukriti at the rate of Rs. 10 per kg from different cow owners. Along with that the cotton waste is also bought and the seeds of different vegetation are also added in these papers which makes the papers recyclable.

Customer Pool: In our conversation with Mr. Bhim rao, we analyzed that as such there are no fixed and major customers to their business. The handicraft stores can be a great medium to sell such things but still, there is the least acceptance of keeping such products even at the stores. The main selling at present is done through online mediums like Amazon and Flipkart. Other than that, a maximum of products are exported to different countries like USA and Italy.

1. **MKV Enterprise** is a manufacturer and a supplier of Areca Plates, Bagasse plates, earthenware, Bamboo products, Fiber products, and Organic products. They are leading merchant and trade exporters of such sustainable products.

• **Product line by MKV Enterprise:** The product range offered by MKV Enterprise is as below:

1. **Areca products** include bowls, cups, rectangle plates, round plates, areca-shaped bowls, and square plates.
2. **Bagasse products** include bowls, containers, meal trays, and plates.
3. **Earthenware products** include biryani pots, cooking pots, clay cups, glass, flower pots, frying pan, ice cream pots, kitchen sets, long handle pots, diyas, rice cooker, S type pots, serving bowls, water filters, water jug, and water pot.
4. **Bamboo products** include bowls, glass, mugs, utensils, water bottles and water glasses.
5. **Coconut shell products** include coconut shell agapai, incense stick stand, bird feeder, bowls, designed bowls, forks, earrings, candle holder, hair clips, ice cream bowl, gift box, oval cups, salad cups, soup cups, semi-polished cups, spoons, teacups, and wine glasses.
6. **Banana leaf** is the other product altogether that is exported to Arabian countries.

Interview gist:

In a conversation with Mr. Kamal Venu, we analyzed that maintaining and offering such a large range of products is not easy, but still taking inspiration from his father; he is working to take this organization to a height. He tried and collects the maximum range of such sustainable products under him so that such customers don't have to keep searching in market for finding these products. There are very few organizations in India that are working hard to bring such products among us, make them available easily among us, and MKV Enterprise is one such among them.

The organization is particularly in the manufacturing of Earthen and Areca products, the other products are bought from different manufacturers and provided at this same platform for the ease of customers.

The thing we analyzed and discussed here again was the lack of awareness and acceptance for using such products in the Indian market and so the maximum of the products are exported to the countries like Europe, Australia, Israel, Canada, the US and other Arabian countries.

Customer Pool: As in the case of Gaukriti, the major customers are not Indians but the people in other countries so the export amount is higher than the local buying.

1. **Other companies:**

The other companies that we were able to understand and know about were:

1. **Plantable** – This is into the making of recyclable papers with seeds providing a range of papers, diaries and wedding invitations.
2. **Fabrefine** – This is into recycling the old jeans into items like handbags and other accessories for females.
3. **Earthen** – This is into manufacturing the products like plates, bowls and spoons out of the palm leaves.
4. **Dinearth** – This is into manufacturing tableware and crockery out of sugarcane bagasse pulp without any plastic or wax coating.
5. **Greenvale eco-products** – This is into manufacturing the products like plates and bowls from sugarcane wastage.
6. **Champs Agro Unit** – This is into the manufacturing of eco-friendly handicraft items out of banana fiber like papers, gift boxes, dairy covers, and other products from palm fibers, and jute wine bags.
7. **Green-o-Tech India** – This is into collecting the paper waste and converting it into stationery products. The other initiative we would mention about them is they plant one tree on recycling of every 100kg of paper waste.
8. **Ecoware** – This is into manufacturing the products like bowls, boxes, cups and plates out of common crop waste.

Discussions

From this research study, we analyzed and understood that there are many organizations and the entrepreneurs behind such organizations that are working on developing sustainable products and their' manufacturing and selling. And to our surprise, we came to know that most of the products are that are manufactured by such units are exported only. And in our conversation with such entrepreneurs, we realized that they are into exporting such products just because there is least awareness of such products in our country. The other thing that we realized is, there are least efforts by the government for pushing such products in the market. India is and has always been rich in terms of agricultural products and major sustainable products are from agricultural by-products and other such things. So we have options always open for such products but it is just the lack of awareness of using such products in our market and such products are in-demand in foreign markets and so are exported in maximum numbers.

Implications of the study:

With this research study, we analyzed that there are lot many organizations coming up with the manufacturing of sustainable products with a motive to protect Mother Nature and the interest of our future generations. We as responsible humans shall support such business organizations by using such products a maximum of times. Such organizations bring up not only innovations in products but are also generating more employment opportunities. The profit is not only earned in terms of monetary resources but also the environment is protected and nothing can be a better profit than protecting the nature for future.

As seen, we always try and imitate the foreign markets and style of living and habits, we also saw that maximum products are exported from our country and then people from our country are inquiring there for such products, but never took care of looking in our own

country for such products. For now, exporting the products in maximum is good, as the earning comes into foreign currency and so ultimately our economy gets support and growth. But we must also focus on the point that we shall not earn compromising on our health and not taking care of the environment that we live in.

We as researchers of this study will like to make points to the future entrepreneurs that; the coming generation will be more careful and concerned about protecting the environment and start using such products and promoting such products. Jumping into innovating and bringing such products in the market right now may seem difficult, but we are sure that the future of such products is going to be the brightest.

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**- Dr. Ramesh Kumar Chaturvedi
- Dr. Sanjay Kumar Yadav**

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Volume 2

Edited By

Dr. Ramesh Kumar Chaturvedi

Dr. Sanjay Kumar Yadav



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Preface

Smug Corona virus seems only real nemesis of Mankind!

Today we are all struck in a world grappling with the impact of Covid-19 pandemic and like a valorous soldier most of us are engaged in mitigating the impact of pandemic in what so ever capacity we are. How so ever the difficult situations are, however life must go on. So we are also continuing our efforts to disseminate knowledge by compiling and releasing second volume of our edited book.

Our previous the first volume of edited book carried articles mainly contributed by budding researchers, now this volume contains the chapters contributed by seasoned academicians and researchers from various fields of management and business administration. The articles contributed by these researchers are mostly outcome of their rigorous and continued research effort over period of time. Dynamics in the business environment warrants managers to be abreast of latest changes happening around it that has potential to impact the business. Some of the forces in the environment put detrimental impact while others bring new opportunities. Being aware of these opportunities is essential to be competitive and develop sound strategy. Further being knowledgeable of potential threats in the environment allows taking proactive steps to mitigate the risks. Scanning the environment and collecting relevant information are important steps to understand the environment. Academic researches provide much needed information to industry practitioners and keep them abreast of latest principles related to their domain of decision making. Though academic research is fundamental by nature, yet managers could get deep insights about changes happening in the business environment, expectations of consumers and stakeholders etc. This book presents compilation in form of chapters of some latest research conducted by academic researchers in field of business and management studies. These researches could prove to be vital for practicing managers by simplifying decision making. The research outputs presented in this book are from diverse areas and cover wide range of contemporary issues. The book is intended to serve both academicians as well as industry practitioners.

Acknowledgement

Editing book is challenging and arduous task. In course of completing and editing this book numerous man hours have been devoted. There were moments when internal light of inspiration was diminishing. I would like to thank all those who rekindled to fire within me to complete the book. Prof. Sanjay Singh, Vice-Chancellor, BBAU has motivated us to take up this literary initiative. Prof. Kushendra Mishra has advised me as and when required. Mr. Digvijay Pratap Singh has provided all necessary IT and DPT support for editing and formatting the contents of the book. My family specially My Mother, Father, Wife and son Rishi has stood by me and constantly inspired to serve the academia, students and industry by presenting this edited book. I specially thank my mentor and guide Prof. Sanjay Medhavi for endowing capabilities to contribute to academia which is channelized through this book. Finally I thank almighty GOD for giving me courage to take up and complete this book.

Ramesh Kumar Chaturvedi

We feel encouraged by the wide spread response from teachers, researchers & students alike to the first volume. We are very glad to present second volume of thoroughly revised and enlarged to our readers in a very humbled manner.

We want to acknowledge that selected papers from the submissions have been edited in the form of book which is being brought out for the inquisitive mind. The collection of papers is a valuable treasure of knowledge, practical experience, theory insight and ingenuity. We hope that the book will continue to ignite thoughts and generate new researchers. We wish to put on record our gratitude to all the authors for joining us in this academic endeavor. We also thank our publishers for bringing it out in such presentable manner.

Sanjay Kumar Yadav

About the Editors

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Dr. Ramesh Kumar Chaturvedi is Electronics and Instrumentation graduate from Mumbai University, MBA from Mahatma Gandhi Kashi Vidyapeeth and MA in Public administration from Pondicherry University. He has earned Ph.D. in discipline of Retail and Consumer Behavior at Dept. of Business Administration, University of Lucknow. He holds Masters Diploma in Software engineering. He has completed certification program on Management of MFI's from IIM, Lucknow. Along with ten years of experience in academics, he also possesses seven years work experience of corporate. To pursue his research interest he has supervised Many Ph.D. and M.Phil. and has published many research papers, refereed and indexed with impact factor. He has made many presentations in national and international seminars as part of his academic achievement and received best paper presenter award twice. He is author of three books and his book on 'Marketing Management - A Contemporary Approach' is well referred by students of various universities. He has interest in subjects like Strategic Management, Business Research Methods and Management of Microfinance. He is adherent believer of collaborative and participative learning. His current research interests are in understanding role of Microfinance Institutions and SHGs in poverty alleviation especially in Rural India. He is currently working as Assistant Professor at Department of Rural Management, Babasaheb Bhimrao Ambedkar Central University, Lucknow. In addition to teaching and research he is assuming administrative responsibilities like Coordinator Mechanical Engineering Department of University Institute of Engineering Technology, BBAU and Program Officer, National Service Scheme.

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About the Book

This is second volume of our continued effort to present the latest thoughts of researchers in domain of management to benefit industry and academia. Like our previous volume this book also intends to fulfill the quest for knowledge for academicians and person from industry having interest in current research in the field of Management and Business Administration. The articles included in this book are rigorously reviewed by peer referees and accepted only after the articles met the stringent criterion of plagiarism test. The research output of respective authors is presented in the form of edited book and carries chapters on issues researched and contemplated by them. Certain contemporary topics of interest in management that are covered in the chapters of this book are Sustainable development as an important aspect of achieving millennium development goals of United Nations, Issues surrounding to slowdown in automobile industry, Engagement of employees for enhancing productivity, Promotion of commercial craft through digital platforms, ICT as intervention tool for modern education, Digital payment and its impact on impulse buying. Understanding and managing employee behavior is discussed in the book through contemporary theories of organization behaviors. Shift of human resource management practices from traditional personnel management to electronic human resource management and spiritual intelligence for effective leadership is also discussed by contributing authors. To address the needs of budding researchers a chapter on designing good questionnaire is also included in this book. Needless to tell the whole world is incarcerated by Covid-19, so most of the contemporary research if focused around it. Hence we also have couple of articles in this volume around Covid-19 and impact of Corona-Virus. Care has been taken to ensure the presentation of original ideas as contributed by respective authors, though due to divergence in interpretation at times it may vary a bit. Editors does not claim the ideas presented in this book as their own nor they vouch the originality of research content, however we neither tolerate nor promote plagiarism and follow best ethical practices of publishing. Chapters are prepared by respective authors and submitted for inclusion in this edited book which is edited and reviewed by subject experts. For academic interest of students, academicians and industry editors have represented research outcomes in compilation form through this book. Concepts discussed in the book are well recognized and has contemporary relevance in this discipline of study. Contents as much possible are properly and suitably attributed to citable references, though may not be exhaustively. Any error typographical, citation or otherwise is regretted.

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CHAPTER -1

AN ANALYSIS OF RESOURCE MANAGEMENT AND SUSTAINABLE DEVELOPMENT IN INDIA

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Abstract

With the changing global scenario and advancement in technology and industrial practices “India” is leading to a bright future; with respect to globalization reforms in 1991 and their resumption in the 2000’s, India has emerged into a free market economy, but despite all these achievements India is still having a population of around 1.2 billion with a population density of 464 per k/m and till 2030 there is an expectancy of 300 million people in addition; whenever a country focuses on economic development & industrialization there is a population shift from rural to urban areas for employment and better life, it has been predicted that looking at the current rate of migration India will possibly have 68 cities with one million population each and 6 megacities having more than 10 million population each, if such a situation takes place the government will be facing a major challenge in providing necessary resources such as power supply, public transportation, medical facilities, clean drinking water and above all environmental balance. This paper is a study of how India can meet the needs of the present state without striking a balance in the needs of the future generation in an effective way.

Keywords: Globalization, Environmental degradation, Resource management, Sustainable development goals (SDG)

Introduction

When we analyse the structure of India, we find two segmentations/diversification, one is categorized as “urban India” which consists of highly developed megacities having all kinds of facilities and resources reflecting a glimpse of the global world, and secondly we see the “rural India” which is still deprived of basic amenities such as schools, hospitals, roads and electricity, this particular gap between rural & urban India is the imbalance which hasn’t been

filled since post-independence. If we look at history we will find that there has been a considerable disproportion in human social culture, for example: India is home to 50% of world's poor population and apart from that worlds 3/4th population is living in countries like India and China alone. Whenever there is a plan of industrial development specifically in rural areas, there are long term impacts which can be complicated, moreover it has been seen that sometimes outcomes are not exactly as they are expected.

With the passage of time India has recognized the importance of resource management with respect to sustainable development goals (SDG), implementing policies and reforms like 'Swacch Bharat mission, Pradhan mantri awas yojana, smart cities, Deen Dayal Upadhyay gram jyoti yojana.

For the past 20 years there has been a considerable amount of rise in air pollution across the megacities of India due to rapid industrialization, automobile, consumption of fuels, for example smog in Delhi is mainly caused by extreme air pollution; in 2017 the pollution index reached its towering levels of particulate matter (PM) 10 and (PM) 2.5 level and since 1999 it has been set down as unfavourable air quality levels in the areas of New Delhi and surrounding regions.

India has seen a tremendous development since 2000's in its megacities in terms of infrastructure and other facilities but on the other hand, it has also seen water scarcity or in other terms national water crisis that affects more than 600 million people each year, despite a population of 1.3 billion people, India accounts for only 4% of worlds fresh water resources, every summer from the period of May-June the scarcity level rises up as reservoirs dry up ,the reason for sustainable development is more important because all the strings are attached to each other ,rapid industrialization results in climate change which is responsible for delayed monsoon . In a country like India which much relies on its agriculture sector, irrigation has alone requirement of 80% water reserve in the country.

In 2019 Chennai experienced the worst water crisis in past 10 years effecting its 9 million people as a result many hotels, business houses, operating units were forced to shut down .Hence it becomes very important to build a framework of sustainable development with optimal resource management

Objective of Research

- I. To analyse and understand the need of research in sustainable development with effective resource management.

- II. To study the effects of rapid industrialization with respect to available resources.
- III. To study and find out possible strategies with respect to sustainable development goals (SDG).

Research Methodology

The particular study is descriptive in nature, and describes more about the definition ,aspects and reasons of implication of this process ;along with the bifurcated impact with respect to different sectors ,the framework of the research is established on the observation analysis and secondary data ,secondary data has been primarily collected from publications, reports ,journals and research papers ,several books have also been taken into account for relevant theoretical information

Analysis of methods to attain sustainable development goals (SDG)

- 1. Establishing effective governance as a medium for resource management at all verticals.
 - (i) At local level: For any government policies to be successful especially sustainable development, participation of every stakeholder is required , in local levels if the institution like panchayats, tehsils, aanganbadi are involved in decision making ,there is a possibility that outcome will be much more relevant in terms of managing the natural resources above all , men, women chosen , members of government bodies , representatives of every group needs to participate in this process without any discrimination especially children's who are the most valuable asset of our nation until & unless all this groups are not synchronized in an effective way government will not get favourable results / outcomes .
 - (ii) At national level: The development of nation's growth is dependent particularly on industrial sector, manufacturing sector, agricultural sector, in addition other areas such as small scale industries, academics, research institutions, civil societies and other subsidiaries of our nation so it becomes very important that development and up gradation of skills is available in all these sectors through partnerships and effective coordination. It becomes very important to indulge all the institutions and verticals, also the social groups to take into account while developing a prompt resource management framework, the outcome has a high rate of contingency in the above factors respectively.
 - (iii) International level : The whole world can be referred as a global village ,sharing resources and pooling manpower but above all, there is a urge of coordination among all the

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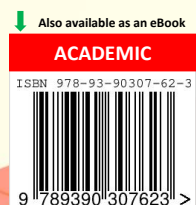
Volume 2

This is second volume of Contemporary Research in Management. This volume is edited by Dr. Ramesh Kumar Chaturvedi and Dr. Sanjay Kumar Yadav. We have invited articles from various authors to address vivid issues of management and Business administration. First volume had most of the articles from young and budding researchers but this volume is having chapters authored by seasoned researchers and academicians. This book carries articles that cover Human Resource Management and Organizational Leadership issues, persevering and protecting aboriginal craft, marketing matters, and of course many research dimensions around Covid-19. This edition is coming in a time when the whole world is grappling with challenges of Covid-19. It is interesting to see that plenty of research is happening in each and every field of study but most of them surround the Covid-19 issue which is quiet natural. So we have also included articles in this volume to covers wide range of issues and aspects connecting management, business administration and economics and Covid-19 and expect they will be helpful to academia and corporate practitioners equally. We are hopeful for continued support of our authors and contributors so that we could keep publishing such wonderful bevy of articles in future also.

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Lecture Notes in Mechanical Engineering

Nicolas Gascoin
E. Balasubramanian *Editors*

Innovative Design, Analysis and Development Practices in Aerospace and Automotive Engineering

Proceedings of I-DAD 2020

 Springer

Review of Polydimethylsiloxane (PDMS) as a Material for Additive Manufacturing



Qusai Alkhalaf, Sarang Pande, and Ritesh Ramesh Palkar

Abstract In manufacturing and product development, tremendous changes have been observed over a decade. The process of developments ensures the transformations to human life as and when required. The additive manufacturing is one of the processes involved in it, which emerged very fast in recent technical improvements/revolution. The additive manufacturing facilitates the development of the new range of materials along with improvements in the properties of existing materials. In this review article, the emphasis is on Polydimethylsiloxane in the additive manufacturing process. This article also discusses the primary considerations and the properties to be considered for the manufacturing of Polydimethylsiloxane to make it suitable for additive manufacturing. The review suggests the various parameters of the PDMS which made it a suitable option for additive manufacturing. Authors also tried to highlight the desired steps involved to enhance the additive manufacturing process with the help of emerging hybrid additive manufacturing processes.

Keywords Additive manufacturing · Polydimethylsiloxane · Photopolymerization · Direct ink writing · Digital light projector

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1 Introduction

In the global market, new products are introduced very rapidly due to varying customer's choices. In order to meet customer preferences, different materials are essential. It is, therefore, necessary to introduce new materials. In such a scenario, the selection of the material depends on the application. The desired criteria which are satisfied by the material in the developing phase are viz. functionality, ability to retain its properties. The metals, polymers and ceramic are main components that are mostly used in the engineering products to meet the customer requirements. The products are manufactured conventionally with the help of a series of operations. The sequence follows primary processes such as casting, forging followed by the secondary processes like machining, involving roughing and finishing operations and then finally by the tertiary processes or the material joining processes, for example, fastening, welding, adhesive bonding.

PDMS, a soft rubber, which is used in many fields such as the medical to make prostheses and microfluidic as well as electrical devices. There is a big challenge in achieving curing and printing the PDMS owing to several reasons, such as it has lower yield stress, lower glass transition temperatures. The curing agents used lately were very much time-consuming; it used to take about 72 h for the curing. Therefore, the parts printed with PDMS generally have support material such as gel and PVA. The curing and hardening agents such as platinum catalysts, TOP-L and ITX are being used to achieve printing without support material along with improved mechanical and electrical properties (Table 1).

Table 1 Different materials used in applications similar to biomedical

Application	Materials	Process for additive manufacturing
Microfluidic	Polyethylene Glycol Diacrylate [1]	–
	PDMS [2–5]	SLA, FDM
	poly(ethylene glycol) diacrylate (PEGDA) [5]	SLA
Biomedical	Stainless steels, (Co–Cr–Mo) and Ti, (especially Ti–6Al–4V) [6]	electron-beam melted (EBM)
	Calcium Polyphosphate (CPP) with Polyvinyl alcohol (PVA) [7]	Solid freeform fabrication (SFF)
	Poly(ethylene glycol)- terephthalate poly (butylene terephthalate) (PEGT/PBT) [8]	FDM
Pharmaceutical	Hydroxypropyl methylcellulose, polyacrylic acid (PAA) [9]	FDM
	Polyethylene oxide, polyvinyl alcohol [10]	FDM

Additive manufacturing (AM) is the latest way to make products layer by layer. Using these processes, one can create a product with complex geometries. The developments in processes of AM have quickly occurred in the last few years. Based on the type of material, i.e. liquid, solid, powder, the processes are classified. In stereolithography (SLA) liquid polymer is used, and in selective laser sintering (SLS) powdered material is used, whereas a solid filament or solid wire is used in fused deposition modelling (FDM). The above-listed processes have a unique method of converting the raw material into the solid part and the different characteristics that help to distinguish each of the processes. In addition to this, all processes have similarities in the layer by layer manufacturing concept to make the solid model. In SLA, the liquid resin is available as a monomer, which is exposed to the UV light in a controlled manner. In this process of polymerization due to the incident light on the liquid resin surface, the spot gets polymerized. The solidification of the resin typically shows the polymerization. Although the resin is solidified, it is not having sufficient strength. Therefore, after the photo-polymerization, the solid part is kept in a UV chamber where the crosslinking of the polymeric chains occurs resulting in the strength of the solid. Usually, in the SLA process, the polymer used is of thermosetting type.

In contrast, FDM converts a thermoplastic polymer filament to make a solid part. A Polymer wire passes through a heated nozzle converting it into a sticky solid of reduced cross-section. The semisolid wire coming out of the extruder is deposited on a horizontal surface with the help of Computerized Numerical Control (CNC) control. Within a few seconds, the wire gets converted back to solid. The sticky polymer gets adhered to the already laid wire. In SLS, the conversion to the solid part happens under laser incident on the powder spread on a horizontal surface. Wherever the laser spot incident, powder grain gets converted to the semisolid state. In that state, it fuses with the adjacent powder grain. As soon as the laser spot moves ahead, the fused powder grains get converted to solid. In this process, the manufacturing of the solid part results from the controlled incidence of the laser. With the help of the controlled incidence of laser, the solid part is manufactured.

The challenges faced in application and use of PDMS in AM are classified into two categories; the first includes the process of printing and the second is about enhancing the properties of PDMS.

Prior involves process, SLA with which, printing PDMS having high viscosity isn't possible. In FDM printing the challenge is printing PDMS without support materials and with more resolution. In addition, there is always problem clogging nozzle. It is possible to print PDMS by increasing its yield stress. The later uses PDMS having low Young's modulus. It should be able to increase Young's Modulus more than 2 MPa.

Even at levels significantly higher than those seen in the field sampling, experiments with both aquatical and terrestrial species demonstrated no adverse effects. Therefore, the environmental risk of PDMS is not expected [11].

2 PDMS Applied in Additive Manufacturing

The selection of material for AM is mostly dependent on the application. There is a large number of materials available for making a part. However, a limited number of materials support the AM. The choice of material is based on several considerations. The necessary points to be evaluated while selecting the material are functional requirements, mechanical properties, geometric criticalities, aesthetical and cost [12]. Over the last four decades, AM has significant applications in almost all fields. It includes engineering aerospace, automotive parts, a medical field such as prosthesis, tissue engineering and art, architectural [13].

Polydimethylsiloxane (PDMS) is a very versatile material that can be used in medical applications like to make prosthetics [14]. PDMS also serves as a promising material to create artificial human body parts like the brain and the heart since PDMS being biocompatible and non-toxic [4, 5]. PDMS is a thermosetting elastomer that finds application in electrical insulations [15]. Nowadays, a lot of research work is being carried out to use PDMS as additive manufacturing material in FDM and SLA processes owing to its versatile applications. In the pharmaceutical field, tablets or medicines are manufactured by embedding PDMS with the drugs [16]. The cost-effective material has prepared using [17].

The PDMS was also used to print in 3-D with digital light and phenyl phosphinate (TPO-L) as a photoinitiator. The parts manufactured using this process showed increased Young's modulus up to 1.44 MPa with lower permeability 15% as compared with a part manufactured with conventional processes [18]. Another way to is The Freeform Reversible Embedding (FRE) is also one of the effective methods to print parts using PDMS. As PDMS has less yield stress, the FRE printing is carried out with the help of support material and carbopol gel. The FRE complex objects can be made usually by adding PDMS with an agent for 72 h [19]. The Hydrostatic 3D printing (H3P) with low one-photon polymerization (LOPP) is applied for printing soft silicone polymer in support material [20]. Besides, LOPP is also used to print PDMS with 2H2M (2-Hydroxy-2-Methylpropiophenone) as a photoinitiator [21]. The PDMS is printed in SLA process with two types viz, PDMS-S (Methacryloxypropyl of group link by side-chains along the PDMS-chain) and PDMS-E (Methacryloxypropyl in the end terminal groups). In this process, with TPO-L photoinitiator it shows an effect on Young's module results in elongation and breaks. It is found that the elongation at a breakpoint for PDMS(E-S) is between 143 and 150%, and it is better than Sylgard 184 [22]. PDMS-DMAA printed with Irgacure 819, which lowers breakdown elongation to 51% and the maximum stress to $\sigma_{\max} = 0.58 \mp 0.09\text{MPa}$ [23]. The Embedded 3D printing with two types of PDMS Sylgard-184 and SE-1700 with particles of the silica and Curing agent. It is also observed that, the silica gives the thixotropic behaviour, and the elastic module G'_{maximum} value is observed to be around 515.3 Pa and maximum shear stress is 127.3 Pa [24]. The soft silicone can be printed in fused deposition moulding using print with poly-vinyl alcohol (PVA). The quality of printing is affected by the adhesion between the silicon and PVA and angle overhanging [25]. The human body parts like, hand and nose, blood vessels, were printed

by PDMS with the help of liquid deposition modelling (LDM). It can be facilitated by mixing two types of PDMS, i.e. SE 1700 and Sylgard 184, with different sizes of the nozzle. In this work, the ultimate strength of 5.036 MPa and Young's modulus 1.672 MPa was observed [26]. The human heart for the training and surgery purpose was made and presented by using silicon PDMS which was printed in FDM. In this work, a group of researchers used the PDMS as pellets with Na-CMC. The modulus for the filament of PDMS/Na-CMC was observed to be 8.515 kPa when extruded at 205 °C, and the viscosity of 1958.45 Pa.s [27]. Scaffolds of size $40 \times 300 \mu\text{m}$ were created by printing (Sylgard 184), PDMS agent and PVA. In the heating stage, the resolution of 500 μm , the nozzle of size 250 μm was used to achieve the thermal stability and [28].

The Direct Ink Writing (DIW) achieves a better modulus G' of 11,360 Pa by mixing PDMS (SE-1700) with Dragonskin 30. In this process of DIW, the different sizes of the nozzles were used with a specific pressure of 200 kPa [28]. The mixture of PDMS-co-PDPS (Polydimethylsiloxane-co-Diphenylsiloxane) with silica HMDZ (hexamethyldisilazane-treated) reveals the value of the coefficient, i.e. $G'/G'' = 410$ Pa. The advantage of HMDZ-treated silica is, it helps to increase the yield stress and also allows to cure the PDMS when it is added with a platinum catalyst [29]. The low yield stress is one of the disadvantages of the LDM for printed LSR (PDMS with silica) solution the problem of low yield stress Polyethylene Glycol (PEG) can achieve the yield stress about 1000 Pa, which is suitable for printing [30]. The excellent elastic strength with 18 μm lateral resolution was achieved by the Laser Direct Writing (LDW) [31]. Apart from all these practices, a Full Reactive Inkjet Printing (FRIJP) accomplishes the printing PDMS by two different types with platinum catalysts as complex shapes [32].

3 Process of Making Solid Objects Using PDMS

3.1 Photoinitiators and Agents Used with PDMS

Polydimethylsiloxane is known as thermosetting material that has a challenge for printing, and it also serves as the potentials to apply in additive manufacturing. Therefore, it has acquired the attention of researchers. The researchers have been trying to experiment in printing this polymer. It is well known that this polymer is applied in several processes. In additive manufacturing, there are many ways for printing PDMS, but almost all of the printing processes of PDMS need an agent or a support material. These agents differ in many parameters as they are used to cure PDMS. The well-known agent applied is the Curing agent (Dow Corning) that can convert the PDMS from liquid to solid during several periods; it depends on the process, such as FRE. This FRE process takes around 72 h to cure the PDMS. The

FRE process helps to achieve an intricate part. The disadvantage of using Curing agent (Dow Corning) is time taken hours. To overcome this issue ultraviolet (UV) light is used so it can be achieved in less time as compared to the conventional process.

Most of the researchers have been using Sylgard-184 and SE 1700 because they have the ability to synthesis by UV light. With developments in processes of synthesis, the PDMS was applied in DLP with Phenyl Phosphinate (TPO-L) photoinitiator. The TPO-L helps to solidify the PDMS when it exposes to the light. The DLP with TPO-L showed an increase in Young's modulus up to 1.44 MPa. In the DLP and SLA process, the resolution of PDMS is based on the absorption of the light. The TPO-L improves the resolution, but the limiting parameter is the amount of TOP-L, it should be less than 2 wt% to achieve better curing. The Orasol Orange is added in this process, to increase the resolution. Though photoinitiation plays a vital role in PDMS, several types of PDMS are insensitive to photoactivity. However, the photoinitiators should have two basic characterizes, which are to be suitable in the synthesis of PDMS: first, the ability to be soluble with PDMS; second, the ability to absorb the light. These two things are more critical for any curing process based on UV light.

Irgacure 819 is another photoinitiator applied to cure PDMS. This photoinitiator is advantageous over other available photoinitiators as it is cheaper, having less toxicity, the ability to absorb the light. The percentage of Irgacure 819 in PDMS is 0.25 wt%. The 2-Hydroxy-2-Methylpropiophenone (2H2M) photoinitiator achieves the absorption of the light and can add N-vinylpyrrolidone (NVP) to achieve proper curing. The Polyethylene Glycol (PEG) can be applied in Liquid Deposition Modelling (LDM). Almost all the agents change the properties of PDMS, but PEG does not change the final properties. The LDM achieves the complex object, under the application of any yield stress. The Young modulus increase with PEG percentage. The printing of PDMS with silica isn't possible without adding PEG because the yield stress of PDMS is low. One of the drawbacks is the poor quality achieved in part with this agent is poor. Figure 1 shows the details of various agents used in the additive manufacturing process. A detailed study of the advantages and disadvantages has also listed in Table 2.

4 The Support Materials Applied with PDMS

The PDMS isn't only with agent or photoinitiator can print. The PDMS has low yield stress; for that purpose, it is challenging to print alone, especially in LDM, for that it can print with other material as support such as PVA water-soluble. The success of the process is based on the adhesive between the PVA and the silicone. It achieves maximum Elastic modulus G'_{maximum} value around 515.3 Pa and maximum shear stress τ_{max} is 127.3 Pa. Direct Ink Writing (DIW) prints the PDMS with Dragonskin 30 to accomplishes a better modulus of elasticity $G' = 11,360$ Pa. Besides, it can print the PDMS with two types PDMS SE1700 and Sylgard 184. This process achieves an

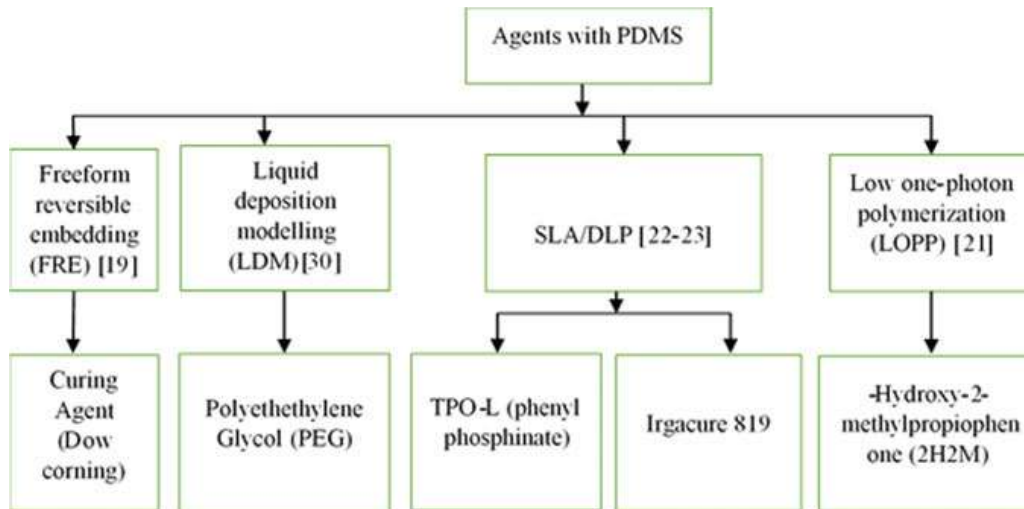


Fig. 1 Details of agents used in additive manufacturing

ultimate strength 3.432 ± 1.216 MPa comparing with casting 2.990 ± 0.414 MPa; if the filament direction is changed, it was 5.036 ± 0.657 MPa.

Figure 2 shows a detailed analysis of the additive manufacturing process, addressing the different aspects of product development.

5 Conclusion

The printing of PDMS has several processes, and all these processes were born early with PDMS. Therefore, it has many drawbacks and challenges to accomplish better properties and characteristics. In addition to conventional practice in product development, there are several hybrid techniques available to meet the needs of the industry. In line with this, we can see the better way to printing PDMS is LDM, as it doesn't lose the properties of PDMS and helps to improve the available properties. Apart from this, it helps to achieve complex shapes such as the human body part. SLA and LOPP processes have many challenges. Those can overcome in near future with detailed study and modifications. The photonics plays a vital role in all this process. The idea to photoinitiate the process to deviate its ability to offer required changes always turned to be as essential criteria for the product development. In addition to this, there are several fronts on which material scientists are taking an effort to produce and deliver the required material.

In this review article, the authors tried to focus on the use of PDMS as a single and mixed material along with necessary agents and conditions. The first study is concerned with the combination of different agents with available methods. In this article, the authors also highlight the use of PDMS as one of the efficient materials with appropriate agents.

Table 2 Summary of agents used in material processing

The agents or photoinitiators	Advantage	Disadvantage
Platinum catalysts	<ul style="list-style-type: none"> • It is using for crosslinking the PDMS 	<ul style="list-style-type: none"> • It's costly
Curing agent (Dow corning) [11]	<ul style="list-style-type: none"> • It applied to cured specific type of PDMS such as Sylgard 	<ul style="list-style-type: none"> • It takes a lot of time to cure PDMS
TPO-L [9, 14]	<ul style="list-style-type: none"> • Improving absorption and optical transparency • Improving the resolution, the penetration depth will be increased • Add the Orasol Orange with TPO-L in PDMS to increase the resolution • The higher amount of TPO-L gives fast curing • The wavelength for the light it can absorbance is 385-400 nm 	<ul style="list-style-type: none"> • When increasing the TPO-L above 0.6, the optical transparency decreases • The solubility in PDMS is limited
Hydroxy-2-methylpropiophenone (2H2M) [13]	<ul style="list-style-type: none"> • Increase the absorption for PDMS • Applied in LOPP system 	<p>It's not sufficiency to cure PDMS; it should add N-vinyl-pyrrolidone (NVP) to advance the curing</p>
Irgacure 819 [15]	<ul style="list-style-type: none"> • Absorption of the light happens in the visible light area • It can be applied with resin, which has a higher reactive • It's cheap • No-toxicity 	<ul style="list-style-type: none"> • The amount of Irgcure 819 effect on the maximum strain and tensile strength • Irgcure 819 isn't sufficiency for curing the PDMS it should add other materials for examples: SilOHflex
Polyethylene Glycol (PEG) [22]	<ul style="list-style-type: none"> • Increase Yield stress for PDMS • It can get high quality when controlling the amount of PEG • Achieving a right ratio mass without failing the layers 	<p>The need for adding silica particles for achieving perfect printing</p>

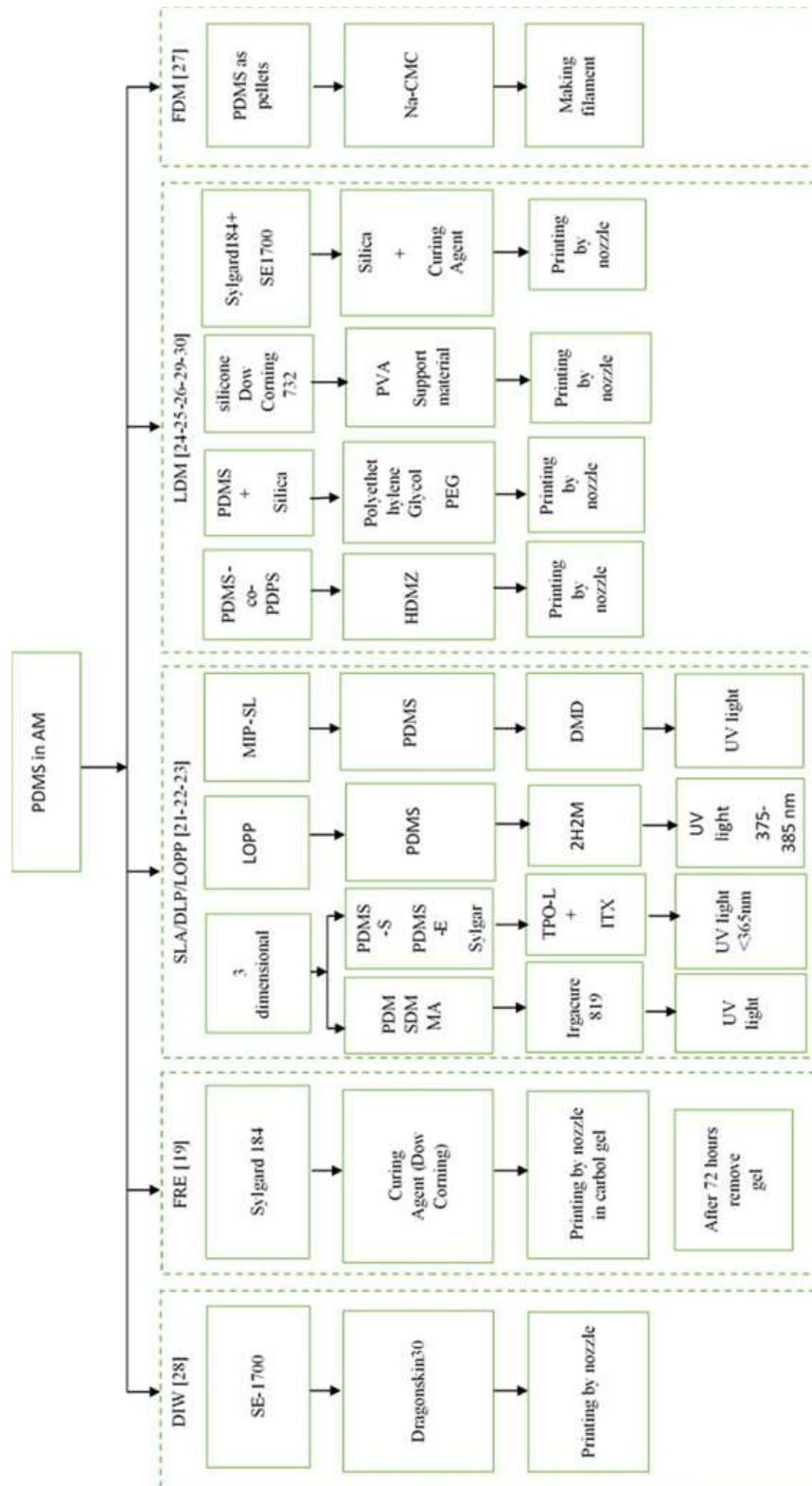
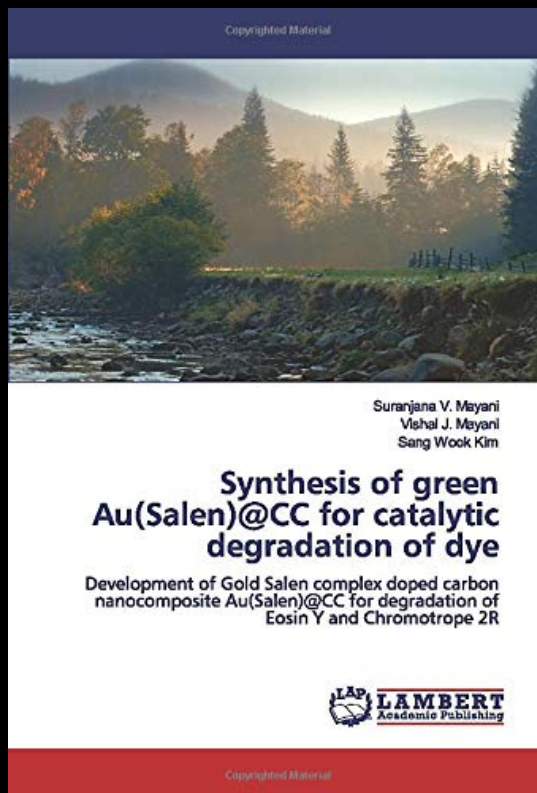


Fig. 2 Distinctive features of additive manufacturing

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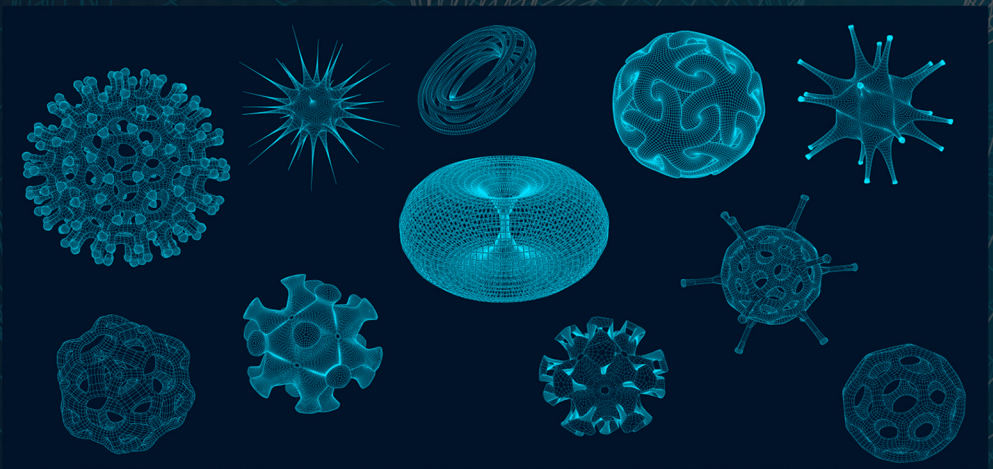
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Information Technology, Management and Operations Research Practices

MATHEMATICAL MODELING AND SOFT COMPUTING IN EPIDEMIOLOGY



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Preface

The edited book *Mathematical Modelling and Soft Computing in Epidemiology* describes different mathematical modeling and soft computing techniques in epidemiology for experiential research in project how *infectious diseases* progress to show the likely outcome of an *epidemic* and help inform *public health* interventions. This book will highlight that the models use some basic assumptions and mathematics to find *parameters* for various *infectious diseases* and use those parameters to calculate the effects of different interventions, such as mass *vaccination* programmers, cancer, and tuberculosis. This book will walk through the emerging trends in modeling of infectious diseases is a tool which has been used to study the mechanisms by which diseases spread, to predict the future course of an outbreak and to evaluate strategies to control an epidemic. It will help the researchers to appreciate the *Mathematical Modeling and Soft Computing in Epidemiology*. This book will provide a comprehensive discussion of epidemiological modeling that refers to dynamic, deterministic modeling where the population is divided into compartments based on their epidemiological status (e.g., susceptible, infectious, recovered), for which movements between compartments by becoming infected, progressing, recovering, or migrating are specified by differential or difference equations. Overall, this book will develop an understanding of the need of work epidemiologists and public health workers that mathematical modeling can be of use to them.

The objective is to bring the mathematical modeling and soft computing in epidemiology methods in a single volume, which can add to the existing knowledge of undergraduate and postgraduate students, researchers, academicians, and industry people. This book intends to cover the main aspects of mathematical modeling and soft computing in epidemiology, and its goal is to persuade epidemiologists and public health workers that mathematical modeling can be of use to them. The primary users for this book include researchers, academicians, postgraduate students, and specialists. This edited book will have separate chapters to facilitate readers of epidemiology will ensuring its continued popularity in adapting this book.

CHAPTER 1

This chapter proposed an approximation-based evolutionary computing framework for predicting and analyzing the dynamics of virus propagation of dengue disease involving virus incubation period. The proposed framework consolidated distinguishes techniques of Padè approximation, penalty function approach, Nelder–Mead simplex (NMS) algorithm, and differential evolution (DE) for solving the underlying model numerically.

CHAPTER 2

This chapter is an attempt to describe mathematically the functioning of fuzzy recombination of chromosomes. Chromosomal diseases happen when either entire

chromosome or enormous fragment of chromosome is duplicated or missing or transformed. In this chapter, the fuzzy topological features of the recombination space are analyzed. Various crossover models are spontaneously produced in the recombination space, and this can be structured using fuzzy pretopology. The outcomes revealed in this chapter of unequal crossover replicate the connectivity of the fuzzy recombination space in genetic epidemiology.

CHAPTER 3

This chapter aims that sufferers of the disease are provided with some initial support and the medical practitioners may get some preliminary ideas about the fatal diseases. Our knowledge in this domain still remains inadequate (as in the case with many other biomedical issues) compared to the information obtained from the study of similar technological structures, and mathematical models are constructed and presented in the investigations related to cause and remedy of the human physiological disorders.

CHAPTER 4

This chapter provides a machine-learned regression assessment of the HIV epidemiology development in Asian region. The presented model with random perturbations aids to advance the accepting of dynamical behavior, and with time, the growth of virus particles can be gradually decreased through these differential equations and then the infection could tend towards zero level, which will after sometimes be more or less not effective inside the body. Great accomplishments have been made for decreasing morbidity and mortality via first decade of 2000, continuously emphasizing for the access to region-appropriate preventive scales.

CHAPTER 5

This chapter presents general mathematical modeling to find the potential number of ways to distribute certain things to certain places in the medical field. Mathematical model is nothing but finding the double twin domination number of a graph theoretical representation of the real-life situation. In this chapter, we provide a mathematical model to obtain the potential number of ways to perform certain tasks in the medical field. We obtain this number for many special types of graphs.

CHAPTER 6

This chapter focuses on addressing an analysis of an epidemic model in the context of fractional calculus. We consider fractional SIRI model with delay described by Caputo–Liouville-generalized fractional derivative. The existence and uniqueness of the SIRI epidemic model have been investigated. We determine the reproduction number R_0 . We establish the disease-free equilibrium point and the endemic equilibrium point. We present the stability analysis of the disease-free equilibrium point and the endemic equilibrium points in terms of the reproduction number R_0 .

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2 Fuzzy-Genetic Approach to Epidemiology

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2.1 INTRODUCTION

The mechanism of world can be described using the models. Mathematical modeling deals with converting such models/systems into mathematical language, which includes concepts from algebra, geometry, differential equation, and topology, whereas its outcomes depend on the parameters considered to model that system. Mathematical modeling of the real-world problem plays an important role in many branches of science and technology. It is used for analyzing the behavior of system and understanding its mechanism. The problems that result in the necessity of studying complex control systems are extremely diverse and are generated by various branches of modern science and technology. Recently, connections between the mathematical sciences and biological sciences are increasing rapidly. New branches of mathematical sciences, including study of issues such as population growth models, epidemic models, and recently including study of genomes arising from the accumulation of DNA sequence data, have made biomathematics an interesting field.

In certain cases, the existing information that has a lack of precision or is qualitative in nature cannot be modeled efficiently by usual mathematical modeling approaches. Many natural processes cannot be described mathematically, or whose descriptions have much complexity to be of practical value, which has motivated mathematicians and researchers in fuzzy modeling and their identification techniques.

This chapter is an attempt to describe mathematically the functioning of fuzzy recombination of chromosomes. Chromosomal diseases happen when entire chromosome or enormous fragment of chromosome is either duplicated or missing or transformed. For instance, Down syndrome is a protuberant example of chromosomal irregularity. Single-gene disorder happens when transformation occurs in the gene, affecting the working of other genes, e.g., sickle cell anemia. Mutation in multiple genes results in multifactorial disorders, frequently accompanied by environmental causes. High blood pressure, arthritis, diabetes, and obesity are few of the multifactorial disorders. Mutations in nonchromosomal DNA, located in mitochondria, result in mitochondrial disorders and can influence other parts of the body, including muscles, veins, or brain. Gene plays a significant role in communicable diseases such as tuberculosis and AIDS. Moreover, it also plays a role in noncommunicable diseases such as diabetes and cancer. This section presents a brief overview about the role of genetics in few leading diseases, which weight down human population worldwide.

2.2 GENETIC EPIDEMIOLOGY AND TOPOLOGY

Conventional genomic analysis emphasizing on the genetic factor is responsible for precise phenotypes, whereas traditional study of epidemics is concerned about ecological causes and associated risk factors for individuals [1]. Genetic epidemiology is a combination of both the factors, namely, the role of genetic factors and their association with environmental factors, as far as the disease in human population is concerned. The study of genetic variation at the molecular level promises to contribute to the understanding of the etiology and pathogenesis of major chronic diseases that appear to have a genetic component, such as coronary heart diseases, cancer, and birth defects [2].

Much of genetic and epidemiological analysis involves determining the relationship between disease and exposure to risk factors, and whether a candidate exposure condition impacts the probability that an individual will have a disease diagnosis. The statistical tests to determine the probability are usually more complicated with multiple exposure variables such as genetic, behavioral, or medical conditions. The massive growth in genetic technology and its ever-expanding register of human genes are further adding to the increasing complexity [3]. One approach to identify risk exposures, and relationships between diseases and condition that are described, is simply to identify whether some patterns occur more frequently than expected. This implies that it becomes possible to explore the logical relationship and identify equality among pattern members. The mathematical structure called topological spaces provides the required platform for the discussion of nearness or sameness of such pattern through neighborhoods. Topology provides a general framework for analyzing structures or data with the advantage of being able to extract information from a large collection while not depending on the choice of any threshold value.

2.3 UNEQUAL CROSSOVER

The genetic data of living organisms is reserved in deoxy ribonucleic acid abbreviated as DNA. Each DNA molecule is packed in a thick-like structure called chromosome. The chromosomes differ in length from 10^5 base pairs in yeast to 10^8 base pairs in human [4]. A chromosome comprises gene blocks of DNA. Each protein is encoded by a gene. Alleles are different versions of the same gene. The whole collection of genetic material, i.e., all chromosomes, is known as a genome. In living organisms, a genome usually consists of homologous chromosomes. One of each homologous pair of chromosomes originates from the mother, while the other originates from the father.

During meiosis, two homologous chromosomes cross over and contribute to reasortment of genetic variation. In this process, both chromosomes break due to the pressure of mutual attraction. Further, these broken ends of chromosomes rejoin to the original chromosomes or can cross over to join the homologous original chromosomes [4]. The physical interchange of chromosomes results in recombination. Recombination generates a new combination of alleles at each generation in diploid organisms. Due to recombination, the new copy of homologous chromosomes may have different alleles. Thus, by the exchange of respective segments between the homologs, recombinant chromosomes can be generated, and these chromosomes are different from the original parental one (Figure 2.1).

Sometimes, it is possible that during meiosis, the breakage of two chromosomes occurs unequally. During this process, the phase length of the original chromosome changes, and in the new copy of chromosomes, one gets longer and the other gets shorter. This is often referred as an unequal crossover. Unequal crossover results because recombination occurs between two sites that are similar in nature, but not aligned precisely. When such an event occurs, the number of repeats increases in one

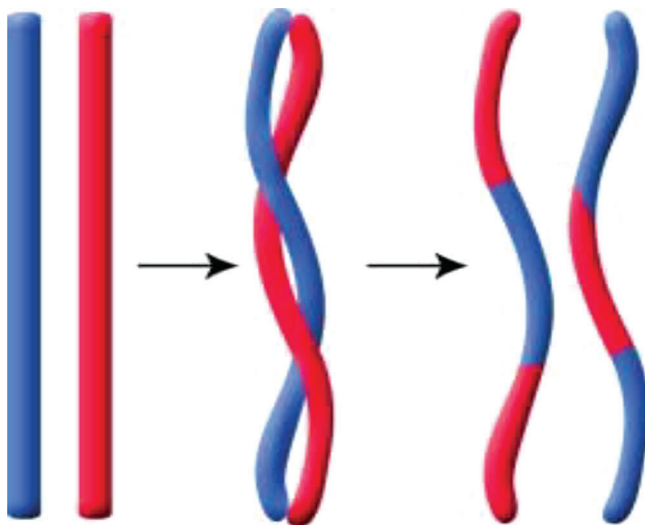


FIGURE 2.1 Recombination.

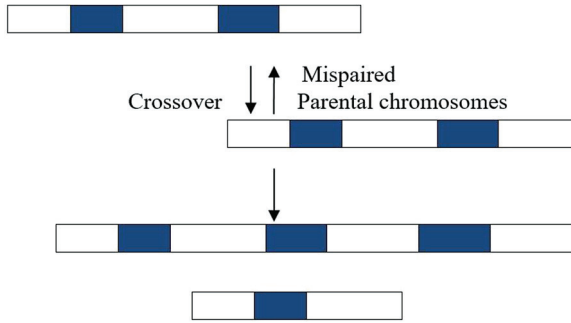


FIGURE 2.2 Unequal crossover.

chromosome, whereas that decreases in the other. In consequence, one chromosome in the new copy of homologous pair has a deletion and the other has an insertion (Figure 2.2).

2.4 MATHEMATICAL BACKGROUND

2.4.1 FUZZY SETS

Mathematically, problems can be defined as the concept of functions and sets, which results in a rigid representation of problems that can be modeled using the concepts of fuzzy [5]. The fuzzy theory has great influence as it brings to our notice the very existence of uncertainty. Fuzzy theory can be treated to be a meaningful tool for treating such uncertainty, although it may not cover all uncertainties. Because of its large possibility, fuzzy theory is useful to an organization and human systems. An ordinary or a crisp set is a well-defined collection of finite, countable, or uncountable objects. A set is represented by the uppercase letters, and the objects in it are represented by the lowercase letters. If A is a set, then an object or element x in it is represented by $x \in A$. A characteristic function can be used to describe and represent a set. A characteristic function of A is mapping χ_A from A to the set $\{0,1\}$ that takes the value 1 if x is in A ; otherwise, 0. However, in case of “fuzzy,” the relation $\chi_A(x)$ of belonging to between x and A is not only “0 or 1” but also has a grade of membership, which may assume any real value between 0 and 1. The concept of fuzzy sets provides us a new way of observing and investigating the relationship between sets and their elements other than the traditional way of black or white. It says that there exists other possibilities besides the relation of *belonging to* with *not belonging to* between an element and a set. Thus, basically, fuzzy sets are the classes of an object with membership grades ranging between 0 and 1.

A fuzzy set F of a non-empty set U is defined through a mapping,

$$\mu_F: U \rightarrow [0,1].$$

This function μ_F is said to be the membership function, and this maps U to a membership space M . The value $\mu_F(x)$ is then said to be the membership grade

of x in F . For simplicity, both the fuzzy set F and its membership function μ_F are usually denoted by F . If M has only the two points 0 and 1, F is crisp (or non-fuzzy) set and μ_F is the same as the characteristic function of the crisp set F . The range set of the membership function is a bounded set of real numbers, and its members are nonnegative.

For a non-empty set U , $I^U = \{F: U \rightarrow [0,1]\}$.

The members of I^U are said to be fuzzy subsets of U . 0_U and 1_U are the functions on U that takes the value equal to 0 and 1, respectively, for each value of a in U .

Let F and G be two fuzzy sets whose standard intersection, union, and complement, i.e., $F \cap G$, $F \cup G$, and F^c , are defined for each $a \in U$ by the following equations [6]:

$$(F \cap G)(a) = \min[F(a), G(a)]$$

$$(F \cup G)(a) = \max[F(a), G(a)]$$

$$F^c(a) = 1 - F(a)$$

$$F \subseteq G \text{ if } F(a) \leq G(a).$$

Note: “min” and “max” are used in place of infimum and supremum, respectively, for a finite collection of fuzzy sets.

For every fuzzy subset $F \in I^U$, support of F is given by

$$\text{supp}(F) = \{a \in U: F(a) > 0\}.$$

A fuzzy point on U is a fuzzy set

$$P_y^x(a) = \begin{cases} x, & \text{if } a = y \\ 0, & \text{if } a \neq y \end{cases}.$$

2.4.2 FUZZY PRETOPOLOGY

In mathematics, general topology, viz., point set topology or ordinary topology, deals with the characteristics of a space that are preserved under continuous distortions, such as stretching and bending, but not tearing or gluing. General topology, which is based on the crisp set, establishes the foundational aspects of other branches of topology. Pretopological spaces are the generalization of topological spaces. Two elements may be close to a third element via some relation; however, there is not sufficient structure to say which one of them is closer or nearer. Such a space is called a topological space. It has a suitable structure to embrace the concept of boundary. If we remove the underlying behavior of boundary from this structure, the weakest notion of nearness is uncovered, and thus, we obtain a pretopological space [7]. It is customary to define topology on a set through a class of open sets or a class of closed sets [8]. However, the concept of topology on a set can also be presented through

operators such as closures, neighborhoods, and interiors instead of the conventional class of open or closed sets [9].

Fuzzy sets can be used in an extensive range of structures such as topological spaces, groups, rings, algebras, ideals, and vector spaces. They can also be applied in quantum particle physics and control theory. C.L. Chang [10] was the first to propose the concept of fuzzy topological spaces. He used fuzzy sets instead of crisp sets in the definition of point set topology and redefined the theory of ordinary topological spaces. Fuzzy topology is defined by extending ordinary topology to fuzzy setting, and the theory of ordinary topology is a special case of it. Although ordinary topology can be generalized to fuzzy topology, fuzzy topology has its own remarkable characteristics. It can magnify our interpretation of some structures in classical mathematics. Besides that, it provides a new way of observing significant results of classical mathematics [5]. For our convenience, we will now term the “topology” based on crisp sets to be crisp topology. Just like crisp topology, it is possible to define fuzzy pretopology by means of operators discussed below.

Definition 2.1 [11]

For a non-empty set U , a fuzzy pretopology on U is defined by an application α of I^U into I^U , which verifies the properties $\alpha(0_U) = 0_U$ and $\alpha(F) \supseteq F$ for each $F \in I^U$. Then, (U, α) can be referred as a fuzzy pretopological space, or in short fpts.

It is possible that α may also satisfy some properties [11], such as

1. $\alpha(F) \supseteq \alpha(G)$, where $F \supseteq G$, and for each $F, G \in I^U$. In this case, (U, α) is said to be fpts of type I.
2. $\alpha(F \cup G) = \alpha(F) \cup \alpha(G)$ for each $F, G \in I^U$. In this case, (U, α) is said to be fpts of type D.
3. $\alpha(\alpha(F)) = \alpha^2(F) = \alpha(F)$ for each $F \in I^U$. In this case, (U, α) is said to be fpts of type S.

If (U, α) is fpts of type I, D, and S, then it becomes a fuzzy topological space. Here, α will be called a closure operator in fpts (U, α) .

Definition 2.2 [11]

By considering the fuzzy pretopological space (U, α) , the interior is a function $i_\alpha: I^U \rightarrow I^U$ defined as $i_\alpha(F) = (\alpha(F^c))^c$, where $F \in I^U$.

Then, the above properties becomes

1. $i_\alpha(0_U) = 0_U$.
2. $i_\alpha(F) \subseteq F$ for each $F \in I^U$.
3. $i_\alpha(F) \subseteq i_\alpha(G)$ for each $F, G \in I^U$ so that $F \subseteq G$.

4. $i_\alpha(F \cap G) = i_\alpha(F) \cap i_\alpha(G)$ for each $F, G \in I^U$.
5. $i_\alpha^2(F) = i_\alpha(F)$ for each $F \in I^U$.

Definition 2.3 [11]

A class of fuzzy preneighborhoods of the point a in U is a collection $\mathcal{B}(a)$ of fuzzy subsets V , which satisfy $V(a) = 1$.

Definition 2.4 [11]

Let $\varphi: I^U \rightarrow [0,1]$ be a function. Then, φ can be referred as the degree of non-vacuity if the following conditions are fulfilled:

- i. $\varphi(0_U) = 0$.
- ii. $\varphi(F) = 1$ if there is a a in U such that $F(a) = 1$.
- iii. $F \supseteq G$ implies $\varphi(F) \geq \varphi(G)$.

We see that $\varphi(F) = \sup_{a \in U} F(a)$.

If F is a fuzzy set of a non-empty set U , then we can construct a function $\alpha: I^U \rightarrow I^U$ defined as

$$\{\alpha(F)\}(a) = \inf_{V \in \mathcal{B}(a)} \varphi(V \cap F).$$

This is a type I *closure* operator on U . This also relates fuzzy preneighborhoods to closure operator.

For our convenience, we sometimes denote $\alpha(F)$ by \bar{F} .

Definition 2.5 [12]

Let U be a non-empty set. Let \tilde{U} be the collection of all fuzzy points of U . Let \tilde{d} be a function on \tilde{U} , which takes the real values and verifies the following properties:

- i. $\tilde{d}(P_a^r, P_b^s) \geq 0$.
- ii. $\tilde{d}(P_a^r, P_b^s) = \tilde{d}(P_b^s, P_a^r)$.
- iii. $\tilde{d}(P_a^r, P_b^s) = 0$ implies $P_a^r = P_b^s$.
- iv. $\tilde{d}(P_a^r, P_b^s) \leq \tilde{d}(P_a^r, P_c^t) + \tilde{d}(P_b^s, P_c^t)$.
- v. $\tilde{d}(P_a^r, P_b^s) = \tilde{d}(P_a^s, P_b^r)$ for all a, b , and c in U .

Then, \tilde{d} is a classical metric on \tilde{U} that satisfies an additional property (v), and it is known as fuzzy metric defined on U .

Definition 2.6 [12]

Let \tilde{d} be a fuzzy metric defined on U . We define for any a, b in U and $\varepsilon > 0$

$$B(P_a^r, \varepsilon) = \{P_b^s : \tilde{d}(P_a^r, P_b^s) < \varepsilon\}$$

$$B'(P_a^r, \varepsilon) = \{P_b^s : \tilde{d}(P_a^r, P_b^s) \leq \varepsilon\}.$$

The first set is called an open ball, whereas the second set is called a closed ball—both centered at a with radius ε . These sets are treated as fuzzy sets of U whose corresponding membership functions are given by

$$B(P_a^r, \varepsilon)(b) = \sup\{s : \tilde{d}(P_a^r, P_b^s) < \varepsilon\}$$

$$B'(P_a^r, \varepsilon)(b) = \sup\{s : \tilde{d}(P_a^r, P_b^s) \leq \varepsilon\}.$$

Thus, \tilde{d} gives a fuzzy topology on U defined by the neighborhood basis

$$\mathcal{B}(a) = \{B(P_a^r, \varepsilon) : \varepsilon > 0\} \text{ for each } a \in U.$$

Definition 2.7 [12]

A fuzzy weakly metrizable space is a fpts U , in which there lies a fuzzy metric \tilde{d} and set $Q, Q' \subset (0, \infty)$ such that

$$\mathcal{B}(a) = \{B(P_a^r, \varepsilon) : \varepsilon \in Q\} \cup \{B'(P_a^r, \varepsilon) : \varepsilon \in Q'\}$$

is a fuzzy preneighborhood basis of U , where $B(P_a^r, \varepsilon)$ and $B'(P_b^r, \varepsilon)$ are the open and closed balls, respectively.

In crisp topology, separation axioms express how rich the population of open sets are. More precisely, each of them tells how tightly the distinct points or disjoint subsets can be wrapped in an open set. The following definitions are some of the separation axioms in fuzzy pretopology.

Definition 2.8 [12]

A T_0 -fuzzy space is a fuzzy pretopological space U in which for all $a \neq b$, there exists $F \in \mathcal{B}(b)$ such that $a \notin F$, i.e., $F(a) = 0$, or there exists $G \in \mathcal{B}(a)$ such that $b \notin G$, i.e., $G(b) = 0$.

Definition 2.9 [12]

A T_1 -fuzzy space is a fuzzy pretopological space U in which for all $a \neq b$, there exists $F \in \mathcal{B}(b)$ such that $a \notin F$, i.e., $F(a) = 0$.

Definition 2.10

A T_2 -fuzzy space is a fuzzy pretopological space U in which for all $a \neq b$, there exists $F \in \mathcal{B}(a)$ and $G \in \mathcal{B}(b)$ such that $F \cap G = 0_U$.

It is clear from the definition that $T_2 \Rightarrow T_1 \Rightarrow T_0$.

Definition 2.11 [12]

A R_0 -fuzzy space is a fuzzy pretopological space U in which for $a \in \overline{\{b\}}$ implies $b \in \overline{\{a\}}$, i.e., $\{b\}(a) > 0 \Rightarrow \{a\}(b) > 0$ for each a, b in U . Note that the fuzzy subset $\{a\}$ is such that $\{a\}(a) = 1$; otherwise, 0.

Theorem 2.1 [12]

A fuzzy weakly metrizable space is a R_0 -fuzzy space.

Theorem 2.2 [12]

A fuzzy pretopological space U is $T_1 \Leftrightarrow \overline{\{a\}} = \{a\} \forall a \in U$.

Theorem 2.3

A fuzzy pretopological space U is $T_1 \Leftrightarrow U$ is both R_0 and T_0 .

We know that finite objects are easy to handle and so they are considered as the well-behaved ones. In crisp topology, the property of compactness is not exactly finiteness, but it behaves a lot in that manner. Compactness tells how firmly a set is packed. The following definitions discuss the compactness in fuzzy pretopology.

For a type I fuzzy pretopological space (U, α) , we have the following terms.

Definition 2.12 [11]

U is said to be 1-compact if and only if for every collection $A_{j \in J}$ of fuzzy subsets of U that satisfies $\bigcap_{j \in J_0} A_j \neq 0_U \forall J_0 \subseteq J$, where J_0 is finite, we have $\bigcap_{j \in J} \alpha(A_j) \neq 0_U$.

Definition 2.13 [13]

U is said to be 1-Lindelof if and only if for every collection $A_{j \in J}$ of fuzzy subsets of U that satisfies $\bigcap_{j \in J_0} A_j \neq 0_U$, where $J_0 \subseteq J$ and J_0 is countable, we have $\bigcap_{j \in J} \alpha(A_j) \neq 0_U$.

Definition 2.14 [13]

U is said to be countable 1-compact if and only if for every collection $A_{j|j \in J}$ of fuzzy subsets of U that satisfies $\bigcap_{j \in J_0} A_j \neq 0_U$, where $J_0 \subseteq J$ and J_0 is finite, we have $\bigcap_{j \in J} i_\alpha \{ \alpha(A_j) \} \neq 0_U$.

Definition 2.15 [13]

U is said to be almost 1-compact if and only if for every collection $A_{j|j \in J}$ of fuzzy subsets of U that satisfies $\bigcap_{j \in J_0} i_\alpha(A_j) \neq 0_U$, where $J_0 \subseteq J$ and J_0 is finite, we have $\bigcap_{j \in J} \alpha(A_j) \neq 0_U$.

Definition 2.16 [13]

U is said to be nearly 1-compact if and only if for every collection $A_{j|j \in J}$ of fuzzy subsets of U that satisfies $\bigcap_{j \in J_0} i_\alpha(A_j) \neq 0_U$, where $J_0 \subseteq J$ and J_0 is finite, we have $\bigcap_{j \in J} i_\alpha \{ \alpha(A_j) \} \neq 0_U$.

1-compact \Rightarrow nearly 1-compact \Rightarrow almost 1-compact.

In crisp topology, connectedness is referred as one of the principal topological properties that are used to differentiate topological spaces. This property can be generalized with the help of fuzzy sets as follows.

Definition 2.17 [14]

Let (U, α) be a type I fuzzy pretopological space. Then,

- i. U is strongly fuzzy-connected if for every $F \in I^U, F \neq 0_U, \alpha(F) = 1_U$.
- ii. U is one-sided fuzzy-connected if for every $A \in I^U, A \neq 0_U, \alpha(A) = 1_U$ or for every $G \in I^U, G \neq 0_U$ if $G \subset \{ \alpha(A) \}^c$, then $F \subset \alpha(G)$.
- iii. U is hyper-fuzzy-connected if for every $F \in I^U, F \neq 0_U, \alpha(F) = 1_U$ or there exists $G \in I^U, G \neq 0_U$ if $G \subset \{ \alpha(F) \}^c$, then $F \subset \alpha(G)$.
- iv. U is apo-fuzzy-connected if for every $F \in I^U, F \neq 0_U, \alpha(F) = 1_U$ or for every $G \in I^U, G \neq 0_U$ if $G \subset \{ \alpha(F) \}^c$, then $\alpha(F) \cap \alpha(G) \neq 0_U$.
- v. U is fuzzy-connected if for every $F \in I^U, F \neq 0_U, \alpha(F) = 1_U$ or $\alpha \left[\{ \alpha(F) \}^c \right] \cap \alpha(F) \neq 0_U$.

Theorem 2.4 [14]

For type I fuzzy pretopological space (U, α) ,

- i. U is one-sided fuzzy-connected if it is strongly fuzzy-connected.

- ii. U is hyper-fuzzy-connected and apo-fuzzy-connected if it is one-sided fuzzy-connected.
- iii. U is fuzzy-connected if it is hyper-fuzzy-connected.
- iv. U is fuzzy-connected if it is apo-fuzzy-connected.

2.5 FUZZY TOPOLOGICAL PROPERTIES OF RECOMBINATION SPACE

2.5.1 MATHEMATICAL DEFINITION OF RECOMBINATION SETS

Recombination spaces can be defined on the basis of concept of recombination functions $R: C \times C \rightarrow P(C)$ [15]. Consider a pair of parental chromosomes a and b , and the set of recombination $R(a, b)$ comprises all recombinant chromosomes that are formed by recombining a and b with the help of certain class of crossover operators. We observe the following given properties:

- a. $\{a, b\} \subseteq R(a, b)$.
- b. $R(a, b) = R(b, a)$.
- c. $R(a, a) = \{a\}$.
- d. $\forall c \in R(a, b)$, the inequality $|R(a, c)| \leq |R(a, b)|$ holds.

Condition (a) is just for notation purpose. Condition (b) signifies the need of simple symmetry. Condition (c) asserts that no new type of chromosome will be created by recombination of one single type of chromosomes. Lastly, condition (d) explains the topological significance of recombination. It fundamentally states that recombinant chromosomes are more likely to be of the parental kinds, than they (parental kinds) are to each other. This essentially asserts the notion that recombinants are blends of the two parental kinds. Additionally, this situation implies that the amount of similarity in two types of chromosomes is in inverse proportion to the number of types of recombinants that are created by recombination process. Properties (a) and (b) are satisfied by a generalized recombination structure. The appropriate recombination sets of homologous crossover, in addition, also satisfy (c) and (d). It appears obvious to infer $R(a, b)$ as neighborhood for each $b \in C$. By (a), we have $a \in R(a, b)$ for all a, b . Thus, the set of recombinants forms a neighborhood basis if and only if for each a, b, c , there is a d such that

$$R(a, d) \subseteq R(a, b) \cap R(a, c) \quad (2.1)$$

Generally, the above restriction is not always satisfied. However, if we take the set of recombinants as a sub-basis of the neighborhood filters, the coarsest pretopology is constructed in which the recombination sets are neighborhoods. In the case of genome set which is finite, there exists a smallest neighborhood $N(a)$, i.e., a minimal element of the neighborhood basis. This is generally true in Alexandroff spaces, the

spaces in which the neighborhood filters have a finite basis. If C is finite, then vicinities can be extracted directly from the *(sub)-basis* of recombination sets as

$$N(a) = \bigcap_{b \in C} R(a, b) \tag{2.2}$$

If C is infinite, then the vicinity $N(a)$ defined in the above result (2.2) should not necessarily be the neighborhood of a . Result (2.2) defines neighborhoods if the size of the recombination sets $R(a, b)$ is bounded.

A closure operator on the set of genotypes is persuaded by recombination set through the closure operator

$$cl(M) = \bigcup_{(x,y) \in M \times M} R(x, y). \tag{2.3}$$

With this closure [15], the recombination space becomes a crisp pretopological space.

2.5.2 UNRESTRICTED UNEQUAL CROSSOVER

In this model [16], an extreme form of unequal crossover, i.e., occurrence of crossover with equal possibility at all intergenic areas wherever possible along with the both sides of the gene cluster is assumed. Every occurrence of crossover incident yields a pair of recombinant chromosomes. Every trial of recombination results in chromosomes with distinct gene copies compared with the original one. Here, a represents a chromosome with certain number of gene copies as well as the number of gene copies on the chromosome. All the possible recombinants between chromosomes with a copies and b copies of genes form the recombination set $R(a, b)$, which is defined as

$$R(a, b) = \{0, 1, \dots, (a + b)\},$$

where the smallest neighborhood is represented by $N(a) = R(a, 0) = \{0, 1, \dots, a\}$.

It is also observed that $N(b) \subseteq N(a)$ if and only if $b \leq a$.

Hence in this form of unequal crossover, the neighborhood shares at least $\{0\}$ if not a much larger set. This may be the case when any two chromosomes have mismatched crossover of any number of gene positions and their recombinant is a chromosome with no gene copy, $a = 0$.

The recombination space in this model is a crisp topology. If we look at the separation axioms, it fails to be, T_1 or R_0 . Even it is not weakly metrizable [16]. With the closure defined in 2.3, it was shown that the recombination space in this model is connected; however, it fails to be strongly connected [17].

2.5.3 FUZZY PRETOPOLOGY IN A RECOMBINATION SPACE

The recombinants obtained from the recombination of chromosomes have different possible outcomes. Whenever recombinants are assigned arbitrary values, the newly proposed set can be viewed as a fuzzy set [12]. Consider the fuzzy set of recombinants μ_{ab} derived from a recombination of chromosome a with chromosome b . The set μ_{ab} is a collection of all possible recombinants obtained from chromosomes with

a and b numbers of gene copies but with variable values of membership. If C represents the set of chromosomes, then the recombinant set of the homologous pair (a, b) has the membership function $\mu_{ab}: C \rightarrow [0,1]$.

Here, the fuzzy subset μ_{ab} is considered as a fuzzy preneighborhood of a as well as of b for each $a, b \in C$, by considering, respectively, $\mu_{ab}(a) = 1$ and $\mu_{ab}(b) = 1$. The closure operator given in (2.4) defines the concept of pretopology on the set of chromosomes

$$cl(\mu)(a) = \inf_{V \in \mathcal{B}(a)} \varphi(V \cap \mu), \tag{2.4}$$

where μ denotes any fuzzy subset on C and $\mathcal{B}(a)$ denotes all preneighborhoods of a . The set of chromosomes C along with the fuzzy closure defined in (2.4) satisfies the basic axioms of the type I fuzzy pretopology, and so we have a fuzzy pretopology on the set of all chromosomes C [12]. In our text, we will refer this fuzzy pretopological space as fuzzy recombination space.

In the fuzzy pretopological model, it is considered that each element of crisp recombination set $R(a, b)$ has different possibilities of occurrence. In case of unrestricted unequal crossover model, if a is a chromosome, then the recombination set $R(a, 0)$ being the smallest neighborhood is contained in the support of all fuzzy recombination subsets of the form μ_{ab} on C .

2.5.4 SEPARATION PROPERTIES

In the unrestricted unequal crossover model [16], the set $R(a, b)$ comprises every single recombinant possible among chromosomes with a copies and b copies of gene, i.e.,

$$R(a, b) = \{0, 1, \dots, (a + b)\},$$

where the smallest neighborhood is represented by $N(a) = R(a, 0) = \{0, 1, \dots, a\}$.

In fuzzy pretopological model, each element has different possibilities of occurrences. For $a < b$, the support of all preneighborhoods of b contains the elements of

$$R(b, 0) = \{0, 1, \dots, a, a + 1, \dots, b\}.$$

This set also contains a . Thus, we can conclude that every preneighborhood of b contains a . So the space is not T_1 [12]. Therefore, the space is not T_2 . Since it is not R_0 , the recombination space is not fuzzy weakly metrizable.

2.5.5 LINDELOFNESS AND COMPACTNESS

Here, we are going to discuss about the properties of 1-Lindelofness and 1-compactness of the fuzzy recombination space in the case of unrestricted unequal crossover model [18].

Let $A_{j|j \in J}$ represent the fuzzy subsets on the set of chromosomes C , such that

$$\bigcap_{j \in J_0} A_j \neq 0_C$$

for a countable subset J_0 of J .

Now, $\bigcap_{j \in J_0} A_j \neq 0_C$ will imply $\inf_{j \in J_0} A_j(a_0) \neq 0$ for some $a_0 \in C$.
 For such a_0 ,

$$A_j(a_0) \neq 0 \text{ for every } j \in J_0.$$

This implies a_0 belongs to support of all A_j . Since the A_j 's are fuzzy recombination sets, their support is non-empty. This is because the support of any fuzzy recombination set μ_{ab} at least contains the elements of the smallest neighborhood of the corresponding crisp recombination set $R(a, b)$. As discussed in Section 2.5.2, the neighborhoods share at least $\{0\}$ if not a much larger set, we can assure that there exists at least one such a_0 .

If we choose $a_0 = 0$, then a_0 belongs to support of all A_j and

$$cl(A_j)(a_0) > A_j(a_0) > 0 \text{ for every } j \in J$$

This implies $cl(A_j)(a_0) \neq 0$ for every $j \in J$. This further gives $\inf_{j \in J} cl(A_j) \neq 0_C$, or $\bigcap_{j \in J} cl(A_j) \neq 0_C$.

This shows that the space is 1-Lindelof. The same is true if J_0 is the finite subset of J .

Hence, the space is also 1-compact. Consequently, it is almost 1-compact as well as nearly 1-compact.

2.5.6 CONNECTEDNESS

Here, we are going to discuss about the properties of apo fuzzy connectedness and fuzzy connectedness in the case of unrestricted unequal crossover model in fuzzy recombination space [14].

Let $A \in I^C$ be a fuzzy recombination set such that $A \neq 0_C$ and $cl(A) \neq 1_C$, and let $B \in I^C$ be a fuzzy recombination set such that $B \neq 0_C$ and $B \subset [cl(A)]^c$. Now, $B(a_0) > 0$ if a_0 belongs to the smallest neighborhood of the corresponding crisp recombination set of B . Then,

$$B(a_0) < 1 - \{cl(A)(a_0)\} \text{ will give } cl(A)(a_0) < 1.$$

Thus, there exists a a_0 such that whenever $B \subset [cl(A)]^c$, $cl(A) = 1_C$ is not true, and vice versa. Now, if $a_0 \in N(0) = \{0\}$, then $B(a_0) > 0$ and $A(a_0) > 0$. This is possible because in this form of unequal crossover, the neighborhoods share at least $\{0\}$ if not a much larger set. Since the fuzzy recombination space is of type I fuzzy pretopological space,

$$cl(B)(a_0) > B(a_0) > 0 \text{ and } cl(A)(a_0) > A(a_0) > 0.$$

This gives $cl(A) \cap cl(B) \neq 0_C$. Hence, the space is apo-fuzzy-connected and consequently fuzzy-connected. Since strongly fuzzy-connected implies connectedness, in any case the fuzzy recombination space is fuzzy-connected.

2.6 CONCLUSION

As we have seen, with the aid of pretopology, we can have the structural analysis of genes. Unequal crossover leads to a mutation in genes [19]. Mutations bring genetic variations as they have adverse effects such as altering the product of genes or preventing them from functioning partially or completely. There are various models in an unequal crossover. In this chapter, we have investigated the properties of compactness and connectedness of the fuzzy recombination space in unrestricted unequal crossover model. It is observed that space is 1- compact and connected in this model. It is also observed that there is a possibility that space could be strongly connected in this model. Further, separation properties are also examined. Among all properties, the property of connectedness plays a dynamic role. To extract the connectivity in genetic development, i.e., the nearness of one population to another, pretopological connectivity gives an appropriate structure. The outcomes revealed in this chapter of unequal crossover replicate the connectivity of the fuzzy recombination space in genetic epidemiology.

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CHAPTER 14

Advances in antibody-based biosensors in environmental monitoring

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1. Introduction

Environmental monitoring is a process of assessing the quality of atmosphere, which is crucial due to ubiquitous presence of harmful pollutants and pathogens as it affects animal's health, quality, and socioeconomic development [1]. While contamination of drinking water and food is a global concern, biological warfare is also a concern these days. Several environmental pathogens cause various diseases thus continuous monitoring of environment becomes essential. The Environmental Protection Agency uses environmental monitoring to set up policy that protects human health and the environment. Proper

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monitoring of environment needs the tools with high speed, sensitivity, and specificity. Particularly for environmental monitoring, we need tools that can detect a wide range of pollutants and pathogens because of their unknown nature. Also, we need methods which are easy to setup, relatively less expensive, very sensitive and specific as virulent pathogens are often present in a low count.

Traditionally, chromatographic and spectroscopic methods are used in the laboratory for detection of pollutants, which are collected from the contaminated sites. Polymerase chain reaction (PCR) based detection is usually used for identification of pathogens. These are laborious, costly, time-consuming process, requires expensive reagents, equipment, and experts for analysis. Moreover, these methods are unable to provide on-site data and not effective for in situ measurements such as acute poisoning and sudden release of pollutants, pesticides, and toxins. Therefore we need alternative approaches that can provide on-site real-time data in a speedy manner with more specificity, sensitivity, and precision. So that analysis results can be analyzed and applied in a timely manner by the authorities to make policy to avoid any health threat.

Biosensor is an analytical device that involves bio-recognition element and a signal transducer that converts biological interaction into readable results. Biosensors provide sensitive and rapid tools for detection of a wide range of pollutants, pathogens, and contaminants. The first biosensor was invented for the diagnosis of blood glucose levels in diabetic patients with electrochemical detection of oxygen or hydrogen peroxide by using enzyme as bio-recognition element [2]. Organelle, tissue slice, whole cell, DNA, receptor, lipid, enzyme, antigens, antibodies, and aptamers can be used as bio-recognition element [3]. Among bio-recognition elements, antibodies are considered as gold standard because of their affinity for their molecular targets, which range from molecules to intact cells. Over the years, tremendous progress has been made in biosensor technology and its applications. Current antibody-based biosensor developments mainly focused on the analytical performance of antibodies such as sensitivity, specificity, and limit of detection. In environmental monitoring, the sensor should provide the maximum response to the concentration of the analyte in environmental samples such as water, the surveillance of agriculture, air and volcano gas, thus achieving the lowest detection limits is necessary. The immunosensors should determine various antigens without cross-react with nonpathogenic microorganism in the environmental sample. Also, immunosensors can simplify through the development of a suitable antibody and, subsequently, an assay format. The following section addresses the limitation and recent advances that solved them during application of biosensors in environmental monitoring.

In addition, various types of antibodies used as a bio-recognition element and different immobilization methods are discussed [4]. This chapter will focus on the recent progress in antibody-based biosensors for environmental monitoring.

2. Antibody-based sensor technology in environmental monitoring of pathogens and emerging contaminants; economic feasibility, time, and reliability

Antigen and antibody-based biosensors use either antigens or antibodies as a bio-recognition element, also known as immunosensors. Antibodies are immune proteins which interact with a specific foreign antigen molecule. Each antibody has two antigen-binding sites that specifically bind to a unique epitope present on antigen or target molecule. Due to the highly specific interaction between antibody and antigen, immunosensors are considered as gold standard tools for environmental monitoring and diseases diagnosis. Immunosensor identifies the formation of an antigen-antibody complex and generates a read-out signal. The signal is detected by a transducer, which may be either optical or electronic or mechanical. The signal is then processed and displayed in a user-friendly manner. Antibody-based biosensors are classified as optical, mass based, electrochemical, or magnetic depending on the type of transducer associated with it. Electrochemical immunosensors measure an electrical signal that can be potentiometric, voltammetric, impedimetric, or conductometric. Surface plasmon resonance (SPR), total internal reflection fluorescence (TIRF), and photon correlation spectroscopy (PCS) methods use optical transducer while potentiometric and amperometric methods use electrochemical transducer [3].

Immunosensors provide an easy, rapid, and high-throughput way of on-site identification of contaminants in the environment with more accuracy, specificity, and sensitivity than traditional methods. It also allows quantification, label-free detection, and needs less hands-on time. Importantly, immunosensors provide real-time analysis/continuous monitoring that is highly useful for environmental monitoring, pharmaceutical, clinical diagnosis, and food industry. Donahue and Albitar used antibody-based biosensor for the first time for immuno-diagnosis [5]. Since then vigorous effort has been made to develop immunosensor as a tool for environmental monitoring and clinical diagnostics [6, 7].

Antibodies specific to the pathogen are generated by administering either whole pathogen or antigenic parts of it into a host animal. Polyclonal antibodies (pAbs) are isolated from serum of host animal. These antibodies recognize the several different epitopes present on the surface of pathogen hence less specific in nature while monoclonal antibodies (mAbs) which recognize only specific epitope are generated using hybridoma technology. Production procedure of these antibodies is time consuming, tedious, and costly [6]. Moreover, batch-to-batch quality variation also occurs, hence quality check and validation procedure take significant time to prepare suitable antibodies to be used as a bio-recognition element in biosensors. Alternatively, a smaller fragment of antibodies instead of full-length antibodies can be used. These include single chain variable fragment (scFv) or fragments of antigen-binding domain that are smaller in size and show more

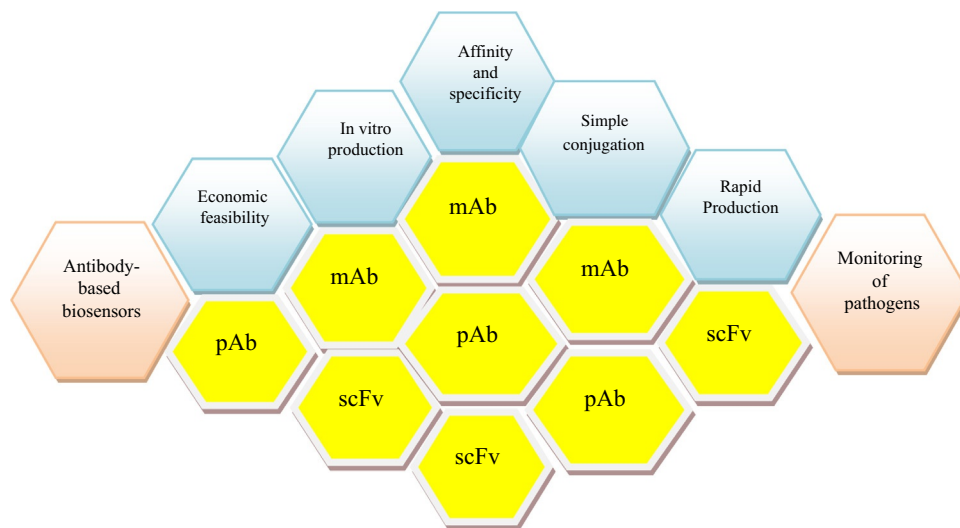


Fig. 14.1 Schematic comparison of monoclonal antibody (mAbs), polyclonal antibody (pAbs), and single chain variable fragment (scFv) for antibody-based biosensors in environmental monitoring of pathogens.

solubility and stability. These small fragments can be expressed using bacterial culture. Since bacterial culture is used for expression so genetic engineering becomes relatively easy. Tags are incorporated with these fragments for facilitating isolation procedure, immobilization, and easy detection (fluorescence). Further sensitivity can be increased by targeting antibody complementarity-determining regions (CDR) using site-directed mutagenesis or class switching [6]. Comparison of antibody types (monoclonal antibody, polyclonal antibody, and scFv) in economic feasibility, time, and reliability is shown in Fig. 14.1.

Estrogen, especially 17β -estradiol is an environmental estrogen pollution discharged from human urine. It disturbs the endocrine system in the ecosystem and regulates the female reproductive system. It is carcinogenic and has a tumor promotion effect relating to breast cancer, lung cancer, and others. By using an α -estrogen antibody, a cost-effective and portable antibody-based biosensor has been developed for detection of 17β -estradiol and testosterone, which has a similar structure and molecular weight as those of 17β -estradiol, was used to study the specificity of biosensor. 17β -estradiol biosensor showed excellent specificity without any interference by similar chemicals, hence this immunosensor can be used for assessment of 17β -estradiol in the environment as well as clinically. Thus immunosensors are of great use in detecting pathogens and emerging contaminants in the environment [8].

In addition, over the last years (2013–17), biosensors have been applied for the detection of pesticides. The pesticides are the most important environmental pollutants because of their extensive use in agriculture. They are a major environmental concern

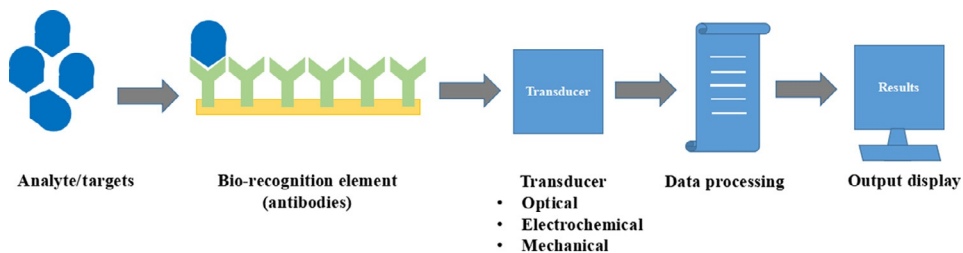


Fig. 14.2 Schematic representation of antibody-based biosensors consisting of antibodies as a bio-recognition element, different transducer (optical, electrochemical, and mechanical) that detect the signal. A further signal is processed and displayed in a readable format.

because of their high toxicity [9]. For instance, atrazine (2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine, ATZ) is one of the pesticides that is broadly used in the agricultural industry. Due to its effect on human's endocrine system, reproductive system, immune system, and central nervous system, the detection of atrazine in drinking water, soil, and crop becomes important. Therefore a simple and sensitive method such as antibody-based sensor (Fig. 14.2) can be useful for the detection and monitoring of pesticides [10].

3. Benefits of antibody-based sensor technology in environmental monitoring (pathogens and emerging contaminants) over other methods

Immunosensors offer several advantages over other methods. They provide an easy, rapid, and high-throughput way of on-site identification of pathogens and contaminants in the environment with more accuracy, specificity, and sensitivity than other methods. It also allows quantification, label-free detection, high-throughput screening and requires less hands-on time. In comparison to DNA-based methods, antibody-based assays require less time to perform as these methods target the molecules present on the surface of pathogens hence does not require sample extraction and cleanup procedures that are needed in DNA-based methods. Various techniques such as SPR, electrochemical (field effect transistors, FET), and so on, have been developed using antibody-based biosensors for environmental monitoring. These biosensors show less limit of detection than the traditional methods like enzyme-linked immunosorbent assay (ELISA). Also, antibody-based sensors can be used for the fast detection in remote environments, where performing conventional techniques such as ELISA is not possible [11]. Importantly, immunosensors provide continuous monitoring that is highly useful for environmental monitoring, pharmaceutical, clinical diagnosis, and food industry. Several environmental pathogens cause various diseases thus continuous monitoring of environment becomes essential. Immunosensors can be used for continuous monitoring of pathogens and toxins

in air and water by positioning immunosensors at desired locations such as an airport, traffic areas, water resources, and so on. Reports can be generated from continuous monitoring and these reports can be utilized by the Environmental Protection Agencies to set up policy in order to protect human health and the environment in a timely manner. Particularly for environmental monitoring, we need tools that can detect a wide range of pollutants and pathogens because of their unknown nature. Table 14.1 provides a summary of various studies carried out using antibody-based biosensors for environmental monitoring.

In comparison to other methods, antibody-based microarray and microbead assays provide an excellent platform for high-throughput screening. These assays can be used for detection and serotyping of bacteria. It is believed that microarray-based biosensors will provide rapid and cost-effective detection and serotyping of pathogens. Automated pathogen detection biosensors (APDS) and BioBriefcase have been developed at Lawrence Livermore National Laboratory (LLNL) using antibody-based assay and tested for continuous monitoring of environment for airborne biological threat. Antibody-based microbeads assays used for the detection of spores of *Bacillus* species and *Yersinia pestis*. For example, McBride et al. [28] developed APDS for continuously monitoring of *Bacillus anthracis* and *Y. pestis* in aerosol detection that can provide early alarms to civilian settings in the event of a terrorist attack.

Recently, Jia et al. [13] proposed using magnetic nanoparticles as an amplifying element for improvement of detection sensitivity in SPR biosensor system for determination of estradiol by a monoclonal antibody. This study demonstrated that use of magnetic nanoparticles can be a presumable general way to enhance sensors possessed for detection of various small molecules in SPR system.

While antibody-based biosensors provide several benefits, it is a big challenge to produce specific antibodies toward the diverse range of pollutants, toxins, and pathogens that may affect the environment [29]. There are several limitations to the use of antibody-based biosensors technology for environmental monitoring. For example, the complexity of each assay and specialized reagents such as antigens, tracers, antibodies, and so on, must be characterized and developed for each compound, while the number of determined compounds is limited as compared to the multiple compounds that contaminate environment [30]. Also, immobilization of antibodies is a challenging issue in immunosensors, because control over the position, number, and orientation of antibodies onto the sensor surface is very difficult. The inevitable loss of antibody activity can be resulted by inadvertent disruption of the binding site when the antibody conjugates with the active sensor surface [31].

Moreover, antibody-based sensors have a limited shelf life. Maintenance of sensitivity of antibodies over the period of time is another challenge that is affected by immobilization method, exposure to external factors, and so on. This suggests that quality of antibodies is crucial for the development of better detection system. The antibody-based

Table 14.1 List of various studies carried out using antibody-based biosensors

S. No.	Biosensor type	Category of the target molecule	Analyte/pollutant detected	Electrode/sensing material	Limit of detection	Improved area	References
1	Electrochemical (amperometric)	Pesticide	Atrazine	Magnetic beads functionalized with protein G	0.2 pg mL ⁻¹	Sensitivity	[10]
2	Electrochemical (FET)	Pesticide	Atrazine	SWCNT	0.01 ng mL ⁻¹	Sensitivity and label-free detection	[12]
3	Optical (SPR)	Endocrine-disrupting chemical	Estradiol	Magnetic nanoparticles with protein A	0.81 ng mL ⁻¹	The detection sensitivity of small molecules	[13]
	Optical (SPR)	Pathogen	<i>Legionella pneumophila</i>	Gold gratings substrate	10 CFU mL ⁻¹	Sensitivity	[14]
3	Optical (SPR)	Pathogen	<i>L. pneumophila</i>	Gold substrate with protein A	10 ³ CFU mL ⁻¹	Sensitivity and simplicity	[15]
4	Electrochemical (amperometric)	Pathogen	<i>Bacillus subtilis</i>	Gold electrode with SWCNT	10 ² CFU mL ⁻¹	Specificity, the detection range, and limit	[16]
5	Optical (electrochemiluminescence)	Pathogen	<i>Escherichia coli</i>	GCE with polydopamine imprinted polymer and nitrogen-doped QD	8 CFU mL ⁻¹	Selective recognition of <i>E. coli</i> O157: H7	[17]
6	Electrochemical (Ppy nanowires)	Viruses	T7 and MS2 phages	Ppy nanowires on the gold electrodes	10 ⁻³ PFU	Direct detection of viruses	[18]
7	Electrochemical	Pathogen	<i>Cryptosporidium parvum</i>	Gold nanoparticle with ITO electrode	3 oocysts mL ⁻¹	Sensitivity	[19]
8	Electrochemical (voltammetric)	Toxin	Microcystin	Gold electrodes with MoS ₂ and gold nanorods	5 pg mL ⁻¹	Immobilization of antibodies and sensitivity	[20]

Continued

Table 14.1 List of various studies carried out using antibody-based biosensors—cont'd

S. No.	Biosensor type	Category of the target molecule	Analyte/pollutant detected	Electrode/sensing material	Limit of detection	Improved area	References
9	Optical (SPR)	Toxin	Domoic acid	Glass side chip with gold surface	0.1 ng mL ⁻¹	Range of detection	[21]
10	Electrochemical (FET)	Toxin	Okadaic acid	Graphene	0.05 ng mL ⁻¹	Specificity	[22]
11	Electrochemical (FET)	Endocrine-disrupting chemical	Nonylphenol	SWCNT	5 ng mL ⁻¹	Disposability of analytical device	[12]
12	Electrochemical (capacitive)	Endocrine-disrupting chemical	17β-estradiol	Gold electrode with MUA SAM	1 pg mL ⁻¹	Sensitivity and label-free detection	[23]
13	Cantilever	Pathogen	<i>Aspergillus niger</i>	Silicon microfabricated cantilever	10 ³ CFU mL ⁻¹	Detection of vital fungal spores	[24]
14	Optical (SPR)	Pathogen	<i>Vibrio cholerae</i> O1	Glass plate with Au, chromium (Cr)	4 × 10 ⁵ CFU mL ⁻¹	Fabrication of immunosensor	[25]
15	Optical (SPR)	Pathogen	<i>Salmonella</i> cells	CM3/F1 surface of sensor chips	1.7 × 10 ³ CFU mL ⁻¹	Sensitivity specificity	[26]
16	A fluorescence-based fiber-optic	Environmental pollutant	Polycyclic aromatic hydrocarbons (PAHs)	Polymethylmethacrylate beads	0.2 μg/L	Sensitivity, time, and cost	[27]

FET, field effect transistor; GCE, glassy carbon electrode; ITO, indium tin oxide; MUA, 11-mercaptopundecanoic acid; SAM, self-assembled monolayer; SPCE, screen printed carbon electrode; SPE, screen printed electrode; SPR, surface plasmon resonance; SWCNT, single-walled carbon nanotubes.

assay could only target the known molecules or pathogens while environmental monitoring needs methods which are capable of detecting unexpected targets, toxins, and new strains of pathogens. We need to generate an antibody against contaminants/pollutants which we want to measure. For generating antibodies, pollutant must have a molecular weight greater than 10,000 Da but some of the pollutants such as pesticides, POPs, EDCs with low molecular weight are nonimmunogenic that are called haptens. These haptens are conjugated with carrier proteins and then used as an immunogen to generate specific antibodies. Moreover, antibodies cannot discriminate between viable and nonviable cells that are a point of concern [1].

4. Applications of antibody-based sensor technology (examples of recent development)

Recent advances in antibody-based biosensor technology for environmental applications have been focused on the mentioned limitations (Fig. 14.3). In this section, we discussed the issues that have been solved during the application of antibodies for biosensors (Fig. 14.4).

4.1 Limit of detection

Comparison of detection limits is crucial for selection of more effective sensor with higher performance and research studies have focused on this issue to develop the performance of sensor for better detection. For instance, atrazine biosensor (voltammetric

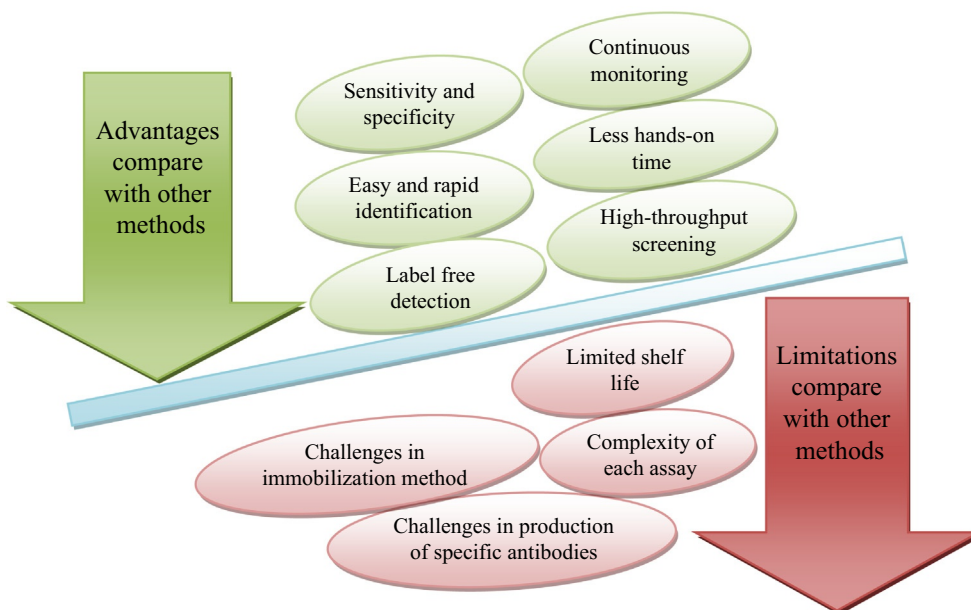


Fig. 14.3 Comparison of the advantages and disadvantages of antibody-based biosensors.

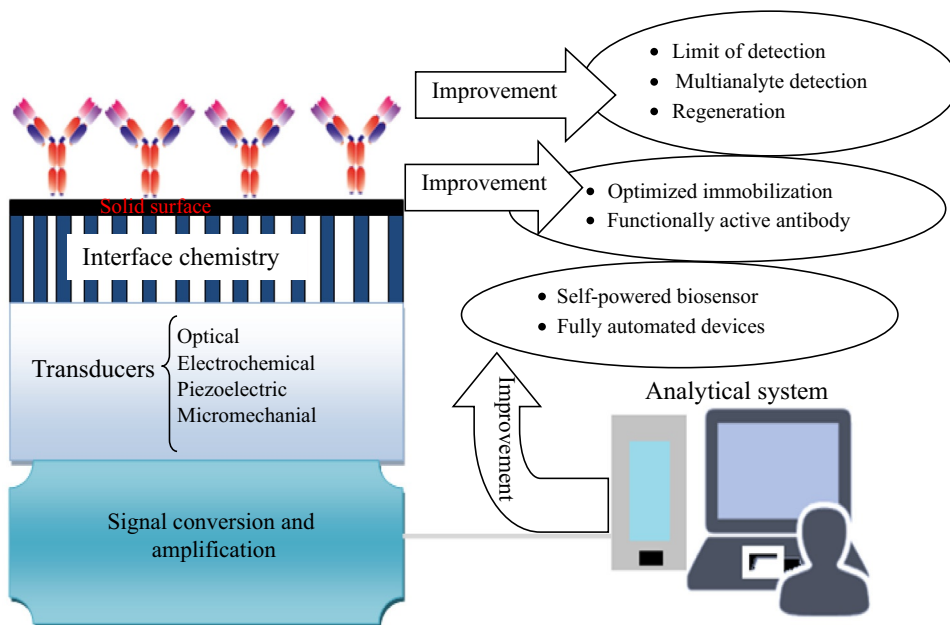


Fig. 14.4 Schematic of an advanced antibody-based biosensor and improvement area for a more effective sensor with higher performance.

immunosensor) displays a limit of detection of 0.016 ng mL^{-1} , while FET immunosensor has 0.001 ng mL^{-1} in detection limit, that both of them are lower to 0.1 ng mL^{-1} [legal limits; the maximum contaminant level of atrazine that is determined by United States Environmental Protection Agency (US, EPA)] [9]. Recently, a highly sensitive atrazine biosensor (electrochemical immunosensor) was suggested using a recombinant M13 phage/antibody complex as a new recognition element constituted and magnetic beads that functionalized with protein G. This biosensor improved the limit of detection approximately 0.2 pg mL^{-1} . The high sensitivity could be attributed to reaction kinetics of the covalent assembly of magnetic beads with protein G and high sensitivity of M13 phage/antibody complex [10].

Enrico et al. [15] proposed a highly sensitive and simple method for detecting *Legionella pneumophila* in aqueous samples. They functionalized the gold substrate with an antibody solution and monolayer of protein A with a limit of detection of 10^3 CFU/mL [15].

Recently, an improved limit of detection with a 1000-fold enhanced (10 CFU/mL) compared to fluorescence assays, good stability and selectivity were obtained for *L. pneumophila* detection. In that study, the electrochemical biosensor based on grating coupling screen plasmon resonance (GC-SPR) principle was used [14]. It is noticeable that limits of detection obtained for sensors should not directly compare unless the same antibody and immobilization chemistry is used.

4.2 Multianalyte detection

Complexity and multianalyte detection are critical issues for application of biosensor technology for environmental purposes. In environmental screening, thousands of contaminants should be analyzed per year. For this reason, the monitoring of pathogenic organisms and also their toxins in water, drinking water supplies, soil, and air is an extremely challenging task. Most antibodies for detection of environmental contaminants are traditional antibodies, including mAbs and pAbs. mAbs are produced by hybridoma cell lines, while pAbs are obtained from hyperimmunized animals. mAbs seem superior to pAbs for immunoassays since: (1) mAbs are cloned indefinitely while antisera of pAbs are limited; (2) mAbs are produced by a single cell offspring with the same specificity and affinity to antigens, while pAbs are secreted by different B cells with diverse affinities that might cause undesirable effects in immunoassay [32, 33].

In this regard, US EPA (United States Environmental Protection Agency) (method 1623, 2005) proposed the use of two separate mAbs steps. The first step involved purification and filtration of the *Giardia* cysts and *cryptosporidium* oocysts from nontargeted material by antibodies conjugated to magnetic beads in samples. The second step was immunofluorescent labeling cysts and oocysts that can be visualized by microscopy [34]. This strategy targets the most common protozoan pathogens (*Giardia* and *cryptosporidium*) but detection of potential emerging protozoan (such as *Microsporidium* and *cyclospora*), bacterial and viral contamination is lost [35]. For improvement of antibody-based sensors, multiplexing of antibodies can be used, but the specificity of these methods and assays may be questionable. For instance, the antibodies used for *C. parvum* can cross-react and detect nonpathogenic *cryptosporidium* species in samples [35].

In addition, mAbs are more expensive than pAbs and require larger scale screening strategies, and also, mAbs do not have better performance in all aspects compared to pAbs. Therefore the use of pAbs is preferred in bioanalytical assays for environmental applications [20]. Although all of the first researches and publications on immunosensors offer the use of pAbs, a number of researches have been done on preparations of mAbs [36–40]. Despite the disadvantages of mAbs, it does not force pAbs as bioanalytical reagents and only about a quarter of immunosensor-related bibliography publications describe the works done using pAbs in recent years [41].

Development of antibody-based multiplexed assays requires extensive validation of analytical performance and assay configuration to minimize assay inaccuracy and imprecision. Ellington et al. [42] discussed these challenges and potential solutions for multiplex immunoassay. They mentioned the challenges involved with multiplex configuration including interference between antibodies and proteins, selection and immobilization of capture ligands, assay diluents, calibration and compatibility of assay limits of quantification [42].

4.3 Immobilization approaches

In generating immunosensors, antibodies have to be immobilized in functionally active conformations onto the surface of the sensor. The direct immobilization of environmental pollutants is difficult onto the bio-recognition sensing surface due to small molecular weight substances in pollutant sample (molecular weight <1 kDa). Therefore the proper method for antibody immobilization should be determined based on the nature of the assay system and the characteristic of the solid substrate used for the system. Immobilization method has a significant effect on antibody-antigen interactions. Multiple studies have shown how the position of the antigen-binding sites affects antigen-binding capacities, so the oriented immobilization of antibodies is critical for the construction of immunosensors [43].

Mostly, direct conjugation of antibodies to the immunosensors surface can result in interfering of antigen detection by steric hindrances, due to the limited mobility of bound antibodies. Use of a flexible and long linker such as poly(ethylene glycol) (PEG) in antibody immobilization can be effective because these linkers can capture target antigens about two times more efficiently than directly conjugated antibodies [44].

Generally, the remaining nonspecific active sites of immobilized antibody must be blocked by proteins (e.g., bovine serum albumin) to minimize nonspecific interactions [43]. Antibody-binding layer such natural proteins as streptococcal protein G, staphylococcal protein A [45, 46], or (strept)avidin coupled to biotinylated antibodies [47] can be used for oriented immobilization of antibodies. For example, Enrico et al. [15] showed that immobilization of antibodies against *L. pneumophila* by protein A in a highly oriented manner was effective and stable in a water sample.

Developments and advances in antibody immobilization methods were reviewed by Jung et al. [43]. They remarked that optimization in antibody immobilization can greatly enhance antigen sensing in immunosensors. The uniform and proper orientation, soft incubation conditions, and minimum antibody modification are the requirements for ideal antibody immobilization. Proper design with antibody-binding proteins may solve some of the problems and limitations in immunosensors [43].

4.4 Transducers selection for antibody-based sensors

Electrochemical and optical immunosensors are the most popular in environmental monitoring [20], but piezoelectric and micromechanical immunosensors have been also used. Optical immunosensors used various optical properties such as light absorption, fluorescence, SPR, or chemiluminescence. In recent years, the development of fiber-optic technology has shown great advantages for applications of optical immunosensors in detecting pollutants because of the availability and broad range of optical transducers [48]. SPR as surface-sensitive optical technique is used to detect environmental contaminants, including dichloro-diphenyl-trichloroethane (DDT), atrazine, carbaryl, 2,4-D,

benzo[a]pyrene (BaP), 2,3,7,8-tetrachlorodibenzo-*p*-dioxin, biphenyl derivatives, and trinitrotoluene (TNT) [49, 50]. Optic fiber-based immunosensor has been developed for the detection of multiple environmental small analytes. Based on immobilization of two hapten conjugates for microcystin-LR (MC-LR-OVA) and TNT (NB-OVA) onto the same fiber optic probe, that could be detected by MC-LR and TNT simultaneously and specifically within nearly 10 min [51].

Electrochemical immunosensors exploit measurement of signal responses through the changes in electron density or ion concentration that is caused by antibody-antigen interaction and they can be measured. These kinds of sensors have a high tolerance against sample turbidity, quenching, and interferences in fluorescing and absorbing compounds that usually occur in biological samples [52]. Also, they have wide use for determination of pollutants and contaminants in environmental, food, and biomedical samples. For example, Sharma et al. [53] constructed a low-cost disposable electrochemical immunosensor for phenyl urea herbicide-diuron determination. This assay exhibited high sensitivity and specificity by diuron specific antibody with detection limit approximately 1 ppt. Also, Wang et al. [54] mentioned that electrochemical biosensors are typically prepared and developed by modifying the surface of carbon and metal electrodes that antibody conjugated to their surface. Biosensor's output signal is generated by catalytic reactions or specific binding of biomaterials on the surface of electrode [54]. The improvement and development of new and innovative types of electrochemical biosensors can be carried out by various types of biomolecules with different electrode stability and selectivity for a wide range of applications [55].

Piezoelectric detectors use the piezoelectric effect that occurs in crystals without a center of symmetry. Pan et al. [56] proposed a novel multiwall carbon nanotube/poly (amidoamine) dendrimer (MWCNT-PAMAM) based piezoelectric immunosensing platform for a carbamate pesticide-metolcarb detection. This platform had a good performance for metolcarb detection with a detection limit of 0.019 mg L^{-1} .

Piezoelectric immunosensors are mostly referred to as quartz crystal microbalance (QCM) immunosensors. The QCM is formed by a thin quartz plate with gold electrodes on the opposite sides and the immobilized antibodies on its surface make QCM highly sensitive device to detect the target antigen. The QCM is considered as a cheaper alternative to SPR and can be used for detection of airborne microorganisms and pesticides residues [57, 58]. Pohanka et al. [59] used the piezoelectric crystal surface to detect *E. coli* by using a polyclonal antibody. This assay provided analysis in 10 min that inclusive of a regeneration step for reanalysis with a limit of detection of $1 \times 10^6 \text{ CFU/mL}$.

Micromechanical transducers can convert a signal caused by the formation of antibody-antigen complex (onto the cantilever surface) into a mechanical motion with high sensitivity. Surface functionalization chemistry in silicon-microfabrication techniques offers an exciting new opportunity in developing and advancing of ultrasensitive microscopic immunosensors. The sensitivity of the molecular binding is dictated by the extent of

microcantilever deflection, while the selectivity is governed by molecular interactions on the microcantilever surface [60]. For monitoring of pesticide, a microcantilever-based immunosensor has been developed with a mAb on a thin gold layer (30 nm) deposited on a cantilever [61]. Recently, Dai et al. [62] reported a microcantilever-based immunosensor for the detection of carbofuran (insecticide) in vegetable and soil samples. In this study, the mAbs against carbofuran were immobilized on the gold-coated microcantilever side to fabricate the immunosensor (with a detection limit of 0.1 ng/mL), the mechanical bending induced by antigen-antibody specific binding [62].

4.5 Regeneration of antibody-based sensors

Successful regeneration has been demonstrated in a number of systems, through the reagents, techniques, and conditions. In this field, the forces between antibody and analyte, in terms of enthalpic (total energy of a thermodynamic system) and entropic (inherent disorder or chaos of a system) contributions should be considered. According to Gibbs' law, the Gibbs free energy (ΔG) is the change in enthalpy (ΔH) minus the change in entropy (ΔS) and a process will be spontaneous if ΔG is negative. For example, Sikarwar et al. [63] determined thermodynamic parameters for the interaction between rpGroEL antigen and immobilized anti-rpGroEL rabbit antibody, and these values revealed that the interaction is exothermic, spontaneous, and driven by entropy. This study proposed a method for modified gold SPR for the detection of *Burkholderia pseudomallei* [63].

Based on the second law of thermodynamics states, the entropy of a system will always increase and result in a more disordered system. Through analyte-receptor binding, it may seem to cause a decrease in the entropy of a system, processes such as solvent displacement are the ways for entropic compensation [64].

5. Pathogen detection methods for antibody-based biosensors

Biological warfare agents are microorganisms such as bacteria, protozoa, virus, or toxins generated by them, which cause illness in plants, animals, and human being when released or scattered accidentally in a region. A number of classical methods exist that identify pathogens may suffer from one or more disadvantages such as high price, assay complexity, low sensitivity, the requirement of a lab environment, and so on. Some methods were recently proposed for detection of pathogens in environmental matrices. In this section, we focused on the methods that involve in antibody-based biosensors for environmental monitoring.

Lateral flow immunoassay (LFA) is presently the gold standard low-cost rapid test that uses the same format of ELISA where immobilized antigen or antibody is bound onto a nitrocellulose membrane instead of plastic wells. Recently, Eltzov et al. [65] have developed a new system based on stacked membranes that each layer has a specific function and provides a one-step assay, miniaturized (5 mm diameter), rapid (5 min), and signal

generation (light production). In these stacked membranes, the sample added onto the sample pad and migrates through the membrane and analyte (case of this paper was *E. coli* bacteria) was captured by the antianalyte antibodies immobilized within the nitrocellulose membrane and analyte-antibody complex produced a visible and putatively measurable colorimetric signal. In this study, the sensitivity and specificity of proposed stacked bioassay were also tested in different environmental water sources in order to make this idea promising for pathogen detection in environmental monitoring [65].

B. anthracis spores and their vegetative cells have gained significant interest and concern because of its potential use as a bioterrorism weapon. Hao et al. [66] developed monoclonal antibody functionalized QCM sensor for detection of *B. anthracis* spores or vegetative cells with a limit of detection 10^3 CFU or spores/ml. As *Y. pestis* is considered as group A bioterrorism bacterium, Huynh et al. [67] used SPR-based immunosensor for the rapid detection of *Y. pestis* in environmental using a monoclonal antibody against an F1 antigen of *Y. pestis*.

Recently, the use of magnetic beads suggested for monitoring the presence of poliovirus in environmental samples. This method can reduce the limitations of environmental surveillance which requires laboratories with equipment for poliovirus concentration. Also, this method requires only inexpensive, simple, and portable equipment that facilitate environmental surveillance for poliovirus in inaccessible remote regions [68]. Furthermore, because of magnetic beads' excellent properties, they become powerful tools for monitoring several different pathogenic species under both biological and environmental matrices. For instance, antibody- and DNA aptamer-based assays with the use of magnetic beads-mediated filtration and capture can detect bacteria as low as 10 cells per mL and several thousands of *C. parvum* oocysts (waterborne pathogens) [69].

Hindson et al. [70] developed a fully autonomous pathogen detection system (APDS) for continuously monitoring the environment for airborne biological threat agents. They combined multiplexed antibody-based and duplex nucleic acid-based assays to reduce false positives. This biosensor provides advantages such as lower reagent costs, automated sample preparation, and significantly expand the detection capabilities. The APDS was tested against *Bacillus globigii*, *B. anthracis*, *Y. pestis*, and *botulinum* toxoid and shown to be effective for identifying them. In this study, the limitations associated with maintenance of active antibody for a period of time and their sensitivity for biological assays in the presence of environmental interfering had to be solved.

Nanotechnology enables researchers in developing a new generation of biosensors for pathogen diagnostics as well as imaging techniques with higher reliability and sensitivity. Mostly, high sensitivity fluorescent dye-doped nanoparticles enable the instrument to detect specimens at very low levels because of increasing the signals by the magnitude of 10^5 – 10^6 times as well as tagging pathogens. Moreover, nanobiotechnology improves the performance of instrument for wider commercial use at the environmental site.

6. Discussions of the trends

Integrated approaches provided tools to develop a better perspective for sensitive and specific biosensors with high regenerative potentials. Biotechnology, bioengineering, electronics, and electrical engineering paved way for developing innovative biosensors with a wide range of detection and applications in the fields of environmental science [55]. For example, genetic engineering antibody provided the advantages such as simple operation, low production cost, and also expanded the range of applications [71]. Due to the large size of antibody genes, it is most difficult to manipulate and express them. Therefore recombinant approaches are used to overcome this limitation and various recombinant antibody-like forms and peptides have been produced. The CDR peptides as the smallest functional unit of an antibody can be produced and also depending on which CDR is produced, their length can vary from 8 to 20 amino acids [72].

Besides that, improving the signal-detecting system and combining multiple techniques gained much attention. Just like a quantum dot or magnetic nanoparticles and colloidal gold can be utilized to improve the sensitivity of biosensors by combining with ELISA, chemiluminescence immunoassay (CLEIA), LFA, and so on [71]. CLEIA is based upon secondary antibodies format which provides higher selectivity, reproducibility, and sensitivity than ELISA. Xin et al. [73] used magnetic particles as the separation tools and the immobilization matrix for a fast, simple, and highly sensitive immunoassay for 17 β -estradiol in environmental water samples. They provided a new CLEIA with a detection limit of 2.0 pg/mL, total assay time of 45 min, and linear range of 20–1200 pg/mL. Therefore the research on combining multiple techniques technology can be a hot topic in the future, since this kind of study is still rare in the field of environmental monitoring.

In addition, the integrated device in immunosensors can omit some complex steps such as reagent addition steps, washing, and also they could be automated to perform analysis without sample preparation and in a miniaturized portable device without the use of lab instruments [74].

Bahadır and Sezgintürk [75] mentioned that despite many biosensors for clinical, food, and biowarfare analysis, only a small part of biosensors are commercially available in environmental analysis. Many biosensors are under development and there is also an extensive literature in this area [75]. It may due to the limitations for in situ operation and the analytical performance, especially in reproducibility as well as the interdisciplinary context of fabrication [9].

Commercial immunosensors should be suitable and robust for use by unskilled operators, so because of such requirements, they may pose a challenge in fabrication and design. The rate of development in commercial sensors being lower than those made for research purposes, mainly due to additional requirements such as lower cost, stability for long term, and is noninvasive. For environmental applications, sampling large areas is a critical issue to cover the entire sample area in such environments as rivers or lakes and fields.

Recently, research efforts related to self-powered immunosensors have been increased as a promising energy-saving technology. In these devices, integrating a biosensing and a biofuel cell power unit offer a self-power sensing opportunity based on enzymes and microbes. This self-powered biofuel cells (BFCs) exploit chemical to electrochemical energy transformations as external power sources. A comprehensive description of the recent advances, new trends, and progress in this field was reviewed by Prodromidis and Economou [76] and Zhou and Wang [77]. LABONFOIL (SmartBioPhone) is a fully automated optical fluorescence device that can be used for the whole process from sample preparation at a low price to interpretation of the results. This platform can be used in different point-of-care applications such as food, environment, drug monitoring, and cancer.

7. Conclusions

Although antibodies provided a high sensitivity and specificity with the target antigen such as pathogens, pesticides, toxins, and endocrine chemicals, some limitations (limit of detection, multianalyte detection, regeneration, and immobilization) lead to the studies for improving the immunosensors which could be costly and time consuming. Research in advanced technologies including improved transducers, immobilization, genetic engineering technologies, and nanomaterials provides more rapid, reliable, and accurate detection of the pathogen in environmental samples.

At present, despite the great number of research in the field of immunosensors, commercially available products are limited. Particularly in environmental assays, only a small part of available biosensors developed are commercial. The advances observed in biotechnology, chemistry, bioelectronics, and nanotechnology will affect future commercial biosensor production. The focus of future research work in this area will be on interdisciplinary contexts of improving general methods for antibody production as well as searching for specialized strategies for assay system.

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Chapter 8

Nanopesticides and Nanosensors in Agriculture



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8.1 Introduction

As per report, pest causes a damage of 5–10% in wheat, 25% loss in rice, 35% loss in oilseeds, 30% loss in pulses, 20% loss in sugar cane and 50% loss in cotton (Dhaliwal et al. 2010). Any substance or mixtures of substance which can be used to prevent, control or destroy any pest are known as pesticide. Pesticides can be used against vectors of disease, undesired species which causes harmful effects or otherwise interfering with the production, processing, storage or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs (Gheorghe et al. 2017). Pesticides are used against insects, rodents, nematodes, fungus, weeds and many more species in order to protect the agricultural crops. It has been found

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that many pesticides are toxic to the environment. In case of some pesticides, the toxicity is so high that their use was restricted by state and international authorities (Jampílek and Kráľová 2017).

Pesticides can be classified on the basis of origin and chemical structures, modes of action, spectrum of activity, target pests, formulations, route of entrance in the target pest and many other characteristic features (Gheorghe et al. 2017). World Health Organization and by International Agency for Research on Cancer has classified pesticides in four classes on their potential toxicity and carcinogenicity risks to human health caused by accidental contact. These are class Ia (extremely hazardous), class Ib (highly hazardous), class II (moderately hazardous), class III (slightly hazardous) and class IV (products unlikely to present acute hazard in normal use) (Tano 2011).

Those pesticides which are of non-biological origin and synthesized artificially are called chemical/synthetic pesticides. These pesticides were first used in 1940 (Laborde 2008). Some common examples of chemical pesticides are glyphosate, acephate, Deet, propoxur, metaldehyde, boric acid, diazinon, Dursban, DDT, malathion, etc. Generally, pesticides act on a broad range of species and thus cause harmful effects on nontarget species too. Nontarget species are also essential part of ecology, and thus pesticides indirectly cause harmful effects on ecology by damaging nontarget species. Many times nontarget organisms are beneficial to agricultural crops. On the basis of application and chemical structure, pesticides are classified as follows:

- Insecticides: pyrethroids, organophosphorus, carbamates, organochlorine, manganese compounds
- Fungicides: thiocarbamates, dithiocarbamates, cupric salts, thiabendazoles, triazoles, dicarboximides, dinitrophenols, organotin compounds
- Herbicides: bipyridyls, chlorophenoxy, glyphosate, acetanilides, triazines
- Rodenticides: warfarins, indandiones
- Fumigants: aluminium and zinc phosphide, methyl bromide, ethylene dibromide
- Insect repellents: diethyltoluamide

Pesticides which are naturally present or are derived from living organism or their metabolites are known as biopesticides. Till April 2016, there were 299 registered biopesticide active ingredient and 1401 active biopesticide products registered. There are three categories of biopesticides – biochemical, microbial and botanical. Usually biochemical pesticides interfere with mating, for example, sex hormones or aroma to attract insects in trap. As it is difficult to determine that a substance meets the criteria to be classified as biochemical pesticide, a special committee of Environmental Protection Agency (EPA) of USA used to make such decisions (United States Environmental Protection Agency 2016). Some microbes colonize with the plant root or live in rhizosphere and protect the host plant from pathogens. These microbes are called microbial pesticides (Gheorghe et al. 2017). Foliar spray of *Pseudomonas fluorescens* and *P. aeruginosa* on chickpea infected with *S. sclerotiorum* induced synthesis of phenylalanine ammonia-lyase (PAL). This increases synthesis of phenolic compounds, such as tannic, gallic, caffeic,

chlorogenic and cinnamic acids. This is found to be effective treatment of microbial pesticide (Basha et al. 2006). Essential oils (EOs) derived from plants are widely used as biopesticides and to control bacterial infections (Gheorghe et al. 2017). Plant-incorporated protectants (PIPs) are pesticidal substances that are produced from those plant genetic materials which were actually incorporated to the plant from other sources. Biopesticides are less toxic than chemical pesticides, and it affects to its target and closely related species (United States Environmental Protection Agency 2016). Moreover they are easily degradable and safer to handle in comparison to synthetic pesticides.

Pesticides are used for different purpose and in different places like agricultural field, veterinary, domestic, etc. They are available in different formulations such as gel, paste, chalk, powder, granules, pellets and many other from concentration 2% to 80% of active ingredient (Laborde 2008).

8.2 Pesticide Toxicity

Pesticides are beneficial in terms of crop protection, disease control, food and material protection. But at the same time, it is toxic to human, animals and nontarget species. Additionally they negatively impact on environment and ecosystem (Laborde 2008). Pesticides are widely used in the prevention of malaria, dengue and other vector-borne diseases, but the same cause negative effect by killing up to one million children per year as per the data of National Research Council of 1993 (Council 1993). One can imagine the situation of current scenario. In agricultural fields pesticides are applied via spray, seed treatment and other required roots which ultimately pollute air, soil and groundwater. Pesticide in surface water may go to aquatic organism or to other organism which remains in sediments. The persistence of pesticides depends upon its stability. Persistent organic pollutants (POPs) are lipophilic and have low water solubility. They can accumulate in the food chain, concentrate there and cause toxic effects. Many persistent pesticides are banned in developed and in some developing countries, for example, DDT. There is concern about potential endocrine and development effects of persistence chemicals in children. Highest concentration of persistence chemicals is found in marine animals. Persistent chemicals are controlled under the Stockholm Convention (Laborde 2008). Dermal, ocular and inhalation are the most common routes of absorption of pesticides. They can easily cross the epithelium and mucous membrane. Children have high surface area in terms of the skin and also their metabolic rate is high. So children are more prone to pesticides. Fat-soluble pesticides get stored at adipose tissue. Biotransformation of pesticides inside an organism involves many chemical reactions such as oxidoreduction, hydrolysis, etc. These biotransformed products may be more or less toxic than its precursor. The excretory routes are urinary, faecal and milk excretion. Here the milk containing pesticide can cause severe damage to new born baby and children. Residues of pesticides have been detected in breast milk which includes DDT, HCB and HCH isomers. Pesticide can also cross the placenta. (Krieger 2010; Pronczuk et al. 2002) The pesticide toxicity can give rise to

irritation, allergic sensitization (e.g. fungicides), enzyme inhibition (e.g. cholinesterases and OPs and carbamates), oxidative damage (e.g. paraquat), inhibition of neurotransmission (e.g. organochlorines), uncoupling of oxidative phosphorylation (e.g. glyphosate) and many other effects (Laborde 2008).

An organochloride is an insecticide containing a minimum of one covalently bonded chlorine atom. Their utilization isn't prescribed in food animals inasmuch as their persistence in animal tissues conducts to their contribution to the human food chain. Such pesticides are still commercially applied, and in spite of the fact that they have a nonanimal use, the intoxication of animals can be exhibited. Amongst the effects delivered by their inebriation are nervous excitement, tremor, convulsions and death. They can restrain diverse enzymes being acetylcholinesterase one of them. An organophosphate is a natural ester of phosphoric acid, which is the premise of numerous insecticides, herbicides and nerve gases. As per the U.S. Ecological Protection Agency (EPA), these pesticides are exceptionally lethal to honey bees, untamed life, and humans due that they are organophosphorus mixes extremely pervasive. A carbamate is any organic ester derived of carbamic acid, which is used as insecticide to kill insects. These have been used in specific medications and insecticides. They are poisonous and may cause convulsions and death through ingestion or skin contact. Such pesticides can cause reversible hindrance of acetylcholinesterase and cholinesterase. A pyrethroid is a manufactured substance utilized as commercial household bug spray. They are generally harmless to human beings in low doses but can harm sensitive individuals. Be that as it may, such pesticides are lethal to oceanic life forms. Albeit few investigations have been acknowledged, enzymes, for example, acetylcholinesterase (AChE) are repressed by these pesticides (Vargas-Bernal et al. 2012).

8.3 Nanopesticides

Around 50–70% of the chemicals used in agricultural fields in forms of fertilizer or pesticides remain unused by leaching, mineralization and bioconversion (Bollag et al. 1992). Chemical pesticides not only do harmful effects on humans, but it also destabilizes the ecosystem. Hence for the sustainable agriculture use of nanopesticides is required.

Nanoparticles have high surface to volume ratio, and they are able to linked with other compounds and be used as carrier. Hence, they can be used as nanocarriers or as an active ingredient or as both. Nanoformulations usually consist of several surfactants, polymers or inorganic (e.g. metal) NPs in the nanometre size range and therefore cannot be considered as a single entity (Perlatti et al. 2013). Nanoparticles can be inorganic, organic or a combination of both. As per the need such as biodegradability, long-term stability, water solubility, etc., the nanocarriers are selected. Nanoparticle-derived or nanoparticle-associated pesticides show higher performance in terms of effectiveness, targeted delivery and action with reduced management costs. This brings acceptability towards nanopesticides (Anwunobi and Emeje 2011; Bhattacharyya et al. 2016).

A nanocarrier enables the controlled release of an active compound stored at the core, so that the adequate concentration of this active compound could be preserved during the whole period of insect growth (Jampílek and Kráľová 2017). Bang et al. (2011) prepared a sustainable nanocarrier through coating of liposomes of etofenprox or alpha-cypermethrin by multiple layers of chitosan. Because of this thick multiple layers of coating and intrinsic the release time of the stored active compound increased (Bang et al. 2011).

Insect pests not only destroy crops, it also infests stored food and food products. The deterioration of food quality and transmission of plant disease due to pests are also considered as loss (Neethirajan and Jayas 2011; Ragaei and Sabry 2014). Chemical insecticides are broad range and also cause harm to nontarget species and increase soil toxicity. Nano-insecticides can be delivered specifically to target, for example an encapsulated pesticide can act as a gut buster if it gets breaks up only when it comes in contact with alkaline environment like the gut of the insect. Hence this type of target-specific delivery system will cause minimum damage to the ecosystem and nontarget species (Prasad et al. 2014, 2017). Some effects of nanonematocides are shown in Tables 8.1, 8.2, 8.3, and 8.4.

A target-specific herbicide molecule, which can inhibit glycolysis, can be encapsulated in NP for targeted delivery and translocation to the site of action specifically. This will ultimately make the specific weed to starve for food and get killed (Ali

Table 8.1 Effect of nanonematocides

S. no.	Nanonematocides	Target species	Effect	References
1.	Uniform spherical nanocapsules of lansiumamide B with the mean particle size of 38.5 nm	<i>Bursaphelenchus xylophilus</i> and second-stage juveniles (J2) of <i>Meloidogyne incognita</i> with the LC50 values of 2.14 and 19.36 mg/L, respectively, at 24 h after treatment	Moreover, treatment with lansiumamide B nanocapsules, lansiumamide B and ethoprophos led to a decrease in the disease progression by 68.42%, 36.84% and 26.32%, respectively, and a decline in the average number of root knots of <i>Ipomoea Aquatica</i> by 83.94%, 78.03% and 63.66%, respectively, indicating that the nematocide nanoformulation performed more efficient and longer effective maintenance against plant parasitic nematodes	Yin et al. (2012)
2.	AgNPs stabilized by a starch	<i>M. incognita</i>	AgNPs inactivated the root-knot nematode <i>M. incognita</i> in 6 h by >99% in vitro	Cromwell et al. (2014)

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Global implications of bio-aerosol in pandemic

[Sneha Gautam](#)  & [Ujwalkumar Trivedi](#)[Environment, Development and Sustainability](#) **22**, 3861–3865 (2020)**3270** Accesses | **39** Citations | **1** Altmetric | [Metrics](#)

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The recent outbreak of COVID-19 coronavirus which is suspected to be initiated from Wuhan city of China has been an immediate and urgent concern globally due to its rapid transmission rate. Coronavirus pandemic has spread over 126 countries and has taken the lives of thousands of people across the globe. Although the accurate pathogenesis of this virus is not yet decoded, it is established that this virus causes systemic failure of the respiratory system. It is also a well-established fact that this virus can spread through the dispersal of bio-aerosols by an infected individual. Bio-aerosols are now identified as major issue posing a threat to the environment and global health standards. Along with the presence of life-threatening respiratory viruses like COVID-19, bio-aerosols are also reported to contain toxic

substances (i.e., volatile organic compounds (VoCs), heavy metals and harmful gases). Pathogenic microbes are also known to be transmitted through expulsion and settling of bio-aerosols (Kim et al. [2017](#)). Ailments caused due to the propagation of such pathogens and their toxic constituents in the environment results in several diseases ranging from allergic asthma, cancer, localized and systemic organ failures (Humbal et al. [2018](#)). It is well-established fact that the respiratory bio-aerosol expulsions of an infected person cause an exponential increase in the spread of respiratory tract viruses like COVID-19, SARS, MERS and HINI Influenza and are a major cause of the global pandemic. (Núñez et al. [2016](#)). These viruses have shown the resilience over a wide range of physio-chemical conditions such as temperature and humidity which makes them a potential threat to mankind. Some of the well-reported bacterial pathogens such as *Bordetella pertussis*, *Bacillus anthracis*, *Corynebacterium diphtheriae* and *Neisseria meningitidis* are known to be transmitted via bio-aerosols causing collapse of the respiratory system and neurological abnormalities (GBD [2013](#)). Certain species of pathogenic fungi such as *Aspergillus fumigatus*, *Fusarium moniliforme*, *Scedosporium apiospermum*, and *Mucorales* spp. are commonly transmitted through bio-aerosols and are also known to cause localized and systemic organ infections, acute toxicity, hypersensitivity, and other respiratory abnormalities in immunocompromised patients (Jung et al. [2009](#)).

Many pathogens release toxic and immunogenic by-products endotoxins and β -glucans which may be transmitted through bio-aerosols and cause hyperactivity or repression of an individual's immune response leading to autoimmune diseases and several types of cancers (Kim et al. [2017](#)). Both the short-term and long-term studies confirm that the exposure of an individual to bio-aerosols associated with daily variations of air pollutants impeaches a significant effect on the individual's health standards (Wu et al. [2015](#)). Even low-level or short-term exposure to bio-aerosol has shown a significant pathophysiological effect on humans (Johnson and Choi [2012](#)).

Bio-aerosol is reported as one of the largest emerging pollutant in modern age (Humbal et al. [2020](#)). All the episodes related to air quality are regional polluted phenomenon in the ambient atmosphere with microbes beings its main constituents (Burger [1990](#); Ghosh et al. [2015](#)). The frequency of severe air pollution due to bio-aerosols has reported higher in last few years. Bio-aerosols contain fungi and virus kinds of toxic substances that could affect the respiratory and circulatory system, with possible detrimental impacts on the cardiovascular, immune and nervous systems, increasing morbidity and mortality in the population (Johnson and Choi [2012](#)).

Effective legislation has been already introduced to minimize air pollution-related issues in few

developed countries. Yet many events still keep allowing air pollution specialist and scientist, who are working on air pollution due to bio-aerosols. In the case of bio-aerosols, the main question that remains same to understand the level of exposure affects life expectancy. Doremalen et al. (2020) highlighted the progress in monitoring, impacts and effects of microbes to understand the exposure to microbes on living organisms. Similarly, Mclean et al. (2004) reported the higher mortality rate in past few years due to effects of higher concentration of microbes. On other hand, Humbal et al. (2019) observed the one of the main critical factor on association of primary/secondary particles with microbes. One-third of the total populations of the world are using organic material (i.e., cow dung, wood, biomass, crop residues, charcoal) for cooking and heating (Pearson et al. 2015). The use of solid fuel for cooking and heating is a traditional pattern, long recognized as being liable to a different type of respirable diseases (Balakrishnan et al. 2015). In 2010, the Global burden of disease study report 3.5 million death attributed because of household air pollution (HAP) and 16% of 3.1 million deaths from Ambient air pollution are credited from HAP (Lim et al. 2012). HAP from the low and middle-income population of developing countries, contributes to occupational health and environmental risk (Balakrishnan et al. 2015). HAP is a result of incomplete combustion of solid fuel during cooking and heating in the rural area (Lim et al. 2012).

Several studies indicated that HAP is the leading

risk factor due to the reported number of deaths in poor countries (Balakrishnan et al. [2015](#); Lim et al. [2012](#)). This problem is very well recognized in developing countries; however, the epidemiological and occupational exposure studies have suffered from simplistic approaches (i.e., binary classification of exposure) to estimate the exposure to particles in rural areas. However, the nature of household air pollution is now going to change. Since 1990, the intervention techniques declining the HAP worldwide as a renewable source of energy (i.e., wind, solar, etc.) and liquid petroleum gas come to replace solid fuel (i.e., forest wood, cow dung, etc.) for cooking and heating. However, due to the rapid expansion of urban area or globalization of industrial production, uncountable production of toxic chemicals and increasing the use of vehicles. Deaths related to air pollution have been cumulating all over the world since 1990, growing are significantly in many industrial countries (Wu et al. [2015](#)).

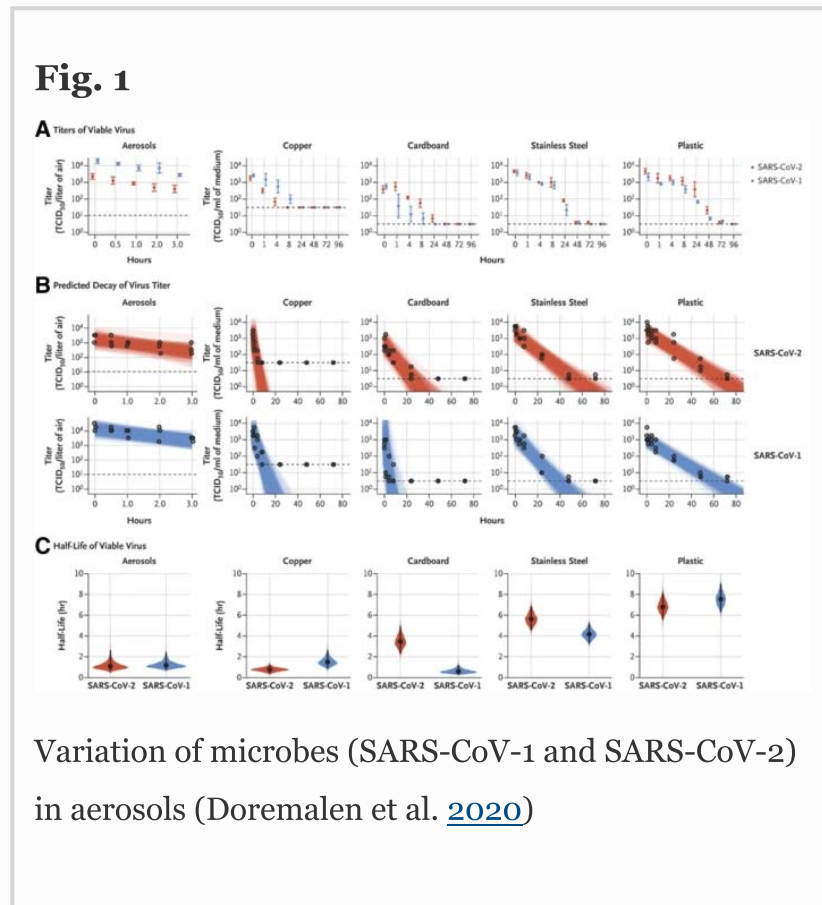
Bio-aerosols is also responsible for economic losses including medical expenditures (i.e., approximately US\$21 billion globally), economic productivity losses (i.e., premature deaths, respiratory diseases, etc.), and environmental degradation and material losses (OECD [2016](#)). This cost seems very large but quite invisible, because it has been spread across the large population in the past two decades. However, the results can create an impact on the

health system and simultaneously the growth prospects of the whole countries.

The positive information is that bio-aerosols can be controlled and the diseases related to the incremental concentration of bio-aerosols can be prevented. Modern economic growth is not responsible for ambient air pollution (Arrow et al. [1995](#)). Ambient air pollution can be controlled and minimized by the wise leadership and taking steps towards the development to help emerging economies to cover the loss done in past. The successes of pollution control in terms of technical, political feasibility and economics, of a particular country, are publicized around the world in shortening air pollution. Recognized strategies include: (1) developing and implementing new environmental standards; (2) minimizing incremental concentration by using intervention techniques; (3) banning the use of polluting materials/fuels in all possible urban and rural area; (4) regulating private vehicles and increasing the number of public transportation; (5) commanding different types of fuel using in vehicles; and (6) formulating effective policies that ensuring the implementation of standard operating protocols at hospitals, industries and crowded workplaces to control and minimize the dispersal of pathogenic microbes.

A novel human coronavirus is now declared a pandemic by the World Health Organization. The

coronavirus emerged in Wuhan—an urban city of China in late 2019 (WHO [2020](#)). Figure 1 shows the relationship between aerosol and surface variability, which indicated the vital information related to human coronavirus.



Doremalen et al. ([2020](#)) observed that the reduction similarity in the air of human coronavirus is same as other microbes. They also highlighted the strong stability, decay and half-lives of human coronavirus especially on plastic and steel-based product (Fig. 1).

IT can be seen that the stability of all microbes is similar in the laboratory workplace or experimental circumstances. Other factors (i.e., high viral loads in the upper respiratory tract, the potential for

persons infected with microbes to shed and transmit the virus while asymptomatic) play important role in the variation in the epidemiologic characteristics of microbes (Bai et al. [2020](#); Zou et al. [2020](#)). The critical analysis of the note is indicated that transmission of bio-aerosol is plausible, as the microbes can remain viable in aerosol and surface for hours and few days, respectively. The outcomes echo those with microbes, in which the possible way of movement or transfer was directly or indirectly associated with super spreading events. Moreover, the findings mention the massive evidence for pandemic extenuation efforts.

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Bioactive Natural products in Drug Discovery pp 335–353

Bioactive Peptides and Carbohydrates from Natural Products: A Source of Functional Foods and Nutraceuticals

[Gurseen Rakhra](#), [Sumit Kumar Jaiswal](#) & [Gurmeen Rakhra](#)



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Abstract

Nature is the quintessential source of secondary metabolites with most of the natural products originating from diversified flora and fauna found on earth. The natural products are an important source of drugs, and there has been a growing scientific interest in drug discovery from the natural resources owing to their non-toxicity and enhanced health benefits. The concept of healthy diet for the prevention of diseases is very well known, and several natural products are being exploited as functional foods, food supplements and nutraceuticals in providing better health. The bioactive substances present in the food help to modulate metabolic processes providing health

benefits leading to an overall positive impact on the body functions. There is an increased awareness of the health-promoting effects of functional foods and nutraceuticals which has provided an impetus for the growth of the nutraceutical market.

Carbohydrates, one of the most important biomolecules, have an essential role to play in the human biological system, but their use as a source of bioactive compounds for functional foods and pharmaceuticals is very limited. In contrast, several bioactive peptides have been obtained over the years from a variety of food proteins like plant seeds (zein peptides LPP) and dairy products (casokinins and lactokinins). However, several roadblocks such as establishment of optimal conditions for mass production and non-availability of suitable and reliable clinical trials hinder their beneficial use. The current chapter discusses the health effects and bioactivities of peptides and carbohydrates of natural origin, the challenges associated with processing methods and also the novel mechanism of production of bioactive peptides and carbohydrates.

Keywords

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Zein peptides

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Conflict of Interest

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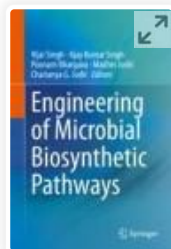
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Engineering of Microbial Biosynthetic Pathways pp 11–32

Microbial Strain Engineering

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Abstract

The utilization of microorganisms for the production of chemicals at industrial scale requires improvements/changes at physiological, metabolic, and genetic levels. Natural or wild-type isolates produce minimal quantity of metabolites/compounds required as a matter of survival. Hence, to use these microorganisms at industrial level, different tools are required for strain improvement. These tools will improve the metabolite production of industrial importance. The strain improvement program traditionally employs classical mutagenesis approach followed by screening and selection of mutant strain. Today, in-depth understanding of genetics and recombinant DNA technology helps in strain improvement via metabolic and genetic engineering. These strain

improvement approaches has increased the product yield with subsequent cost reduction. These approaches have also served other goals like reduction of undesirable products and elucidating the complex biosynthetic pathways. Further combination of different omics approaches like transcriptomics and proteomics with recombinant DNA technology has increased the prediction of accurate genes responsible for overproduction of metabolites/compounds.

Keywords

Mutagenesis **Physiology**

Metabolic engineering **Genetic engineering**

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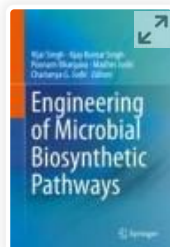
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Engineering of Microbial Biosynthetic Pathways pp 11–32

Microbial Strain Engineering

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Abstract

The utilization of microorganisms for the production of chemicals at industrial scale requires improvements/changes at physiological, metabolic, and genetic levels. Natural or wild-type isolates produce minimal quantity of metabolites/compounds required as a matter of survival. Hence, to use these microorganisms at industrial level, different tools are required for strain improvement. These tools will improve the metabolite production of industrial importance. The strain improvement program traditionally employs classical mutagenesis approach followed by screening and selection of mutant strain. Today, in-depth understanding of genetics and recombinant DNA technology helps in strain improvement via metabolic and genetic engineering. These strain

improvement approaches has increased the product yield with subsequent cost reduction. These approaches have also served other goals like reduction of undesirable products and elucidating the complex biosynthetic pathways. Further combination of different omics approaches like transcriptomics and proteomics with recombinant DNA technology has increased the prediction of accurate genes responsible for overproduction of metabolites/compounds.

Keywords

Mutagenesis **Physiology**

Metabolic engineering **Genetic engineering**

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Engineering of Microbial Biosynthetic Pathways pp 11–32

Microbial Strain Engineering

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Abstract

The utilization of microorganisms for the production of chemicals at industrial scale requires improvements/changes at physiological, metabolic, and genetic levels. Natural or wild-type isolates produce minimal quantity of metabolites/compounds required as a matter of survival. Hence, to use these microorganisms at industrial level, different tools are required for strain improvement. These tools will improve the metabolite production of industrial importance. The strain improvement program traditionally employs classical mutagenesis approach followed by screening and selection of mutant strain. Today, in-depth understanding of genetics and recombinant DNA technology helps in strain improvement via metabolic and genetic engineering. These strain

improvement approaches has increased the product yield with subsequent cost reduction. These approaches have also served other goals like reduction of undesirable products and elucidating the complex biosynthetic pathways. Further combination of different omics approaches like transcriptomics and proteomics with recombinant DNA technology has increased the prediction of accurate genes responsible for overproduction of metabolites/compounds.

Keywords

Mutagenesis **Physiology**

Metabolic engineering **Genetic engineering**

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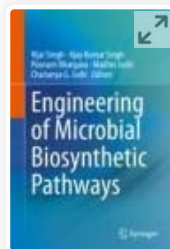
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Engineering of Microbial Biosynthetic Pathways pp 11–32

Microbial Strain Engineering

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Abstract

The utilization of microorganisms for the production of chemicals at industrial scale requires improvements/changes at physiological, metabolic, and genetic levels. Natural or wild-type isolates produce minimal quantity of metabolites/compounds required as a matter of survival. Hence, to use these microorganisms at industrial level, different tools are required for strain improvement. These tools will improve the metabolite production of industrial importance. The strain improvement program traditionally employs classical mutagenesis approach followed by screening and selection of mutant strain. Today, in-depth understanding of genetics and recombinant DNA technology helps in strain improvement via metabolic and genetic engineering. These strain

improvement approaches has increased the product yield with subsequent cost reduction. These approaches have also served other goals like reduction of undesirable products and elucidating the complex biosynthetic pathways. Further combination of different omics approaches like transcriptomics and proteomics with recombinant DNA technology has increased the prediction of accurate genes responsible for overproduction of metabolites/compounds.

Keywords

Mutagenesis **Physiology**

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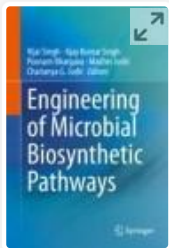
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Engineering of Microbial Biosynthetic Pathways pp 11–32

Microbial Strain Engineering

[Gaurav Sanghavi](#) , [Prabuddha Gupta](#), [Mahendrapalsingh Rajput](#), [Tejas Oza](#), [Ujwal Trivedi](#) & [Nitin Kumar Singh](#)

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Abstract

The utilization of microorganisms for the production of chemicals at industrial scale requires improvements/changes at physiological, metabolic, and genetic levels. Natural or wild-type isolates produce minimal quantity of metabolites/compounds required as a matter of survival. Hence, to use these microorganisms at industrial level, different tools are required for strain improvement. These tools will improve the metabolite production of industrial importance. The strain improvement program traditionally employs classical mutagenesis approach followed by screening and selection of mutant strain. Today, in-depth understanding of genetics and recombinant DNA technology helps in strain improvement via metabolic and genetic engineering. These strain

improvement approaches has increased the product yield with subsequent cost reduction. These approaches have also served other goals like reduction of undesirable products and elucidating the complex biosynthetic pathways. Further combination of different omics approaches like transcriptomics and proteomics with recombinant DNA technology has increased the prediction of accurate genes responsible for overproduction of metabolites/compounds.

Keywords

Mutagenesis **Physiology**

Metabolic engineering **Genetic engineering**

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Measurement, Analysis and Remediation of Environmental Pollutants pp 199–209

Spatial Variation of Airborne Allergenic Fungal Spores in the Ambient PM_{2.5}—A Study in Rajkot City, Western Part of India

[Charmi Humbal](#), [Sneha Gautam](#) , [Suneel Kumar Joshi](#) & [Mahendrapal Singh Rajput](#)

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Abstract

Fungal spores in the fine particle is an emerging pollutant of the technological age, which can create adversely effect on human health and their surrounding environment. Probably the first time in the western part of India, an investigation was organized to assess the spatial distribution of PM_{2.5} associated fungal spore concentration levels in an urban city. Five urban locations selected to cover probably all major areas of a city to conduct the study by using fine particulate sampler with 24 hours' interval. Highest ($101.79 \pm 8.09 \mu\text{g m}^{-3}$)

concentrations of PM_{2.5} have been observed in the industrial area only. The highest (8.0×10^{13} Colony-forming unit (CFU) m⁻³) in industrial area and lowest (2.0×10^8 CFU m⁻³) fungal concentrations were found in the residential area. Spores of seven fungal species (i.e., *Aspergillus*, *Candida*, *Fusarium*, *Penicillium*, *Alternaria*, *Cephalosporium* and *Mucor*) were significantly predominant in all selected locations in the urban area. In these views, *Aspergillus*, *Candida* and *Penicillium*, and *Fusarium* species were the dominant fungi in Industrial, slaughter house and dump site, respectively. The highest concentration of fungal spores was reported in industrial area and poultry farm as compared to other locations. Outcomes of the current work suggested that fungal spores were observed in the respirable fraction (<2.5 μm) and so had the potential to penetrate the deeper part of the lungs. In addition, the meteorological parameters i.e., temperature and relative humidity, were recorded to understand the relationship between meteorology and enhanced viability of fungal spores.

Keywords

PM_{2.5}

Bioaerosols

Fungal spores

Health issues

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Fabrication of supercapacitor using banyan leaves-based activated carbon electrode and formic acid-based polymer electrolyte

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ABSTRACT

In the present studies, activated carbon as an electrode material and polyvinyl- alcohol (PVA) as a polymer. Formic acid (FA) and potassium iodide-based electrolyte system have been synthesized for the fabrication of energy storage devices, supercapacitors. The diluted formic acid (CH₂O₂) in the double-distilled (DD) water has been optimized so that it exhibits maximum conductivity. The electrolyte system has also been prepared with PVA, redox additive (KI) with optimized formic acid (4.0 M). The redox additive concentration has also been identified that can have maximum conductivity. The selected system (PVA + FA + KI) shows the highest conductivity in the range $\sim 10^{-1}$ Scm⁻¹. The banyan leaves (biomass) based carbon electrode (BAC) synthesized as an electrode material. The electric double layer capacitor (EDLC) has been fabricated using BAC as electrodes and (PVA + FA + KI) as electrolyte material. The result of (BAC) based EDLC cell has been compared with the cell fabricated using commercially available activated carbon (AC). The performance of cells has been determined by impedance spectroscopy (IS), Cyclic voltammetry (CV) and charge-discharge (CD) techniques. The overall capacitance of BAC / (PVA + FA + KI) / BAC and AC / FA (4.0 M) / AC have been found to be ~ 356 mFcm⁻² and ~ 100 mFcm⁻². © 2020 Elsevier Ltd. All rights reserved.

Selection and Peer-review under responsibility of the scientific committee of the International Conference on Advanced Materials and Nanotechnology.

1. Introduction

Presently, there is a lot of interest in developing the supercapacitors, which is a promising candidate for energy storage. The charge storage devices are being significantly utilized in the consumable market. The supercapacitor, an electrochemical device has attracted the extensive interest of researchers due to its advantages over batteries. Basically, EDLCs are classified into two classes, specifically, electric double layer and pseudo capacitor [1]. The advantage of EDLCs is that the unique characteristics which include; discharge time and power density, the stability of cycles, the highest voltage, storage of charges are especially higher in comparison with other electrochemical devices. Enhancement in the overall performance matrix is the most important aspect to make those electrochemical devices commercially available for use in the consumable electronic market.

Many portable electronic gadgets including cellular phones, laptops, computer systems, digital cameras, etc., bio-clinical gadgets to hybrid electric-powered vehicles are powered by EDLCs. Such wide applicability of the supercapacitors and the merit

factors, such as progressive power density, quicker charging/discharging, and longer cyclic stability has developed a worldwide interest [2,3]. In the existing work, the conductivity of formic acid (FA) (CH₂O₂) is optimized. The optimized formic acid with four molar concentration solution gives maximum conductivity. It is of the order of 0.1 Scm⁻¹ approximately. The electrode material has been synthesized from the banyan tree leaves. The electrode material and electrolyte system has been evaluated by fabricating a EDLCs cell. The capacitance of the constructed EDLCs cell A: BAC || PVA + KI + FA (4.0 M) || BAC and cell B: AC || FA (4.0 M) || AC have been measured using general techniques, which include cyclic voltammetry charge-discharge and impedance spectroscopy.

2. Materials and methods

2.1. Preparation of polymer electrolyte with formic acid

Initially, 22 M CH₂O₂ concentration purchased from (Fisher Scientific) has been diluted using double-distilled water. The mixture

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is stirred for 5 min at room temperature. The conductivity measurement of diluted formic acid has been performed. The conductivity has been extracted using the equation, $\sigma = 1.042 / R$ (S/cm), where R is the resistance in ohm, and 1.042 is cell constant. The PVA and KI have also been added into optimized CH_2O_2 to prepare polymer electrolyte. The concentration potassium iodide has also identified so that the prepared polymer electrolyte results in maximum conductivity. The optimized electrolytes [PVA + KI + FA (4.0 M)] chosen for further studies. Prepared polymer electrolyte is sandwiched between two BAC electrodes to form a supercapacitor.

2.2. Synthesis of banyan tree leaves-based activated carbon

Biomass banyan tree leaves-based activated carbon material has been synthesized by following steps:

- (1) First of all, we selected the banyan leaves and washed them properly to remove the dust particles and dried them in sunlight for 7 days. The dried material was burnt at 500 °C for 6 h that resulted in the charcoal. The crushed fine powder of charcoal was soaked in 5 M CaCl_2 solution prepared in double-distilled (DD) water for 24 h. The CaCl_2 contents were removed by washing with double-distilled water followed by drying at 110 °C temperature for 12 h.
- (2) The prepared banyan leaves charcoal with KOH in the ratio of (1:1) is stirred at 60 °C for 2 h, and then placed in the oven at 110 °C for 12 h.
- (3) The activated powder was subjected to heat treatment in a tubular furnace at 700 °C for 2 h in the nitrogen ambient which was maintained by flowing nitrogen at the rate of 150 ml/min. The sample was now allowed to cool at room temperature. The sample was washed using 5 M HCl followed by washing with water until the pH value of the residual reduces to 7. The obtained powder was dried at 110 °C. The prepared powder of activated carbon was used to fabricate the electrode of the supercapacitor.

2.3. Preparation of electrode

conductivity measurement was carried out using LCR (3522-50, Hioki, Japan). The impedance measurement was performed using the frequency range between 1 Hz and 100 kHz at a signal level of 10 mV.

4. Results and discussions

4.1. Room temperature ionic conductivity

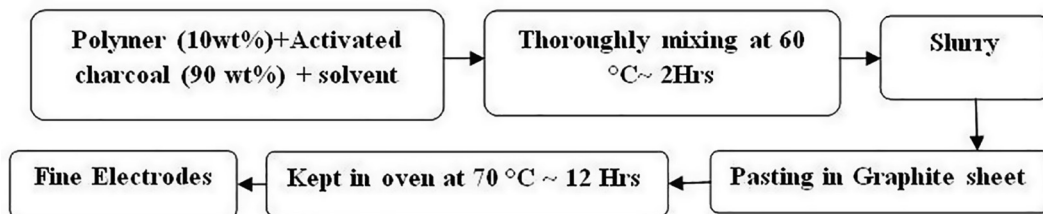
The room temperature ionic conductivity and formic acid molar concentration (in DD water) plot is provided in Fig. 1. It is observed that the four molar concentration has maximum conductivity. It is of the order of 10^{-1} Scm^{-1} . Initially, the number of free mobile ions increases with an increase in the concentration of formic acid leading the rise in ionic conductivity of liquid electrolytes. Further increase in concentration leads to the formation of clusters results in reducing conductivity. Thus, the optimized composition of electrolyte [PVA + KI + FA (4.0 M)] has been selected as an electrolyte for further studies.

4.2. Supercapacitor analysis

The fabrication of EDLC has been performed using charcoal obtained from banyan leaves (BAC). It basically depends on the electrodes and the optimized acid-based polymer electrolyte. The electrolyte is sandwiched between the two electrodes. The performance of cell A: BAC || PVA + KI + FA (4.0 M) || BAC has been analysed and compared with the supercapacitor, cell B fabricated using commercially procured activated carbon-based electrodes and formic acid electrolyte. Cell B configuration is as AC || FA (4.0 M) || AC. The performance of the fabricated supercapacitor has been evaluated using various techniques, such as ac impedance spectroscopy, cyclic voltammetry, and charge-discharge characteristics.

4.3. Impedance analysis

Figs. 2a and 2b show the impedance plot of cell A, and cell B. Impedance measurement is one of the methods that provide a



For the electrode preparation, the binder, PVDF has been utilized. The activated charcoal prepared from banyan tree leaves has been mixed with PVDF in acetone by maintaining ratio of 9:1 respectively, to prepare a slurry. The mixture has been dissolved at temperature 333 K for 2 h with constant magnetic stirring. The slurry was coated on one of the sides of the graphite sheet and kept in the oven for 12 h. The prepared electrodes were used to fabricate the supercapacitors.

3. Instrumental description

All the characteristics of supercapacitors have been measured by (CHI 608C) CH-electrochemical analyzer instrument while the

way to obtain the electric parameters of supercapacitor. Impedance spectra, in general, provide the response of material with frequency. Various aspects, such as relaxation, switching, an electrode-electrolyte interface can be studied from the impedance spectra [4,5].

From impedance (Z'' vs. Z') plot, the specific capacitance of the supercapacitor cell has been evaluated by the following relation:

$$C = -1/\omega Z'' \quad (1)$$

In Eq. (1), ω indicates the angular frequency, the imaginary part is represented by Z'' of complex impedance. The analysed parameters for the cells; cell A and cell B have been shown in Table 1. The frequency varies between 1 Hz and 100 kHz. Impedance plot

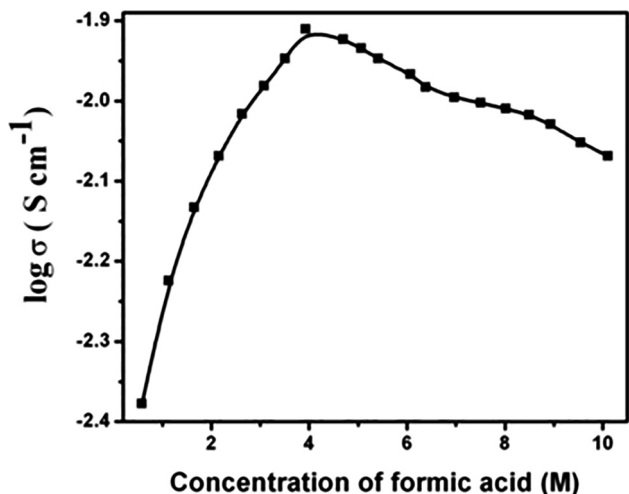


Fig. 1. Room temperature ionic conductivity as the Function of formic acid molar concentration of formic acid.

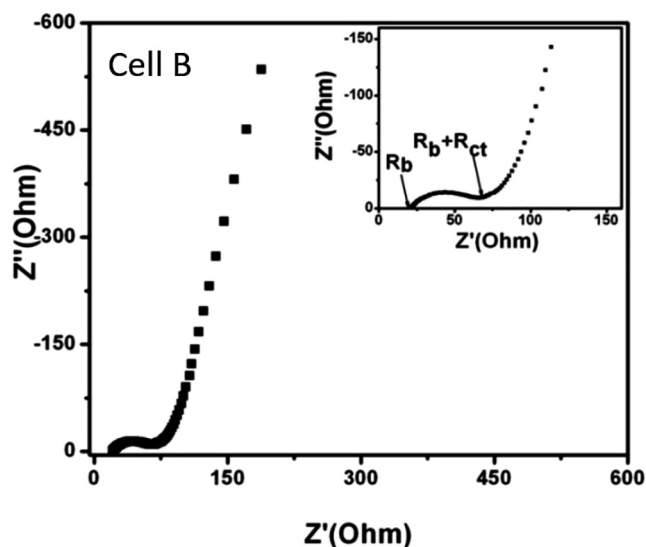


Fig. 2b. Typical impedance plot of Cell B: AC || FA (4.0 M) || AC.

Table 1
Electrical Parameters of An EDLC Cell A and B From ac Impedance Analysis.

Cell R_b ($\Omega \text{ cm}^2$)	R_{ct} ($\Omega \text{ cm}^2$)	1 mHz R ($\Omega \text{ cm}^2$)	C	
			(mF cm^{-2}) ^a	(F g^{-1}) ^b
A 2.3	10.7	22.9	356.2	222.6
B 5.3	10.9	47.1	100.6	58.2

^aOverall capacitance of the cell.

^bSingle electrodes specific capacitance of the cell.

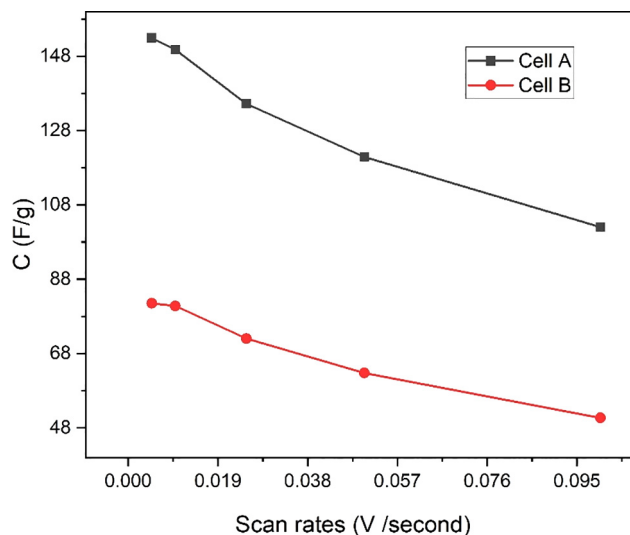


Fig. 3. Variation of the capacitance of cell A: Cell A: BAC || PVA + KI + FA (4.0 M) || BAC and Cell B: AC || FA (4.0 M) || AC as a function of scan rates.

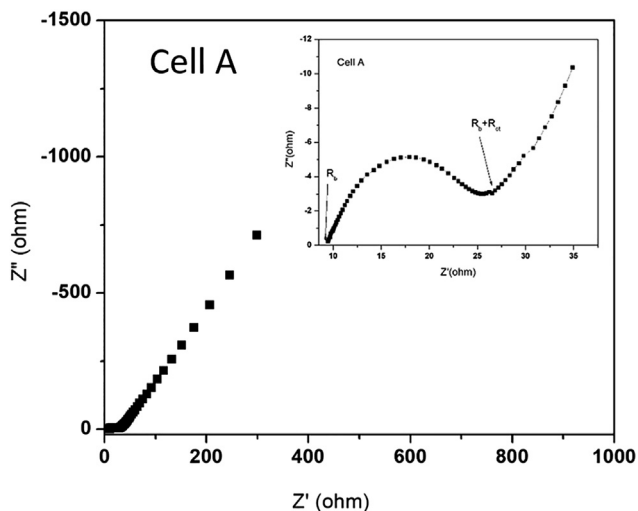


Fig. 2a. Typical impedance plot of Cell A: BAC || PVA + KI + FA (4.0 M) || BAC.

certainly indicates a single semicircle from semicircle, bulk resistance (R_b) and the transfer resistance (R_{ct}) is calculated [4]. Impedance plot exhibits the capacitive nature of fabricated EDLC cell [5].

4.4. Cyclic voltammetry studies

The cyclic Voltammetry analysis of the cells at various scan rates is shown in Fig. 3. In Fig. 4, indicates CV characteristics for cell A and cell B at 5 mV/s. In cell A, the redox peaks has been observed

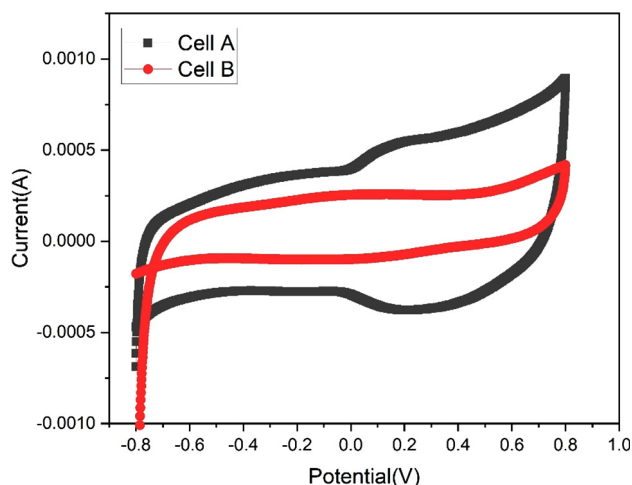


Fig. 4. Cyclic voltammogram of Cell A: BAC || PVA + KI + FA (4.0 M) || BAC and Cell B: AC || FA (4.0 M) || AC at 5 mV/second scan rates.

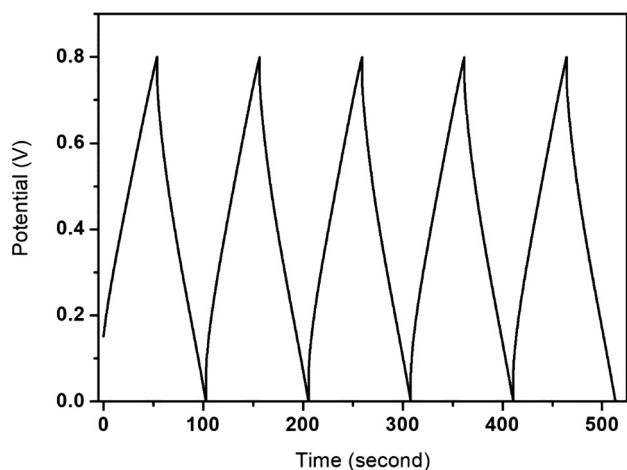


Fig. 5a. Charge discharge curve of Cell A: BAC || PVA + KI + FA (4.0 M) || BAC at a current density of 1.0 mA cm^{-2} .

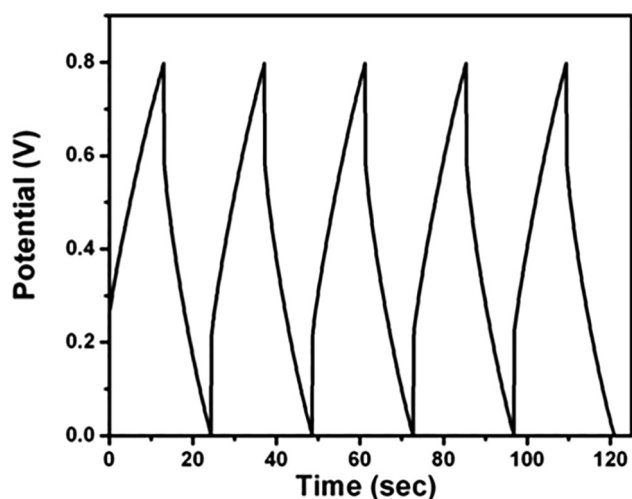


Fig. 5b. Charge discharge curve of Cell B: AC || FA (4.0 M) || AC at a current density of 1.0 mA cm^{-2} .

which indicates the redox reaction and the ion diffusion at a constant rate with less impact on ohmic resistance [6–11]. The porosity of electrodes can enhance the capacitive nature of the cells. Hence, this electrode is appropriate for supercapacitors. This is a primary characteristic of a great supercapacitor cell and is due to speedy ion switching at the electrode–electrolyte interfaces. The specific capacitance is evaluated with the aid of the following relation:

$$C = i / s \quad (2)$$

where i is the current and s is the scan rate.

Table 2
Typical Discharge Characteristics of An EDLC Cell A and B at 1 mA cm^{-2} Current Density.

Cell	Current Density (mA cm^{-2})	R (Ohm-Cm^{-2})	C_d		Working Voltage (V)	Energy Density (Wh Kg^{-1})	Power Density (Kw Kg^{-1})
			(mF cm^{-2}) ^a	(F g^{-1}) ^b			
A	1	257	315.4	147.2	0.8	20	1.57
B	1	53.4	77.8	45.06	0.8	5.0	1.63

^aOverall capacitance of the cell.

^bSingle electrodes specific capacitance of the cell.

The capacitance value determined from CV indicates excellent agreement with that of the values obtained from the ac Impedance and charge–discharge technique. The calculated capacitance value of a cell at 1 mV/s scan rate using equation (2) is about 310.2 mFcm^{-1} , which is also equivalent to the single electrode capacitance of 253.3 Fg^{-1} for the synthesized banyan leaves activated charcoal powder based electrodes.

The banyan leaves activated charcoal electrode based EDLC shows desirable capacitance value, which suggests that the activated charcoal and electrolyte are good candidates for electrode material, respectively. The capacitance values measured for the fabricated cell using the above electrode and synthesized electrolyte with scan rates have been presented in Fig. 3.

4.5. Charge discharge

The charge–discharge curve for the supercapacitor fabricated from the activated charcoal electrode obtained from the banyan leaves is given in Fig. 5a while the charge–discharge characteristic for a device fabricated using commercially procured activated carbon electrode with formic acid electrolyte-based cell has been indicated in Fig. 5b. The charge–discharge profile shows an excellent linear triangular shape profile which verifies the capacitive nature of cells, and power storage capability. A preliminary voltage drop, describe to internal resistance, is found throughout charging, discharging of the cell [7,12–17].

The capacitance value from the discharge curve is measured with the aid of mathematical relation:

$$C_d = i\Delta t / \Delta V \quad (3)$$

where i is current in 1 mA , Δt change of time during discharging of cell and ΔV is change in the voltage in volt. The capacitance values of the cell at constant current 1 mA are tabulated in Table 2. Using equation four and five the amount of energy density (ED) and power density (PD) have been calculated and is presented in Table 2:

$$\text{Energy density} = 1/2 CV^2 \quad (4)$$

$$\text{Power density} = 1/2 CV^2 / \Delta t \quad (5)$$

5. Conclusion

The combination of prepared formic acid based electrolyte system [PVA + KI + FA(4.0 M)] as an electrolyte material and prepared electrode using activated charcoal prepared from banyan leaves have shown promising behaviour. The performance of the supercapacitor fabricated using these materials has resulted into quite acceptable energy and power density. The specific capacitance of the cell is determined from CV analysis to be 315.4 mFcm^{-2} , which is also identical to that of a single electrode capacitance of 257.8 Fg^{-1} .

CRedit authorship contribution statement

Mukta Tripathi: Conceptualization, Methodology, Supervision, Writing - original draft, Writing - review & editing, Validation.
Aparajita Dixit: Data curation. **Santosh M. Bobade:** Visualization, Investigation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Management in the New Normal

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**FACULTY OF MANAGEMENT, GLS UNIVERSITY,
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From the President's Desk



Albert Einstein very rightly said that 'If I had an hour to solve a problem and my life depended on it, I would spend the first 55 minutes in deciding what questions to ask' And that's what true research means.

We at GLS University thrive on strong academic learning along with a focused impetus on research, inspiring faculty members and students to undertake research projects and discuss outputs at such a research conference where corporate practitioners, academicians, and students can deliberate nuances and contemporary practices of Management. A good business school enriches its students with the managerial skills required for a successful career. A research-oriented business school not only equips its students with requisite managerial skills but focuses on the research to help them make innovative and well-thought-of decisions. At Faculty of Management majority of faculty members are Ph.D. holders and strong impetus on research has resulted in this third edition of the conference on Advances in Theory Research and Practices in Management (ATRPM-2021).

It is indeed my pleasure to forward this book which is a result of the contribution of quality research papers from academicians, corporate fraternity, and students from across the nation and continents. I am sure this book will enhance our understanding of managing new normal.

Shri Sudhir Nanavati

President, GLS University

From the Dean's Desk



At the outset I would like to thank all the frontline health workers, law enforcement authorities, all government agencies and essential services providers who are relentlessly serving the nation, our thoughts and prayers are with those who have lost their loved ones in this pandemic.

The theme and scope of GLSU ATRPM 2021 intend to reflect the current challenges researchers & practicing managers are facing regarding the changing global business scenario. Amidst the economic disruption being faced due to the COVID-19 outbreak, businesses are being challenged with how best to ensure business continuity. The conference aimed to cover research conducted to assess the impact of the emerging trends, digital technologies, financial challenges, and the difficulties faced across the managerial functions like planning, organizing, coordinating and controlling.

However with challenges, this pandemic has opened many positive possibilities and a new way of doing business such as work from home, online education, telemedicine, vaccine development in record time, rapid capacity building in healthcare, genomics, and many more which will be the future scope of the research.

I am sure this book which has documented theory, research, and practices in new normal will be a treasure for the body of research and will be a guiding beacon for budding researchers.

Dr. Hitesh Ruparel

Dean, Faculty of Management

Preface

GLSU ATRPM 2021 is an effort to bring out the current challenges researchers faced during this lockdown scenario, which is new and abnormal to everyone. Due to COVID-19 outbreak, almost every businesses are being challenged, and are struggling to ensure business continuity. The conference aims to cover research conducted to assess the impact of the emerging trends, digital technologies, financial challenges and the difficulties faced in human resource management.

To start with as a part of the consequence of the Covid-19 pandemic situation, a lot of schools in Ahmedabad, Gujarat; India closed in March 2020. Teachers were asked to adapt to online teaching with training and workshops related to technology been provided to them from their respective schools.

The worldwide pandemic situation caused by the Coronavirus disease (Covid-19) has led to a state of despair for a lot of sectors. The education system changed dramatically with distinctive rise of e-learning platforms. There was a sudden shift from the classrooms in many parts of the globe, wondering whether the adoption of e-learning will continue post pandemic. The descriptive study demonstrates how the education system was re-designed to provide students teachers with opportunities to learn and teach online.

Moving towards the Small Business Enterprises are playing a vital role in the nation progress. Small businesses, including those run by businesspersons, are being hit toughest by the economic fall-out of the pandemic. Unprecedented lockdown procedures enacted to hold the spread of the coronavirus have resulted in supply chain interruptions and an enormous drop in demand in most segments and some sections required the more demand. In this time the small enterprises impacted with the rules and compliances of Goods and Services Tax.

Progressing further the outbreak of pandemics has been witnessed in various parts of the world at various intervals for ages. Our next paper studies the impact of the adoption of the contact tracing application of Covid19 by South Asian countries i.e India, Singapore, Hongkong, and South Korea. As the number of cases was on the rise, European states despite the advance in technology and education were struggling while the Asian countries got the contact tracing right. The study highlights some significant factors that make the adoption & usage of the application irrespective of its capabilities in technology.

Further talking about impact of Covid 19 on Gross domestic product. GDP helps in the identification of economic snapshot of country and facilitate to estimate the size of economic growth its growth rate for particular year. In this study researcher identified COVID-19 effect on GDP for selected nations because covid-19 considered as worldwide epidemic in the year 2019-20.

As they say Covid 19 is much more than a disease. The next study aimed to explore the psychological effect on employees who were forced to work from home during the Covid-19 pandemic in India. The study focuses on challenges the respondents faced during such unexpected situation and control imposed by government of India during the period of pandemic. The study identifies various strategies utilized to overcome the psychological impact and stress due to unplanned work from home situation for a longer time period.

No sector is left untouched due to the effect of pandemic. Pharmaceutical industry is in the limelight after covid-19. Next paper examines the financial performance and market share of top 10 pharma companies of India before covid and after covid.

Coming to some positive aspects of Covid-19. As it has ravaged the restaurant industry completely and the precautionary measures of this has made the small restaurants infeasible to work. Many of the restaurants have been shuttered during lockdowns in March – April 2020. This resulted in the downfall of the restaurant industry. But digitization opened the door of new hope and growth to this industry that is Virtual Kitchen or Cloud Kitchen. In Indore many people have started their cloud kitchens from home during the lockdown. Forthcoming paper explores the concept of cloud kitchens with reference to Indore city.

The advent of online education although has its advantages, yet it is not giving the comfort zone students need. Also it is natural to feel sad, worried, confused, scared or angry. Mental health issues can significantly impair students' academic success and social interactions affecting their future career and personal opportunities. Increased social distancing and imposed self-isolation can cause a havoc to the mental health of students. This paper tries to study the impact of pandemic on the mental health of students through a cross sectional analysis.

Moving on to next research it shows the Emergence of Pharmaceutical Industry Start-ups providing artificial intelligence and related technology services as a single entity or in collaboration. Humongous utilization of online/digital marketing strategies is the key method deployed for promotion of artificial intelligence and related technology platforms. Pharmaceutical industry start-ups are making humongous efforts in highlighting their unique artificial intelligence capabilities and offerings on their websites and social media platforms to tap and gauge requirements of their existing and prospective customers.

Showing our concern towards Nature and working on renewable sources of energy, next paper measures the awareness of various solar energy products, government initiatives and the concept of renewable energy among the society.

Discussing something else besides this pandemic.....and moving towards Indian stock market. Our next research analyses the impact of Macro economic factors like FDI, GDP, Money supply, structure of interest rates, Inflation, gross capital formation, trade balance on Sensex. Detailing ahead in finance segment next paper focuses on liquidity positions of selected auto mobile companies in India.

Progressing ahead our next paper explores entrepreneurship education development and and important implications for the further improvement of entrepreneurship education. It applies novel method of comparative education research and assessment items for university-based entrepreneurship ecosystems (U-BEEs), with a specific focus on universities in India.

Evaluating the concept of Smart cities, next research paper analyses the progress plotted by Smart Cities Initiative specifically with reference to cities of Gujarat state namely - Ahmedabad, Surat, Rajkot, Gandhinagar, Vadodara and Dahod.

India being spiritual country, diverting our attention towards one such research. "Spiritual Capital" is an emerging field of study that considers the advantages of faith on entrepreneurial efficacy. Social enterprises are a part of the entrepreneurial spectrum and have been under intense focus over the last many years. The next study presents a case to explore "How the capacity of FBSOs (Faith Based Social Organizations) could strengthen Social and Economic Contribution".

Focusing ahead on the Knowledge management. It's is the process of creating, storing, and transferring, applying and evaluating knowledge for making it available at the right time to the right people. This paper works on the relationship between organisational cooperation and knowledge management practices as perceived by the teaching staff of Higher Educational Institutions in Gujarat State.

Representing ahead religious products and business opportunities related to it. Exploring online opportunities to develop a broader market and reach of religious products. Trying hands on startup opportunity and presenting a viable model of it.

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Dr. Jasmin Padiya

Dr. Chinmay Gandhi

Dr. Tanvi Pathak

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From Chalks to Stylus: Teaching Efficacy during Covid-19 in Ahmedabad City

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ABSTRACT

As a part of the consequence of the Covid-19 pandemic situation, a lot of schools in Ahmedabad, Gujarat, India closed in March 2020. Teachers were asked to adapt to online teaching with training and workshops related to technology been provided to them from their respective schools.

The worldwide pandemic situation caused by the Coronavirus disease (Covid-19) has led to a state of despair for a lot of sectors. The education system changed dramatically with distinctive rise of e-learning platforms. There was a sudden shift from the classrooms in many parts of the globe, wondering whether the adoption of e-learning will continue post pandemic. The descriptive study demonstrates how the education system was re-designed to provide students teachers with opportunities to learn and teach online. The paper presents the results of a survey conducted in August and September, 2020 based on teaching efficacy during the times of Covid.

Analysis of potential factors such as school- computer technology, teacher- education learning techniques, Information and communication technology tools (ICT) access etc.

Findings from regression analysis show changes in the teacher competence and teacher education opportunities to learn digital competence.

Keywords: Teaching efficacy, Teacher education, pandemic education situation, teacher competence, schools in Ahmedabad.

INTRODUCTION

During the 2019 Covid virus (pandemic situation) has led to a number of challenges both for the teachers as well as the students. The schools faced a lot of challenges in terms of online teaching transition. The first half of 2020 witnessed a lot of schools to close due to the lockdown. All schools were required to shift to the online teaching mode.

However, much is still unknown about the nationwide practice of online teaching across all levels of schools in the state. Lack of experience in online teaching, separation of teachers from students, school administrative process and unsatisfactory student academic performance were identified as the major associated factors. The study thus concluded that teachers' online teaching efficacy for technology application increased among school teachers in Gujarat during COVID-19 school lockdown.

LITERATURE REVIEW

Prior to Covid-19, various forms of online teaching were in existence in terms of distance education and other open courses. The transition of online teaching as a result of Covid-19 brings about number of challenges both from the teacher's and student's perspective.

Teachers face restrictions with online teaching as compared to face-to-face teaching. The need to replace physical classroom sessions with online teaching cannot be changed over time during natural disasters, crises or pandemic. Compared with the physical classroom teaching, teachers reported spending extra time to accustom themselves to the online teaching environment, designing methods to engage with students and knowing individual students' comprehension of the teaching content (Scull et al. 2020). These challenges were associated with the separation between teachers and their students as opposed to the conventional classroom teaching (Moore 2014) and/or lack of online teaching experience (Johnson et al. 2020).

For instance, teachers can enhance the teacher-student connectedness using facial expressions and body languages, whose influences could be affected in an online context, which leads to greater reliance on voice communication (Bao 2020). Teacher self-efficacy (TSE) has been described as a subjective indicator of the extent to which teachers can achieve specific tasks in the teaching profession and has been one of the most studied constructs in teacher education (Morris et al. 2017).

RESEARCH METHODOLOGY

Research Design

Research Design is a framework for research and the research approaches could be classified into three categories of research which are Exploratory, Descriptive and Causal. This study is conducted with explanatory research as the study needs to investigate the impact of servant leadership on employee performance. The explanatory research design involves formulating of the hypothesis and collecting the data to achieve the objectives.

Quantitative method has been used as teaching efficacy is measured with the adaption to the pandemic for the study. It will help in analysing the information statistically to achieve its objectives.

Research objectives

- To know the impact of Covid-19 on teaching efficacy.
- To investigate the changes in online teaching during the COVID-19 school lockdown in the state.
- To collect information to investigate their moderation effects on changes in online teaching.
- To understand the adaptability situation with the help of this study.

Data collection

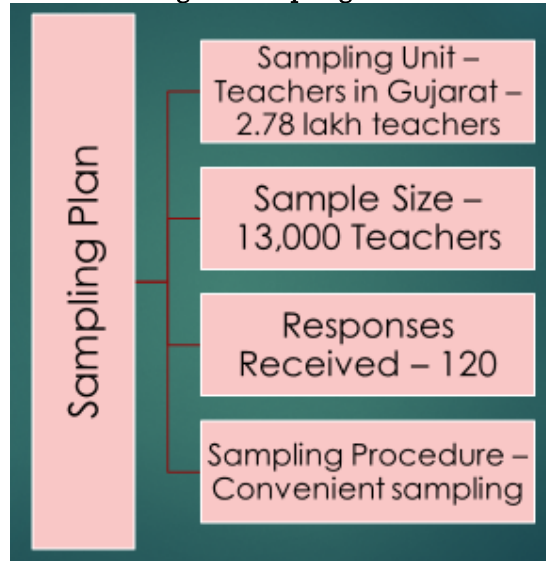
The most suitable data collection method for this study is through questionnaires. So, primary data will be collected by teachers of different schools in Gujarat in terms of questionnaires based on five-point Likert Scale. The Likert scale format is: 1) Agree 2) Neutral 3) Disagree 4) Strongly agree and 5) Strongly disagree

The development of the questionnaires is based on the following variables: teaching efficacy and covid online base teaching. Servant leadership pertaining to factors such as generosity, humility, supportive attitude, caring and understanding, while employee performance is compared with democratic, autocratic and servant leadership styles.

Questionnaires were distributed to a total of 200 teachers using convenience sampling method from

different schools in Gujarat with affiliations such as ICSE, CBSE, Gujarat Board and other. However only 120 respondents were received. 9 respondents did not complete the questionnaire, which gives a total of 111 valid responses. Hence, a total of 60 percent valid response rate.

Fig. 1: Sampling Plan



Accessibility and Ethical Issues

Consent of the involving parties was taken before carrying out the investigation. The researcher ensures no revelation of the identity or other personal information. The researcher made sure no violation of responses arose.

Table 1: Descriptive characteristics of participants (n = 111)

Variable	n	%
Gender		
Female	88	80.73%
Male	23	19.27%
Age Limits		
Under 25 years	20	15.60%
26-35 years' old	30	27.52%
36-45 years' old	33	30.28%
45 years or older	28	26.61%
Level of teaching		
Pre-primary	14	12.84%
Primary	45	41.28%
High School	18	13.76%
Location of schools		
Urban	89	81.65%
Rural	22	8.75%
Total	111	

DATA ANALYSIS

This study involved quantitative approach using statistical tools to evaluate the collected data, facts and figures. SPSS (Statistical Package for the Social Sciences) has been deployed to conduct meaningful conclusions.

Demographic Analysis, Descriptive Analysis, Data Analysis was conducted by using SPSS to determine the impact of online teaching on teachers and student's performance in the state of Gujarat. Demographic Analysis. Demographic analysis is a statistical technique used to develop and measure the dynamics and dimensions of the population.

Demographics of Respondents

Functional department: Most of the respondents are from all the functional areas.

Tenure: The years of experience varies and starts with lowest 0 – highest 20 years of experience of teaching in schools.

The educational level bifurcation of teachers was quantified in terms of their graduation, post-graduation and diploma degrees, making the data more reliable in terms of knowledge and experience of their hierarchical positions.

The demographic analysis of this research was measured by gender, age and work experience.

Gender was categorized into males and females: 23 males and 88 females.

Age was grouped into under 25, 25-35, 36-45 and 45 & above. The frequency of the respondents are 20, 30, 33 and 28 respectively.

Table 2: Demographic analysis

Variables		Frequency	%
Gender	Female	88	80.73%
	Male	23	19.27%
Age	under 25	20	15.60%
	25-35	30	27.52%
	36-45	33	30.28%
	45 and above	28	26.61%

Fig. 2: Gender

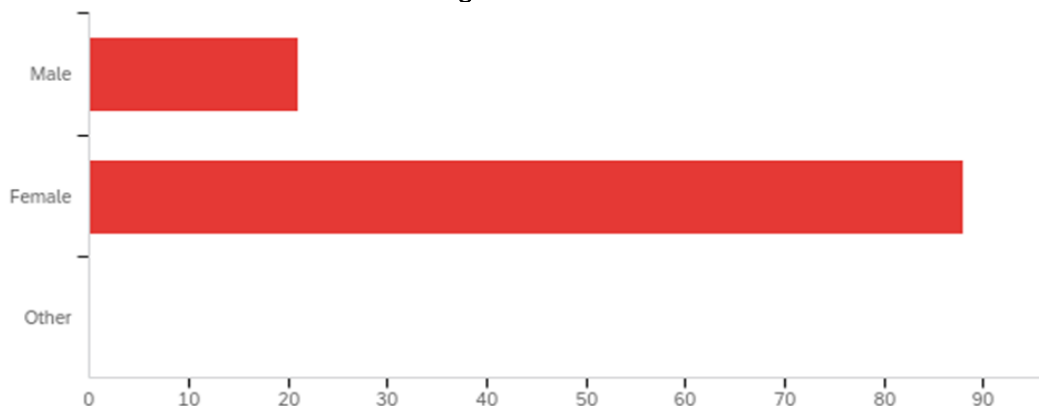


Table 3: Moderation effects of adaptability in the teaching efficacy due to Covid-19 Pandemic

Variable	β	SE	t	p
Online instruction	0.495	0.175	2.825	0.005
Adaptability	0.33	0.138	2.386	0.018
Effectiveness	0.198	0.177	-1.121	0.263
Technology	419	0.188	2.231	0.026

Table 4: Emerging themes about challenges experienced in online teaching during COVID-19 (n = 111)

Themes	Exemplary quotes
Engaging with students	"It's easy for student to lose their attention"
Technology	"Not familiar with applying technology in online teaching"
Workload	"Too much time spent on restructure the lesson online"
Student supervision	"It's difficult to supervise students in time"
Student management	"How to control students' behaviour online?"

RESULTS

Quantitative data

Open-ended question

Of the 111 teachers who filled in the open-ended questions about the major challenge(s) they experienced during online teaching, various themes emerged (Table 6) above.

Theme 1: Engaging with students

The data reported that, the online teaching has separated them from their students. Teacher's sometimes couldn't see the students on such interface and even had to mute them sometimes due to the noise issues in online sessions. Teachers were unable to detect student's understanding immediately.

Theme 2: Technology

One of the main challenges with technology is the lack of familiarisation with the technological devices or digital devices. The lack of usage of digital devices in terms of even understanding the technical operations related to them was a challenge so far. Reported problems related to technology was online video editing, uploading documents, software usages and internet connectivity issues.

Theme 3: Workload

It was reported from the data that the number of working hours increased from pre-covid phase to covid phase. The daily productive working hours increased from 3-4 to 5-6 hours. And it affected into an increase in the weekly working hours as well. A lot of administrative work increased along with teaching.

Theme 4: Student Supervision

The inability to provide supervision was also reported. Chatting windows were a disadvantage to understand the issues and problems students face during online sessions. Students were even reported of cheating during tests and identical answers were reported during assignments and projects.

Theme 5: Student Management

Student management was the bigger challenge for a few as the data reported that, managing students on online platforms became difficult. As teachers had to mute them time & again which would hinder the class or they weren't keeping their videos on, on time. Few became inattentive even during online sessions as they could just start the class and not be interactive in the same.

The students sometimes would not understand the content hence the teachers had to give instructions again & again or conduct additional tutorial sessions as well.

LIMITATIONS

A little research to confirm these conclusions as the data is related to Gujarat and not the country at large.

As the sample selected is from 220 teachers limiting to actual 111 respondents, it cannot justify the impact of teaching efficacy due to covid-19 situation because a large number of population cannot be studied with this sample.

Thus, this limitation explains the hurdles a researcher might face in concluding the investigation and fulfilling the objectives being more accurate. The upcoming research can be conducted with inclusion of more and varied variables.

The future research can ensure a larger number of sample size in different states and country at large. Furthermore, expansion of the model can be done if the researcher includes the turnover rates, experience with the superiors, and work commitments.

CONCLUSION

On the basis of the results, Covid-19 has a significant impact on the teaching efficacy in schools of Gujarat. Hence, more schools must be trained properly to adapt to the current scenario. Innovation, team work and creativity must be encouraged so that it keeps the teachers and students motivated.

The study would increase the awareness amongst different schools. The study would provide them with a clear holistic picture of their standing and the scope for the further improvement. The study would also help to get a clear idea about the impact of pandemic on the teacher performance and personal growth, if any.

Hence, attention must be provided to this education sector to make teachers more motivated and oriented towards the ultimate school goals. The study has found teachers are capable of having profound personalities and pitching in with self-interest in such crisis.

The study finds teachers who have been supported less experienced less growth in innovative tools and techniques.

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Challenges of Goods and Services Tax during Covid – 19: A Study with reference to Small Business Enterprises of Hyderabad District

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Abstract

Demosthenes says, “Small opportunities are often the beginning of great enterprises”. The Small Business Enterprises are playing a vital role in the nation progress. Small businesses, including those run by businesspersons, are being hit toughest by the economic fall-out of the pandemic. Unprecedented lockdown procedures enacted to hold the spread of the coronavirus have resulted in supply chain interruptions and an enormous drop in demand in most segments and some sections required the more demand. In this time the small enterprises impacted with the rules and compliances of Goods and Services Tax. That may affect the functioning of these enterprises. The present paper is going to depict the condition of small enterprises like Medical Shops challenges during the pandemic in Hyderabad district of Telangna state.

Keywords: Small Business Enterprises, Lockdown, Segments and Goods and Services Tax.

INTRODUCTION

Small business enterprise means a business investment in Plant and Machinery or Equipment value should not be more than 10 crore rupees and turnover does not exceed 50 crore rupees. These businesses are playing a major role in the context of not only Gross Domestic product but also in the development of the nation, in all kind of economies developed, developing and underdeveloped. In India, such enterprises also part of the economic development of the country. Micro Small and Medium Enterprise businesses are contributing nearly 29 percentage for the Gross Domestic Production (GDP) through its not only national but also international trade. But in the pandemic situation these enterprises suffered a lot. In the present paper focusing on the medical shop’s challenges in the lock down period in connection with the Goods and Services Tax rules and compliances.

LITERATURE REVIEWS

(Saini, 2019), issued article Impact of GST on Small Business Enterprises articulates that how business enterprises were before the implementation of Goods and Services Tax in India, the effect of its on small and medium enterprises, the limitation effect of GST on business regulation of small and medium enterprises, analyses the positive influence of GST on Small and Medium Enterprises, start-ups and studied Challenges faced by SMEs and Start-ups.

(Dr. Ankita Verma and Dr. Sonia Justin Raj, 2018), the research paper Impact of GST on the Regulation of Small Business, they produced that the effect of Goods and Services Tax on Micro Small and Medium Enterprises, the limitation effect of GST on business regulation of MSMEs and study the impact of technology with respect to Goods and Services Tax with the conclusion of implementation of GST Act has had a great effect on the survival in the market. Some enterprises found it beneficial, but majority faced difficulty in accepting it for existing enterprises.

(Dr. Mukesh, K. Sharma Suniti and Saini, 2019), the offered article Awareness and Impact of GST among Small Business Owners: A Study of Mandsaur City in M.P., conversed that the awareness of

GST among the business owners dwelling in Mandasaur city and evaluated the impact of Goods and Services Tax among the business owners living in that city more over they stated that in the time of globalization there is the need for the influential and efficient tax structure for challenging India at Global level. The Goods and Services Tax not only bring the transparency but also it promotes the ease of doing business. Previous every state used to have own levied tax rates which was difficult and increased the price of the goods by cascading effect which impediment the foreign direct investment also. So, the Goods and Services Tax reduce that effect.

(Chellammal and Dr. T. Eugene, 2018), uttered in the article GST- Positive and Negative Impacts on Small Scale Industries, that revised about History of GST in India in detail and the positive and negative impacts of GST on Small Scale Industries in addition to that extended their words such as MSMEs feel that the rate of GST in higher and would restrict their growth in this era of stiff competition. To avoid this situation the government can try to reduce the present rate of GST composed on MSMEs and thereby promote the growth of such enterprises and make them compete globally.

(Shetty Deepa Thangam Geetha and SP. Mathiraj, 2019), presented the research paper Impact of GST on MSMEs with the terms of appraise the impact of Goods and Services Tax on MSMEs in Sivagangai District, Tamil Nadu state and exposed that the attentiveness in respect of Goods and Services Tax by Micro, Small and Medium Enterprises, need for creating the Goods and Services Tax network and other such related trends are turning out to be the bottle neck factors for appreciating the actual consequence of Goods and Services Tax enactment.

(Sharma, 2017), in circulated article A Study of Impact of GST on Micro, Small and Medium Enterprise- A Critical Analysis, deliberate that favorable and unfavorable impact of GST on Micro, Small and Medium Enterprises and stated that one tax principle fundamental Goods and Services Tax provide benefit to MSMEs. Goods and Services Tax would be in the lead to improve in production, employment prospects, economic development, and growth of the nation. Goods and Services Tax is beneficial for the Micro Small and Medium Enterprises.

(Bharti Wadhwa and Akhansha Uppal, 2019), in an article, GST: Awareness and Perception of Small Business Persons' (SBPS), they presented that the awareness and the perception of Goods and Services Tax among businessmen, the capability of businessmen and the authority level in assisting Small Business Persons' to get familiar with the new indirect tax and the readiness for that tax among businessmen moreover stressed on maximum Small Business Persons' acknowledged that they had wrong insight about Goods and Services Tax. That wrong opinions were spread due to sharing of false knowledge by people who were not competent enough to note on Goods and Services Tax and the concerned authority not provided training to the officers for GST at right time.

(Ashtekar, 2018), in issued paper Impact of GST on MSME, he expressed that the issues of Micro, Small and Medium Enterprises relating to Goods and Services Tax, measure on the difficulties of MSMEs with enforcement of GST Act and stated there is a prerequisite to integrate India into one economy and get rid of the multiple taxes and its cascading effect. Initiation of Goods and Services Tax resulted in generalization of indirect tax structure in the country and thereby ensures harmonious business transactions across the country and worldwide would lead MSMEs.

(Jain, 2019), in issued paper An Overview of Goods and Service Tax engrossed that tax related slab rates, previous and present tax scheme in India and expressed that the present indirect tax system facilitates economic condition flattening in the nation more over it will bond the harmony of nation tax structure.

(Prajapati, 2016), the published article Challenges and Implementation of GST in India, he examined that the concept of GST, the challenges of Goods and Services Tax in India and before the employment of such tax in India the government must face various problems and it must overcome them in a proper way.

RESEARCH GAP

With the observation of literature review it found that there is a scope to study on challenges faced by the small business enterprises at the time of Covid period, so here the title of the paper taken as Challenges of Goods and Services Tax during Covid – 19: A Study with reference to Small Business Enterprises of Hyderabad District.

IMPORTANCE OF THE STUDY

The study is going to provide challenges faced by the small business enterprises during the pandemic period with the rules and compliances of Goods and Services Tax, it would depict the facet of these businesses to claim the input tax credit in lockdown time and present the role of them to overcome the claiming procedure to get back the input tax credit at the specified period.

OBJECTIVE OF THE STUDY

To collect input tax credit claiming problem in connection with masks and sanitizers provision for employees by medical shops.

To produce the issues of small business enterprises.

HYPOTHESIS

H₀: Medical shops turnover and input tax credit claiming problem are not independent.

H₁: Medical shops turnover and input tax credit claiming problem are independent.

RESEARCH METHODOLOGY

Personal interview method is used to collect the primary data for the paper purpose from various medical shops of the city. Nonprobability sample method applied to gather the information that too convenience sample type with the sample size of 42. SPSS statistical software utilized to test the data with the tool of Chi-Square test at confidence level is 95% and level of significance is 5% i.e., α is 0.05. And the requisite secondary data collected through various published sources such as articles, research produces and publications of government and non-government.

SAMPLING PLAN

Population of the test is medical shops of the Hyderabad district of Telangana state, with sample size of 42 of nonprobability sample method of convenience sample type.

LIMITATION OF THE STUDY

The present study is constrained to medical shops of Hyderabad district of Telangana state and the time of the study is restricted to lockdown period of covid situation.

DATA ANALYSIS

Table 1: Case Processing Summary

Annual turnover in lacs * Input tax credit claiming problem on provision of masks and sanitizer to employees	Cases Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
	42	100.0%	0	0.0%	42	100.0%

(Source Primary data)

Interpretation

To check the validity of the variables for conducting test of annual turnover in lacs and input tax credit claiming problem on provision of masks and sanitizers to employees of medical shops, the valid cases are 42 with 100% and there are no missing values 0 i. e. with 0%. It is better to move for the test.

Table 2: NPar test

Annual turnover in lacs			
	Observed N	Expected N	Residual
below Rs. 10 lacs	16	14.0	2.0
Rs. 10 lacs to Rs. 20 lacs	19	14.0	5.0
above Rs. 20 lacs	7	14.0	-7.0
Total	42		

Table 3: Test Statistics

	Annual turnover in lacs
Chi-Square	5.571 ^a
df	2
Asymp. Sig.	.062

(Source Table 2 and 3 primary data)

Interpretation

The degree of freedom for the goodness of fit test are less than one of categories here 3 minus 1 is 2. The significance of Chi-Square shows that the frequencies are not equally distributed that can be taken as ^a 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 14.0. Here N is 42, Chi-Square value is 5.571 and P is 0.062 it represents that more than the standard value that is 0.05.

Table 4: Annual turnover in lacs * input tax credit claiming problem on provision of masks and sanitizer to employees crosstabulation.

Annual turnover in lacs	Yes	%	No	%	Total	%
below Rs. 10 lacs	15	35.7	1	2.3	16	38.0
Rs. 10 lacs to Rs. 20 lacs	19	45.3	0	0	19	45.3
above Rs. 20 lacs	7	16.7	0	0	7	16.7
Total	41	97.7	1	2.3	42	100

(Source primary data)

$$\text{Degree of freedom} = (R-1) * (C-1) = (3-1) * (2-1) = 2$$

Interpretation

As per table 4 the problems facing on provision of masks and sanitizers to employees based on turnover the top position out of three categories occupying Rs. 10 lacs to Rs. 20 lacs category with 45.3% and the least one is above Rs. 20 lacs with 16.7%. Only below Rs. 10 lacs one not facing the problem and got 2.3%.

Table 5: Chi-Square Tests

	Value	df	Asymp. Sig.	Exact Sig. or P value	H ₀ Status
Pearson Chi-Square	1.665 ^a	2	.435	.584	Accepted
Likelihood Ratio	1.970	2	.373	.548	
Fisher's Exact Test	1.853			.548	
Number of valid cases	42				

Interpretation

Table 5 presents that the P value ie. is exact significance value 0.584 greater than the level of significance value 0.05. On the other hand, for the safe side asymptomatic significance here value 0.435 also more than the level of significance value. Here a 3 cells (50.0%) have expected count less than 5. The minimum expected count is .17. So, Fisher's exact value must consider for the decision making.

Decision: $\chi^2 (2) = 1.853$, $P = 0.584$ is more than the level of significance i. e. 0.05. Hence H_0 (Null Hypothesis) accepted. It means claiming of input tax credit problem depends on medical shops turnover represents when turnover increases there is possibility of improving the claiming problem of input tax credit.

ISSUES OF SMALL BUSINESS ENTERPRISES

1. Lack of technological knowledge in relation to filing returns online must approach experts such as tax consultants and Chartered Accountants.
2. Delayed input tax credit leads the business into jam of regular funds of the business.
3. There is a gap between decision taken by GST Council and actual implementation of the rule, it takes some time to applicability to the businesses.
4. Late up filling of invoices by supplier may cause the delay of input tax credit.
5. Own business format of invoice in some cases cause the rejection to claim the input tax credit, shows that mismatching of invoice with supplier invoice.
6. In lock down period relaxation of due date to file the returns cause the delay of input tax credit.

CONCLUSION

During the pandemic situation, the small business enterprises faced a lot of problems among them one of the considerable issues is claiming of input tax credit. In case of medical shops its essential to run the business for emergency purpose, so that the shops must provide proper requirements to their employees, here focused on masks and sanitizers supply. Most of the shops are facing problems to claim the input tax credit on specified items. That may be both the sides from supplier and the medical shops, and in some case the relation given by the government to file the returns due to extension of due date of filing returns.

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<https://www.ibef.org/industry/msme.aspx#:~:text=India%20has%20approximately%206.3%20crore,it%20national%20and%20international%20trade.>

<https://www.bajajfinserv.in/insights/impact-of-gst-on-small-and-medium-businesses-benefits-and-challenges>

To Study the Factors of Adoption of the Contact Tracing Application by South Asian Countries during Covid19

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Abstract

The outbreak of pandemics has been witnessed in various parts of the world at various intervals for ages. The FluPhone app from the Cambridge University developed in 2011 is one among the initial example. However, the contact tracing application has changed the game show this time during the outbreak of COVID19. This application essentially works using either Bluetooth technology or General Positioning System to log more than one users in its proximity for a certain period. If a person is diagnosed with COVID-19, those close to that person can then be notified. As per World Health Organization (WHO), the globe has been divided into the global north and global south where the major population has been found in the south and especially the Asian region. This paper studies the impact of the adoption of the contact tracing application of Covid19 by South Asian countries i.e India, Singapore, Hongkong, and South Korea. As the number of cases was on the rise, European states despite the advance in technology and education were struggling while the Asian countries got the contact tracing right. Thus, this paper highlights some significant factors that make the adoption & usage of the application irrespective of its capabilities in technology.

Keywords: Covid19, South Asian Countries, Contact Tracing Applications, ITC, Arogya Setu App, Governance.

INTRODUCTION

A contact tracing is an age-old method to prevent the worsening of the situation. Traditionally, manual contact tracing used the information collected on people's feedback, however, the usage of digital application has changed the scale of this method with just the click of a smartphone. (Ferretti et al., 2020). This digital contact tracing has gained a lot of popularity globally to combat the virus of COVID19. (Sun & Viboud, 2020). However, such usage of technology requires significant factors that makes the adoption of the method worth in the crisis. There are a three-sixty degree of factors that can be involved as the pandemic related variables such as social, cultural, political, and economic, but as Ferretti et al., 2020 states the role of the significant user base is at the center of all the other factors. This significant user base is achieved by the country-based governance approach (Morley et al., 2020). This paper focuses on the study of the adoption factors of the four-country India, Singapore, Hongkong, and South Korea of the South Asian region. With the uncertainty of the COVID 19 situation, there is no timeline for the post *hoc* analysis of digital application of the contact tracing governance, however, this helps to understand the gap in the definition and meaning of the contact tracing application. It is an attempt to understand each factor can help us plan better.

LITERATURE REVIEW

Our literature illustrate the use of information technology during crisis. These crises have been in various manners. Until past decade not many of them have been explored but experiments have been during Ebola, malaria and polio drive of various the South Asian countries. In the place where there is no alternative to the vaccine. In the country it becomes necessary for the 60% of the population to have the contact tracing application in order to have the effectiveness.

There is no alternative to testing but this shall help. **As Ferretti and Morley (2020)** have highlighted, the significance of the user base and the government approach accepted in the South Asian region have been considered the key factor for the study of this paper.

SIGNIFICANT USER BASE

As per the estimates, effective use of contact tracing application reduces the pandemic spread if 50 to 70% of the citizens of the total population would use it (**Ferretti et al., 2020; Scott, 2020**). This wide user-based adoption is to be managed by a proper governance structure. Various governments around the globe had adopted technological interference to curb the pandemic until the vaccine stage arrives. This interference worked based on either Bluetooth or the GPS system for tracing the location. However, Kai Reimer 2020 showed that there is no nomenclature for an ideal approaches but a customized locally contextualized models can be created for the immediate health risk, prior experience with pandemics, societal values, and national culture, the role of government, trust in government, and trust in technology in each society. To encounter with the issue, we begin with the literature review of the population as an important factor for the contact tracing application success. **Kai Merai 2020** has concluded that in theory the population-wide adoption of proximity tracing as a collective action problem. However, this again changes as per the governance of the country. Thus, this paper specifically focuses on 4 countries of the South Asian region.

THE GOVERNANCE APPROACH

The governance approach is considered as the act of decision-making through a collective effort (**Hufty, 2011**). IT governance particularly “*represents the framework for decision rights and accountabilities to encourage desirable behavior in the use of IT*” (**Weill, 2004, 3**). However, the technology disruption has bought this definition into question and demands a more individualistic approach (**Gregory et al., 2018**). Similarly, Kai reamer 2020 states that the transformation of the IT governance approach demands more at the societal level rather than the inter and intra organizational level. However, at this societal level, the individual interest conflicts with the collective interest (**Dawes, 1980**). And this collective interest raises the issue of the public good dilemma. It is a dilemma where the public benefits if all cooperate but individuals benefits as free riders (**Allison & Kerr, 1994**) also known as the free-rider problem. One such study (**Thöni & Volk, 2018**) mentions that cooperative behavior is highly conditional: major cooperation of the population is out of reciprocity, not altruism (**Axelrod & Hamilton, 1981**). In A systematic review of 7000 individuals showed in the collective action problems involves 3% of a population which is expected to cooperate independently of others, 20% can be expected to act selfishly (i.e., free ride), 60% cooperate on the will of others, 10% ceases to cooperate in connection to the others. Of all 7% behave unpredictably. Hence the countries like India, Singapore, and HK made their application compulsory installed. Such mandated enforcement would yield the best outcome in the pandemic situation however it may backfire as illegal and intolerant in many countries particularly western societies. In the further study we compare the governance model of each of the chosen countries based on the voluntary, encouraged, nudged, and mandated (**Kai reamer 2020**). The accountability level for the enforcement in the context of digital contact tracing are thus as follows

(Grant & Tan, 2013; Provan & Kenis, 2008; Wareham et al., 2014; Weitzner et al., 2008):

- **Voluntary:** Action are uncontrolled or enforced and the engagement is fully autonomous to engage or not.
- **Encouraged:** The encouragement for people to engage in collective actions
- **Nudged:** The active guiding to engage the people in collective action through incentives at the same time give the freedom to choose otherwise. (Thaler & Sunstein, 2009; Weinmann et al., 2016).
- **Mandated:** The forced governance where the people are controlled to engage in collective action through contracts, legal frameworks, technological designs, etc. Kai 2020 says this is the most successful approach in adopting the high user rate approach.

Adoption factors analysis for the contact tracing application in the the four South Asian countries

Hong Kong:

Application name: Stayhomesafe an application that was also liked to the wrist band monitoring the home quarantine –

Technology used: the geofencing technology

User Base:

Governance Approach:

Expected:

Gap:

India:

Application name: Arogya Setu Application

Technology used:

User Base:

Governance Approach: Democratic country where initially the application download was mandatory

Expected: Huges user baase to track each of the Covid Positives

Gap: Lack of guidelines and implementation, this includes lack of information in the privacy and its usage.

Singapore:

Application name: Trace together

Technology used: open-source – works on Bluetooth model and does not trace the location

User Base:

Governance Approach: democratic country. Citizens were encouraged to download an application

Expected:

Gap:

South Korea –

Application name: Corona 100m, Corona map

Technology used: the geofencing technology

User Base:

Governance Approach: been most aggressive in the use of smartphone location with its previous experience in MERS/SARS1

Expected:

Gap:

ANALYSIS

Governance approach: It has been seen that if once the trust of its citizen is conquered. in the opaqueness hence this time “most “preferred the public good to individual rights.” will find it easier to mandate and enforce contact tracing, as the public will be more understanding of its role in curbing the threat at hand (Yun, [2020](#)).This results showing South Kore’s application has one of the most successful under the head of governance approach. The adoption and the need of technology – mandatory or voluntary – As the Havard review writes the same might not go true with the western countries as there is a fundamental conflict between these requirements and deeply entrenched Western liberal values, such as the expectation of privacy, consent, and the sanctity of individual rights. Apart from the said strategy, the governance approach is highly influenced by the societal and cultural approach of the country (Hofstede, [1980](#), [2001](#); House et al., [2004](#)). This can be one of the reasons for the success of the contact tracing application as success in the Asian region in comparison to the west

Technology used: As Prades mentioned on how the technology “is not driven by the technical people, but instead by the users, by the operators.” Hence most of the country found this as the gap during the implementation of the tracing application, where without a national healthcare system, there’s no way to easily track tests or overall cases.

Gap: As evident in most of the case studies and with the news reports, A seamless data sharing between government and business that may afford privacy – when data is being shared by Private firms there is a high risk that they can be weaponized for future against an individual’s approval as is the case in China where the data of population movement of is more known to a private firm like Alibaba and Tencent than government.

CONCLUSION

There is no one aspect to the exercise that works independently but they work by reinforcing each other. As a summary Morley et al., 2020 mentions that the governments of countries in the cry of privacy have to alleviate it to maximize its user population base for the contact tracing application. As Havard Business review states, in the case of lack of widespread adoption, these contact tracing drives shall fail. And this maximizing user population will require a better governance approach at the individualistic level. Besides this, the paper contributes to understand the system of disaster-response infrastructure in the said factors that can be deployed for the critical in shaping the pandemic’s trajectory.

In the call of the governance, The nationalization of the activity as collectivism such as Asian cultures i.e China, India and South Korea (Chhokar et al., 2007; House et al., 2004), will be more accepting of mandated government action, said to be perceived in line with the public good. Collectivist societies (typical of many Asian countries) may then embrace even surveillance tracing which is against the western liberal thoughts and hence “unacceptable” in individualistic societies (typical of Europe and the Americas) due to privacy and individual freedom concerns (Wagner & Rogers, 2020). However, an article in Harvard business review on **“How Digital Contact Tracing Slowed Covid-19 in East Asia writes**, type of regime is less important than it might seem. Both the top and bottom performers in Covid-19 containment span the spectrum from autocratic to democratic.

The future is not limited to this contact tracing technology as we see, countries like China have got aggressive in the application of AI via its high-tech firm like SenseTime and Megvii that aim to use the temperature detection software. As SenseTime has already developed Smart AI Epidemic Prevention Solutions.

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COVID-19 effect on economy- comparative analysis based on GDP

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Abstract

Gross domestic product is the total monetary market value of all final goods and services produced by country in a given particular year. It is also consider as scorecard of the country's economic health. GDP helps in the identification of economic snapshot of country and facilitate to estimate the size of economic growth its growth rate for particular year. There are three ways to calculate GDP like using expenditures, production and income and it is considered as main aspect for policymaker, investors and businesses for strategic decision making. In this study researcher identified COVID-19 effect on GDP for selected nations because covid-19 considered as worldwide epidemic in the year 2019-20. For this study time period should be considered as 2013 to 2020 and most affected nations by Covid-19 would be selected for analysis. The major Findings of this study reveal United States, Spain and Italy are most affected nations by Covid-19 but significant impact on Italy would take to note in concern with GDP growth rate. All selected countries are indicated negative impact on GDP growth rate due to epidemic of Novel Corona Virus.

Keywords: GDP, Covid-19, Estimated, UNESCAP, WTO.

INTRODUCTION

The COVID 19 is developing destruction for the Indian economy. Due to the corona virus brought on lockdown is weakening the country's GDP increase in view that it's miles having fundamental disturbance throughout a couple of sectors. A highly-computerized manufacturing infrastructure will shop electricity and now no longer simplest decrease manufacturing costs, however additionally enhance quality. The ensuing discount in human operating hours will assist us preserve higher health, and could permit companies to hold on without interruptions have to a disaster hit again. Increased self-beliefs in technology, technical performance, and on line fee sectors are inflicting an alternate in customer behavior, far from conventional methods. This forces us to evolve to new trends, along with operating from home, and pass in the direction of a destiny that would be freed from brick-and-mortar places of work at massive. There could be a long-time period lower in enterprise tour because of the emergence of video-conferencing tools, with High Net really well worth Individuals who prefer to tour through non-public jet in place of exceptional air tour. Governments, enterprise leaders, and agencies will allocate greater budgets for making an investment in healthcare and healthcare merchandise after coming across the gaps within side the international device whilst preventing the corona virus. More tech start-ups will emerge with innovative applications. Central Banks have injected massive sums for economic establishments and supplied unparalleled exemptions that had been now no longer supplied before.

LITERATURE REVIEWS

(Alexander Chudik, Kamiar Mohaddes, M. Hashem Pesaran, Mehdi Raissi, Alessandro Rebucci, October 2020) The Covid-19 pandemic is remarkable in its international attain and effect, posing bold demanding situations to policymakers and to the empirical evaluation of its direct and oblique results in the interconnected international economic system. This column makes use of a 'threshold-augmented multi-united states of America econometric model' to assist quantify the effect of the Covid-19 surprise alongside numerous dimensions. The effects of the evaluation display that the worldwide

recession could be lengthy lasting, and not using a United States of America escaping its effect no matter their mitigation strategy. These findings name for a coordinated multi-united states of America coverage reaction to the pandemic.

(Dr. Kishore Kumar Das & Shalini Patnaik, May 2020) The gift pandemic state of affairs has negative deep effect on Indian commercial enterprise. Domestically, the effect of the corona virus pandemic COVID-19 ought to cause slowdown in home call for. This will bring about erosion of buying energy because of task losses or pay cuts and slow-down impact of deferred call for could have a longer lasting effect on unique sectors, specifically in which call for is discretionary in nature. India's actual GDP depleted to its backside in over six years in the course of 4Q 2019-20. India's boom for subsequent yr 2020-21 is forecasted in among of 5.3% to 5.7%.

(Fernandes, April 2020) has analyzed monetary results of corona virus outbreak (covid-19) on the sector economic system. In this file dialogue became made monetary effect of covid-19 disaster throughout industries and international locations and monetary channels thru which monetary pastime could be impacted. Due to this fundamental project for international coverage makers to have a coordinated coverage responses to the virus and its monetary influences. The fundamental dialogue at the file is that international locations with greater provider orientated economies could be greater laid low with this virus and feature greater task chance for its economic system. In this file end result recommended on common every extra month of disaster prices 2.5-3% of world GDP and monetary price of recession aren't similarly distributed.

(Hartley, April 2020) have studied at the price of covid-19: a hard estimate of the 2020 us GDP effect. In this examine they diagnosed the mitigation measures followed like partial monetary shutdown and social distancing will impacted heavy price on society that isn't always diagnosed. In this examine researcher diagnosed that effect varies with the aid of using industry, and they have been capable of degree effect however supporting with a few assumptions like industries will stay in commercial enterprise quarter in percentage to their diploma of digitalization. Further they did granular dataset spoil down at the extent of commercial pastime inside international locations, which beneficial to them to make GDP forecast at countrywide level. Researcher expected the actual GDP boom price will decline with the aid of using 5% for every month of partial monetary shutdown because of this that the monetary price of the primary months for combating the epidemic could be \$2.14 trillion.

(Warwick McKibbin, February 2020) have analyzed the worldwide macroeconomic influences of Covid-19: seven scenarios. They have been analyzed that the outbreak of corona virus named covid-19 has surprisingly effected on economic system and spreading worldwide. Due to covid-19 and its monetary effect is surprisingly unsure which makes it tough for policymakers to formulate the suitable macroeconomic coverage making in issue with economic system. In relation with recognize feasible monetary consequences this paper discover seven unique situations for the way covid-19 have an effect on in coming years. The fundamental locating of this paper display that even a contained outbreak ought to appreciably effect on the worldwide economic system. The scale of price is prevented with the aid of using extra funding in public fitness structures in all economic system and growing economies indicated fitness care structures are much less evolved and populace density is high.

IMPORTANCE OF THE STUDY

- This study analyze about Covid-19 based on GDP comparison.
- Based on GDP comparative study helps to take decision for future action plan.

OBJECTIVES OF THE STUDY

- To analyze effect of covid-19 on Gross Domestic product of selected countries.

HYPOTHESIS

H₀:- There is no effect of COVID-19 on Gross Domestic Product of selected countries.

H₁:- There is effect of COVID-19 on Gross Domestic Product of selected countries.

RESEARCH METHODOLOGY

Researcher analyzed all the data based on secondary data and after considering these authenticated journals, articles etc. done all the analysis of effect of COVID-19 on Gross Domestic Product of selected countries.

Secondary data are collected through:

1. Existing research in the related field
2. Journals
3. Books
4. Internet

The countries are selected basis on most influence of Covid-19 on particular nation and criteria of influence should be considered as number of cases in particular country. This study mainly considered selected countries like United States, Spain, Italy, United Kingdom, Russia, France, Germany, Brazil, Turkey and Iran. The period of the study have been considered as from 2013 to 2020.

Data Analysis & Interpretation

Table: 1 GDP Growth Rate in Percentage

Covid-19 most affected nations	2013	2014	2015	2016	2017	2018	2019	2020 Est.
United States	1.8	2.5	2.9	1.6	2.4	2.9	2.3	-5.9
Spain	-1.4	1.4	3.8	3	2.9	2.4	2	-8
Italy	-1.8	0	0.8	1.3	1.7	0.8	0.3	-9.1
United Kingdom	2.1	2.6	2.4	1.9	1.9	1.3	1.4	-6.5
Russia	1.8	0.7	-2	0.3	1.8	2.5	1.3	-5.5
France	0.6	1	1.1	1.1	2.3	1.7	1.3	-7.2
Germany	0.4	2.2	1.7	2.2	2.5	1.5	0.6	-7
Brazil	3.0	0.5	-3.6	-3.3	1.3	1.3	1.1	-5.3
Turkey	8.5	5.2	6.1	3.2	7.5	2.8	0.9	-5
Iran	-0.3	3.2	-1.6	12.5	3.7	-5.4	-7.6	-6

(GDP Growth Rate in Percentage)

Interpretation

Above Table indicated gross home product boom price of maximum affected Covid-19 international locations. The desk additionally indicated GDP boom price of decided on international locations from 2015 to 2019. These records allows to are expecting GDP boom price of 2020 and there are a few additionally elements which might be incredibly affected on it like Covid-19 and because of lockdown in decided on international locations and plenty of extra things. In the yr 2013 maximum GDP boom price 8.5% that is possessed via way of means of Turkey and lowest GDP boom price turned into -1.8% that is possessed via way of means of Italy amongst decided on international locations. In the yr 2014 maximum GDP turned into 5.2% possessed via way of means of Turkey and lowest 0% GDP taken via way of means of Italy. In The yr 2015 additionally maximum GDP of Turkey and lowest GDP of Brazil as 6.1% and -3.6% respectively. In the yr 2016 Iran indicated maximum percent 12.5% and lowest percent of -3.3% in Brazil. In the yr 2017 all of the international locations are indicated extra or much less comparable overall performance of GDP. In the yr 2018 and 2019 Iran indicated terrible GDP price is -5.4% and -7.6% respectively. United States indicated 2.9% and 2.3% GDP price for the yr 2018 and 2019 respectively and it's far the very best price for above aspect years.

During the look at length decided on Nations like United State indicated barely fluctuating fashion of 2019 in worried with GDP price and with inside the yr 2013 Spain indicated -1.4 % GDP price in a while it's far indicated superb fashion and with inside the yr 2017 maximum 2.9% GDP indicated via way of means of it however with inside the yr 2018 and 2019 it appears to be downward fashion like

2.4% and 2% respectively. In the yr 2013 Italy well-known shows -1.8% GDP however with inside the yr 2014 it might be stood at 0% method it's far expanded in GDP price in a while it seems like growing fashion besides the yr 2018 and 2019. United States indicated reducing fashion as much as 2018 however it the yr 2019 it turned into expanded 1.3% to 1.4% particularly yr. Russia well-known shows incredibly fluctuating fashion at some point of the yr 2013 to 2019. Trance well-known shows growing fashion from 2013 to 2017 however after that with inside the yr 2019 it might be reduced as much as 1.3 %. Germany well-known shows fluctuating fashion at some point of look at length of 2019. In the yr 2013 to 2019 Brazil indicated incredibly zigzag fashion amongst decided on international locations. The maximum GDP from 2013 to 2019 possessed via way of means of Turkey besides the yr 2019. Iran well-known shows majority terrible fashion at some point of look at length besides the years 2016 and 2017.

From 2013 to 2019 GDP records are beneficial to prediction and Identification of Covid-19 effect on maximum affected international locations in problem with wide variety of cases. It is regarded that Italy have incredibly affected in relation with GDP due to the fact the price of GDP will be -9.1% and 2d one is Spain due to the fact it's GDP price will be -8% with inside the yr 2020. Remaining decided on international locations like United States may have -5.9% GDP and United State, Russia, France, Germany, Brazil, Turkey and Iran may have GDP percent as -6.5%, -5.5%, -7.2%, -7%, -5.2%, -5% and 6% respectively.

Table: 2 Paired t-tests for impact of Covid-10 on selected Nations GDP

	<i>2019</i>	<i>Est.2020</i>	<i>df</i>	9
Mean	0.36	-6.55	t Stat	4.646896
Variance	8.173778	1.669444	P(T<=t) one-tail	0.000604
Observations	10	10	t Critical one-tail	1.833113
Pearson Correlation	N/A		P(T<=t) two-tail	0.001207
Hypothesized Mean Difference	0		t Critical two-tail	2.262157

Interpretation

Above table indicted paired t-test to know whether covid-19 impacted on GDP or not and results of above test indicated one and two tails *p-value is less than 0.05* which means *null hypothesis* should be rejected and stated that there is significant negative impact of covid-19 on gross domestic growth rate for selected nations.

FINDINGS

In problem with quantity of instances United States was relatively affected state from maximum ten affected countries however because of Covid-19 impact on GDP boom charge could be -5.9% withinside the yr 2020.

Italy has 1/3 maximum affected state from the phrase however effect on GDP boom charge could be taken into consideration as -9.1% that is maximum impact of Covid-19 on GDP boom charge however there also are different elements could be affected which aren't noted here.

The GDP growth charge of Spain could be -8% that is 2d maximum charge amongst decided on maximum affected countries via way of means of Covid-19 however in problem with impact of Covid-19 Spain is on Second function after United States.

France and Germany have 6th and 7th function in maximum affected international locations via way of means of Covid-19 and with inside the yr 2020 GDP boom charge could be -7.2% and -7% respectively.

United Kingdom has forth function in Covid-19 affected international locations and it's miles indicated -6.5% GDP boom charge could be with inside the yr 2020.

Russia, Brazil, Turkey and Iran have Fifth, Eighth, Ninth and Tenth function in maximum affected countries however GDP boom charge could be -5.5%, -5.3%, -5%, and -6% respectively.

Overall decided on international locations indicated terrible fashion because of Covid-19 impact on monetary sports of the international locations and United States is maximum affected state however barely low effect of Covid-19 on it and great effect of Covid-19 on Italy due to the fact GDP boom charge will -9.1% with inside the yr 2020.

With the assist of above statistics and evaluation it is able to state that Covid-19 have great impacted on GDP for numerous relatively affected countries.

CONCLUSION

COVID-19 has highlighted the environmental folly of 'extract-produce-use-dump' monetary version of cloth and electricity flows. Short-time period rules to deal with the urgency of the pandemic are not going to be sustainable fashions within side the lengthy run. Nonetheless, they shed mild on vital problems that deserve emphases, which include the clean hyperlink among environmental pollutants and transportation/industrialization. The position of unrestricted air journey in spreading pandemics specifically the viral influenza types (of which COVID-19 is one) isn't always in doubt, with sectors like tourism and aviation being walloped (a few airways might also additionally in no way get better or go back to profitability in a protracted time) because of decreased passenger volumes. The fallout will re-form the aviation sector, which like tourism has been some of the toughest to be hit economically, albeit with suited consequences for the discount in unfavourable environmental impacts. Peer-to-peer (P2P) or sharing financial system fashions (e.g. Uber, Airbnb) that have birthed a brand new technology of provider vendors and personnel are discovered to be non-resilient to international systemic shocks.

Going forward, resilience wondering ought to manual classes learnt and improvements emanating from round wondering ought to goal the overall wellbeing of the population and now no longer simply recognition on boosting the competitiveness, profitability or boom of agencies and countrywide economies. The post-COVID-19 investments had to boost up closer to extra resilient, low carbon and round economies ought to additionally be included into the stimulus applications for monetary recuperation being promised through governments, because the shortcomings within side the dominant linear monetary version are actually identified and the gaps to be closed are known.

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Strategies to Overcome the Psychological Impact of Work from Home during COVID-19 Pandemic: A Case Study

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Abstract

This study aimed to explore the psychological effect on employees who were forced to work from home during the Covid-19 pandemic in India. The study focuses on challenges the respondents faced during such unexpected situation and control imposed by government of India during the period of pandemic. A telephonic semi-structured interview was used to collect primary information from few working employees working in various fields and data collected was then analysed to support the case study. The study identifies various strategies utilized to overcome the psychological impact and stress due to unplanned work from home situation for a longer time period.

Keywords: Covid-19, Work from home, Stress.

INTRODUCTION

The COVID-2019 has been identified as the cause of an outbreak of respiratory illness in Wuhan, Hubei Province, China beginning in December 2019. In December 2019, Wuhan a city in China experienced an outburst of a novel coronavirus (Kaur, 2020). Given its devastating impact thus, a public health emergency at national and international level has declared and the extraordinary measures have taken by the governments to prevent the contamination and limit the outbreak.

With regards to the prevention and intervention of the COVID-19 and related issues, after it achieved its pandemic status, World Health Organization has issued guidelines for managing the problem and steps to stop the spread of Covid-19 (Kaur, 2020). On 24 March 2020, the Prime Minister of India, Narendra Modi, appeared on TV at 8:00 pm and announced that from midnight the whole of India would be under a lockdown (Chattopadhyay, 2021). WFH would gain acceptance in India post COVID-19 and also many corporates are now including this option in their HR policies.

Work from home, a phrase commonly used since the onset of COVID-19, can be defined generically as employees working outside company offices. It includes four basic characteristics: (1) a person who is an employee of a company or a staff member of an organization; (2) actual work engagement with a company or an organization on specific tasks; (3) work being performed outside the company's physical premises; and (4) telecommunication with the employer (Savic, 2020). The hard reality of the impact COVID-19 has had on the economy and people's livelihoods has brought the concept of digital transformation into focus. This has especially been the case for the hard-hit workforce. Because WFH has become inevitable, new work models have had to be quickly developed and deployed. (Savic, 2020). The impact of COVID-19 on the workforce is visible on multiple levels. This includes a change in the nature of work, its variety, volume, velocity, and value. Digital transformation is more than just the implementation of a new technology. Also, there are many psychological impacts of covid-19. There is anxiety among people, some are getting panic attacks or are even depressed (Kaur, 2020).

METHODOLOGY

In this study, a qualitative research design was employed. It allows the investigation and understanding of respondent's responses through directly dealing with their issues in depth. Based on this concept, a researcher used the phenomenological approach of the qualitative methods. This

research is an exploratory case study and the sample was selected using the purposive sampling method. There is no limit to the number of respondents to make a purposive sample, provided the desired information can be obtained and generated (Bernard, 2002). To conduct a case study research, Creswell (2013) provides observations and several sample size recommendations, which range from no more than four to five cases (Purwanto et al., 2020).

Having the primary purpose of exploring the living experiences of individuals from different sectors related to COVID-19, the psychological impact and the ways to cope with stress and anxiety, the findings would contribute to fill the gaps in the literatures and suggesting practical solutions in the area of the psychological effects of working from home in relation to COVID-19 pandemic. To achieve this purpose, the study's basic research questions therefore were designed as below.

RESEARCH QUESTIONS

- What are the major work from home challenges described by the participants?
- What are the coping strategies used among these participants to respond to COVID-19 and work from home challenges?

MEASURES

In this study, based on the research questions, semi-structured interview was used. It is a form of qualitative research tool where questions are asked about people's perceptions, attitudes, beliefs, opinion or ideas. In this type of interview either all of the questions are more flexibly worded or the interview is a mix of more and less structured question. But most of the interview is guided by a list of questions or issues to be explored, and neither the exact wording nor the order of the questions is determined ahead of time. In addition, the researcher has used documents, journals, and research papers published and unpublished materials as secondary source for the accomplishment of this study. Interviews were conducted through telephone due to Covid situation. All interviews were held in the agreed upon time according to the informant's willingness. Before, conducting an interview, the participants were contacted to get their consent to participate or not to participate in the study and to explain the purpose of the study in detail. The interview with eight (8) individuals was conducted in this study. The interview sessions were conducted by the researcher himself and each session was lasted for about 30 to 45 minutes. The total of eight participants with, 5 (62.5 %) male participants and 3 (37.5%) female participants were participated in this study. Accordingly, interviews were conducted to comprehend the ways in which participants view issues related to work from home during and post COVID-19. The collected data to answer the research questions was qualitatively analysed. All interviews were transcribed verbatim.

DISCUSSION

Dr Patel(P1), Director in a prestigious academic institute offering various graduate and post graduate management courses in India. She has been working for 25 years in the industry has worked as consultant on several projects in the area of Branding, Tourism and Advertising apart from teaching. she is a very dedicated and an asset to her organization. She is well-motivated, has a great personality, and is well-qualified in her educational background. Her experience and dedication had enabled her to reach her current position as a Director. Ms Patel embraces a very demanding job responsibility in the organization where she coordinates the team of teaching and non-teaching staff.

The Covid19 pandemic had also forced all academic organization to comply with the lockdown policy. This compelled Ms Patel to move towards the unique experience of working from home. This unexpected change had imposed a huge challenge on her psychologically.

P1:

“In our conversion from offline to online, we continued to focus on the needs of the students and adapted towards innovative methods to engage students in the online sessions. We believe that being in the education sector is not merely a job but is responsibility for shaping the students to become successful professionals and also better citizens. Since the college campus closed from the third week

of March 2020; 1) Our campus was given to volunteers who prepared food packets for distribution 2) Our students created positive videos to spread the message of being positive which we uploaded on social media. 3) Our senior students took it upon themselves to guide first year management students.”

“The institute has worked on the philosophy of being for the students, by the students and of the students and whether we are in the offline or online space, we have always attempted to never leave our focus from the comfort and safety of our students.”

The Covid19 pandemic had also forced her organization to comply with the lockdown policy. This compelled her to move towards the unique experience of working and teaching from home. This unexpected pressure had imposed a huge challenge on her psychologically.

She stated that ever since she started her career in teaching never has been such situation wherein teachers are required to teach absolutely online in higher education institutes. She confessed using online platforms and training the teaching and non-teaching staff for various online teaching platform was a challenging task. Never faced such situation before, neither the organization nor she was prepared for such transition of going digital.

Her experience indicated stress and anxiety due to major changes taking place in teaching and administration. One of the major issues faced by the organization was infrastructure for online teaching.

Moreover, she is also mother of two children. This added the responsibilities on her shoulders. The schools in India were also conducting classes online. As a result, she had dual responsibility as an employee and as a mother to ensure work life balance. To enable her to function well in operating her job responsibilities, she worked for extended hours in a day. This caused her more stress, exhaustion, and finally burn-out.

Mr Jathal (P2), Founder of Client First offering Financial Planning and Wealth Management Services in India. He has been working since 2018 in the industry. He is a very meticulous and devoted to his work. He is well-motivated and is well-qualified with academic qualifications like MBA and CFP. He has good influencing skills, has a workaholic nature and is a self-motivated person.

His normal work hours were 7 days a week and 12 hours per day which did not changed post pandemic.

P2:

“The current situation post Covid 19 has not impacted my workhours. Face to face meeting were impossible because of the coronavirus. I had to conduct webinars and use conference calls or video calls to interact with clients. As a result, I felt lots of stress and anxiety.”

Ms Niyati (P3), Founder of Client First Holidays has work experience in the field of tourism for more than 10 years and has started her own firm since 2018. She has completed her bachelors in business administration and master’s in business management. She describes herself as a positive person and a go-getter. She is a one-woman Army of Client First Holidays- taking care of Sales, Marketing, Back office, Query handling, Negotiations and Content development. In short everything related to a business is done by her. She works for 8-9 hours per day and 6 days in a week. Being mother of a child she has addition responsibility of her child.

P3:

“Travel industry was one of the worst hit industry during the lock down so for 3 months till June 2020 there was almost NIL work. One of the biggest challenges for the travel industry was managing cancellations and refunds. As a travel agent we can refund the guest only if we get it from the hotels, transport vendors, etc. There was a big liquidity crunch on the travel sector as a whole and a lot of money was blocked.”

Many people who were working in travel domain have shifted to alternate careers in organic farming, food and beverages, laundry business, etc to keep their homes running. But Ms Nyati was

determined to continue with her work despite of such bad phase never seen before. She had faced lots of pressure and anxiety due to such unplanned changes in the industry.

“One more big challenge once the UNLOCK began was deciding which hotels are genuinely following covid hygiene and safety precautions and then promoting them. People are now asking for branded hotel chains like Ananta, Fern, Taj, Lalit etc because they perceive that these are renowned hotel chains and so safety and hygiene will be taken care of. These hotels are also promoting safety and hygiene through videos, images, guest feedbacks, etc.”

She had personally used this time in doing a lot of content development in terms of making packages, searching new places of travel, making attractive social media creatives using free online software like Canva. She also took some proactive measures to control customer anxiety towards their cancelled bookings and refunds. Instead of clients chasing her during this critical situation, she decided to chase clients to keep them informed about the current scenario. She stayed in regular touch with all the clients over a concall/video call to update them about the Covid situation in different parts of the world and how situation could spread out across India. she realized that in all pursuits, it's prudent to stop and take a step back in order to go forward. She also encouraged them to make early cancellations as a precautionary measure rather than adopting a wait and watch policy.

Dr Rao (P4), a very senior associate professor of a very reputed management institute has vast teaching experience of more than 20 years. She had earned her doctorate in management with BE and PGDM as her academic background. She has been conscientious with respect to personality and has above average motivation levels. When working at home, teachers can create a safer, more comfortable and conducive atmosphere on one hand whereas one of the disadvantages of Work from Home is that someone can lose work motivation. Also teaching online from home requires knowledge of various platforms and technical knowhow.

P4:

“One of the major challenges faced during the pandemic was no domestic help. The shift to online education has meant rethinking lesson plans to fit a very different format. Also losing that personal interaction is one of the most difficult aspects of online teaching. Other than the technological issues various other hurdles faced during online classes were figuring out online class etiquette.”

Lack of internet facilities to the students, difficulty to follow up the learning of students are the major challenges faced. Adapting to technology took time for everyone. In this situation, the teacher's role was challenging. Besides, teaching online, they also had to support students to *Lack of internet facilities to the students, difficulty to follow up the learning of students are the major challenges faced.* Adapting to technology took time for everyone. In this situation, the teacher's role was challenging. Besides, teaching online, they also had to support students to complete assessments and tests.

Mr Amit, Layer and Partner at Dave Associates has been practising at High Court since 2008. He has completed his Bachelor of Business Administration and LLB. He has a strong belief that an individual's demeanour talks more about the attitude he or she carry towards various aspects of life and he is no exception to it. Having been brought up around a well-educated family his mind was well occupied with studying well and ultimately joining the bar as a lawyer since he saw his father working tirelessly for the litigants. That always motivated him to join litigation practice without emulating his mentor and rather have his own carved out way towards work which has helped him stay motivated throughout his years in practice. He also gives credit to his dynamic nature of work where no two cases are same which makes him feel challenged right from the time, he was naive to now being an experienced litigation lawyer.

P5:

“During lockdown the High Court and Supreme Court came up with a wonderful initiative of hearings through Zoom platform which is well managed by the IT department of the courts and

we are still not functioning physical hearings so the system is still helping us appear before Courts in a virtual manner. There has been a significant decrease in the amount of work owing to Covid-19 pandemic and that has affected the work hours as well. I prefer to meet clients virtually and most case papers are scanned and send by them which helps us to E-file the petition at times. Work hours are flexible now since we are at luxury to argue before courts from Home or Office chambers”

Since he is primarily in litigation practice, the nature of work involves preparing and researching for the cases coming up for hearing which helps to come over many intricacies. The first and foremost step is dealing with the clients and getting as much as relevant information about his case since at times they act cagey and try to withhold information. Even before the Judge hears a lawyer, he would read the case papers and henceforth drafting the petition is of equal importance as hearing. In normal course they handle the clients and back-office work post court hours that is from 5 to 7 in the evening and otherwise most time is spend inside court premises. Covid led to online work from home which he had never imagined.

“I had appeared before a Judge through zoom platform and after some arguments the matter was adjourned to next week. That Hon’ble Judge was infected with Covid-19 on the next day and he succumbed to it before even the matter could come up before hearing. It was first instance of any Sitting High court judge to have succumbed to this virus. These painful experiences on work front will stay with me.”

Stress during lockdown and covid period is a state of mind experienced by one and all throughout the world. While the reasons might be different the mindset of many went through tough times. I noticed myself being a victim of the same and decided to divert my frustrations to achieve something better. I made a routine and followed it with utmost discipline.

“I made a routine and followed it with utmost discipline. This included having food on time and getting better sleep. I tried my hand in making different dishes and also had luxury of my gym to workout. Any state of mind is temporary and so was this period which passed away and we are now looking forward to ostracise this virus for all times to come”.

Mr Ruchir (P6) is Vice President of KCS for 8 years. He has done his BBA and MCA. He is friendly and a self-motivate person. His primary responsibilities include Business development, account management, strategy planning, team management. His work has increased a lot post Covid 19. During Covid 19 he had worked from home due to which he felt lonely and was missing the routine office hanging out with colleagues. He felt face to face siting with the team leads to completion of work much faster. Work life balance was a major issue faced by him.

P6:

“As work hours were extended, there was lot of pressure and stress which also impacted my personal life. I started spending more time with family during weekends. Exercise helped me to maintain my fitness levels. I learnt lots of new things in life post this pandemic.”

Mr. Dave(P7), Managing Director Siamp India Pvt Ltd. Takes care of over all management since 2014. With a huge experience in the area of sales and marketing he has reached to this position where a pragmatic motivation is required along with lots of travelling worldwide. He has amicable personality and is highly motivated towards his work and organization. The major challenge as faced by him was coordination which was more difficult while working from home as compared to workplace. His being a manufacturing unit, work from home was not feasible in many activities. Travel stopped even what was absolutely necessary. This resulted in increased pressure and apprehension.

P7:

“Think Less. Short Term Planning and Goals, Meditation and Yoga were few things that help me during this tough period to deal with unplanned and uncertain situation like this which I had never seen before”

Mr Desai (P8) an Intern at reputed chain of hotels in Pune, said While it is good that he will be at least able to complete his internship, it won't be the same as a physical office. Summer internships for college students are essentially a first step into the corporate world and an opportunity to learn how a professional workplace function. While companies are trying to use the online medium to deliver a similar experience considering the pandemic, students will lose out on being physically present in an office setting. They need access to necessary technology and strong internet connection to perform their task.

P8:

“Oh God, COVID-19 switched off all social interaction. Visiting close friends and family member face to face was difficult. I missed my gatherings. Generally, I feel my lifestyle in every aspect has disturbed.”

Internships in hospitality and tourism critically develop students' workplace skills, essential to employment in the work domain. Such skill-based learning outcomes assist the learner in blending theory with actual workplace experience. Furthermore, student interns learn to interact with customers and managers, develop the will to take initiative and basic obligations such as punctuality, self-confidence and social interaction. While there have been other health pandemics that have affected the global economy, the hardest-hit sector by the coronavirus pandemic is the hospitality and tourism industry.

“The student must also have self-discipline and be able to motivate themselves without the presence of a teacher or supervisor or similar interaction. A highly motivated self-regulated learner has a much better chance of learning. Skill is required in developing a rich online environment to attract and stimulate students”

Hence the major challenges as faced by various respondents include

- Work Life Balance
- Anxiety and Stress
- Technology and Knowhow
- Reduced Concentration and Focus
- Domestic help
- Multitasking

The strategies adopted by them to cope up with such challenges were:

- Spend time with family
- Kitchen garden and terrace farming
- Follow passion - gardening, reading, birdwatching, listening to music, or online volunteering
- Exercise to maintain fitness
- Yoga and Meditation
- Explore kitchen and Cook different dishes
- Extensive use of social media to connect with friends, family and clients
- Short term planning and goals

- Set schedule and prioritize
- Dedicated office space at home

LIMITATIONS & FUTURE SCOPE

Considering this current health crisis will most likely have long lasting effects (Liu et al., 2020; Sun et al., 2020), follow-up studies are needed to obtain a clear picture of the magnitude of the psychological impact of COVID-19 pandemic. The current study was limited in generalisability by the small qualitative sample. It would be further beneficial to consider how the competencies for work from home can be further developed to support an individual's quality of work and non-working life. The impact of work from home on mental health should also be further investigated in various sectors in order to develop preventative and protective practices.

CONCLUSIONS

Work from Home has become a policy priority for most governments worldwide to cope with the pandemic. In doing so, the policies must be made keeping in mind the practicality for both employers and employees as there will be some consequences for the two groups in one way or another. This paper has provided a tiny window into looking at how few employees working from home had to endure various issues such as IT technical issues, sharing workspace with family, and having distractions while maintaining her mental wellbeing. With longer work hours and a work from home set-up during the COVID-19 pandemic, a large percentage of individuals in India have been negatively impacted in some form or the other due to the work-life balance becoming worse. Every aspect of our lives, from wellbeing to work, and everything else in between, will be massively disrupted in the coming years. Work from Home in the COVID-19 era seems to have many negative consequences on workers' life domain. Nonetheless, through the time of the pandemic, new style of working has reshaped the traditional ways of work. It is very important for all of us to understand that the new normal, or next normal in the post-COVID era will be shaped more definitively by technology than any other force in the global theatre today.

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Impact of Covid-19 on the Financial Performance of Selected Pharmaceutical Companies: An Indian Perspective

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Abstract

Pharmaceutical industry is in the limelight after covid-19. This paper will examine the financial performance and market share of top 10 pharma companies of India. The financial performance of Indian top 10 pharmaceutical companies would be analyzed before covid and after covid. The pharmaceutical industry after the launch of covid vaccine have taken all together a different turn as far as the Indian market is compered. The paper also focuses upon analyzing the market trend and forecasting the financial performance of the companies. Handsome amount of money went into R&D and the core supply chain and data management have become a major question for them. The pandemic is still on its high and pharma companies still must respond and thrive.

Keywords: Financial performance, Pharma, Generic medicines.

Introduction

India is a growing economy and with increased population and changing the health conditions there are chances of high demand of medicines in coming years. India in a way have a huge market for all the global pharma companies. The biggest advantage is that India has many pharmaceutical companies who can match this supply of medicine in India. So, we have our own growing pharmaceutical Industry. So many Indian companies would be the potential thread for all the global competitors. As the growth of Indian pharma companies is taking a high, they have become the pioneers of supplying the generic medicines as well as vaccines.

Objectives

1. To measure the profitability of top 10 pharma companies in India.
2. To compare and analyze the profitability of selected Indian pharma companies before and after covid-19.
3. To study the impact of Covid-19 on selected Indian pharmaceutical companies.

Literature review

Simon Friend et al, India's domestic pharmaceutical industry was worth around US\$11 billion in March 2009 and PwC estimates it will rise to approximately US\$30 billion by 2020.⁴³ The domestic market is very fragmented; more than 10,000 firms collectively control about 70% of the market.⁴⁴ Many of the local players are generics producers specializing in anti-infective. India's appeal is growing rapidly in a number of respects. It has long been a formidable player in pharmaceutical manufacturing, but its socio-economic strengths provide even greater grounds for optimism. If the economy outpaces that of every other emerging country for the next half century, as many commentators expect, large portions of the population will be able to afford modern medicines. India's increasing scientific expertise will also equip it to play a significant role in researching and developing those drugs.

Nikita Jadav et al. (2020), studied the role of Indian pharma industry towards pandemic. The COVID 19 flare-up has additionally commenced the Indian pharmaceutical organizations an opportunity to

transform into a supported trade place point for gathering drugs and intermediates. An enormous pharmaceutical industry in India has consistently been a foundation of reasonable human services, and this pattern would now be able to be required to heighten further.

Rashmi Mabiyan, (2020), the impact on the cash flows has led many of the companies in the pharma sector to impose a freeze on the hiring process. Currently, no layoffs have been considered by companies and further decisions on increments are yet to be finalized and have been put on hold. However, unlike the other industries, the pharmaceutical industry is expected to see a positive impact, on an overall basis, on its growth in this year. The market expectations are on similar lines as indicated by the stock prices which for many pharma companies had risen by 20-30% in Apr'20 compared to the Q3FY20 period. The situation will vary with the portfolio and size of the companies.

Some very small companies may find themselves under stress and could become a source of the additional capacity that the larger players with deeper pockets are looking at. Some companies that are seeing increased demand for their portfolio and have also started incentivizing employees especially in the production function who are supporting plant operations during this COVID period. However, like all others, pharma companies too are deploying methods of “trimming the fat”, revisiting capital expenditure, looking at renegotiating rentals, looking for new sources of incomes from owned assets as well as using digital mechanisms for meetings and conducting business.

Research methodology

Research Design: Analytical Research

Population elements: Indian Pharmaceutical companies

Sampling units: companies of Indian Pharmaceutical Industry

Sample size: Top 10 companies of Indian Pharmaceutical Industry

Data taken for the period: Before Covid 1 year (2019) and after Covid 1 year (2020)

Data collection: Secondary data analysis

Data Analysis tools: Paired sample T test

Data Analysis

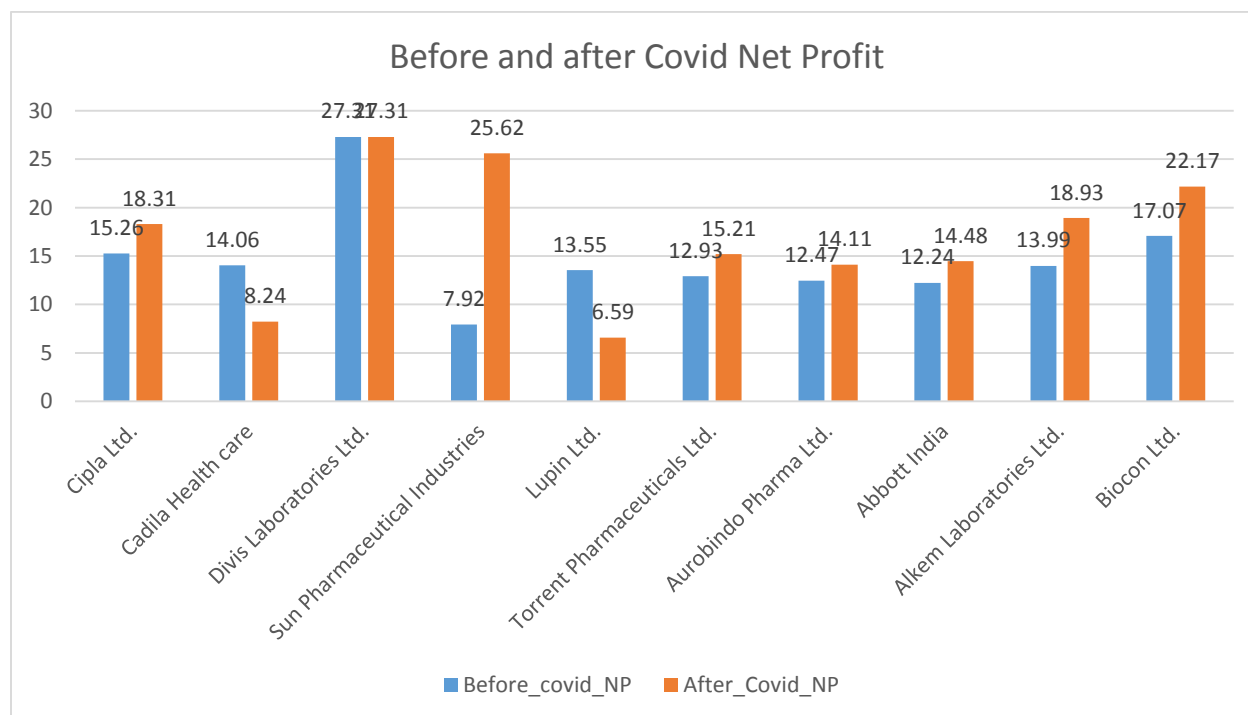
Table 1: Before and after Covid-19 Profitability Ratios

Company	NP		ROE		ROCE		ROA		ATR	
	Before	After	Before	After	Before	After	Before	After	Before	After
Cipla Ltd.	15.26	18.31	12	13.3	15.63	16.9	10.3	11.36	67.18	62.03
Cadila Health care	14.06	8.24	17.8	11.3	16.02	14.3	7.87	4.96	56.06	60.17
Divis Lab	27.31	27.31	19.1	18.8	25.48	23.9	16.6	16.12	60.69	62.37
Sun Pharma	7.92	25.62	3.57	13.2	10.12	13.5	2.16	8.36	27.31	32.62
Lupin Ltd.	13.55	6.59	8.98	4.16	15.36	10.3	7.81	3.51	57.67	53.31

Torrent Pharma	12.93	15.21	14.9	18.3	15.84	18.2	6.19	7.87	47.91	51.78
Aurobindo Pharma Ltd.	12.47	14.11	13.5	14.4	19.25	19.9	8.43	9.58	67.57	67.91
Abbott India	12.24	14.48	22.4	24.4	33.64	30.5	15.3	16.71	125.1	115.4
Alkem Lab	13.99	18.93	14.6	20.1	17.29	21.1	11	13.88	78.35	73.34
Biocon Ltd.	17.07	22.17	6.92	5.85	4.91	5.13	5.97	5.3	35	23.92

The profitability ratios like Net profit ratio, return on equity, return on capital employed, Return on Assets and Asset turnover ratios of 2019 (before covid) and 2020 (after covid) is taken in to consideration. The ratios seem to be improving in most of the cases. Only the profitability of Cadila and Lupin ltd seems to be decreased in 2020.

Fig 1: Before and after Covid-19 Net Profit of selected companies

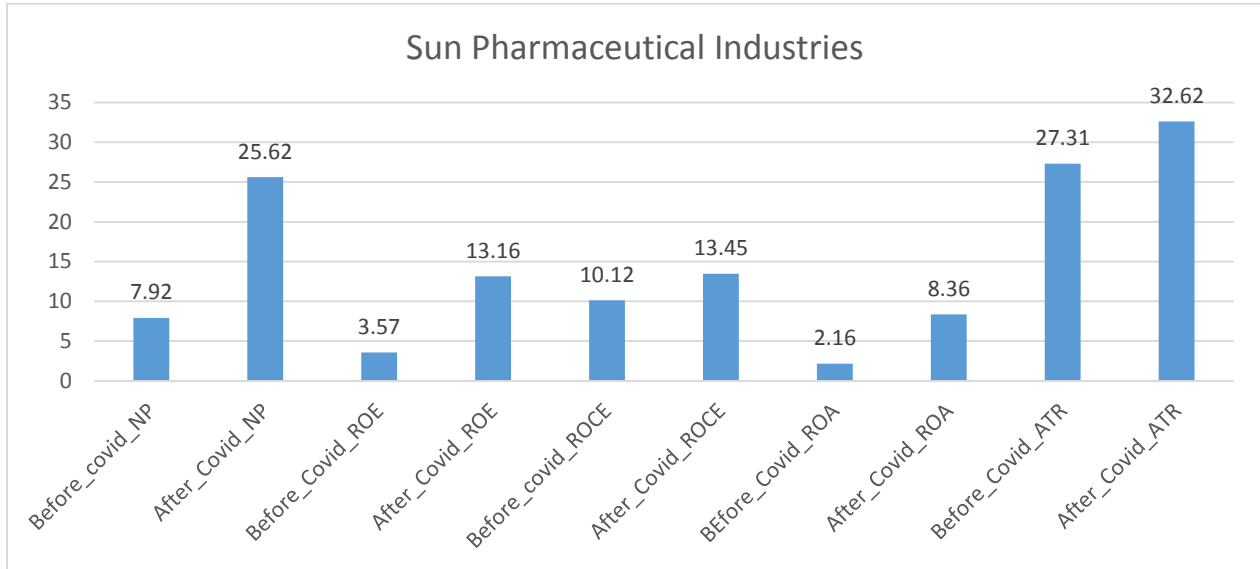


From the above chart it can be seen that the Net profit of Cipla, Sun pahrma, Torrent Pharma, Abbott India, Alken Laboratories, and Bibcon show an increase in the profit whereas Cadila Health care and Lupin Ltd shows a down fall in their net profit in 2020. Divis Laboratories seems to have not much difference in their net Profit over this two year of before and after covid period.

Out of all 10 companies Sun pharma seems to have good numbers as far as profitability is concerned. There is a huge jump in their net profit from 2019 to 2020. All the other profitability ratios also seems to have a positive increase which is a good sign and witness the positive growth of company and industry as a whole.

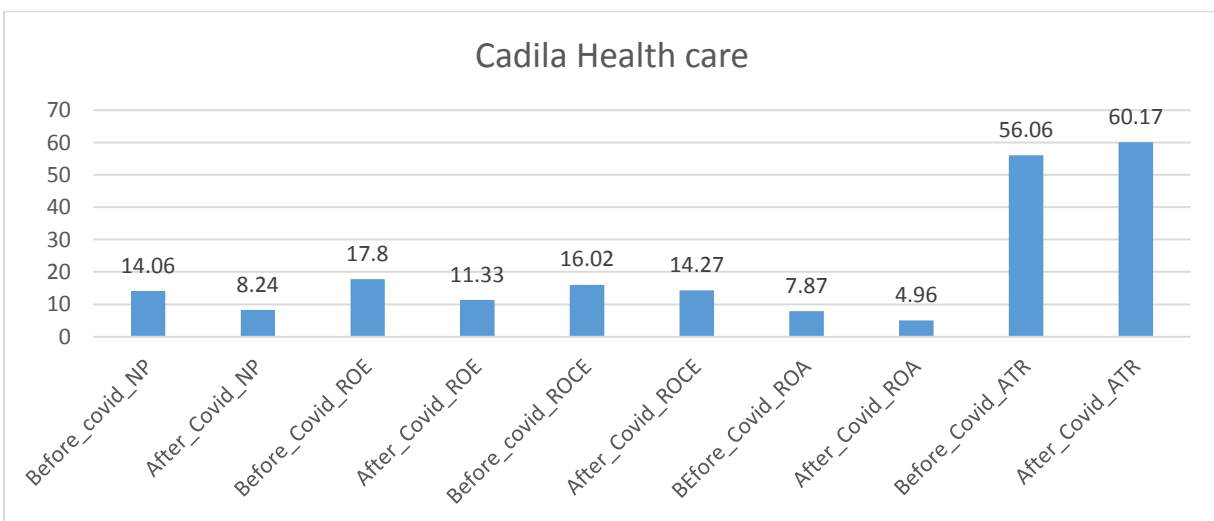
Mr. Dilip Shanghvi, Managing Director of the company said that “their endeavor will be to gain market share in each of our businesses by doing better, despite the near-term uncertainties related to COVID-19.”

Fig 2: Before and after Covid-19 All Profitability ratios of Sun pharmaceutical Industries



On COVID-19, the company said that the pandemic has resulted in most countries imposing lockdowns on almost all economic activity, temporary bans on travel and transportation, restrictions on people-to-people physical contact and closure of business operations for most of the industries. The pharmaceutical sector, being a supplier of essential items, has been relatively better-off compared to most other industries. "Despite our proactive COVID risk response initiative, we do estimate some softening of sales in the near term due to the lockdown and stocking up by customers, although it is difficult to quantify the impact as of now. Our endeavor will be to ensure that we are least impacted," the drug maker said. [8]

Fig3: Before and after Covid-19 All Profitability ratios of Cadila Health Care



Cadila Health care seems to have a tough time during this pandemic as their profits have gone down in 2020. Not only net profit but their return on equity, return on capital, and return on asset have gone down. They have made good use of their asset and their asset turnover ratio have slightly improved. That clearly means that they are managing their existing assets efficiently.

Fig 4: Before and after Covid-19 All Profitability ratios of Cipla Ltd.

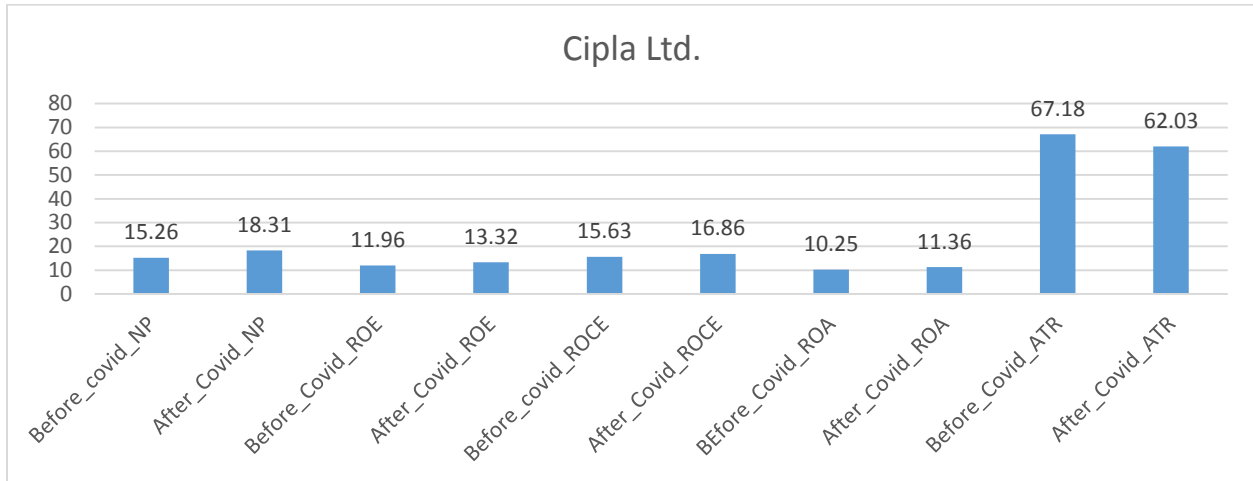


Fig 5: Before and after Covid-19 All Profitability ratios of Divis Laboratories Ltd

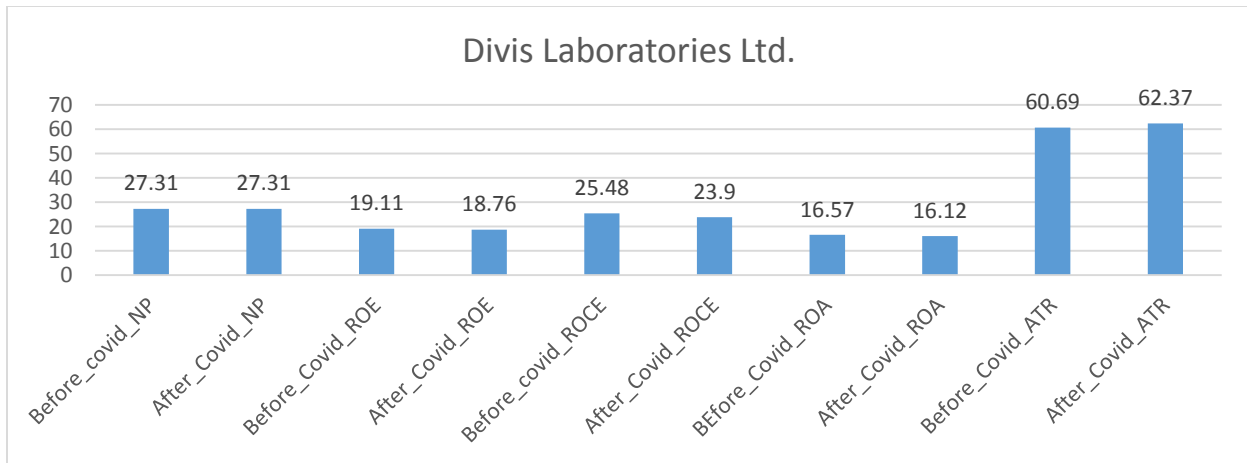


Fig 6: Before and after Covid-19 All Profitability ratios of Lupin ltd.

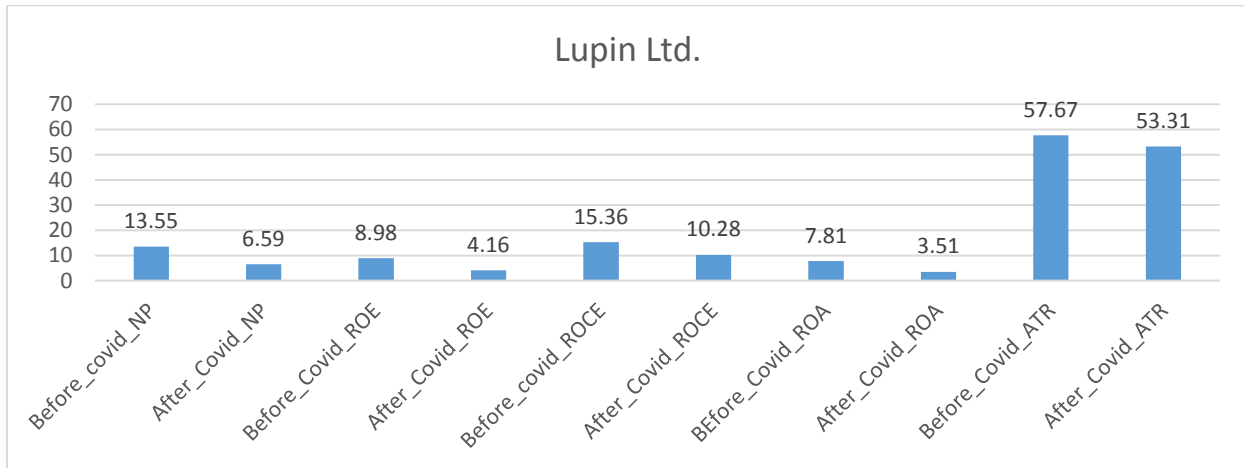


Fig 7: Before and after Covid-19 All Profitability ratios of Torrent Pharmaceuticals Ltd.

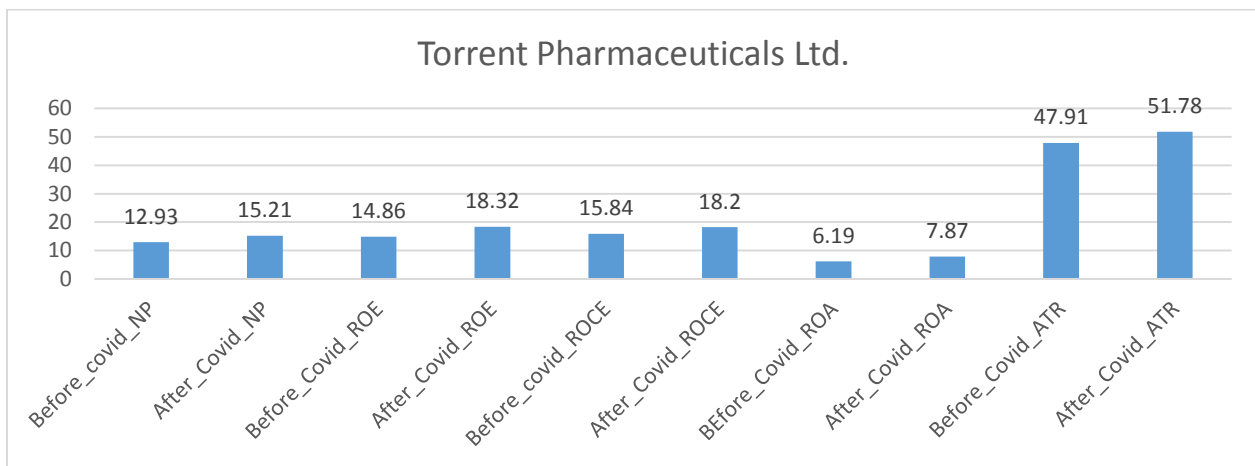


Fig 8: Before and after Covid-19 All Profitability ratios of Aurobindo Pharma Ltd.

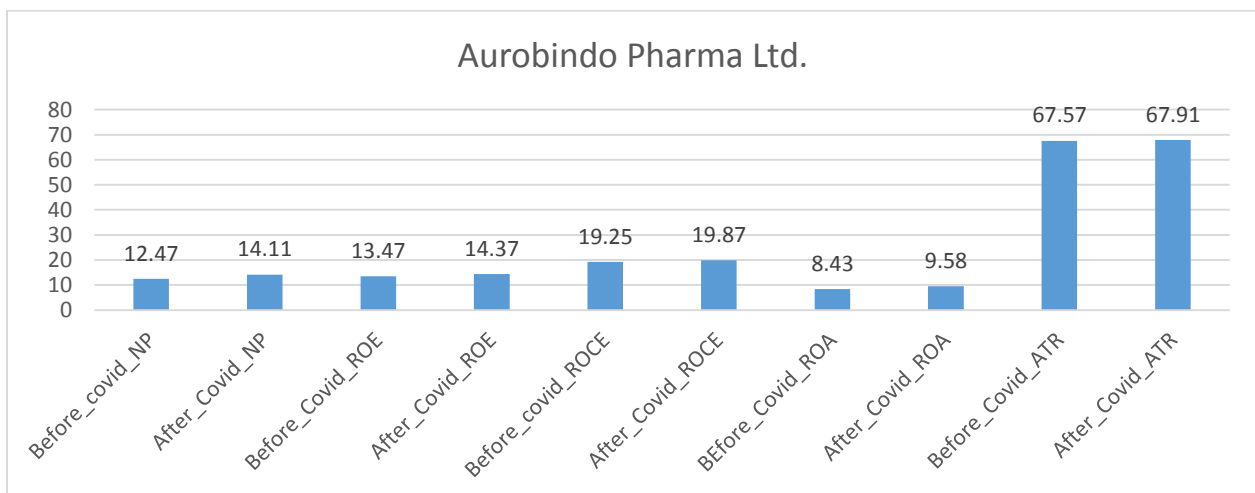


Fig 9: Before and after Covid-19 All Profitability ratios of Abbott India

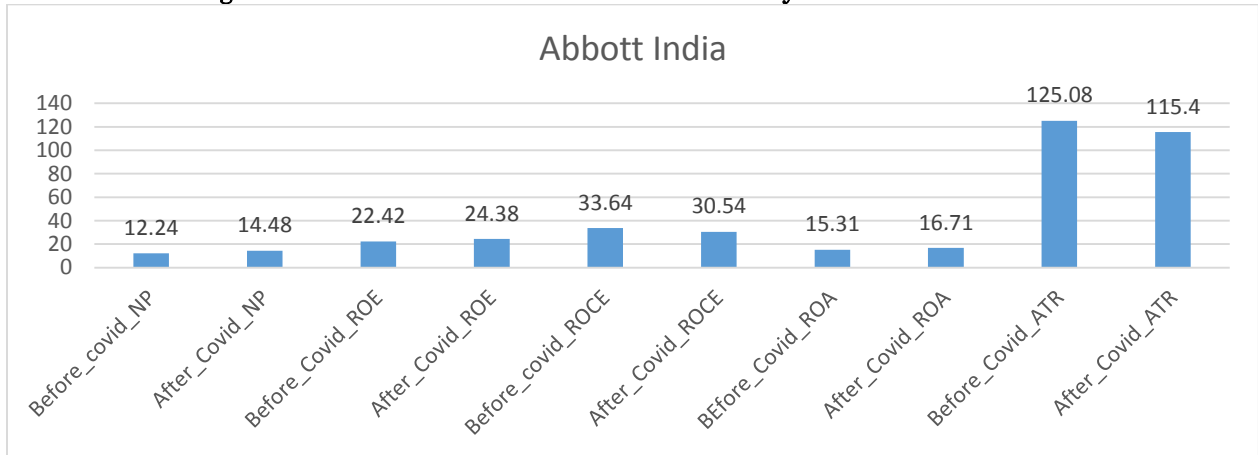


Fig 8: Before and after Covid-19 All Profitability ratios of Alkem Laboratories Ltd.

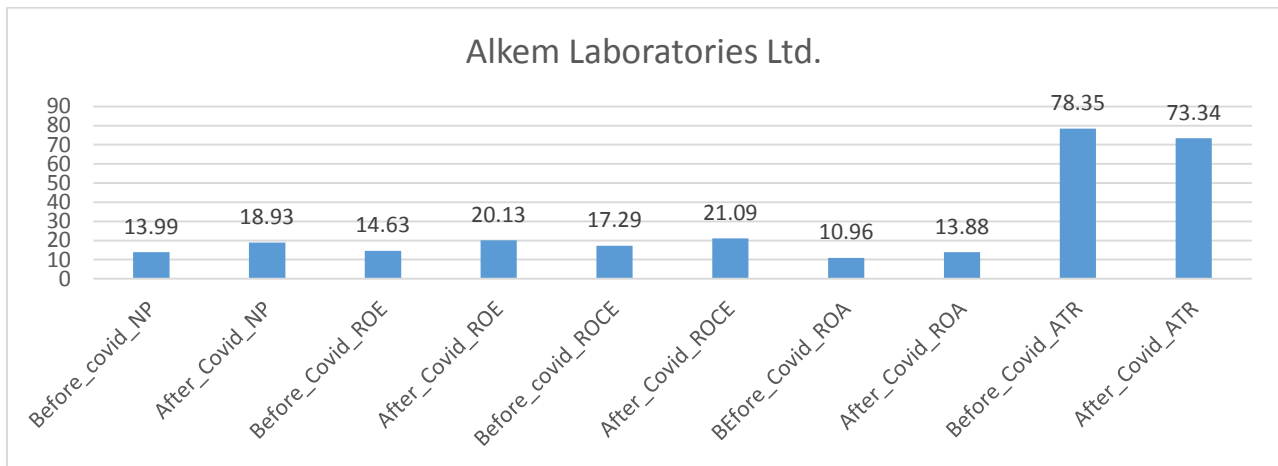
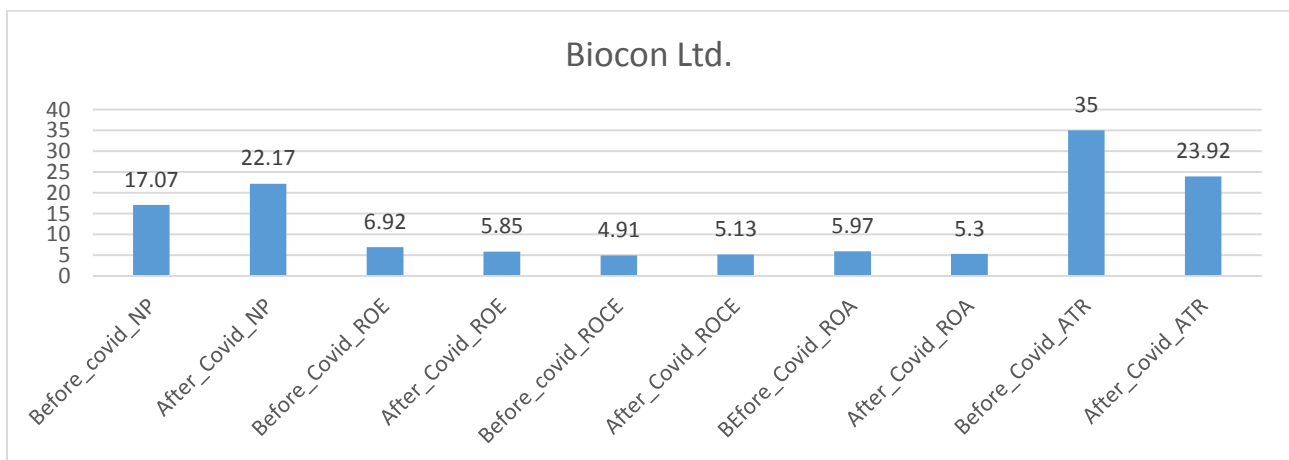


Fig 8: Before and after Covid-19 All Profitability ratios of Biocon ltd.



Hypothesis Testing:

H₀: There is no significant difference in the profitability of selected pharma companies before and after Covid-19.

H₁: There is a significant difference in the profitability of selected pharma companies before and after Covid-19.

Table 2: Paired Sample Test

Paired Samples Test

		Paired Differences				t	df	Sig. (2-tailed)	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower				Upper
Pair 1	Net Profit - Net Profit	-2.41700	6.74790	2.13387	-7.24415	2.41015	-1.133	9	.287
Pair 2	Return on equity - Return on equity	-1.00600	4.67774	1.47923	-4.35225	2.34025	-.680	9	.514
Pair 3	Return on Capital Employed (%) - Return on Capital Employed (%)	-.00500	2.86781	.90688	-2.05651	2.04651	-.006	9	.996
Pair 4	Return on Assets (%) - Return on Assets (%)	-.61300	2.94685	.93188	-2.72105	1.49505	-.658	9	.527
Pair 5	Asset Turnover Ratio (%) - Asset Turnover Ratio (%)	1.99700	5.87106	1.85659	-2.20290	6.19690	1.076	9	.310

From the above SPSS table of paired sample T test it can be interpreted that the significant values in case of all 5 profitability ratios seems to be more than 0.05 so we fail to reject H₀ that there is no significant difference in the profitability of selected pharma companies before and after Covid-19. Which intern means that Covid-19 have not affected the profitability of pharma companies negatively. The t-value measures the size of the difference relative to the variation in your sample data. T is simply the calculated difference represented in units of standard error. The greater the magnitude of T, the greater the evidence against the null hypothesis. Here the T values are also very low which also indicated that there is not much difference in the profitability across all 10 companies.

FINDINGS

Company wise

1. Cipla have increased their net profit and shown a positive up in all their profitability ratios except asset turnover ratio which have a slight decrease.
2. Cadila Health care and Lupin have faced a tough time and have a decrease in to all their profitability ratios, but they have managed their assets very efficiently as their asset turnover ratio shows an increase.
3. Divis Laboratory have shown similar net profit but their return on equity, return on capital employed. Used their assets properly as asset turnover ratio have slightly improved. Sun Pharma, Abbott India, Alkem Laboratories Ltd. Are top 3 companies as far as their profitability ratios are concerned. They have made tremendous profit in the Covid times due to the sell of their generic medicines. Favipiravir by sun pharma, along with another antiviral, remdesivir has emerged as one of the most sought-after drugs at hospitals fighting COVID-19 in India, (Health world, August 04, 2020) [6]. Abbott Indian due to the covid vaccine launch by its US parent company have all time high on their profit in 2020. Alkem Laboratories Ltd. Reported all time high their net profit and other profitability ratios due to companies out performance in the Indian market with its effective sales, marketing strategies and new product launches.

Objective wise

To measure the profitability of top 10 pharma companies in India.	As far as net profit is concerned before covid sun pharma was far behind than its competitors and due to its covid vaccine launches in 2020 its now far ahead then the other nine companies shown a tremendous growth in 2020. Overall, most of the companies were able to maintain their existing profit.
To compare and analyze the profitability of selected Indian pharma companies before and after covid-19.	Cadila health care and lupin shown down fall in profit and others could maintain their profit level. Sun Pharma, Abbott India, Alkem Laboratories Ltd. Are top 3 companies as far as their profitability ratios are concerned.
To study the impact of Covid-19 on selected Indian pharmaceutical companies.	By the hypothesis testing its been found that the pharma companies are not much affected by covid-19.

CONCLUSION

It is been observed that pharmaceutical industry is not been much affected as far as profitability is concerned but yes, the challenges for developing the vaccine and getting people trust for it is a big challenge for them. Those companies who have launched the Covi-19 vaccines and they have seen their all-time high in their profit. The challenge to face over here is to match the demand and supply of medicines. Now with the increasing demand of covid vaccines many other companies will be making it and the growth of the Indian pharmaceutical companies is sure to happen in 2021.

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Impact of Covid-19 on Consumer Behaviour with reference to Cloud Kitchens in Indore City

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Abstract

Covid-19 has ravaged the restaurant industry completely and the precautionary measures of this has made the small restaurants infeasible to work. Many of the restaurants have been shuttered during lockdowns in March – April 2020. This resulted in the downfall of the restaurant industry. But digitization opened the door of new hope and growth to this industry that is Virtual Kitchen or Cloud Kitchen. In Indore many people have started their cloud kitchens from home during the lockdown. This paper explores the concept of cloud kitchens with reference to Indore city. Results show that Cloud Kitchens offer higher benefits in comparison to brick and mortar restaurants. Most of the people are happy with the digitization of food delivery as it reduces the chances of getting infected with severe diseases like COVID- 19. The food is also delivered by following the safety measures and hygiene. Innovative menu items, new concepts and themes etc. are key features which makes Cloud Kitchens different from the restaurants. Running a Cloud Kitchen is easy and stimulating, and with limited resources one could become successful.

Keywords: Cloud kitchen, Indore city, palatable economics, Covid 19

INTRODUCTION

Cloud kitchens started popping up in the early 2010s in response to increased demand for high-quality meal delivery and rising rents in city centre locations. One of the consequences of pandemic is the rising numbers of cloud kitchens. Covid-19 has ravaged the restaurant industry completely and the precautionary measures of this has made the small restaurants infeasible to work. Many of the restaurants have been shuttered during lockdowns in March – April 2020. This resulted in the downfall of the restaurant industry. But digitization opened the door of new hope and growth to this industry that is Virtual Kitchen or Cloud Kitchen. A cloud kitchen is a restaurant that relies exclusively on takeaways that is these restaurants do not offer dine-in facilities. Consequently, these outlets are like food factories where production of food takes place. Also, the orders are only received online. Hence, the term “cloud kitchen” is used. The food/ beverage is then sent to the customer in the form of a takeaway. In the city of Indore, many people have started their cloud kitchens from home during the lockdown. The trend is driven by the coming of age of millennials with disposable income demanding digital, mobile-friendly solutions.

LITERATURE REVIEWS

Research suggests that the mantra these days seems to be stay home and order in. The trend of cloud kitchens had started to catch up even before Covid hit us and it was deemed as the future. The pandemic has fast tracked their growth, as cloud kitchens are able to home-deliver gourmet meals at a much lower cost as they don't have to invest in elaborate dine-in set ups and interiors (www.financialexpress.com).

According to **Sachin Chavan (2020)**, Cloud kitchen business is continually thriving and revolutionizing the way people prepare and consume food. Shrivastava and Baranwal (2019) opine that the spurt in

online delivery has offered ample opportunity to home chefs as well with Home chefs also introducing authentic home style dishes to foodies. Ajaz et al. (2019) studied the satisfaction of consumers who use Online Food delivery services. The authors posit that the important factor is to package food in a manner that customers can just heat and eat saving them from all the fuss.

NEED FOR STUDY

According to an analysis by Deloitte, convenience is an important consideration for millennials on account of their hectic lifestyle. Lack of time is one of the key reasons for growth in online shopping and online ordering from restaurants. Millennials are eating out or ordering food more frequently compared to Gen-Xers, who are now in their late 30s and 40s, and 'Baby Boomers', who are close to the age of retirement. Over 60% of millennials order food in or dine out at least once or more than once a month. Riding on the increased purchase power and high demand, the Indian online food delivery market (aggregators and cloud kitchen) is expected to be an over \$5 Bn opportunity by the end of the year 2023. As per DataLabs estimates, the projected market size of cloud kitchens is expected to reach \$1.05 Bn by 2023. Amidst the COVID-19 pandemic, the restaurant industry is among the worst-hit. According to the National Restaurant Association of India (NRAI), which represents over 500,000 restaurants across the country, over 20 lakh people directly employed in the restaurant industry may be rendered jobless. The only silver lining for the sector were cloud kitchens and self-operated online ordering platforms that operated even during the peak of the lockdown in March and April. As per RedSeer Consulting Management Consulting, the cloud kitchen (online ordering) market is projected to become a \$2 billion industry in India by 2024, up from \$400 million in 2019.

OBJECTIVES OF THE STUDY

1. To understand the consumer behaviour towards the concept of cloud kitchen with special reference to the city of Indore.
2. To study the impact of Covid-19 on the working of Cloud kitchens.

RESEARCH METHODOLOGY

Google forms were created and circulated to acquaintance and asked them to share it further. In all, 80 responses were gathered. They were asked questions related to their buying habits, preferences, important and least important factors, average amount spent on online food purchases. Basic statistical tools were applied in order to understand the changing consumer behaviour patterns with regards to ordering food online.

INTERPRETATIONS

The results revealed

- 75% respondents are aware of the term "Cloud Kitchen" and 8.8% respondents were not aware about this.
- Out of 80 respondents, 81.4% respondents gather information on internet before making any online food purchases
- 35% respondents were the key decision makers in their family as far as ordering food online is concerned, 37.5 % influenced the decision maker.
- 92.4% respondents have internet connection on their phone which shows that there is a huge scope for the Cloud kitchen businessmen to grow their business
- On an average 56.4% respondents spend less than 30 minutes (per order) to find food online
- 53.8 % respondents use to order food frequently by using online application
- 52.6% respondents find electronic food delivery secured
- On an average 38.7% respondents spend Rs. 1,000, 29.3% spend Rs.3000, 22.7 % spends Rs.2000 and 9.3% respondents spend more than Rs.3,000

- On an average 48.1 % respondents buys food online occasionally
- 48.1% respondents ordered food online unplanned, due to Social Media exposure
- 43% respondents are self-influenced to buy food online
- 40.5% respondents agrees and 20% strongly agrees with the statement, “Online food delivery application saves time even when I’m busy with my tight work schedule”
- 40.5% respondents thinks that “healthy and hygienic food could be delivered at doorstep” drives their attention towards online food delivery applications
- 34.2% respondents thinks that hygienic food is the primary advantage when using Online Application
- 35% respondents said health and wellness is now the most important criteria to order food online.

Fig 1: Relative importance of factors while ordering food online

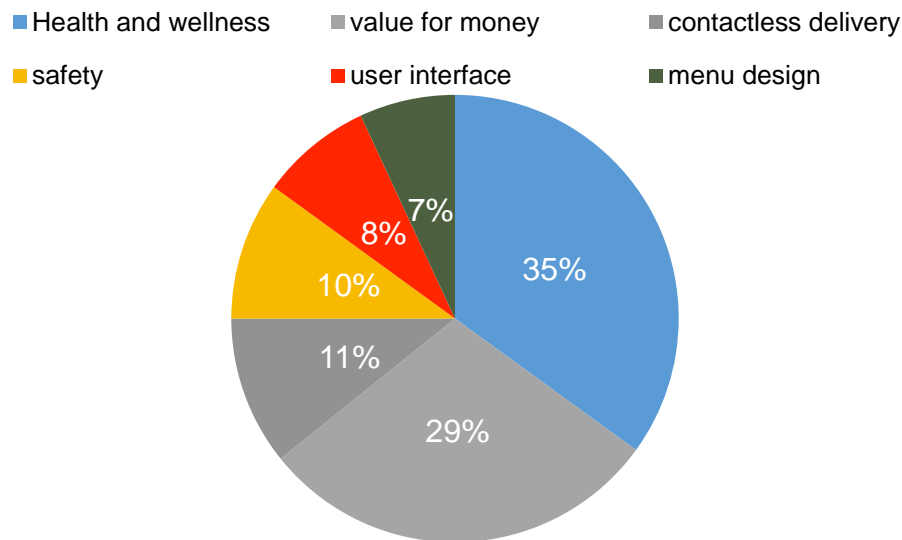
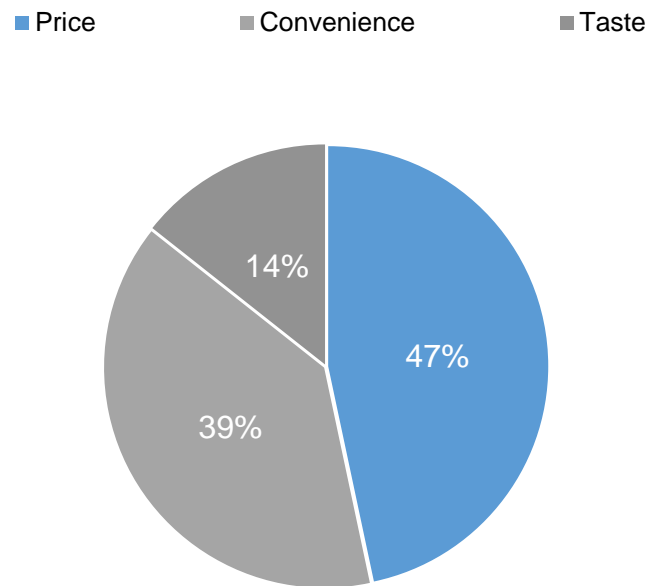


Fig 2: Weightage of factors behind ordering food through Cloud Kitchens



CONCLUSIONS AND SUGGESTIONS

1. Health and wellness stands out as the most important factor for customers to order food through cloud kitchens. Value for money and contactless services take the centre stage too. While larger-than-life elaborate service was key at fine dining restaurants, they now boast of contactless service.
2. We are seeing that Covid-19 has resulted into restaurants struggling to make any money. Also, the customers sometimes find the food to be very expensive. The research reveals that if the food items are fairly priced and prepared in a homely manner, many customers would prefer to order daily. This could be because the number of working spouses have increased which means they have little or no time for cooking. These days, families prefer to spend their evenings in the comfort of their homes rather than travelling long distances to reach restaurants. This is the reason why a large portion of all meals from restaurants are now delivered to the customer's homes. One advantage of Cloud kitchens is that it can keep the real estate costs low. Since customers do not visit these kitchens, ambience and location is not very important. This means the restaurants can cut costs. As a result, these kitchens can provide superior quality food to their customers for a fraction of the costs.
3. Digital brand awareness without high marketing spend: Virtual restaurant brands can gain quick exposure through delivery apps, rather than having to market themselves. Although a new virtual restaurant concept will have to pay for visibility, which is part of the delivery app business model, this can still work out cheaper overall, especially if you are creative about building your brand.
4. Variety of food items is a must: Cloud kitchens should not have a limited menu. Instead of offering many items, cloud kitchens usually focus on simplifying the menu so that more automation can be introduced.
5. Cloud kitchen companies have successfully automated all the packaging activities. These activities contribute to about 25% of the total workload. A lot of pre-preparation activities have also been fully automated. Cloud kitchen startups are also trying to aggressively explore more technologies that will allow them to automate the entire operation.
6. The need for personalized customer engagement: When a customer is not at the store, a personal touch with the customer is challenging. There's a good chance now that customer engagement platforms will increase as more businesses go digital.
7. Traditional restaurants have a lot of overhead expenses. So they have very little money left to incorporate high quality food items in their dishes. This is the reason why restaurant food has traditionally been considered to be unhealthy. However, cloud kitchens can change that. The objective of these kitchens is to add value to the customers. Many of these customers are regular customers of these cloud kitchens. Hence, these kitchens should be very much concerned about the quality of inputs that are used since it directly impacts their health. This is the reason why cloud kitchens focus on food quality. In fact, many of these kitchens have built their entire marketing programs around the promise of better quality food at the same or lower price.

In a nutshell, the Covid-19 has brought about unprecedented changes in the food and beverages industry. The culture of going to restaurants is slowly fading away. Although we have seen restaurants reopen with strict safety precautions, home deliveries from cloud kitchens has picked up its pace. While larger-than-life elaborate service was key at fine dining restaurants, they now boast of contactless service. Contactless and frictionless are now terms we have all adopted and thus cloud kitchens have emerged victorious. Cloud kitchens have gained momentum in the collective consciousness. They are a relatively new invention. However, they help serve a very important market niche which was earlier being neglected by traditional restaurants. As a result, they are not taking market share away from current restaurant owners. Instead, they are expanding existing markets thereby benefitting the industry as a whole.

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Pandemic Affecting the Mental Well Being of Students: An Empirical Study

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Abstract

Covid-19 has affected students physically, academically, financially and mentally like never before. The advent of online education although has its advantages, yet it is not giving the comfort zone students need. Also it is natural to feel sad, worried, confused, scared or angry. Mental health issues can significantly impair students' academic success and social interactions affecting their future career and personal opportunities (Kecojevic A, 2020). Increased social distancing and imposed self-isolation can cause a havoc to the mental health of students. This paper tries to study the impact of pandemic on the mental health of students through a cross sectional analysis. Adaptability, agility and innovative thinking emerges as the key survival strategies for students facing such issues. The results also reveal varying degree of impact the pandemic has on students and suggests the coping strategies thereafter.

Keywords: Contactless education, mental wellbeing, covid-19, survival strategies

INTRODUCTION

With the shutting down of schools and colleges due to Covid-19, education has shifted mainly to the online mode. This home education has brought a lot of shocks to students' productivity as the teaching has transcended from physical to virtual classrooms at an untested and unprecedented levels (Borges and Sievertsen, 2020). The current lives of all students, educators and families have observed a complete disruption and has made everyone stay away from the place where they used to spend a maximum of their time viz. schools, colleges, workplaces (Chandra, 2020). In usual circumstances, parents support in their children's development at home could be extremely positive and rewarding. Parents are certainly educators for children however, it cannot be assumed that all parents have the knowledge, confidence and time to maximise the learning opportunities for their children. Schools/ colleges and settings usually support parents in promoting and evaluating their children's development in areas of learning. The pandemic has caused a number of mental health issues some of which are not easily traceable. The pandemic is also a mental health risk for our society. The uncertainty, the anxiety, the fear of becoming ill or seeing a loved one become ill, the loss of our normal routines, the difficulties of social connection, and in many cases the disruption to education could have a profound impact on the nation's mental health.

LITERATURE REVIEWS

Borges, and Sievertsen,(2020) studied impact of COVID-19 on Education, Schools, Skills, and Learning and pointed out that these interruptions will not just be a short-term issue, but can also have long-term consequences for the affected cohorts and are likely to increase inequality. They cite **Lavy (2015)**, who estimates the impact on learning of differences in instructional time across countries. The rapid rise in the number of infected cases and deaths, disruption of daily routines, home confinement, fear of infection, social distancing from peers and friends, and lack of access to educational resources have created a feeling of uncertainty and anxiety among the children and the adolescents

(www.cdc.gov). **Shanmugam T.E. (2014)** has found in his research that the age group of 15 years was characterized by greater emotional instability. A survey was conducted by **Chandra (2020)** on the general public in China to better understand the psychological impact, anxiety, depression, and stress during the initial stage of the COVID-19 outbreak. Her findings indicated significant differences were observed between the fear of academic failure and online and home environment among male and female students

NEED FOR STUDY

Covid-19 has affected students physically, academically, financially and mentally like never before. With social activities no longer available, boredom may strike in, and one may also get bogged down mentally. The advent of online education although has its advantages, yet it is not giving the comfort zone students need. Increased social distancing and imposed self-isolation can cause a havoc to the mental health of students. Students are unable to manage the crucial balance between studies and play. They feel physically and emotionally distant from their friends along with finding no way to vent out their energies and boredom resulting into an increased potential stress level. Mental health interventions and professionally trained counsellors could help students address academic and financial concerns, which may alleviate mental health burden of the COVID-19 pandemic. In public health emergencies like this, many students will have special needs and emerging challenges that will require responsive programming by colleges.

OBJECTIVES OF STUDY

1. To find out Impact of pandemic on mental health of students.
2. To understand hardships experienced during pandemic by students.
3. To find out activities that are perceived to be helpful to release stress.
4. To understand challenges of remote support/ mental helplines for students.

ANALYSIS AND DISCUSSION

A cross sectional survey was done on students (age group 15-25 years) of Indore region. They were asked questions related to extent of impact of pandemic on their mental health, what are the hardships they faced during Covid -19 times, what are the challenges they feel as far as remote support is concerned and the activities that they feel might alleviate the problems with their mental stress. The findings were:

1. When asked what impact the pandemic was having, the students response was (Fig.1):
 - 32% said that it had made their mental health much worse
 - 51% responded that it had made their mental health a bit worse
 - 10% thought that it made no difference to their mental health
 - 6% opined that their mental health had become a bit better
2. The next response was as regards the hardships students are facing during the pandemic. The response was (Fig. 2):
 - Irritability and mood swings experienced by 34% respondents
 - Anxiety and low mood experienced by 25%
 - 53% admitted becoming over dependent on video games
 - Emotional binging was reported by 16% respondents
 - 75 percent admitted that increased social media use that leads to panic.

Fig 1: Response of students on their mental health during Covid-19

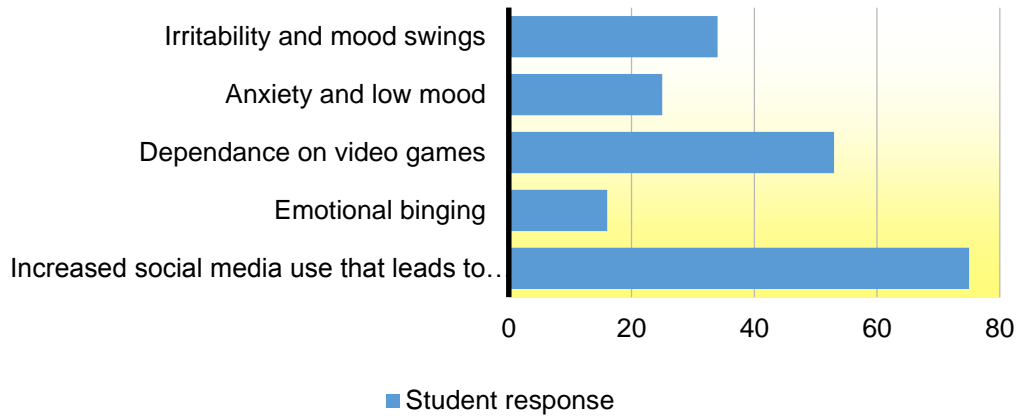
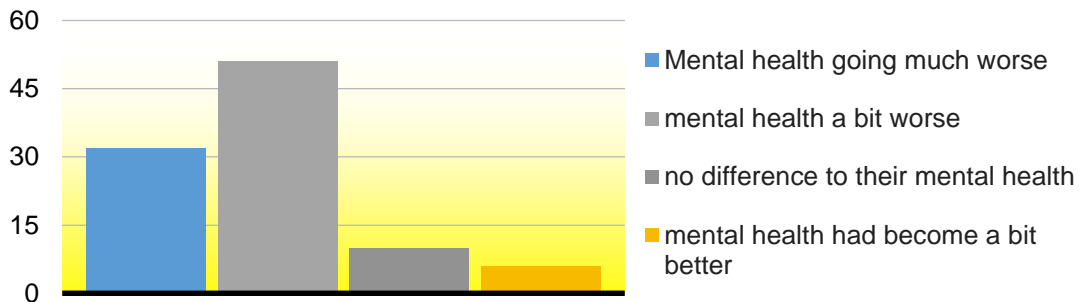


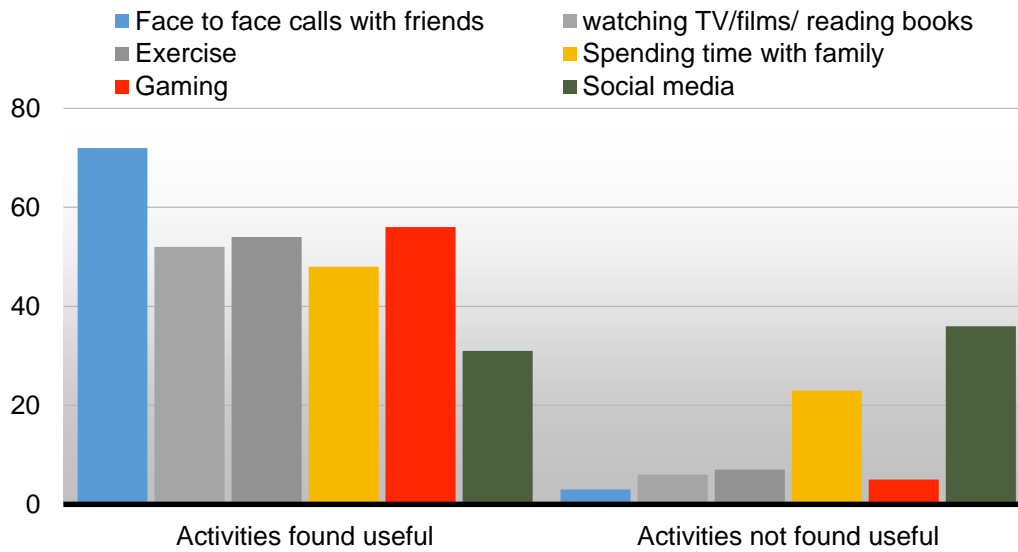
Fig. 2: Hardships experienced during the pandemic



3. This question discussed about Activities that are perceived by students to be helpful in releasing stress. Students responded (Fig. 3)

- 72% said Face to face phone calls with friends was useful. Only 3% found that the face to face talks did not help them in relieving their mental stress.
- 52% believed watching TV or reading books was helpful. 6% however found this ineffective in handling their stress.
- 54% said Exercise kept them stress free. Only 7% said it was of no use to them.
- 48% confessed that the family time made them stress free. A surprisingly 23% however found no solace in time spent with their families.
- 56% enjoyed their video games which they thought came as the biggest rescue while 5% of them showed no interest in gaming.
- 31% resorted to social media for keeping themselves stress free whereas 36% said that social media increased their mental trauma rather than being of help.

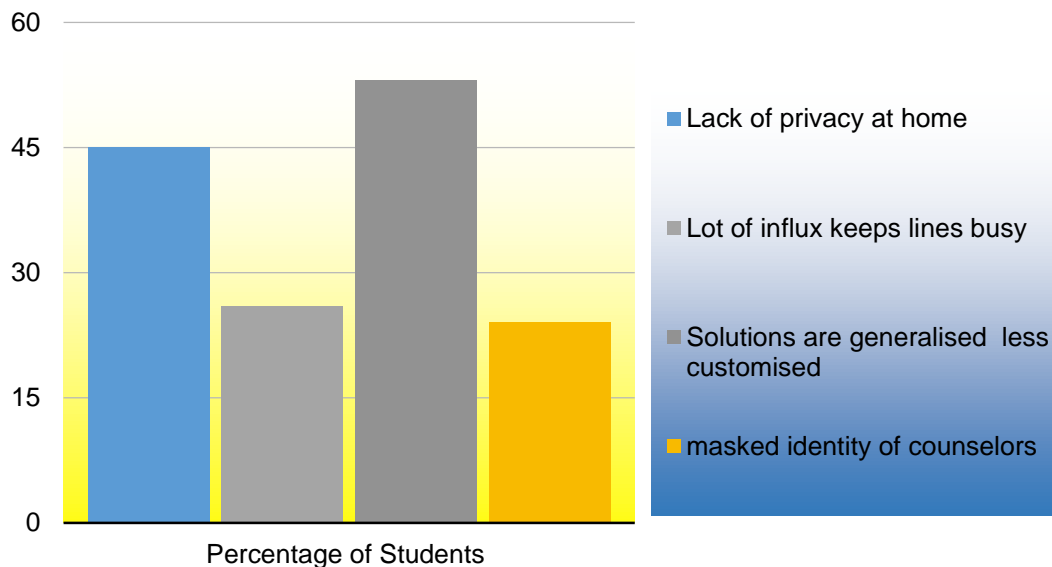
Fig. 3: Activities students found helpful/ not helpful in relieving stress



4. As regards the perception of remote support amongst students, the students response was as follows (Fig.4)

- 53% responded that solutions given during remote support are generalized and less customized hence do not serve purpose.
- 45% students were reluctant to discuss with counsellors over phone due to lack of privacy at home.
- 24% students said that the counsellors delegated their tasks to their junior or other amateurs and hence the approach varied. The masked identity of counsellors at times was another area of concern.
- 26% said the Lot of influx keeps lines busy so it was harder to get their calls answered when they contacted helplines.

Fig 4: Response of students towards remote support/ online counselling services



CONCLUSIONS AND SUGGESTIONS

The results suggest that the current COVID-19 pandemic is making a noteworthy negative influence on mental health of students. Students who otherwise in normal time show greater academic and life difficulties are particularly vulnerable to higher mental health distress. The current pandemic may further exacerbate already existing problems. The timeline of the pandemic is uncertain further impacting students' academics, lives, and mental health (Chandra, 2020). An early diagnosis and treatment by professionals can make a significant difference. Right choice of activities and counselling can show a more demonstrable and positive impact. Additionally, it is important that parents and teachers set realistic expectations from students and children, establish open communication. Timely assistance from peers, parents and teachers can ease mental stress unto a great extent. For students who have to face quarantine with parents or guardians who are going through mental health issues themselves can also impact the children. The pandemic is also a mental health risk for our society. The uncertainty, the anxiety, the fear of becoming ill or seeing a loved one become ill, the loss of our normal routines, the difficulties of social connection, and in many cases the disruption to education could have a profound impact on the nation's mental health. The biggest problem sometimes with mental health during pandemic is the stigma attached to it. So it is important to remove that stigma and discrimination feeling through proper interventions. Depressive thoughts and recurrent suicidal thoughts because of social isolation need to be handled properly. We have seen that students rely on their friends more than parents to help them relieve their stress. Video calls with friends can have a great soothing effect. Similarly social media has its own limitations. So it needs to be borne in mind that behavioral and emotional disorders due to spending long screen hours can affect the well-being and hence need to be controlled.

As regards the challenges of remote support for these students, some were happy with the efforts that professionals had gone to in order to continue to provide support. However, most respondents felt that support by phone or online would be ineffective or less effective than face-to-face support, because of a lack of privacy at home or a fear of their family overhearing the session. In some cases, the families did not know that they were receiving mental health support – and they did not want them find out. Some young people remained more generally anxious about talking on the phone or via video calls. Some young people who usually access online support feel like it takes longer to get it due to influx of people with mental health needs arising from the COVID-19 crisis and felt it was harder to get their calls answered when they contacted helplines.

The suggestion therefore is that helplines need to provide more customized solutions rather than generalized. Also counselors could talk to students while they are on a walk (for their one permitted piece of exercise per day), in order to ensure they can talk with privacy. Parents and teachers can help children tackle mental health problems by spending time with them and trying to understand their situation through open conversations, teachers play an important role in motivating the kids even while teaching online. Educational Institutions should also help older students deal with the lack of surety in getting jobs and college admissions during the Covid-19 chaos. Students should be kept apprised of the changes happening in the industry due to the pandemic, its impact and how to embrace technology to come to the forefront in difficult times. Parents are their children's first educators and time to support their children's development at home could be extremely positive and rewarding. However, it cannot be assumed that all parents have the knowledge, confidence and time to maximize the learning opportunities for their children. Schools/ colleges and settings have a crucial role to play here.

Key learnings through these tough times is adaptability, agility and innovative thinking that emerges as drivers for survival. Regular webinars, talks, close group discussions and virtual one-on-ones help students to gain a perspective and understand the situation better and deal better. It is recommended that individuals should minimize exposure to news about Covid-19. Prolonged exposure is associated with exaggerated fear and negative reactions. Moreover, social media and other communication methods can be a source of misinformation, which may increase the level of stress. Social influencers

including religious leaders, should have a role through communicating messages that can help reduce stigma and support stigmatized groups. Positive relationships, practicing mindfulness and an enabling environment can help ease the mental stress of students.

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Emerging Trends in Global Pharmaceutical Industry Start-ups

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Abstract

The paper shows the Emergence of Pharmaceutical Industry Start-ups providing artificial intelligence and related technology services as a single entity or in collaboration. Humongous utilization of online/digital marketing strategies is the key method deployed for promotion of artificial intelligence and related technology platforms.

In-depth research of more than 200 websites of Pharmaceutical industry start-ups, Bio pharma start-ups and allied sectors reveals the following facts related to their online/digital promotion focus:

- *Across the drug discovery and development value chain , artificial intelligence plays a key role in identifying both the micro and macro areas with reference to aggregation and synthesis of information, understand disease mechanism, repurpose existing drugs and generate novel drug candidates , validate and optimize drug candidates, drug design & discovery , clinical trial design and patient recruitment, and optimizing clinical trials from Phase I –Phase IV, publish data, and analyze real world evidence.*
- *Online marketing strategy of Pharmaceutical Industry start-ups is mainly predominated by Artificial intelligence as a key driver of achievement of business/ solution methodology across the drug development value chain. Drug Research and Artificial intelligence are the key word mentions in the online promotions on company websites and social media platforms. Majority of the companies have their company pages on various key social media platforms where postings and pages are updated on an ongoing basis.*
- *Collaborations in Artificial Intelligence have gained extensive online momentum and visibility since the last few years.*

Pharmaceutical industry start-ups are making humongous efforts in highlighting their unique artificial intelligence capabilities and offerings on their websites and social media platforms to tap and gauge requirements of their existing and prospective customers.

Keywords: Pharmaceutical Industry, Pharmaceutical Industry Startups, Artificial Intelligence, Marketing communication, Online/digital Communication, Drug research, Drug, Clinical trials, data, Technology, Websites, social media, Marketing Strategy, Collaborations

INTRODUCTION

Return on investment from pharmaceutical innovation has been on a continuous decline over the last few decades. Sales per asset continues to grow at a slower pace compared to the cost of discovery, development and manufacturing of drugs. Artificial intelligence (AI) based technologies have emerged as a new era of hope for the pharma industry. Use of AI in pharma applications has the ability to provide data-driven solutions to persisting problems.

LITERATURE REVIEWS

The research objective is based on the fact that Artificial Intelligence is helpful in driving greater efficiencies in the pharma industry by providing an additional boost to creativity with enhanced technology-aided processes. Artificial Intelligence helps in reducing timelines and aids data

processing. AI based solution in the pharmaceutical industry reduce the need for manual intervention and thereby help to reduce costs of R&D in pharma through large scale and more focused research. Pharma-focused AI start-ups are not only attracting attention from big pharma, but also VC firms and technology conglomerates. In January 2020, investment into AI in pharma reached \$5.2 billion.

RESEARCH OBJECTIVE AND METHODOLOGY

Research involves data collection from online sources like pharmaceutical directories for various pharmaceutical start-ups. From the directory listings, variables like name, service area, AI collaboration, contact details, technology used and therapeutic area are collected in excel sheets. Data is then processed using pivot tables to arrive at the relevant conclusions.

3 Phases of data Collection:

- Phase 1: Data Collection of 43 key Big Pharma companies involved in Artificial Intelligence collaboration from reputed and authentic online sources
- Phase 2: Data Collection of 67 key Small and Medium sized Biotechnology Companies reputed and authentic online sources.
- Phase 3: Data collection from online sources of 229 Pharmaceutical start-ups

Data was collected with respect to name, contact details, type of technology, funding, listed versus non private funded companies, artificial intelligence category, Artificial Intelligence usage, Researcher Usage and their social media strategies with respect to their funding and types of platforms used for their online communication.

The final analysis aims at understanding of 15 key categories of Application of Artificial Intelligence in Pharmaceutical start-ups, growth in terms of Number and volume of funding both listed and privately funded, geographical spread in terms of key countries and Key cities.

The Collaboration Model for Ai -Pharma Initiatives in Artificial Intelligence

Large Pharmaceutical Companies have taken great strides in adopting artificial intelligence across their value chain. Some of the key names include GSK, Janssen, Novartis, Bayer, AstraZeneca, Pfizer, Sanofi, Boehringer Ingelheim, AbbVie and Amgen. These companies feature as the top 10 Companies in Artificial Intelligence partnerships since the year 2011. The Top 10 Big Pharma companies are responsible for greater than 50% of the total artificial Intelligence collaborations since the year 2011.

Since the year 2011, Big Pharma has been involved in 133 collaborations in artificial collaborations with AI Start-ups, Biotechnology and biopharmaceutical companies with AI focussed pharmaceutical initiatives. (Table 1)

Table 1

Rank	Name of Big Pharma	% AI Collaboration
	Grand Total	100
1	GSK	7.5
2	Janssen	6.8
3	Novartis	6.8
4	Bayer	6.0
5	AstraZeneca	5.3
6	Pfizer	5.3
7	Sanofi	4.5
8	Boehringer Ingelheim	3.8
9	AbbVie	3.0
10	Amgen	3.0

Geographical spread of Big Pharma Artificial collaborations shows, the United states, Germany and United Kingdom as the top 3 among the total 12 countries in AI collaborations. (Table 2)

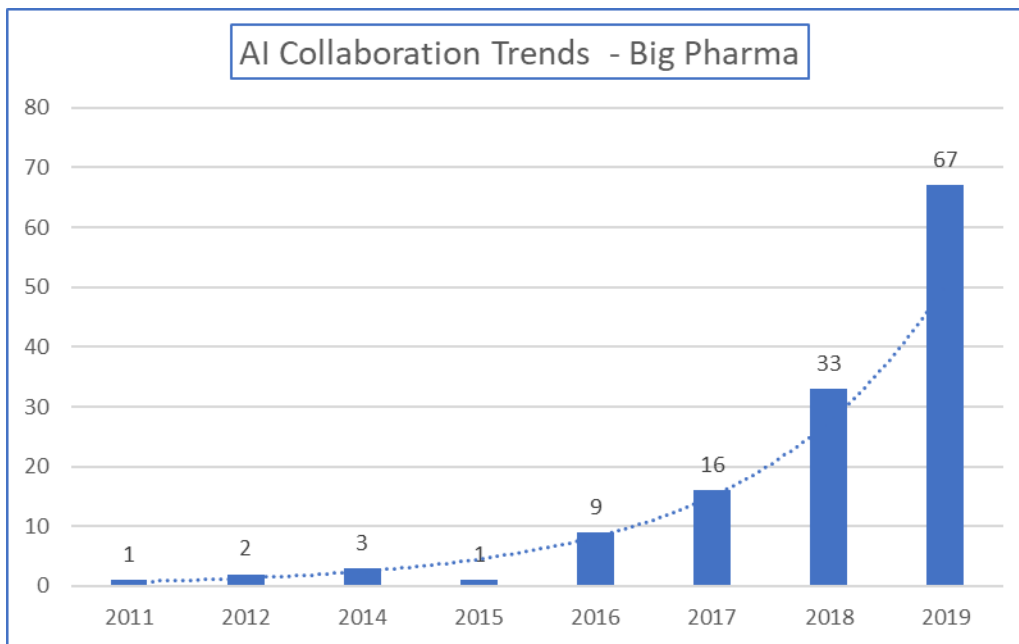
Table 2

Rank	Country	% No of AI collaboration
1	United States	27.8
2	Germany	16.5
3	United Kingdom	12.8
4	Japan	9.0
5	Switzerland	9.0
6	France	7.5
7	Belgium	6.8
8	South Korea	3.8
9	Denmark	3.0
10	China	2.3
11	Italy	0.8
12	Spain	0.8

Growth in Artificial Intelligence Usage Trends in the Pharmaceutical Industry

The Artificial Intelligence collaboration in the pharmaceutical industry saw an exponential growth in collaborations from 2016 to 2019 and the trend is expected to continue. The Number of collaborations has doubled 2017 to 2018 and from 2018 to 2019. (Fig.1)

Fig 1: AI Collaboration Trends -Big Pharma



Some notable mentions of Artificial collaborations with Big Pharma with emerging healthcare start-ups, biotechnology and biopharmaceutical companies in the period 2011-2019 are as follows:

1. **AbbVie** and **Calico** Announce a Novel Collaboration to Accelerate the Discovery, Development, and Commercialization of New Therapies
2. **Iktos** and **Almirall** Announce Research Collaboration in Artificial Intelligence for New Drug Design
3. **GNS Healthcare** Adds \$6M, Led by Amgen, for Machine Learning Tech,
4. **Schrödinger**: AstraZeneca is collaborating with Schrödinger to deploy its drug design platform, which combines physics-based modelling and machine learning, to identify new therapeutic candidates and improve the likelihood that synthesized compounds will have desired properties.
5. **Exscientia**: Bayer and Exscientia entered into a three-year collaboration in January 2020. The partnership aims to identify and optimize novel lead structures for cardiovascular and oncological diseases.
6. **Sensyne Health**: Bayer and Sensyne entered into a collaboration to develop treatments for cardiovascular disease. Sensyne has a unique partnership with the NHS to leverage its electronic patient record data while protecting patient privacy.
7. **Atomwise**: Atomwise announced a collaboration on up to 10 drugs with Lilly. It appears that Lilly will use Atomwise's technology to screen molecules that Lilly synthesizes for their therapeutic potential.
8. **ATOM**: GSK was the first pharmaceutical company to participate in the Accelerating Therapeutics for Opportunities in Medicine (ATOM) Consortium, which aims to leverage artificial intelligence to go from drug target to patient-ready therapy in less than a year. GSK gave ATOM chemical and in vitro biological data for more than 2 million compounds it has screened.
9. **Google**: While there is no mention of any formal partnership announcement, GSK researchers have worked with Google researchers on applying AI to drug discovery, including to develop a machine learning algorithm to identify protein crystals.
10. Alliance for Artificial Intelligence in Healthcare (AAIH): Janssen is a founding member of the AAIH. Johnson & Johnson Innovation Champions Leading Edge Science with 15 New Collaborations with Potential to Impact Patients' Lives
11. **Numerate** Forms Drug Discovery Collaboration with Merck to Utilize Numerate's In Silico Drug Design Technology
12. **Benevolent**: BenevolentAI announced a partnership with Novartis to use its AI platform for personalizing oncology treatments
13. **XtalPi**: Pfizer also announced a partnership with XtalPi to combine quantum mechanics and machine learning to predict the properties of drugs
14. **Berg**: Sanofi and Berg Health also announced a partnership in October 2017 to assess potential biomarkers for seasonal flu vaccine performance
15. **Exscientia**: Sanofi is also another prominent Exscientia partner. Their partnership, announced in May 2017, focuses on finding bispecific small molecule drugs for metabolic diseases such as diabetes and their comorbidities. In August 2019, Exscientia announced that Sanofi exercised its option for a bispecific small molecule targeting inflammation and the progression of fibrosis.

Biotechnology Start-Up Companies and Their Strategic Approach to Collaboration in Artificial Intelligence with Big Pharmaceutical Companies

Biotechnology companies have been in existence since the year 1989. However, collaboration in the area of Artificial Intelligence has picked up momentum only in the last decade. This has been mapped in an analysis of 67 Biotechnology companies in existence since the year 1989. The period since the year 2000 has seen an increase in funding initiatives by these 67 companies in artificial intelligence collaborations. (Table 3)

Table 3: Biotechnology companies by inception Year and Artificial Intelligence funding

YR of company inception	Funding \$ US Mn for AI	No. of Start-up / Company Name
1989	147.1	1
1995	74.2	1
1999	65.6	1
2000	16.5	1
2003	85	1
2006	496.8	3
2007	3.25	1
2008	119.2	2
2009	222.3	2
2010	100	1
2011	78.2	1
2012	292.495	6
2013	988.9	4
2014	2267.147	9
2015	1046.42	8
2016	136.8	3
2017	628	6
2018	243	1
2019	5.9	2
YR not mentioned	427.2	13
Grand Total	7444.012	67

- The total funding in the Artificial Intelligence collaboration market spanning 67 companies has crossed US \$ 7 billion till the year 2019. The maximum fund infusion has taken place in the period 2012-2015 with an approximate sum of nearly US \$ 5 billion spread across 27 Companies. An average of US \$ 111 million has entered the Artificial intelligence collaboration market.
- Top Countries in Biotechnology funding in artificial intelligence collaboration are United States, United Kingdom, Switzerland and France. Key cities which top the Biotechnology funding for artificial intelligence are Basel, Basel, Massachusetts, California, New York, Utah and New York.

A few biotechnology company start-ups utilizing their proprietary platforms for artificial intelligence:

1. **Roivant** aims to develop transformative medicines faster by building technologies by leveraging the Roivant platform to launch **Vants** – nimble and focused biopharmaceutical and health technology companies.
2. **Relay Therapeutics** was built upon unparalleled insights into protein motion and how this dynamic behaviour relates to protein function. These insights are driven by our **Dynamo** platform, which integrates an array of leading-edge experimental and computational

approaches and enables us to effectively drug protein targets that have previously been intractable or inadequately addressed.

3. **Dicerna Pharmaceuticals** uses its proprietary GalXC™ platform to develop safe and potent RNAi therapies that target and suppress genes. Dicerna Therapeutics is advancing its growing pipeline of product candidates designed to inhibit the genetic causes of diseases and disorders that affect the liver, kidney, cardiovascular system and central nervous system.

Social Media strategies of Biotechnology start-up companies (67) and their correlation in their funding initiatives:

1. Facebook platform is utilized by only 11 companies across United States and United Kingdom and 2 companies in India
2. LinkedIn is the most preferred platform by 51 companies across United States, United Kingdom and Few European Countries like Switzerland and France. Twitter shares a similar preference to LinkedIn among biotechnology start-ups spread across 43 companies in United States and United Kingdom.
3. The other upcoming platforms used by Biotechnology companies' start-ups are Instagram and YouTube.

Emerging companies in Artificial Intelligence collaboration:

Pharmaceutical Industry Start-ups and Biopharmaceutical Industry Start-ups

AI can be implemented in almost every aspect of the pharmaceutical industry, right from drug discovery and development to manufacturing and marketing. By leveraging and implementing AI systems in the core workflows, pharma companies can make all business operations efficient, cost-effective, and hassle-free.

Since AI systems are designed to deliver better outcomes as they continually learn from new data and experience, they can be a powerful tool in the research and development wing of the pharmaceutical industry.

Artificial Intelligence has major application in Research & development, Drug Development, Diagnosis, Disease Prevention, Epidemic prediction, Remote Monitoring and Manufacturing in the Pharmaceutical Industry.

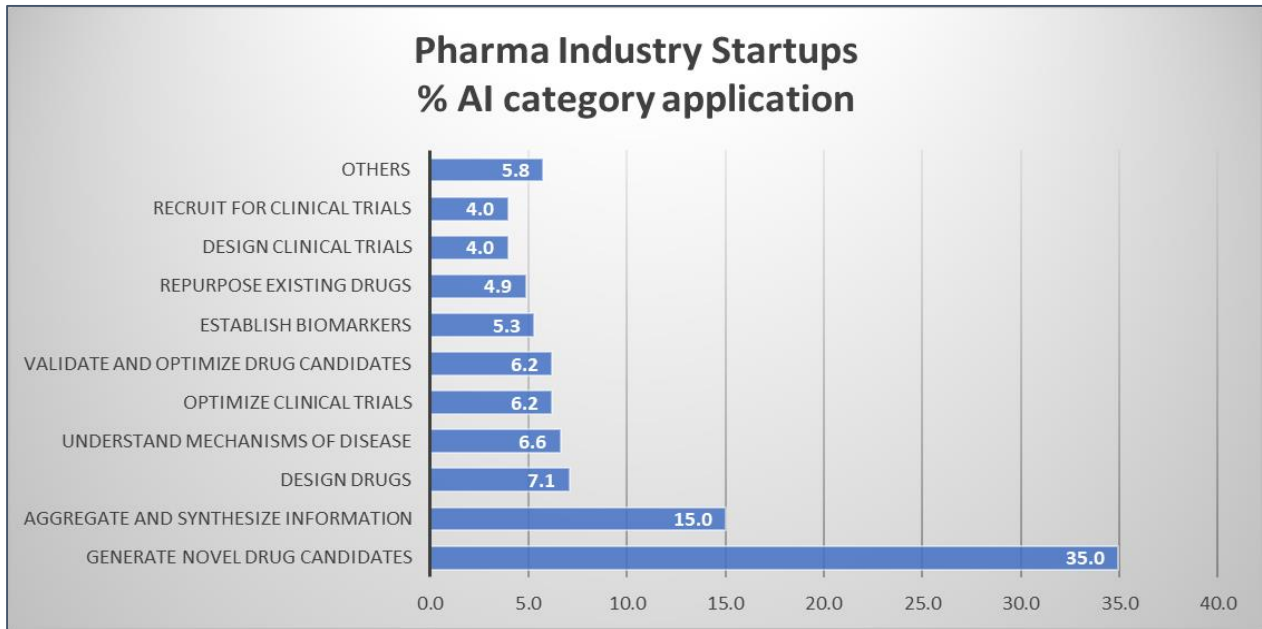
However, according to a report published by PreScouter – a Chicago-based research intelligence company focused on the applications of artificial intelligence.

Researchers are using artificial intelligence to catalyse drug discovery and preclinical drug development - improving predictive models to guide efficient design and optimizing multi-drug regimens, as 2 recent examples.

Pharma start-ups by AI Category

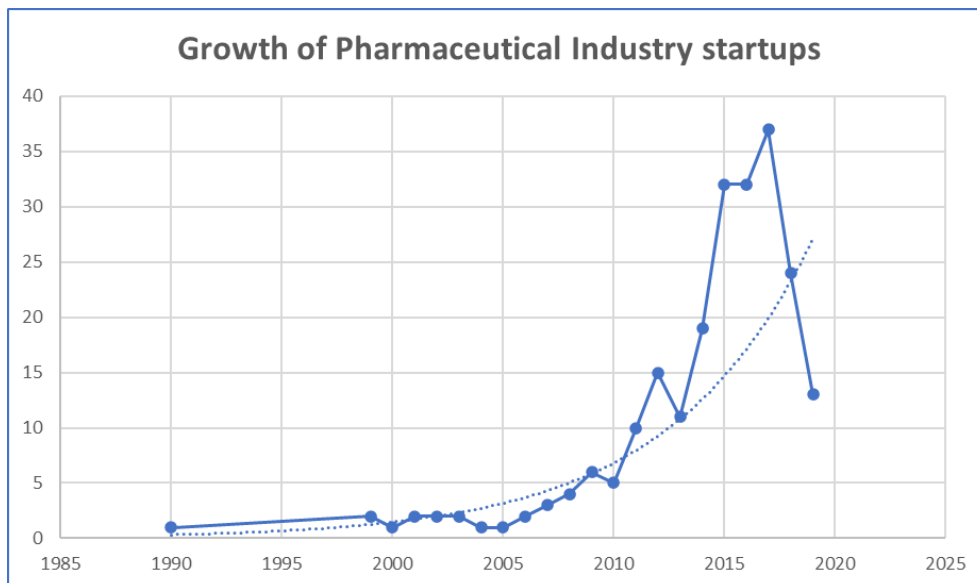
In an analysis of 229 Pharmaceutical Industry start-ups, it was found that Generation of novel drug candidates, Aggregate and synthesizing information and Design drugs were the top 3 categories of Artificial intelligence application. These top 3 categories contribute to nearly 60 % of the total artificial intelligence applications being utilized by the pharmaceutical industry start-ups. (Fig. 2)

Fig. 2: Pharmaceutical Industry Start-ups by % AI category application



The “roots” of the Pharmaceutical Industry start-up market have been since the 1990’s. The market remained dormant for almost 2 decades where only 2-4 start-ups per year contributing to the growth trajectory. The growth spurt started in the years 2010-2011 where private funding started contributing to the pharmaceutical industry start-up market owing to the rising need to speed up drug development cycle from the big pharmaceutical companies. Hence Artificial intelligence oriented pharmaceutical industry start-ups started placing their foothold. A total of 180 New pharmaceutical Industry Start-ups emerged in the period of 2011-2019 alone and the numbers are expected to rise even further across the various AI categories. (Fig. 3)

Fig 3: Industry Growth Snapshot 1999-2020



Pharmaceutical Industry Start-ups by Funding

127 Pharmaceutical Industry Start ups have a contributed to a total US\$ 5202 million in the last decade alone. The remaining 99 Start ups have either not disclosed their funding sources or are in the process of seeking funding or are self-sufficient in their business models. Needless to say, Out of the top 10 start ups by funding, 9 are from the United states alone and 1 from the United Kingdom and contribute to almost 61% of the total funding. (Table 4 and Table 5)

Table 4

Rank	Pharmaceutical Industry Startup By Funding	Country	Total Funding US\$ Mn	% Share of Total Market Funding
1	Tempus	United States	620	11.9
2	Recursion Pharmaceuticals	United States	465	8.9
3	XtalPi	United States	385	7.4
4	Erasca	United States	300	5.8
5	BenevolentAI	United Kingdom	292	5.6
6	Insitro	United States	243	4.7
7	Berkeley Lights	United States	225	4.3
8	Atomwise	United States	174	3.4
9	Cellarity	United States	173	3.3
10	Concerto HealthAI	United States	150	2.9

Only 12 out of the total 226 Pharmaceutical Industry Start-ups are listed and 8 of them are from the United States alone. Of these 12 start-ups, only 6 have available funding details on their websites.

Table 5

Rank	Listed Start up Company Name	Country	Funding US\$ Mn
	Grand Total		384
1	Berkeley Lights	United States	225
2	BioXcel Therapeutics	United States	69
3	e-Therapeutics	United Kingdom	67
4	Evaxion Biotech	Denmark	17
5	Cotinga Pharmaceuticals	United Kingdom	4
6	Resonant Therapeutics	United States	2
7	AbCellera	Canada	0
8	Biodesix	United States	0
9	Gritstone Oncology	United States	0
10	Predictive Oncology	United States	0
11	Relay Therapeutics	United States	0
12	Sensyne Health	United Kingdom	0

Pharmaceutical Industry Category Wise Funding contribution snapshot

Generation of Novel Drug candidates contributes 42% to the total Artificial Intelligence Pharmaceutical Industry Start-up market with 79 Companies as major growth drivers. Recruitment for Clinical Trials and Repurposing Existing drugs are the next categories which dominate the pharmaceutical industry funding platform. These 2 categories have 20 companies contributing to 27% of the total funding in the 15 categories. Category 5: Run preclinical experiments contributes the highest funding (US \$ 225.3mn) in the listed category followed by Generate novel drug candidates (US \$ 90mn) and Repurpose existing drugs (US \$ 69 Mn) respectively(**Table 6**)

Table 6

Rank	AI category	Funding US\$ Mn	% Contribution to the total AI Funding	No. of companies	Avg Funding per company per AI category
	Grand Total	5201.7	100.0	226	23.0
1	Generate novel drug candidates	2206.5	42.4	79	27.9
2	Recruit for clinical trials	717.9	13.8	9	79.8
3	Repurpose existing drugs	690.9	13.3	11	62.8
4	Validate and optimize drug candid	411.1	7.9	14	29.4
5	Run preclinical experiments	374.7	7.2	5	74.9
6	Analyse real world evidence	243.6	4.7	2	121.8
7	Aggregate and synthesize information	193.9	3.7	34	5.7
8	Design drugs	95.3	1.8	16	6.0
9	Optimize clinical trials	85.1	1.6	14	6.1
10	Design clinical trials	79.0	1.5	9	8.8
11	Design preclinical experiments	55.4	1.1	2	27.7
12	Understand mechanisms of disease	23.6	0.5	15	1.6
13	Publish data	21.6	0.4	2	10.8
14	Establish biomarkers	3.3	0.1	12	0.3
15	Generate data and models	0.0	0.0	2	0.0

The United States emerges as the largest market by funding (US\$ 4013 Mn.) for Pharmaceutical Industry start-ups followed by the United Kingdom (US\$ 689mn), a few European countries and Canada. The United States Pharmaceutical Industry Start-up market contributes to 77% of the total funding across the 15 Categories of artificial intelligence with a total of 125 companies. Artificial Intelligence for Generation of novel drug candidates is the prime focus of 51 of the total 125 start-ups based in the United States alone and these contribute US\$ 1512.2 mn of the total funding in the United States pharmaceutical Industry market.

The recruit for clinical trials, repurpose existing drugs, Validate and optimize drug candidates, Run preclinical experiments, Analyse real world evidence & Aggregate and synthesize information are the next 6 leading categories of the United States Artificial Intelligence market by funding. The category Aggregate and synthesize information has 19 start-ups (US \$ 110mn) and all other 5 Categories have less than 10 start-ups contributing to the artificial intelligence funding market. The category of Aggregate and synthesize information has many emerging companies despite low contribution in the funding domain.

The United Kingdom has 24 Pharmaceutical Industry start-ups by funding which are mainly focussed on the Generation of novel drug candidates. A total of 8 companies are focused towards Generation of novel drug candidates (US\$483mn) alone followed by Running preclinical experiments, Repurpose existing drugs and Recruit for clinical trials.

Canada and France have a total of 31 Pharmaceutical industry start-up companies which contribute nearly US\$ 230 mn to the total funding. The focus of the Pharmaceutical Industry start-ups in Canada

is mainly towards the Design drugs and Design preclinical experiments category of artificial intelligence whereas the Companies in France are pitching their funding interests for artificial intelligence in the Repurpose of existing drugs followed by recruitment and design of clinical trials.

Other emerging European nations like Germany, Italy, Spain, Bulgaria, Hungary, Austria and Ireland have started their in artificial intelligence start-up funding with 1-4 companies and a small volume approach in the categories of Aggregate and synthesize information, Establish biomarkers, Design drugs, Generate novel drug candidates, Repurpose existing drugs, Understand mechanisms of disease and Optimize clinical trials. Among the CEE countries , Hungary and Poland are the key emerging countries in the area of Generate novel drug candidates, v validate and optimize drug candidates and design drugs using artificial intelligence with nearly 4-5 pharmaceutical Industry funded start-ups.

Among the Nordic Countries, Finland and Denmark occupy miniscule presence with a 1 company each. Hong Kong, China, South Korea, Singapore and India are the Key emerging Asian countries on the Pharmaceutical Industry start up segment with Artificial intelligence focus areas such as Aggregate and synthesize information, Design drugs, generate novel drug candidates, publish data and Validate and optimize drug candidates.

Table 7: Top 11 Cities by Funding in Artificial Intelligence Pharmaceutical Industry Start ups

Funding by AI Category & City	Funding US\$ Mn	No of companies
Cambridge	797.7	18
Chicago	620.0	1
San Francisco	492.8	18
Salt Lake City	465.3	1
London	439.4	13
New york	300.1	13
South San Francisco	296.5	3
Emeryville	225.3	2
Boston	150.2	5
Toronto	146.3	10
Oxford	109.7	2

Among the top 11 cities, 7 cities from the United States dominate the Pharmaceutical Industry start-ups by funding. **(Table 7)**

From an Artificial Intelligence perspective, the top category i.e. the Generation of Novel drug candidates, some **62 key research areas** which are key growth segments of the in the pharmaceutical Industry Start-ups:

1. Accelerate experimentation for discovering therapies for aging and related diseases.
2. Accurately predict ADMET properties.
3. Aggregate and mine disparate biomedical datasets to reveal novel vulnerabilities in cancer.
4. Analyse biomedical data to predict how drug compounds would interact with people in the real world.
5. Analyse chemoproteomics data to find temporary binding sites in human proteins and how to selectively target them with new drugs

6. Analyse clinical and genomic data from consenting participants who are members of insurer Clover Health
7. Analyse many drug discovery factors simultaneously, such as effects, side effects, and toxicity.
8. Analyse metabolomic and bioassay datasets to uncover insights into human health and disease, as well as potential new chemical scaffolds.
9. Analyse omics data related to aging
10. Analyse RNA data from patients to identify new biomarkers and drug targets
11. Analyse the gut microbiome.
12. Assess and prioritize a library of drug candidates derived from analyzing tumor microenvironments.
13. Curate and mine gene variants
14. Design novel compounds that optimize for specific objectives.
15. Design protein drugs through reinforcement learning.
16. Discover connections between drugs and diseases at a systems level by analyzing hundreds of millions of raw human, biological, pharmacological, and clinical data points.
17. Elucidate novel tumor biology and innovative strategies that shut down key cancer pathways
18. Filter and score compounds prior to testing
19. Find correlations and patterns that can be used for protein design
20. Find novel small molecules that can bind and inhibit targets that are specific to cancer cells.
21. Find the best hits in large numbers of antibodies evolved to activate or inhibit a drug target
22. Find undiscovered molecules encoded in environmental microbial DNA.
23. Generate cross-reactive antibodies targeting evolutionarily conserved epitopes with novel mechanisms of action and excellent developability
24. Generate insights from molecular data for a deep understanding of disease biology and patient subtypes
25. Generate models from large, high-quality datasets.
26. Generate molecular structures based on user-defined criteria
27. Generate molecules that have high affinity for a target, in conjunction with proprietary statistical mechanics algorithms
28. Generate novel insights and predictions from biological data, chemical data, and curated databases of approved drugs.
29. Generate novel insights into neurobehavioral health from proprietary data sources including brain imaging and functional assessment tools
30. Identify suitable targets for vaccines and antibodies in complex immunological data
31. Identify the mechanisms of action of molecules and the non-structural analogs of those molecules with similar biological activity.
32. Identify, predict, and select the most therapeutically relevant neoantigen (newly formed antigen not previously recognized by the immune system) targets associated with a patient's tumor.
33. Identify, prioritize, and validate genetic markers of antibiotic resistance
34. Illuminate molecular pathways of disease through deep analysis of small RNA
35. Ingest scientific research data sets, then form and qualify hypotheses and generate novel insights
36. Integrate clinical trial data with real-world evidence and public datasets to eliminate silos of health information
37. Iterate small molecules to find candidates with optimal properties for a target
38. Learn best-practices from drug discovery data and experienced drug hunters
39. Map hundreds of genes that cause a disease, then find drugs that target all at once.
40. Optimize activity, specificity, and stability of peptides, proteins, and enzymes.
41. Optimize drug candidates identified through a quantum computing-driven search of large chemical datasets.
42. Perform de novo molecular design and molecular simulation.
43. Perform structure-based drug design and discovery (using AtomNet from Atomwise).

44. Predict antibody-antigen binding
45. Predict biological activity from molecular structures
46. Predict drug candidates by leveraging a convolutional neural network trained on a huge amount of organic chemistry data
47. Predict immune targets for cancer immunotherapy using a model trained on extensive human tumor data.
48. Predict pharmacological properties of drugs and supplements, and identify novel biomarkers.
49. Predict properties of compounds and enable low-cost and efficient drug development.
50. Predict synergistic plant mixes
51. Predict the function of sequences for adeno-associated virus capsids, which are used as vectors for gene therapy
52. Predict the therapeutic potential of food-derived bioactive peptides.
53. Predict toxicity to weed out toxic compounds and increase the efficacy of computational drug discovery
54. Screen compound libraries for efficacy against a disease, identify new drug candidates from a public library, and identify biologic targets.
55. Screen compounds for multiple properties to move them toward drug candidacy
56. Screen compounds to use as vaccine adjuvants.
57. Search 69 billion molecules with the goal of generating a library of 1,000 compounds to manipulate cell biology
58. Search a virtual chemical space, predict binding affinity and allow filtering for drug-like properties, safety, and synthesizability
59. Shorten discovery and screening, lead optimization, and ADMET studies.
60. Simulate, filter, and search for molecules with "Generative Tensorial Networks
61. Uncover and exploit unappreciated molecular and cellular behaviours by analyzing digital representations of biology and drug actions
62. Uncover gene interactions and biological networks underlying diseases, and test therapies that target them

Table 8: Social media Strategies of Pharmaceutical Industry start ups

Funding by Social media platform	No of Companies using the Social media platform	Funding US\$ Mn of the Social Media platform
Facebook	60	1470.5
Twitter	143	3714.0
LinkedIn	169	4210.7
Instagram	19	246.1
You Tube	27	1572.7
<p>Note: Total will not add upto the total funding and total no of companies as more than 1 social media media platform is being used by all 226 companies</p>		

United States and United Kingdom emerge as the leading countries across all social media platforms. Using Artificial intelligence for Generate novel drug candidates, Recruit for clinical trials, repurpose existing drugs and Run preclinical experiments are the key areas pf promotion on social media platforms across the pharmaceutical industry start-ups.

Contemporary updates related to Artificial Intelligence in the Pharmaceutical Industry in Covid 19 pandemic

Covid-19 resulted in a dramatic increase in the volume and quality of digital engagements, thanks in part to AI-driven personalization strategies

Email open rates in the pharmaceutical industry historically hover around 18%, according to Mail Chimp. Compare that to the high 45% open rate from AI-driven emails sent to HCPs (Health care professionals) during the height of the pandemic. It is clear the impact that a data-driven approach to digital engagement – including personalized recommendations about when, who, and what to send – make a major difference in getting and keeping the attention of busy physicians.

Challenges to Artificial Intelligence usage

According to a recent news release (March 18, 2021), on a leading research and development magazine:

The Pistoia Alliance, a global, not-for-profit alliance that works to lower barriers to innovation in life science and healthcare R&D, **announced the results of a survey of life science professionals, on the implementation of AI and blockchain in the life sciences industry.** The survey shows there is a high level of interest in AI among respondents, with 57% already engaging in computational drug repurposing. Similarly, the findings revealed that understanding of blockchain has increased, with 89% now aware of the technology, compared to 82% in 2018. Despite this increase, the survey identified that once again, lack of access to people with relevant blockchain skills remains the biggest barrier to widespread adoption (selected by 30%).

Another recurring challenge identified in the survey was data quality and data standards. Behind skills, participants ranked lack of standards (19%) and interoperability (17%) among the next biggest barriers slowing blockchain adoption. Likewise, 38% think algorithmic bias poses a barrier to AI for drug repurposing, and a further 42% think it has potential to be a barrier.

Recommendation from the Pistoia Alliance survey:

Technologies including AI and blockchain have the potential to transform drug development. Yet no matter how powerful these technologies become, challenges and bias will exist until there is an improvement in the quality of data feeding algorithms

LIMITATIONS

1. The data of pharmaceutical Industry start-ups is captured from online available directories
2. The data collected is from the websites of the pharmaceutical Industry start ups
3. Data captured is till the year 2019 and a few months of the year 2020 (pre Covid 10 era)

SUMMARY AND CONCLUSIONS

Big Pharmaceutical and biotechnology companies are increasingly looking at artificial intelligence to enhance their drug development initiatives.

Big Pharma and Biotechnology companies are increasingly collaborating with Pharmaceutical Industry technology start-ups with artificial intelligence capabilities to design, structure and aid their drug development programmes. These collaborations are spread across geographies and are expected to rise exponentially in the coming decade.

Pharmaceutical Industry start-ups will play a key role in these collaborations as they have the artificial intelligence capacities of numerous dimensions.

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Application of Artificial Intelligence in Pharmaceutical and Biomedical Studies

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Survey finds 62% of life science professionals say AI will lead to faster R&D, but is held back by skills
gap and data bias

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Trends

A Study on Society's Awareness towards Renewable Energy with Special Emphasis on Solar Energy Products

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ABSTRACT

In India, Solar energy Products are dispatched basically with the goal to make ecological attention to mass force utilization and the need to moderate force utilizing Solar energy Products. As of late, the expanding costs of petroleum derivatives and worries about the ecological results of ozone depleting substance emanations have restored the interest in the advancement of sustainable power and especially solar energy items and assets. The significant disadvantage of solar energy Products is its significant expense and space necessity to arrangement a gadget. In India the introduced limit of petroleum derivative-based force plants has expanded from 1362 MW in 1947 to 27122 MW in 2015, yet, in 2015 there is a pinnacle power shortfall of 2.6%, This pinnacle power shortage will ascend to 5.6 % in 2022 as request ascends because of financial development and expansion in populace. To put a stage, forward a similar way the Ministry of New and Renewable Energy of India has dispatched numerous activities like sunlight-based endowments and a few plans and advantages for practical turn of events and to investigate and successfully utilize the sun-based energy accessible at the doorstep of the Indian subcontinent. The Scope of this paper measures the awareness of various solar energy products, government initiatives and the concept of renewable energy among the society. Descriptive research methodology has been carried out to analyze awareness towards solar energy products. Hence, the present study examines about the customers' awareness about the usage of solar energy Products in district of Ahmedabad and their evolution in the market trend. Data has been collected through on the findings of this paper, researchers suggests that industry can know the current preference and will help them to form future strategies to create awareness.

Keywords: Renewable Energy, Solar Energy, Awareness, Solar Energy Products.

INTRODUCTION

Sustainable power, frequently alluded to as clean energy, comes from natural sources or cycles that are continually renewed. For instance, sunlight or wind continue to shine and blowing, regardless of whether their accessibility relies upon time and climate. Renewable energy is regularly considered as another innovation, harnessing nature's force has for some time been utilized for heating, transportation, and the sky is the limit from there. Since we have progressively creative and more affordable approaches to catch and hold wind and Solar energy, renewables are turning into a more significant force source. The development in renewables is likewise occurring at scales enormous and little, from roof Solar panels on homes that can sell power back to the framework to giant seaward wind ranches. Renewable energy sources assume an essential part in protecting reasonable energy with lower outflows & emissions. It is as of now acknowledged that sustainable power advancements may essentially cover the power demand and reduce emissions. According to the Central Electricity

Authority (CEA) gauges, by 2029-30, the portion of sustainable power age would increment from 18% to 44.

Solar energy is a definitive and best type of renewable energy. It's the most practical source of force, which is acquiring prevalence continuously. As indicated by researchers, daylight energy is a complete solution of the present energy emergency in light of the fact that the measure of solar energy occurrent on Earth in 1 hour is identical to the aggregate sum of energy devoured by people every year.

Lately, the India has built up a manageable way for its energy supply. Familiarity with saving energy has been elevated among citizens to expand the utilization of solar energy, wind, biomass, waste, and hydropower energies. India is planning to achieve 175 GW of sustainable power which would comprise 100 GW from solar energy, 10 GW from bio-power, 60 GW from wind force, and 5 GW from small hydropower plants constantly by the year 2022. Recent evaluations show that in 2047, solar potential will be in excess of 750 GW.

LITERATURE REVIEWS:

1. **Rosemary Gibbons (2009)**, found in his research that 96% respondents were aware about the renewable energy and its sources. The result of this survey shows that 38% of respondents had a renewable source of energy appliances installed. 87% of respondents agreed that renewable energy will ensure a sustainable future and there is still poor adoption in renewables.
Rosemary G. (2009), "Exploring consumer perception and attitudes towards renewable energy with a view to developing best practice for marketing renewable energy", James Kearns school of business. 2009.
2. **T. Blenkinsopp, Coles K., Kirwan Demirbas (2013)**, found in their study that socio-economic factors that affect the development and uptake of sustainable or renewable energy projects in small rural communities in India. The results showed that there is interest in using sustainable or renewable energy sources over more traditional methods.
3. **Dr. R.Mohanasundari and Nirmala Devi (2018)**, did a research on consumer's awareness of solar energy products. They concluded in their study that the consumption of energy has been increasing in abundant amount and the customers have become more conscious about saving power and switching on to other sources of power like solar energy for their consumption.
4. **T. Blenkinsopp, Coles K., Kirwan Demirbas (2013)**, found in their study that socio-economic factors that affect the development and uptake of sustainable or renewable energy projects in small rural communities in India. The results showed that there is interest in using sustainable or renewable energy sources over more traditional methods.
5. **Menichetti E. (2010)** in her doctoral thesis has stated that Solar PV is the fastest growing technology when it comes to Renewable Energy. Thus, and in depth analysis of investors perception as to solar PV would be extremely beneficial. It is also stated that, "policy plays a paramount role in increasing investor's confidence and decreasing the investment risk.
6. **Dr. M.V. and Ms. U.S (2014)**, studied on customer's attitude towards solar energy devices. They found in their research that 100% of respondents were aware about solar energy devices and 54% got to know that from advertisements. Majority of respondents think that ads related to solar energy products were informative. The respondents buy solar energy devices first due to its durability. Most of the respondents were used solar energy products and satisfied after using it. Most of the respondents think that the best feature in solar energy products is, it reduces power consumption. At last, most of the consumers think that installation of solar energy products is costly.

IMPORTANCE OF THE STUDY

- Private companies & Government can analyse the research and can know what Products awareness is there in the Society.
- This study will be helpful to the Companies to understand the reason behind society not using Solar Energy Products.
- It will be beneficial for government to know which Products marketing should be done in order to create awareness.

OBJECTIVE OF THE STUDY

- To analyze society's awareness towards solar energy products.
- To examine society's awareness towards Government's effort.

RESEARCH METHODOLOGY

- The research design will be the descriptive research and it will be carried to find out people's awareness towards solar energy products. Subsequently collecting all the acknowledgments from respondents within a week, the data will be interpreted by SPSS and Microsoft excel. Subsequently, the intact analysis and hypotheses will be presented in the order of a detailed report.
- The primary data was collected through a questionnaire and there were 110 respondents from Ahmedabad. The secondary data was collected through articles and research papers.

HYPOTHESIS

- H₀: There is no significant relationship between occupation and willingness to pay for solar energy products.
- H₁: There is significant relationship between occupation and willingness to pay for solar energy products.

SAMPLING PLAN:

- Sampling method: Non-probability Convenience.
- Sample unit: People from Ahmedabad and Gandhinagar.
- Research tool: Microsoft Excel, SPSS and MS word.

ANALYSIS & INTERPRETATION

Interpretation: Table 1

- 110 respondents filled the questionnaire.
- Out of 110 respondents, 9 respondents are in the age group of 20 or below 20.
- 43 respondents are in the age group of 21-30.
- 29 respondents are in the age group of 31-40.
- 22 respondents are in the age group of 41-50.
- 7 respondents are in the age group of 51 and above.

Interpretation: Table 2

- 110 respondents filled the questionnaire.
- Out of 110 respondents, 72 are male and 38 are female.

Table 1: Demographics

AGE			
		Frequency	Percent
Valid	20 Or Below 20	9	8.2
	21-30	43	39.1
	31-40	29	26.4
	41-50	22	20.0
	51 and above	7	6.4
	Total	110	100.0

Table 2: Demographics

GENDER			
		Frequency	Percent
Valid	Male	72	65.5
	Female	38	34.5
	Total	110	100.0

Table 3: Demographics

OCCUPATION			
		Frequency	Percent
Valid	Student	24	21.8
	Employee/Salaried	44	40.0
	Self-employed	27	24.5
	Housewife	15	13.6
	Total	110	100.0

Interpretation: Table 3

- 110 respondents filled the questionnaire.
- Out of 110 respondents, 24 (21.8%) respondents are students.
- 44 (40%) respondents are employee/ salaried.
- 27 (24.5%) respondents are self-employed.
- 15 (13.6%) respondents are housewife.

Interpretation: Table 4

- 110 respondents filled the questionnaire.

- Most of the respondents are not using any of these (solar cooker, solar charger, solar air conditioner, solar water heater, solar microinverter, and solar panel) solar energy products that is 99 respondents.
- There are 11 respondents who use any of these solar cooker, solar charger, solar air conditioner, solar water heater, solar microinverter, and solar panel) solar energy products.

Table 4: Do you use any of these solar energy products?

		Frequency	Percent
Valid	Yes	11	10.0
	No	99	90.0
	Total	110	100.0

Interpretation: Table 5

- 110 respondents filled the questionnaire.
- The majority (89) of respondents who are aware & 21 respondents are not aware of a solar cooker.
- There are 51 (46.4%) respondents who are aware & other 59 respondents who are not aware of a solar charger.
- The majority (75) of respondents are not aware of a solar air conditioner. There are 35 respondents who are aware of a solar air conditioner.
- The majority (102) of respondents are aware of a solar water heater. There are 8 respondents who are not aware of a solar water heater.
- Most of the respondents (83) are not aware of a solar microinverter. There are 27 respondents who are aware of a solar microinverter.
- Most of the respondents are aware of a solar panel that is 95.5% (105) and 5 respondents are not aware of a solar panel.

Table 5: Awareness about solar energy products

STATEMENT	AWARE	NOT AWARE
Are you aware of the following solar energy products? [Solar Cooker]	89	21
Are you aware of the following solar energy products? [Solar Charger]	51	59
Are you aware of the following solar energy products? [Solar Air Conditioner]	35	75
Are you aware of the following solar energy products? [Solar Water Heater]	102	8
Are you aware of the following solar energy products? [Microinverter]	27	83
Are you aware of the following solar energy products? [Solar Panel]	105	5

Table 6: To what extent do you agree or disagree with the following statements

To what extent do you agree or disagree with the following statements?	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
It takes years for the investment to pay back.	25	45	25	14	1
Solar energy products can reduce the negative impact on the environment.	61	28	10	8	3
Lack of government incentives for the industry.	9	31	20	24	26
Lack of appropriate loan options for the industry.	10	25	21	28	26
Maintenance of solar products costs a lot of money.	16	23	30	33	8
Solar energy products save the money.	41	46	20	2	1
Solar energy products are reliable for all weather conditions.	17	29	45	16	3

Interpretation: Table 6

- 110 respondents filled the questionnaire.
- 15 respondents have disagreed that It takes years for the investment to pay back while 70 respondents have agreed & 25 respondents are not aware of it.
- 11 respondents have disagreed that Solar energy products can reduce the negative impact on the environment while 89 respondents have agreed with the statement & 10 respondents are not aware of it.
- 50 respondents have disagreed that there's Lack of government incentives for the industry while 20 respondents have agreed with the statement & 40 respondents are not aware of it.
- 54 respondents have disagreed that there's Lack of appropriate loan options for the industry while 35 respondents have agreed with the statement & 21 respondents are not aware of it.
- 41 respondents have disagreed that Maintenance of solar products costs a lot of money while 39 respondents have agreed with the statement & 30 respondents are not aware of it.
- 3 respondents have disagreed that Solar energy products save the money while 87 respondents have agreed with the statement & 20 respondents are not aware of it.
- 19 respondents have disagreed that Solar energy products are reliable for all weather conditions while 46 respondents have agreed with the statement & 45 respondents are not aware of it.

Interpretation: Table 7

- 110 respondents filled the questionnaire.
- Out of 110 respondents, 47 respondents rated that marketing efforts made by the solar power companies in promoting their products to households are low.
- 30 respondents rated that marketing efforts made by the solar power companies in promoting their products to households are high.
- 33 respondents rated that marketing efforts made by the solar power companies in promoting their products to households are medium.

Table 7: Rate the marketing efforts made by the solar power companies in promoting their products to households

		Frequency	Percent
Valid	Very Low	11	10.0
	Low	36	32.7
	Medium	33	30.0
	High	29	26.4
	Very High	1	.9
	Total	110	100.0

Interpretation: Table 8

- 110 respondents filled the questionnaire.
- Out of 110 respondents, 26 respondents rated that Indian government's effort in promoting solar energy are low.
- 52 respondents rated that Indian government's effort in promoting solar energy are high.

Table 8: How effective according to your knowledge, is the Indian government's effort in promoting solar energy?			
		Frequency	Percent
Valid	Very Low	3	2.7
	Low	23	20.9
	Medium	32	29.1
	High	40	36.4
	Very High	12	10.9
	Total	110	100.0

Interpretation: Table 9

- 110 respondents filled the questionnaire.
- Out of 110 respondents, 62 respondents (56.4%) are aware of subsidy programs and facilities provided by the government for solar energy products.

- 48 respondents (43.6%) are not aware of subsidy programs and facilities provided by the government for solar energy products.

Interpretation: Table 10

- 110 respondents filled the questionnaire.
- Out of 110 respondents, 36 (32.7%) respondents rated that ‘cost’ is the core disadvantage of solar energy products.
- 16 (14.5%) respondents rated that ‘uses a lot of space’ is the core disadvantage of solar energy products.
- 58 (52.7%) respondents rated that ‘solar energy storage is expensive’ is the core advantage of solar energy products.

Interpretation: Table 11

- 110 respondents filled the questionnaire.
- Out of 110 respondents, 34 (30.9%) respondents rated that ‘renewable energy’ is the core advantage of solar energy products.
- 66 (60%) respondents rated that ‘lower electricity bill’ is the core advantage of solar energy products.
- 6 (5.5%) respondents rated that ‘domestic source of energy’ is the core advantage of solar energy products.
- 4 (3.6%) respondents rated that ‘less energy storage’ is the core advantage of solar energy products.

Table 9: Are you aware of subsidy programs and facilities provided by the government for solar energy products?

		Frequency	Percent
Valid	Yes	62	56.4
	No	48	43.6
	Total	110	100.0

Table 10: According to you which of the following is the core disadvantage of solar energy products?

		Frequency	Percent
Valid	Cost	36	32.7
	Uses a lot of space	16	14.5

	Solar energy storage is expensive	58	52.7
	Total	110	100.0

Table 11: According to you which of the following is the core advantage of solar energy products?

		Frequency	Percent
Valid	Renewable energy source	34	30.9
	Lower electricity bill	66	60.0
	Domestic source of energy	6	5.5
	Less energy shortage	4	3.6
	Total	110	100.0

HYPOTHESIS TESTING

Table 12: ANOVA (WILLING TO PAY FOR SOLAR ENERGY PRODUCTS * OCCUPATION)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.113	3	4.038	2.601	.056
Within Groups	164.578	106	1.553		
Total	176.691	109			

Interpretation: Table 12

The significance value is more than 0.05 therefore null hypothesis failed to reject. So, it can be concluded that there is no significant relationship between occupation and willingness to pay for solar energy products.

FINDINGS

- 80.9% of respondents are aware of a solar cooker, 46.4% of respondents are aware of a solar charger, 31.8% of respondents are aware of a solar air conditioner, 7.3% of respondents are aware of a solar water heater, 24.5% of respondents are aware of solar microinverter, and 95.5% of respondents are aware of solar panel.
- Most of the respondents are not using any of these (solar cooker, solar charger, solar air conditioner, solar water heater, solar microinverter, and solar panel) solar energy products that is 90% respondents.

- Majority of respondents are aware of subsidy programs and facilities provided by the government for solar energy products.
- According to most respondents 'solar energy storage is expensive' is the core disadvantage of solar energy products.

CONCLUSION

From this research we can conclude that the popularity of solar based controlled & powered items will keep on filling later on. In the course of the most recent quite a long while extraordinary upgrades have been made in the regions of Solar energy assortment and capacity. New innovations are being developed and built up consistently. Despite the fact that there is developing help for solar oriented energy, the truth of the matter is that until propels have been made in the assembling and designing of solar energy boards & panels, solar energy will be a reasonable option in contrast to customary petroleum products. In our research the respondents are aware about different solar energy products (Solar charger, solar panel, solar air conditioner, solar water heater, solar microinverter) and the usage of solar energy products is less amongst the respondents. Also, according to the respondents marketing efforts by solar energy companies and government are very low & neutral respectively. Furthermore, respondents are aware of subsidy programs and facilities provided by the government for solar energy products.

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A Study on Impact of Macro Economic Variables on Indian Stock Market

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ABSTRACT

The stock market plays a pivotal role in mobilizing the savings, financing the requirement of the corporate, providing liquidity to the corporate sector and to the investors. Liquidity in the market improves the distribution of resources and aids in the economic growth and development of the country. In turn, various economic variables also affect the stock market. Indian capital markets have been receiving global attention and the rapid integration with the world economy has increased India's global competitiveness. The global ratings are awarding India with investment grade ratings, indicating comparatively lower sovereign risks.

The Securities and Exchange Board of India (SEBI), the regulatory authority for Indian securities market, was established in 1992 to protect investors. In the same year, Controller of Capital Issues (CCI) was abolished, which removed administrative controls over the pricing of new equity issues. In less than a decade later, the Indian financial markets acknowledged the use of technology (National Stock Exchange started online trading in 2000), which increased the trading volumes by many folds. There is a sharp surge and rapid growth in the stock markets.

This paper would study if there is any impact of Macro economic factors like FDI, GDP, Money supply, structure of interest rates, Inflation, gross capital formation, trade balance on Sensex. The tools to study this objective would be descriptive statistics, OLS multiple linear regression model.

Keywords: Sensex, GDP, inflation, gross capital formation, FDI

INTRODUCTION

Financial system is the most important institutional and functional vehicle for economic transformation. It helps in the acceleration of rate of savings, mobilization of savings belonging to those who save a part of their income and channelization of the same into the productive activities.

In any economy, financial markets play a pivotal role and in order to boost and capture the world market a country needs to have developed primary and secondary markets. These markets are necessary for providing liquidity to the corporate sector and to the investors. Liquidity in the market improves the distribution of resources and aids in the economic growth and development of the country. In order to maintain their economic and social stability and economic level, every country should focus on its financial system. Economies look at financial markets to finance its BOP (balance of payments) accelerating its development agenda for social and economic stability. Stock market and economy are interrelated and various economic factors influence the financial system of the country directly or indirectly. Many researchers have tried to claim that macro-economic variables affect the stock market. In fact, this has been an area of intense interest among academicians, investors and stock market regulators since 1980s. There always has been a debate regarding whether stock price movements are influenced by economic changes or stock market performance helps in promoting economic growth. It has been a subject of empirical research.

The macroeconomic factors are interdependent and influence each other. It describes how the economy as a whole functions and how the level of national income and employment is determined on the basis

of aggregate demand and aggregate supply. It helps to achieve the various goals like economic growth, a higher GDP level, and higher level of employment, strong exchange rate, and strong financial market performance and so on. Foreign exchange rate is influenced by various macro-economic variables like interest rate, inflation rate, the balance of payments, etc. Overall economic performance is also affected by the exchange rate.

The study investigates the relationship between the Indian stock market performance (BSE Sensex), Market capitalization and six macroeconomic variables, namely, index FIIs, consumer price Index, oil prices, real effective exchange rate and the lending rates over the period of 2010 to 2019 using yearly data.

After liberalizing the Indian economy, Indian capital markets have undergone a series of major changes which has resulted in notable improvement in Indian stock market in terms of its size and depth. Due to increase of foreign institutional investment the process of development of domestic stock market has been further accelerated. The stock markets of India is sensitive to factors such as changes in the level of economic activities, changes in political and international economic environment and also related to the changes in other macroeconomic factors which has been revealed by many studies.

LITERATURE REVIEW

Various studies have been done in the past to predict the relationship between stock market movement and macroeconomic variables. But in the changing scenario, whether there is a relationship between stock market and macroeconomic variables exist or not should be tested.

According to a study by Chen et al. (1986), it was found that equity returns are significantly explained by a set of macroeconomic variables for developed countries. The study included various macro-economic variables like growth in industrial production, changes in the risk premium, twists in the yield curve, measures of unanticipated inflation and changes in expected inflation during periods of volatile inflation.

Lyndon M. Etale and Philomena I. Tabowei mentioned in their study the effect of selected macroeconomic variables on market capitalization in Nigeria. The study adopted Nigerian stock market capitalization as the dependent variable, while macroeconomic variables such as gross domestic product, interest rate, inflation and exchange rate were used as the independent variables. The results of their study showed that gross domestic product has significant positive effect on market capitalization, exchange rate has significant negative effect on market capitalization; while interest rate and inflation have insignificant negative association with market capitalization in Nigeria.

Gjrde and Sættem (1999) examined the causal relation between stock returns and macroeconomic variables in Norway. They found a positive link exists between oil price, real activity and stock returns. According to one of the studies by GIRI A. K. And JOSHI Pooja confirm a long run relationship among the macro economic variables and stock market. It was mentioned that Economic growth, inflation and exchange rate influence stock prices positively. According to this study crude oil price influences the stock price negatively.

As per Cheng and Ng (1998) and Sharma (2002) who established the long-run relationship between the fundamental macroeconomic variables and stock prices and the results suggested that in the long run, stock prices would be positively related to growth and output.

DATA

For this present study the data has been considered from 2010 to 2019. The reason for not including 2020 in the data set because of the exceptional situation of covid and non-availability of data for some variables.

DESCRIPTION OF VARIABLES

SENSEX: A figure indicating the relative prices of shares on the Mumbai (Bombay) Stock Exchange. It is our dependent variable. In many studies, Analysts, Investors and Traders use it to gauge the behaviour of the Economy. We have considered BSE, It is a free-float market-weighted stock market index of 30 well-established and financially sound companies listed on Bombay Stock Exchange. The 30 constituent companies which are some of the largest and most actively traded stocks, are representative of various industrial sectors of the Indian economy. S&P BSE SENSEX, is the country's first equity index launched (Base Year: 1978-79 =100) so considered for present study.

Market Capitalization: It refers to the total value of shares traded on the stock market. It is defined as the number of shares to be multiplied by the share prices. As per market cap, companies can be divided into Large market cap, Mid-market cap and Small market cap. This is also one of the dependent variable in our study

Oil Prices: Changes in the international crude oil prices are often considered an important factor for understanding fluctuations in stock prices. For the purpose of study, international crude oil prices per 1000 barrels have been used.

GDP: It represents economic growth and economic growth is the increase in the inflation-adjusted market value of the goods and services produced by an economy over time. Various studies have tested Gross domestic product (GDP) and has often been used to measure the growth of real economic activity. It is regarded as one of the important determinants of stock market performance which needs to be tested again in the changing scenario.

FII: Foreign Institutional investment is an investor or investment fund investing in a country outside of the one in which it is registered or headquartered. The term foreign institutional investor is probably most commonly used in India, where it refers to outside entities investing in the nation's financial markets. The levels of FIIs have the capacity to impact the stock market.

Inflation CPI: here inflation is measured taking into consideration the consumer price index.

Lending rate: The lending rates at which borrowings can be availed

Exchange Rate: The exchange rate is the value of a country's currency vs. that of another country.

DISCUSSION & ANALYSIS

Dependent variable: sensex

Independent variables: FII, GDP, INF(CPI), oil prices, lending rates, exchange rates

FII: foreign institutional investment, GDP: gross domestic product, INF: inflation, CPI: consumer price index

Descriptive Analysis

Table 1

Here table 1 shows descriptive analysis of dependent and independent variables. In these descriptive statistics, we include, Mean which measures average of variables for 10 years, standard deviation which measures the variation from the central value and also including extreme values. In case of Foreign Institutional Investment (FII), we found that standard deviation is higher than the mean value which indicates that over the period of these 10 years there is a much more variation in FII. For the rest of the variables, standard deviation is lesser than the mean value which suggests the reasonable variation over the period of these 10 years.

Table 1: Descriptive Statistics

Variables	Mean	Standard Deviation	Minimum	Maximum
<i>GDP</i>	6.65883	1.429688328	4.1807	8.4976
<i>FII</i>	99658.1	105602.6496	-80917	256211
<i>INF(CPI)</i>	6.642	2.859909866	3.43	10.53
<i>Oil Prices</i>	72.453	21.79785211	43.29	97.98
<i>Lending Rates</i>	9.773	0.645687403	8.33	10.6
<i>Exchange Rate</i>	60.021	8.875324658	45.65	70.39
<i>Sensex</i>	28981.4	10507.43928	15455	47751

Table 2: Correlation Analysis

	<i>FII</i>	<i>GDP</i>	<i>INF(CPI)</i>	<i>Oil Prices</i>	<i>Lending Rates</i>	<i>Exchange Rate</i>	<i>Sensex</i>
FII	1						
GDP	0.063008	1					
INF(CPI)	0.238982	-0.07749	1				
Oil Prices	0.283784	-0.28796	0.78242113	1			
Lending Rates	-0.01036	-0.36175	0.09490916	0.3960974	1		
Exchange Rate	-0.26005	-0.08283	-0.9024103	-0.6909387	0.04813987	1	
Sensex	-0.17739	-0.21705	-0.839493	-0.6906218	-0.303814808	0.880251576	1

Table 2

Here table 2 represents the correlation coefficient which measures the impact of each independent variable FII, GDP, INF, Oil Prices, Lending Rates, Exchange Rates on the dependent variable Sensex and also measures the correlation within themselves. From this analysis we find that INF, Oil prices and Exchange Rates have more impact on Sensex compared to other independent variables. Also within the group of independent variables, we find that INF is correlated to oil prices and exchange rates whereas oil prices and exchange rates are also related to each other which is quite obvious.

Regression Analysis

Dependent Variable: Sensex

Independent Variables: FII, GDP, INF (CPI), Oil Prices, lending Rates, Exchange Rates

Table 3: Regression Analysis

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
<i>Intercept</i>	68509.72297	17495.75486	3.9157912	0.029608041
<i>FII</i>	0.006523684	0.006331317	1.03038344	0.378628641

<i>GDP</i>	-2403.14541	514.2125678	-4.67344744	0.018502729
<i>INF(CPI)</i>	-807.2744077	600.7551422	-1.34376612	0.271618835
<i>Oil Prices</i>	27.26273218	58.29193114	0.46769307	0.671882539
<i>Lending Rates</i>	-7457.375619	1225.131748	-6.08699891	0.008904205
<i>Exchange Rate</i>	867.8838681	184.0514475	4.71544169	0.018059518
<i>R Square</i>	0.989256749			
<i>Significance Value</i>	0.004809148			

Table 3

The table 3 shows the impact of all the independent variables on the dependent variable Sensex. We find $R^2 = 0.9892$ which suggest that almost 99% variation in Sensex is completely explained by the set of independent variables which are considered here. So, we infer that over this period of 10 years, FII, GDP, INF, Oil prices, lending rates and exchanges rates have more impact on SENSEX compared to other macroeconomic indicators which are not considered under this study. From all p-value of independent variables, we find that in the case of GDP, Lending rates and Exchange rates they are significant as they are less than the level of significance 5%. It suggest that GDP, Lending rates and Exchange rates have more impact on Sensex rather than FII, INF and oil prices have. We also find the overall significance value = 0.004809148 for our regression model which indicates the model is fit to the data. Thus, the regression model is given by,

$$\text{Sensex} = 68509.72297 + 0.006523684 (\text{FII}) - 2403.14541 (\text{GDP}) - 807.2744077 (\text{INF}) + 27.26273218 (\text{Oil Prices}) - 7457.375619 (\text{Lending Rates}) + 867.8838681 (\text{Exchange Rates})$$

Descriptive Analysis

Dependent Variable: Market Capitalization

Independent Variables: FII, GDP, INF (CPI), Oil Prices, lending Rates, Exchange Rates

FII: Foreign Institutional Investment, GDP: Gross Domestic Product, INF: Inflation, CPI: Consumer Price Index

Table 4: Descriptive statistics

Variables	Mean	Standard Deviation	Minimum	Maximum
<i>GDP</i>	6.65883	1.429688328	4.1807	8.4976
<i>FII</i>	99658.1	105602.6496	-80917	256211
<i>INF (CPI)</i>	6.642	2.859909866	3.43	10.53
<i>Oil Prices</i>	72.453	21.79785211	43.29	97.98
<i>Lending Rates</i>	9.773	0.645687403	8.33	10.6
<i>Exchange Rate</i>	60.021	8.875324658	45.65	70.39
<i>Market Capitalization</i>	1.6277	0.445534897	1.007	2.332

Table 4

Here table 4 shows the descriptive analysis of dependent and independent variables. In these descriptive statistics, we include MEAN which measures average of variables for 10 years, standard

deviation which measures the variation from the central value and also including extreme values. In case of Foreign Institutional Investment (FII), we find that standard deviation is higher than the mean value which indicates that over the period of these 10 years there is a much more variation in FII. For rest of the variables, standard deviation is lesser than the mean value which suggests the reasonable variation over the period of these 10 years.

Table 5: Correlation Analysis

	<i>FII</i>	<i>GDP</i>	<i>INF(CPI)</i>	<i>Oil Prices</i>	<i>Lending Rates</i>	<i>Exchange Rate</i>	<i>Market Capitalization</i>
<i>FII</i>	1						
<i>GDP</i>	0.063008	1					
<i>INF(CPI)</i>	0.238982	-0.07749	1				
<i>Oil Prices</i>	0.283784	-0.28796	0.782421	1			
<i>Lending Rates</i>	-0.01036	-0.36175	0.094909	0.396097	1		
<i>Exchange Rate</i>	-0.26005	-0.08283	-0.902410	-0.690938	0.048139	1	
<i>Market Capitalization</i>	0.099013	-0.03178	-0.749128	-0.667428	0.526981	0.665002975	1

Table 5

Here table 5 represents the correlation coefficient which measures the impact of each independent variable FII, GDP, INF, Oil Prices, Lending Rates, Exchange Rates on the dependent variable Market Capitalization and also measures the correlation within themselves. From this analysis, we find that INF, Oil prices, Lending Rates and Exchange Rates have more impact on market capitalization compared to other independent variables. Also within the group of independent variables, we find that INF is correlated to oil prices and exchange rates whereas oil prices and exchange rates are also related to each other which is quite obvious.

Regression Analysis

Dependent Variable: Market Capitalization

Independent Variables: FII, GDP, INF (CPI), Oil Prices, lending Rates, Exchange Rates

Table 6: Regression Analysis

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
<i>Intercept</i>	6.083101699	1.809511814	3.36173638	0.043677108
<i>FII</i>	1.29118E-06	6.54821E-07	1.97180812	0.143194443
<i>GDP</i>	-0.09008022	0.053182828	-1.69378396	0.188880334
<i>INF(CPI)</i>	-0.098126307	0.06213356	-1.5792803	0.212392355
<i>Oil Prices</i>	0.000505489	0.006028888	0.08384447	0.93846158
<i>Lending Rates</i>	-0.405666103	0.126710187	-3.20152714	0.049274249
<i>Exchange Rate</i>	0.009920795	0.019035662	0.52116889	0.638275587
<i>R Square</i>	0.936081947			
<i>Significance Value</i>	0.065400072			

Table 6

The table 6 shows the impact of all the independent variables on the dependent variable market capitalization. We find $R^2 = 0.93608$ which suggest that almost 94% variation in Market Capitalization is completely explained by the set of independent variables which are considered here. So we say that over this period of 10 years FII, GDP, INF, Oil prices, lending rates and exchanges rates have more impact on market capitalization compared to other macroeconomic indicators which are not considered under this study. From all p-value of independent variables, we find that the p-value of Lending rates is significant as it is less than the level of significance 10%. It suggest that Lending rates has more impact on Market Capitalization rather than other independent variables have. We also find the overall significance value = 0.065400072 for our regression model which indicates the model is fit to the data. Thus, the regression model is given by,

$$\begin{aligned} \text{Market Capitalization} = & 6.083101699+ 1.29118\text{E-}06(\text{FII}) -0.09008022(\text{GDP}) \\ & -0.098126307(\text{INF}) + 0.000505489(\text{Oil Prices}) \\ & -0.405666103(\text{Lending Rates}) + 0.009920795(\text{Exchange Rates}) \end{aligned}$$

FINDINGS

1. GDP, Lending Rates and Exchange Rates have been found significantly influential. GDP and lending rates are negatively influencing the Sensex which means with the rise in GDP and lending rates there has been decrease in the value of Sensex. In a low interest rate scenario, there is hardly any incentive for fixed instruments, investors are more inclined towards stock market to gain from even speculative activities. Investing in stock market can generate high returns. On the other hand, exchange rates has a positive and significant impact on Sensex. From this we can infer that when INR is getting stronger the Sensex is also moving up.
2. In the second model of Market Capitalization, Lending rate is found to be influential which clearly states that investors more inclined towards investment in stock market due to less attractive interest rates.
3. In general, no other macroeconomic variable has been found having a significant impact on market capitalization.
4. Since most of the companies are involved in international business the favourable exchange rate will impact the profitability of companies and hence its performance which will ultimately have impact on the market capitalization.

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Liquidity Position of Selected Automobile Companies in India

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ABSTRACT

This research study indicates overall liquidity of selected Automobile companies in India. To fulfil the purpose of the study secondary data of five years (2016-2020) has been collected from annual reports and money control. Liquidity analysis has been done with the help of Mean, Standard Deviation, and One Way ANOVA in order to analyse collected data and present it in tables. Graph portrays presentation of the selected companies. The collected components were analysis in excel sheet, SPSS software and current ratio and quick ratio calculated. Finally this study concluded with overall liquidity position of Eicher Motors is excellent Escorts and M & M also batter liquidity position but Ashok Leyland need to make some efforts to improve their liquidity position. Maruti Suzuki needs to make more effort to reach desired liquidity level as it does not have sufficient liquidity to meet its short term obligations. Finding and suggestions for further improvement are given at the end of the study.

Keywords: Automobile companies, Liquidity Ratios, one way ANOVA.

INTRODUCTION

The Automatic industry is the strength of Indian Economy. Automobile is the basic component as many other sectors of economy are dependent on it. In this study, Liquidity is one of the significant factors to identify financial performance of any industry as its shows and industry is able to meet its short term debts or not. When industry does not have enough cash or market securities to pay its short term debts that indications industry has liquidity risk. Liquidity is measured as short-term liquidity which is the capability of the organization to repay its current liabilities out of its current assets. Liquidity ratios measure the ability to meet its current debts when they fall due for payment.

Every industry requires maintaining a desired level of liquidity as more liquidity implies that industry has idle funds and is not giving any earnings. The short liquidity is also not desirable as industry cannot pay its near future debts, credit image may loss, sureness of creditors may go down in dealing with industry, even industry may suffer from long lawful procedure. The study intends at analysing the liquidity position of the selected automobile industries using different liquidity ratios like Current ratio, quick ratio, inventory turnover ratio and absolute liquidity ratio have been used to analysis to be overall liquidity position of selected Indian industries.

LITERATURE REVIEWS

T.Harikrishnamurthi & Dr.R.Gopi (2019) “Liquidity Analysis of Select Automobile Companies in India” According to this research paper, various liquidity ratios like current, quick, cash to current Assets, Net working capital to sales and cash as used variable. This research study deal with analytical types of research design with the help of secondary data and for the purpose the research took last five year’s data. In research methodology statistics tools as descriptive statistic and ANOVA Applied

finally, the researcher concluded that the selected companies has not maintained ideal current ratio and quick ratios. Further the study reveals that the net working capital situation of the Eicher motors ltd and, SML Isuzu was in a satisfactory level but other companies were not in satisfactory level.

Prof. Ramesh C. Ganvit & Dr. Kamlesh S. Dave (2018) “An Empirical Study of Liquidity Analysis of Selected Automobile Companies of India” According this research paper two liquidity ratios current ratio and quick ratio as used variable. This research study deals with analytical types of research. This research study last ten year’s financial data based. In research methodology statistics tool F-Test – two ways analysis of variance applied. Finally the researchers obtained that selected research unit of automobile companies during research period while unit base current ratio seen to unequal norms during research period.

R.SATHISHKUMAR and G.BALAMURUGAN (2020) “Liquidity And Solvency Analysis of Lease company- A case Study of Bajaj Finance Limited” According this research article Leasing, liquidity ratios like Current, Cash, Fixed Assets, Shareholder’s Funds, Proprietary and Debt to Long-Term as used variable. This research study deals with analytical types of research. This research study based on last five year’s data based. Here in research methodology Comparative Financial Statements used for data analysis. According the researcher concluded that Bajaj Finance Limited is the first among the leasing companies in India might concentrate on maintaining liquidity and solvency position to run a business in the long run thereby satisfy the stakeholders.

K. Jayakumar (2018) “A Study on Liquidity Analysis of Ashok Leyland Ltd” According to this research paper, the research liquidity ratios used like Current, Quick, Absolute Liquidity, Debt Turnover, Average collection Period, Working Capital Turnover, Fixed Assets Turnover, Total Assets Turnover, Proprietary and Debt Equity as variable. This research study deals with analytical type of research design with the help of secondary data last ten year’s data based; in research methodology different statistics tools applied like Mean, Standard Deviation, Co-efferent of variance & Motel’s comprehensive test. According this case study the company liquidity position is satisfactory level so the company improve the assets. Separately from this company is having a good background and sound reputation with which no doubt. It will have an excellent progress in future. Thus, firm manger should concern on inventory and receivables in purpose of creation shareholder wealth.

OBJECTIVE OF THE STUDY

- To analysis the liquidity position of the selected companies from automobile Industry in India.

HYPOTHESIS

H₀: (1) There is no significant difference between current ratio of selected automobile companies.

H₁: (1) There is significant different between current ratio of selected automobile companies.

H₀: (2) There is no significant difference between quick ratios of selected automobile companies.

H₁: (2) There is significant different between quick ratios of selected automobile companies.

RESEARCH METHDOLOGY

The study has used tables and charts represent the (liquidity ratios) descriptive statistics and one way ANOVA analysis of selected five automobile companies for the period ranging from 2016-2020.

- Current Ratio :- $\frac{\text{Current Assets}}{\text{Current Liabilities}}$
- Quick Ratio :- $\frac{\text{Liquid or Quick Assets}}{\text{Current Liabilities}}$

SOURCES OF DATA

Secondary sources of data will be utilized for this research study. Secondary data have been collected from automobile company's annual reports, companies' websites: money control.

PERIOD OF THE STUDY

The liquidity study is made for a period of 5 years from 2016 to 2020.

SAMPLING DESIGN

For this study five automobile companies selected on the basis of their market capitalization performance selected companies are as under.

Company Name	Market Capitalization Rs.
Maruti Suzuki	189,115.71
Eicher Motors	56,355.90
Escorts	15,287.54
Ashok Leyland	14,281.34
M & M	75,399.63

STATISTICAL TOOLS FOR ANALYSIS

- Mean
- Standard Deviation
- Graph
- One way ANOVA

DATA ANALYSIS

TABLE 1: CURRENT RATIO (Per cent)

Years	Maruti Suzuki	Eicher Motors	Escorts	Ashok Leyland	M & M
2016	0.71	0.87	0.96	1.06	1.18
2017	0.66	0.92	1.00	0.93	1.31
2018	0.51	1.15	1.28	0.91	1.24
2019	0.87	2.22	1.45	0.93	1.26
2020	0.75	3.40	1.66	0.77	1.38
Mean	0.700	1.71	1.27	0.92	1.274
Standard Deviation	0.13153	1.09081	0.29732	0.10296	0.7537

Table 2: ANOVA CURRENT RATIO

Source of Variation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2.989	4	.747	2.848	.051
Within Groups	5.247	20	.262		
Total	8.237	24			

INTERPRETATION

- The Current ratio of Maruti Suzuki in the years up-down seems in presentation in 2016 was 0.71 highest . In 2017 down to 0.66, again in 2018 it seems to go down to 0.51 then after jumped and reached highest in 2019 (0.87) again it seems to change in 2020 (0.75). we shall talk about Eicher Motors which seems to have an increment in 2016 which was (0.87), in 2017 increases to (0.92), in 2018 (1.15) it was good, then in 2019 (2.22) .and in 2020 more liquidity increase to (3.4).
- The Above Table-1 shows that Eicher Motors has highest mean (1.71) followed by Mahindra & Mahindra (1.27) and Escorts (1.27) in second and third position respectively. Mean of Ashok Leyland (0.92) is least among all selected automobile companies as it does not have significant liquidity to pay its short term obligations.
- The P-value of the ANOVA analysis is 0.051 which is more than 0.05 that means here the null hypothesis is accepted. This means there is no significant difference in current ratio of selected automobile companies.

Fig 1: CURRENT RATIO

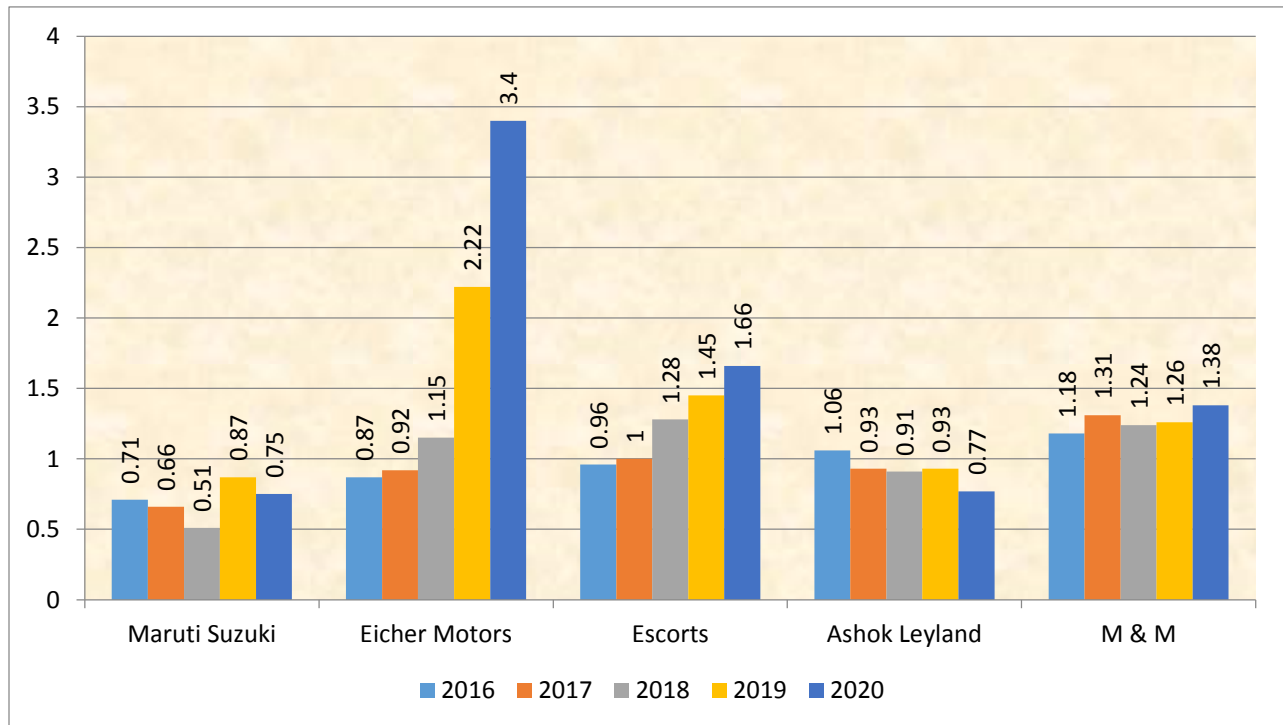


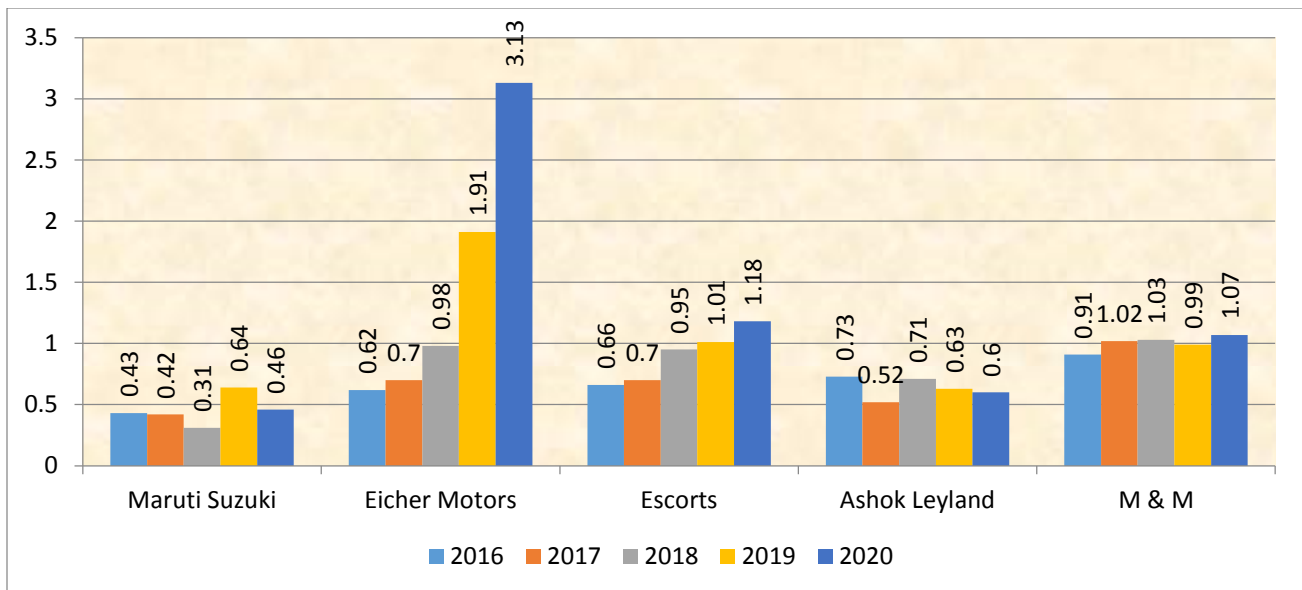
TABLE 3: QUICK RATIO (Per cent)

Years	Maruti Suzuki	Eicher Motors	Escorts	Ashok Leyland	M & M
2016	0.43	0.62	0.66	0.73	0.91
2017	0.42	0.70	0.70	0.52	1.02
2018	0.31	0.98	0.95	0.71	1.03
2019	0.64	1.91	1.01	0.63	0.99
2020	0.46	3.13	1.18	0.60	1.07
Mean	0.45	1.46	0.91	0.64	1.00
Standard Deviation	0.11946	1.06121	0.22041	0.08526	0.05983

TABLE 4: ANOVA QUICK RATIO

Source of Variation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3.012	4	.753	3.141	.037
Within Groups	4.796	20	.240		
Total	7.808	24			

FIGURE 2: QUICK RATIO



INTERPRETATION

- The Quick ratio of Maruti Suzuki in the years up-down seems in presentaion in 2016 was 0.43 highest . In 2017 down to 0.42 again in 2018 seems to go down to 0.31 then after jumped to reach highest in 2019 (0.64) again it seems to change in 2020 (0.46). we shall talk about Eicher Motors which seems to increase in 2016 to (0.62), in 2017 increase to (0.7), in 2018 (0.98) it was good, then in 2019 (1.91) and in 2020 more liquidity increase to (3.13).
- The Above Table-3 shows that Eicher Motors has highest mean (1.46) followed by Mahindra & Mahindra (1.00) and Escorts (0.91) in second and third position respectively. Mean of Ashok Leyland (0.64) is least among all selected automobile companies as it does not have significant liquidity to pay its short term obligations.
- The P-value of the ANOVA analysis is 0.037 which is less than 0.05 that means here the null hypothesis is rejected. This means there is significant difference in quick ratio of selected automobile companies.

FINDINGS

From the above data analysis following finding has been found.

- It is found that current ratio of Eicher Motors is highest among all selected automobile companies as it has maintained ideal ratio of 2:1.

- Eicher Motors and Mahindra and Mahindra both have maintained ideal quick ratio 1:1 but Eicher Motors gets first position as it has the highest ratio.
- There are significant differences between the automobile companies of India in the area of Liquidity position.

SUGGESTIONS

- Maruti Suzuki has lowest current ratio as it needs to work on raising its current assets pay it is short term obligations.
- Maruti Suzuki has least quick ratio as it need to make efforts on converting its quick assets immediately or at reasonable cost to meet payment of its near future obligation.

CONCLUSION

Sustaining a desired level of liquidity has much importance for automobile companies according to the effect of recession and epidemic which has been seen in this sector. In the present study, liquidity position of top five automobile companies have been compared and analysed to know their overall liquidity in the industry. The study concluded that overall liquidity position of Eicher Motors is excellent, Escorts and M & M are also in better liquidity position but Ashok Leyland needs to make some efforts to improve their liquidity position. Liquidity analysis shows that Maruti Suzuki needs to make improvement in order to survive against its rival companies as it has the lowest liquidity.

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A Comparative Study of Cash Position between Tata Motors and Mahindra Ltd.

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Abstract

The official name for the Cash flow statement is the reports of cash. It is one of the principle financial statements. (The other budget reports are the balance sheet, Income Statement, and proclamation of investors' value.) In the companies there is required to maintaining working capital or cash and without cash business of company cannot run. The cash is most important aspects of the business organizations. The main purpose of this study is to analyze the liquidity position of Tata Motors and Mahindra ltd. In this work researcher has taken 10 years and includes the statistical tools like Means, Standard deviation and t-test. This research paper will be very useful to the research students for the purpose of the study.

Keywords: Cash Position, Cash Flow Statements

INTRODUCTION

A Cash flow statement is a budget report that gives total information with respect to all money inflows an organization gets from its progressing activities and outside venture sources. It likewise incorporates all money outpourings that pay for business exercises and speculations during a given period.

An organization's financial statements offer speculators and experts a picture of the multitude of exchanges that experience the business, where each exchange adds to its prosperity. The cash flow statement is accepted to be the most natural of the relative multitude of fiscal summaries since it follows the money made by the business in three primary manners—through activities, investment, and financing.

The main segment of the cash flow statement is income from tasks, which incorporates exchanges from all operational business exercises.

Income from venture is the second segment of the cash flow statement, and is the consequence of speculation gains and misfortunes.

Income from financing is the last area, which gives an outline of money utilized from debts and equity.

REVIEW OF LITERATURE

Varshney N. and Jain M. (2019), in this research paper he has concentrated on relative cash flow statements between two banks for example Canara Bank (public area) and Kotak Mahindra bank(private area) for term of 5 years beginning from 2012-13 to 2016-17. They have utilized measurable examination strategies like Average (Mean), Standard Deviation, Co-efficient of Variation and Multiple Regression Analysis. The research outcome mirrors that Canara Bank was carry out better contrasted with Kotak Mahindra Bank because of the cash was not influenced the net benefit of Canara Bank yet cash flow of Kotak Mahindra Bank are influenced its net benefit.

Bhasker D. and Krishnavamsi B. (2018), examined on cash flow examination of Eidiko Systems Integrators Private Limited and Tanla Solutions Limited for the hour of five years beginning from 2013 to 2017. The reason for the examination was to analyze explanation which grouped cash flow from operation, investing, and financing exercises during the exploration period. The yield of the examination mirrors that working operating activities (net) was positive which was good. Net cash

flow from contributing exercises and monetary exercises were contrarily as they have been putting huge sums in ascending of resources just and where the organization has used the money for reimbursing getting and their premium and has put resources into rising

OBJECTIVES OF THE STUDY

To examine cash position of selected two companies.

SAMPLE DESIGN

In India there are many companies working in various sectors so that the researcher has used random sampling techniques for this study and select two auto mobile industries from India.

PERIOD OF THE STUDY

This study is restricted for the 10 years because of researcher can judged the cash position outcomes from this long period of time.

STATISTICAL TOOLS AND TECHNIQUES

In this research study researcher has taken various secondary data from websites and online sources. Here different statistical tools are used which are as follows:

- Mean (Average)
- S.D.(Standard Deviation)
- C.V. (Co-efficient of Variance)

T-test paired two samples for means

COMPARATIVE DATA ANALYSIS AND INTERPRETATION

Table 1: Comparative analysis of Operating Activities from the year 2010-11 to 2019-20

Year	Tata Motors	Mahindra Ltd
2010-11	1,505.56	2,979.78
2011-12	3,653.59	2,734.95
2012-13	2,258.44	4,145.71
2013-14	2,463.46	3,727.64
2014-15	-2,562.67	3,219.49
2015-16	2,702.98	5,470.50
2016-17	1,453.45	3,710.00
2017-18	4,133.94	7,027.08
2018-19	6,292.63	4,923.87
2019-20	-1,454.59	3,677.83
Avg.	2044.68	4161.69
Rank	2	1
SD	2576.95	1310.28
Rank	2	1
CV	126.032	31.48
Rank	2	1

(Source: Annual Report of Selected companies from 2010-11 to 2019-20)

It was seen that from the above table the average of Mahindra ltd is higher compare to Tata Motors. Look at the operating activities the Mahindra ltd has good performance during the study. In these activities there is also fluctuation is found within the study.

Fig 1: Operating Activities

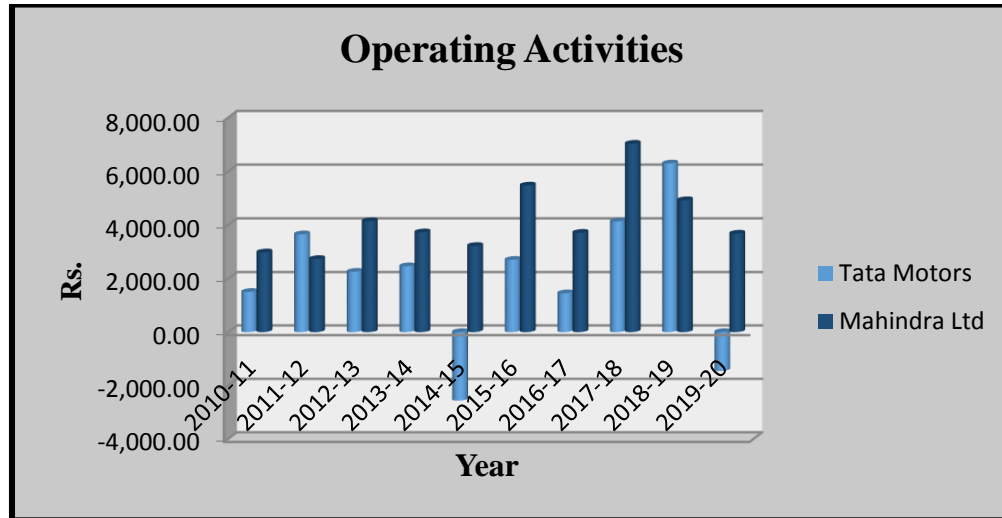


Table 2: Comparative analysis of Investing Activities from the year 2010-11 to 2019-20

Year	Tata Motors	Mahindra Ltd
2010-11	-2,521.88	-3,734.99
2011-12	144.72	-1,936.54
2012-13	991.50	-2,895.95
2013-14	2,552.91	-2,407.08
2014-15	601.74	-2,423.09
2015-16	-3,264.22	-3,537.93
2016-17	-2,859.00	-2,781.83
2017-18	-710.27	-5,110.42
2018-19	-3,820.55	-2,548.71
2019-20	-4,718.86	-2,575.72
Avg.	-1360.39	-2995.23
Rank	1	2
SD	2402.19	915.35
Rank	2	1
CV	-176.59	-30.57
Rank	2	1

(Source: Annual Report of Selected companies from 2010-11 to 2019-20)

In these investing activities the average of Tata Motors is lower compare to Mahindra ltd. As per this activities performance of Tata motors has superior in the research study. There was found fluctuating trend in Tata motors and also seen that the negativity in Mahindra ltd compare to Tata motors.

Fig 2: Investing Activities

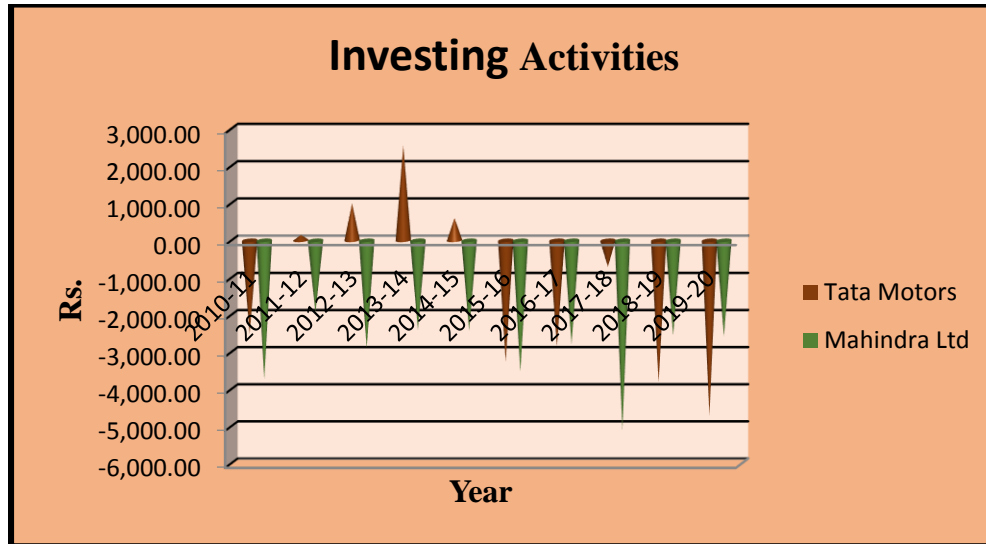


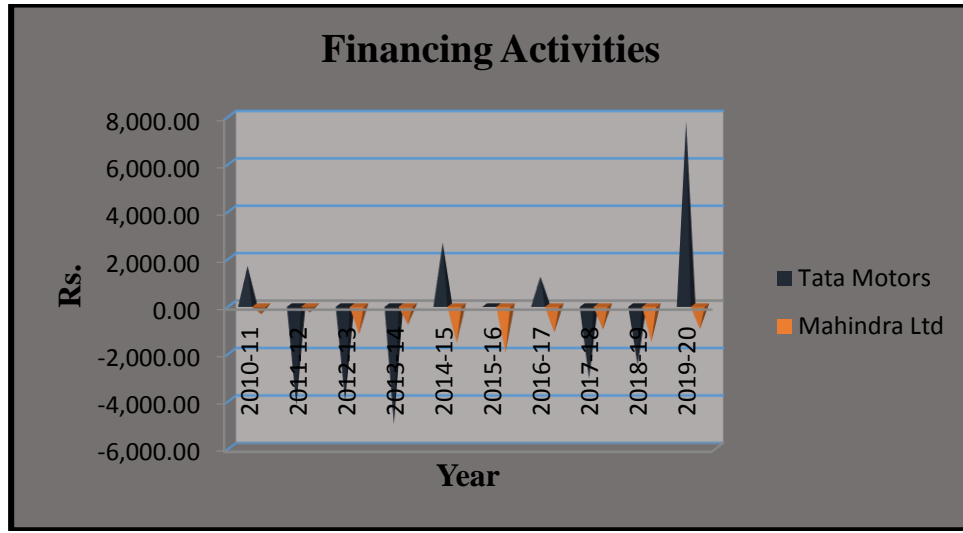
Table 3: Comparative analysis of financing Activities from the year 2010-11 to 2019-20

Year	Tata Motors	Mahindra Ltd
2010-11	1,648.42	-383.75
2011-12	-4,235.59	-306.15
2012-13	-4,045.69	-1,221.89
2013-14	-5,033.81	-823.93
2014-15	2,631.53	-1,584.82
2015-16	-78.87	-2,007.20
2016-17	1,208.80	-1,161.49
2017-18	-3,105.63	-1,033.31
2018-19	-2,529.70	-1,555.22
2019-20	7,749.21	-1,015.46
Avg.	-579.13	-1109.32
Rank	2	1
SD	3993.02	528.53
Rank	2	1
CV	-689.486	-47.6445
Rank	2	1

(Source: Annual Report of Selected companies from 2010-11 to 2019-20)

According to the financing activities the average of Tata Motors is lower compare to Mahindra ltd. As per this activities performance of Tata motors is better in the study. There was found fluctuating trend in Tata motors and also seen that the negativity in Mahindra ltd compare to Tata motors.

Fig 3: Financing Activities



Hypothesis Testing

Table 4: T-test: Paired two samples for mean for Operating Activities

	<i>Tata Motors</i>	<i>Mahindra Ltd</i>
	1505.56	2979.78
Mean	2104.581111	4293.007778
Variance	7430366.379	1737411.197
Observations	9	9
Pooled Variance	4583888.788	
Hypothesized Mean Difference	0	
Df	16	
t Stat	-2.168309231	
P(T<=t) one-tail	0.022777848	
t Critical one-tail	1.745883669	
P(T<=t) two-tail	0.045555696	
t Critical two-tail	2.119905285	

This hypothesis is accepted (determined estimation of t for operating activities - 2.168309231 is lower than the tables regard (2.119905285). It demonstrates that there is no significant difference between the means of operating activities of selected companies through the examination stage.

Table 5: T-test: Paired two samples for mean for Investing Activities

	<i>Tata Motors</i>	<i>Mahindra Ltd</i>
Mean	-1360.391	-2995.226
Variance	5770493.035	837850.0923

Observations	10	10
Pooled Variance	3304171.564	
Hypothesized Mean Difference	0	
Df	18	
t Stat	2.01107207	
P(T<=t) one-tail	0.029769475	
t Critical one-tail	1.734063592	
P(T<=t) two-tail	0.05953895	
t Critical two-tail	2.100922037	

It can be seen that this hypothesis is accepted (determined estimation of t for investing activities 2.01107207 is lower than the tables regard (2.100922037). It reveals that there is no significant difference between the means of investing activities of selected companies during the examination period.

Table 6: T-test: Paired two samples for mean for financing Activities

	<i>Tata Motors</i>	<i>Mahindra Ltd</i>
Mean	-579.133	-1109.322
Variance	15944150.55	279341.9793
Observations	10	10
Pooled Variance	8111746.267	
Hypothesized Mean Difference	0	
Df	18	
t Stat	0.416254112	
P(T<=t) one-tail	0.341072602	
t Critical one-tail	1.734063592	
P(T<=t) two-tail	0.682145204	
t Critical two-tail	2.100922037	

It is observed that the hypothesis is accepted (determined estimation of t for financing activities - 0.416254112 is lower than the tables regard (2.100922037). It shows that there is no significant difference between the means of financing activities of selected companies through the examination stage.

FINDINGS

1. The average of Mahindra ltd is higher compare to Tata Motors. Look at the operating activities the Mahindra ltd has good performance during the study.
2. In these investing activities the average of Tata Motors is lower compare to Mahindra ltd. As per this activities performance of Tata motors has superior in the research study.
3. According to the financing activities the average of Tata Motors is lower compare to Mahindra ltd. As per this activities performance of Tata motors is better in the study.
4. The overall situation regarding the cash position of Tata motors was best compared to Mahindra ltd in this study.
5. Standard deviation to spot variation in numerous activities of cash flow statement. It's found that the SD of Mahindra ltd in operative activities, investing activities and financial activities found

lower compared to Tata motors which suggests there was no fluctuations are found throughout study from 2010-11 to 2019-20.

6. Co-efficient of variation is besides proportions of scattering here likewise lesser the worth higher position will be given and higher the estimations of Co-efficient of variety lower rank will be given. The value of Mahindra ltd is set up lower judge against to Tata motors so in these all activities Mahindra ltd has secured first rank during the research phase.

CONCLUSION

In this study we can observed that the operating activities of Mahindra Ltd was good compare to Tata Motors during the study period and in investing activities Tata Motors was performed well through the entire study. As per the financing activities we can say that the performance of the Tata Motors was better during the year 2010-11 to 2019-20. In this research study the cash position of Tata Motors was very good in the study and Mahindra ltd should improve the cash position for the future benefits.

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A Study on Entrepreneurship Ecosystem Development in Indian University Setup: A Project Management Perspective

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Abstract

Entrepreneurial ecosystems show an interconnected community between various components that support each other in giving birth to new entrepreneurs. According to a study of more than 150 university incubators and almost 900 companies, university-incubated businesses created more jobs and generated more sales than those incubated elsewhere. In fact, in developed ecosystems like the United States, the chances of student entrepreneurs succeeding are more likely, if the idea is launched within premises of a university-located incubator. In India, most college-level incubators, accelerators, and innovation centres fail to create measurable impact or deliver on their value proposition. With this backdrop then, it is important to understand the challenges that universities face when trying to establish successful incubators, which can help create sustainable businesses. To overcome some of these challenges, fortifying individual elements of the ecosystem and tying it to the larger ecosystem; having competitions or programs that facilitate start-ups finding adequate funding will play an important role. The purpose of this study is to apply a novel method of comparative education research and assessment items for university-based entrepreneurship ecosystems (U-BEEs), with a specific focus on universities in India. In this paper, entrepreneurship education development will be explored, and important implications for the further improvement of entrepreneurship education shall be provided. The study will be based on the comparative education research method and proceeds in four steps (i.e., description, interpretation, juxtaposition, and comparison). The U-BEE items will be applied to exemplify the similarities and differences of the process by which entrepreneurship education developed in various Universities in India.

Keywords: University Ecosystem, Entrepreneurship education, Comparative education research method, University-based entrepreneurship ecosystems.

INTRODUCTION

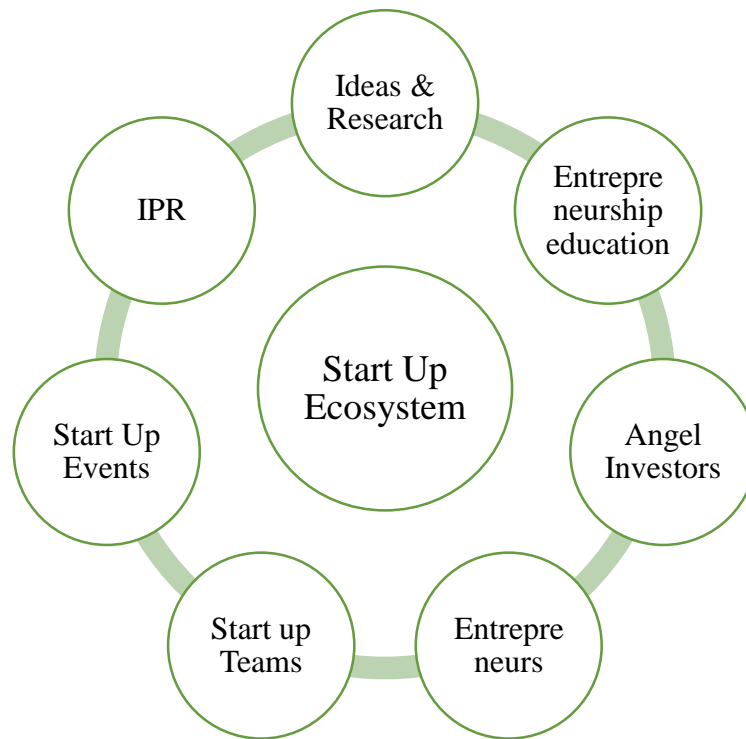
Entrepreneurial ecosystems show an interconnected community between various components that support each other in giving birth to new entrepreneurs. New entrepreneurs can emerge and develop not only because of the heroic, talented, and visionary individual (entrepreneur). New businesses also arise because they are in an environment or "ecosystem" that allows them to be easy and supportive in starting a business. A conducive entrepreneurial ecosystem is needed in giving birth to prospective new entrepreneurs. The government strongly encourages the birth of entrepreneurs among the younger generation. The government realizes the role of entrepreneurs in determining the progress of a nation has been proven by several developed countries such as America, Japan, and neighbouring countries such as Singapore, Malaysia, and Thailand.

India is witnessing a tremendous rise in the start-up creation and business incubation, driven by an extremely diverse, inclusive entrepreneurial landscape and easy access to capital. It all started with

the National Science and Technology Entrepreneurship Development Board (NSTEDB). NSTEDB launched the Science and Technology Entrepreneurs Parks (STEP) in the early 1980's and the Technology Business Incubators (TBI) in early 2000.1 A number of academic and non-academic institutes have now joined the forces.

Entrepreneurship ecosystem refers to the social and economic environment affecting the local/regional entrepreneurship. The entrepreneurship ecosystem has eight domains that are the key to promote entrepreneurship. Each entrepreneurship ecosystem is unique. It can be described under eight domains (Audretsch, 2007). India is a Changed world today. Products are being developed here for the Indian market because it has a big consumer base. According to NASSCOM Start-up report India has the third largest start-up ecosystem in the world. Indian ecosystem has the innovative ideas. The need is the channel and guidance in terms of acceleration, scaling up and funding. Launching incubators and R & D centres can help the start-ups to be incubated. Technology is fast changing. It is important to comprehend the new forms of technology by the manpower who can work. The Government of India has undertaken several initiatives and instituted policy measures to foster entrepreneurial culture in the country. To nurture innovation, Government of India integrated a number of sectors that include academia, industry, investors, entrepreneurs and non-governmental organizations. A start-up ecosystem constitutes people, start-ups in their various stages and various types of organizations to scale new start-up companies. The Elements of the start-up ecosystem is mentioned below:

Fig 1: Components of Start-up Ecosystem



In addition, academic institutions are important stakeholders of the Entrepreneurship Ecosystem. The remainder of this chapter focuses on the university as a stakeholder in the larger Entrepreneurial Ecosystem, while acknowledging that the university exists within a broader domain of academic institutions. The focus on the university reflects an assessment that it is the most prominent institution under the academic domain, insofar as the Entrepreneurial Ecosystem is concerned. Figure 2 describes the various components of University of Entrepreneurship Ecosystem. Scholars and practitioners discussing EEs consistently recognize the potential and demonstrated importance that higher education generally, and universities specifically, play in building and maintaining a growing

and thriving Entrepreneurship Ecosystem. The term University-Based Entrepreneurship Ecosystem, or UBEE. Like the larger EE, UBEEs can range from less to more developed. On the embryonic end, you might see limited offerings (such as single courses and/or a student club), while on the scaled-up end, you might see a full range of formal and informal components at play (such as active Technology Transfer Offices, widespread faculty consulting, majors/minors, workshop series, social gatherings, makers' spaces, and incubators/accelerators).

Fig 2: Components of University-Based Entrepreneurship Ecosystem (U-BEE)



Figure 2 illustrates the potentially significant components of the UBEE. In this case, entrepreneurs are centered on a field of university-related resources surrounded by supporting or contributing stakeholders that ultimately results in outputs and outcomes. The entrepreneurs may include faculty, staff, and students located within a campus with connections bridging to the broader community.

LITERATURE REVIEW

The definition of Entrepreneurial Ecosystem is defined by **(Liliana Fonseca, 2020)** mentions that it is the socio-economic environment shaping and fostering local and regional entrepreneurship as an economic development strategy. Within this framework, actors orient their focus to regional development and value-creation.

(Jain, 2016) In her article mentioned the growth of start-up ecosystem in India where India declared Innovation Decade (2010-2020) which has increased the industrialization in India. **(Hussain, 2020)** Developed a framework model for academic institutions to promote and develop the contemporary requisite for entrepreneurship. Another study on knowledge triangles within Dutch entrepreneurial ecosystems reflects a connection with research, education and innovation for productive entrepreneurship in regional ecosystems.

(Isenberg, 2011) Contributed with his Entrepreneurial Ecosystems Model for economic development and identified six domains - a conducive culture, enabling policies and leadership, availability of appropriate finance, quality human capital, venture-friendly markets for products, and a range of institutional and infrastructural support. Isenberg stated that each of them are unique and has various elements interacting with each other in many ways. A university-based entrepreneurship ecosystem model proposes entrepreneurship development through a variety of initiatives related to teaching, research and outreach **(Khattab, 2017)**.

(Adhana, 2020) Analysed that through the incubator, enterprises can develop a more technological profile and universities more business-like behaviour. At the same time, the incubator is an extremely quintessential mechanism for achieving effective communication between technology-based enterprises and universities. Moreover, the study also highlights that the universities play a crucial role in creation and development of technology-based enterprise.

(Asrado, 2015) This study evaluates the contingency by examining whether firms graduating from university incubators attain higher levels of post-incubation performance than firms participating in non-university affiliated incubators.

(Auschra, 2019) The study reveals that shaped by their institutional context – patterns of project-like organizing have become pertinent to the new venture creation process. It identifies a set of facets from the entrepreneurial ecosystems – more specifically different types of organizational actors, their occupational backgrounds, and epistemic communities – that enable and constrain the process of new venture creation in a way that is typical for project-based organizing.

(Stam, et al, 2016). A research study about the current situation of start-ups in respect to universities proposing the knowledge exchange, collaborations and engagements with different stakeholders brings motivation, synergies and network effect for start-up process and ecosystem (Stagars, Manuel, 2015).

There have been many contributions and perspective given for the development of entrepreneurship ecosystem. According to The Entrepreneurial Personality Model (Khattab, 2017), entrepreneur is a complex personality and willing to take risk by utilising the available resources and capabilities to exploit the opportunities. It relates to immediate environment and current market circumstances.

Another study identifies a theoretical framework with 5 dimensions of environment factors (government policies and procedures, socioeconomic conditions, entrepreneurial and business skills, financial assistance and non-financial assistance) and relates them with 5 core elements (opportunity, entrepreneur, and abilities, business) as Entrepreneurial Process Model (Khattab, 2017).

OBJECTIVES

The purpose of this study is to apply a novel method of comparative education research and assessment items for university-based entrepreneurship ecosystems (U-BEEs), with a specific focus on universities in India. In this paper, entrepreneurship education development is explored, and important implications for the further improvement of entrepreneurship education are provided.

- To explain opportunities and challenges face by universities in supporting Entrepreneurship;
- To outline the role of universities and affected factors.
- To compare the performance of top incubation centres across India.

RESEARCH METHODOLOGY

This study is based on the comparative education research method and proceeds in four steps (i.e., description, interpretation, juxtaposition, and comparison). The U-BEE items are applied to exemplify the similarities and differences of the process by which entrepreneurship education developed in various Universities in India.

Data Collection Method: This study has been carried out with the help of secondary data only, all the data has been collected from the various sources such as websites & reports and compiled as said by the need of the study.

Data Collection Method: This study has been carried out with the help of secondary data only, all the data has been collected from the various sources such as websites & reports and compiled as said by the need of the study. The list of top institution providing Incubation support is as follow:

Table 1: List of Institutions

Sr. No.	List of Top Institutions providing Incubation Services across India	
	Name of the Incubation Centre	Affiliation with University/Institution
1	Society for Innovation & Development (SID)	Indian Institute of Science (IISc), Bangalore

2	NS Raghavan Centre for Entrepreneurial Learning (NSRCEL)	Indian Institute of Management (IIM), Bangalore
3	Xavier Institute of Management & Entrepreneurship (XIME)	Xavier Institute of Management & Entrepreneurship, Bangalore
4	Society for Innovation & Entrepreneurship (SINE)	Indian Institute of Technology (IIT), Mumbai
5	Centre for Entrepreneurship Development (CED)	S.P. Jain Institute of Management & Research, Mumbai
6	National Design Business Incubator (NDBI)	National Institute of Design (NID), Ahmedabad
7	Technology Business Incubator (TBI)	Indian Institute of Technology (IIT), Delhi
8	Amity Innovation Incubator (AII)	Amity University, Noida
9	Centre for Innovation, Incubation and Entrepreneurship (CIIE)	Indian Institute of Management (IIM), Ahmedabad
10	The International Centre for Entrepreneurship & Technology (iCreate)	Ahmedabad
11	Technology Business Incubator (TBI)	Birla Institute of Technology & Science, Pilani
12	SIDBI Innovation & Incubation Centre (SIIC)	Indian Institute of Technology (IIT), Kanpur

Source: <https://yourstory.com>

DATA ANALYSIS

To compare the above-listed Incubation centres, five key themes/parameters were identified based around the entrepreneurial process and the role of place. The five key parameters are as follow:

- **Infrastructure:** Infrastructure is one of the crucial elements for any university as it talks about availability of the resources, Equipment etc. There is strong evidence that high-quality infrastructure facilitates better instruction, improves student outcomes, and reduces dropout rates, among other benefits
- **Entrepreneurial Finance:** The key questions for an Entrepreneur are: Is it worthy to invest time and money in this business? Financial planning allows entrepreneurs to estimate the quantity and the timing of money needed to start their venture and keep it running.
- **Business Support:** The enrolled students will always expect certain kind of support from the university as starting up the new venture is always considered as a risk in a country like India.
- **Network:** Network includes Alumni network, Industrial network which helps the students to build a relation with for collaboration if needed.
- **Leadership:** Here, leadership talks about the entrepreneurial leadership which helps the entrepreneurs to get involve in influencing others and motivating them.

The below-mentioned table 2 showcase the comparison of the top 12 incubation centres across India on the basis of 5 parameters.

Table 2: Comparative Analysis of the incubation centres with the key parameters

Sr. No.	Name of the Incubation Centre	Parameters				
		Infrastructure Facilities	Availability of Entrepreneurial Finance	Business Support Services	Network with Industry	Leadership
1.	SID	✓				
2.	NSRCEL	✓		✓		✓
3.	XIME				✓	✓

4.	SINE			✓	✓	
5.	CED	✓	✓			✓
6.	NDBI			✓	✓	
7.	TBI		✓			
8.	AII		✓	✓		✓
9.	CIIE	✓			✓	✓
10.	iCreate	✓				
11.	TBI, Pilani	✓				
12.	SIIC		✓	✓		

Source: Self-made based on the analysis

The above-mentioned table showcase the comparison of 12 top incubation centres. Here, the author tries to compare through the rating method. To provide the rating the secondary data is used. The researcher used the web-based sources and identified the information from the same. To cross verify, the researcher has also analysed the rankings of the University from various sources and on what bases the Rankins are given.

SUGGESTION

Figure 3: A Key parameters-based model for the University-Based Entrepreneurship Ecosystem

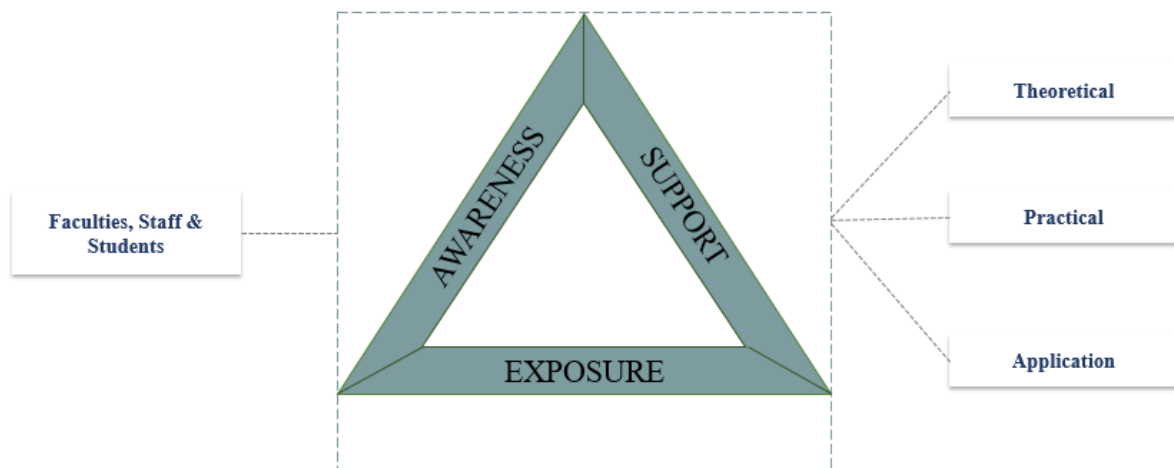


Figure 3 provides a model which explains about the various elements classified under 3 focus areas (parameters): Awareness; Support & Exposure. The elements are arranged on three levels of learning which are: Theoretical Knowledge, Practical Knowledge and Application. Integration of all three focus areas (parameters) and various elements is recommended to facilitate an effective entrepreneurial ecosystem for educational institutions. The elements in the respective areas are interrelated to each other in developing the essential skills for an entrepreneur. Each of the elements has a varied impact in the development of the entrepreneurial capabilities according to the involvement and as moving from theoretical level to the application level. With the proper integration of the model with the external environment and the stakeholders would harvest the essentials requisites for entrepreneurship development in rapidly changing environment.

1. Awareness

Awareness should be Subject-oriented and related to skill development. Awareness can have a sub component of Knowledge as the universities are going to provide the courses elated to the sane. Courses also incorporate skill development and entrepreneurship development teaching-learning conducted in the campus including the elective and inclusive subjects offered in the existing courses offered by the institute. For instance, Financial Knowledge includes the financial awareness, information and knowledge that is imparted to the students with respect to resource planning, sourcing of funds, fund management, various financial assistance available etc; Market Knowledge includes planning and analysis of external environment, current market situation, market trends and forecasting, understanding of economy, market knowledge in global setting, global trends, sales and distribution and general management. Moreover, knowledge and awareness of government schemes introduced by various ministries; information about apex bodies; policies; Intellectual Property Rights (IPR); rules, norms and regulations laid by the government, opportunities for young entrepreneurs, financial aids provided by the government etc. in context to entrepreneurship and skill development. This provides useful viewpoint for young entrepreneurs and small businesses to plan, build, and execute their ideas with available aids and assistance. Furthermore, the success stories and case studies of Alumni and networking with those can create a better impact.

2. Support

Support is in terms of Infrastructure; Services: MOUs with other institutions; Experts etc. Infrastructure includes Physical infrastructure facilities provided by the institution such as Entrepreneurship Cell, Innovation Centre, Incubation Centre, Research and Development Centres, Accelerators, Clusters, Zones, Hubs etc. for entrepreneurial activities both on-campus and off-campus. Support Institutions include tie ups/MOU with other entrepreneurship assisting institutions; government institutions, non-government institutions, angel investors, venture capitalist etc.

Support Services include all support in the form of expert guidance, expert committees, mentorship, technical experts, professional assistance and services such as legal, banking, finance, accounting etc.

Expert Sessions include short-term session provided from industry representatives, technical experts, professional etc. These kinds of sessions are effective in communicating strong motivation and constructing enthusiasm and providing insights to the young entrepreneurs. Alumni Network includes the former students who are serving as entrepreneurs, owning a start-up, working with good companies, MNCs, big giants and other. They are ought to be useful in mentoring, supporting the students with their stories to motivate and provide useful insights to them. They may extend support as industry experts, technical advisors and financial guide to the students.

3. Exposure

This mentions the development Program which includes, entrepreneurship awareness camps, entrepreneurship development programs conducted for day, week or few weeks in order to develop and strengthen necessary skills and abilities for an entrepreneur. These programs provide motivation, basic management skills; explain the process and procedure of setting up of small-scale enterprise, environment assessment techniques etc.

Seminars and Conferences provides platform to present oneself and hear from researchers, academicians, subject matter experts, government officials, support institutions, industry professionals etc. about new trends, outcomes, discoveries and to gain insights of emerging opportunities and concepts.

Workshops involve both training workshops and activity-based workshops to utilize and implement range of techniques and identifying best approaches for a situation. It helps students to enhance their skills by putting them into practice. Events organized in the institutions such as annual events, fests, topic-based events, product/ service-based events etc. boosts confidence,

creativity and develops skills among students with participation. Events in educational institutions are generally student centred, also to enhance its outcomes it is essential that such events shall be conducted and organized by students in guidance with the concerned or faculty. Projects and Assignments represent work assigned to achieve specific objective to be completed under stipulated timeframe. It develops and enhances self-exploration, problem solving, situation handling, and resource planning and outcome-based learning. If projects and assignments are based on real life situations and live projects, it helps in yielding higher motivation, confidence and strategy building.

IMPLICATION

The suggested model for entrepreneurship development aims at implementing the ecosystem centric to the students with the involvement of all the stakeholders to promote and enrich the entrepreneurship culture. Equal importance is to be given to all three parameters at different levels of learning. This balanced ecosystem model will help in reinforcing the new generation entrepreneurs and achieving sustained outcomes. This model is tailored to cater the dynamic needs of entrepreneurship and prepare the entrepreneurs for diverse circumstances. This model will help the policy makers, researchers and academicians to look their way forward towards economic development and successful entrepreneur.

CONCLUSION

This paper had four purposes including (1) introducing the reader to the entrepreneurship ecosystem perspective with a particular focus on the university, (2) taking a closer look at the ways that universities influence the ecosystem, (3) assessing performance by comparing the top incubation centres, and (4) discussing implications for practice and research.

The paper provided an overview of entrepreneurship ecosystems, touching on their literature lineages and describing the larger component parts. It also took a closer look at the University-Based Entrepreneurship Ecosystem, offering several advanced illustrations of the component parts and relationships. Next, the paper discussed literature reviews of multiple ways in which universities influence the ecosystem. Knowledge spill overs and filters are discussed throughout the research, given their importance. Finally, the paper presented a model and discussed implications for both practitioners and researchers.

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A Study on Smart Cities Initiative in Gujarat: The Way Forward to Urban Revitalization

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Abstract

For the economy of every country, cities are considered as engines of growth, same with India. Hence, holistic development of cities must be ensured by all the countries. In support to this statement; sustainable and inclusive growth of the state, every compact area of cities should be tapped with smart solutions. Smart Cities Mission is working for better urbanization of 100 cities from the nation selected by Union Ministry of Urban development; six cities from the state of Gujarat. This movement needs to be addressed the sustainable living elements like smart economy, smart mobility, smart governance, smart environment, etc. Through this mission, retrofitting and redevelopment parameters can be served easily.

Urban revitalization is all about focusing on the activity of improving the quality of urban environment and quality of the life of citizens, creating smart ecosystem and attracting investment for further economic growth.

This research paper analyses the progress plotted by Smart Cities Initiative specifically with reference to cities of Gujarat state namely - Ahmedabad, Surat, Rajkot, Gandhinagar, Vadodara and Dahod. This paper discusses effectiveness and challenges marked during the implication of mission on the basis of available secondary data from official website of the mission, government reports, literatures and authenticated news realizes. This paper also flashes intra-state comparison regarding fund allocation by government.

Keywords: Smart cities, Urban, Sustainable Development, Revitalization

INTRODUCTION

In India, as a smarter way of urban revitalization, Smart Cities Mission was launch by the Prime Minister Narendra Modi on 25th June, 2015. The prime objective of the mission is to push cities that offer core infrastructure, clean and sustainable environment provides a good quality of life to their citizens through the appliance of 'smart solutions'. The mission focuses to drive economic process and improve the quality through comprehensive work on important pillars of the smart city i.e. social, physical, institutional and economical.

As the people have started migrating from rural to urban areas, unprecedented growth in size of the cities, industrial growth, motorized transportation etc., urban areas are getting a lot of congested and unmanageable. These issues square measure adding pressure to the present resource base, during the phase of increasing the demand for energy, water, sanitation, and public services like education and health care.

Each city is unique in its own characteristics in terms of its size, environment, resources etc. These differences influence the capacity of cities to attract smart investment as well as to invest in smart technologies.

LITERATURE REVIEW

Wantmure R. & Dhanawade M. (2016) emphasized on the use of the internet of things for building smart cities in India. Internet of things is a rising technology in the IT world that can be discovered to its summit to achieve the goal of establishing the concept of smart cities. The model of the smart city is not the way out. The reason behind it is that every city is unique in its existence. However, prototype development is highly needed through the logical structure of IoT.

Nicola Ianuale, et al. (2015) established the connection of cross sectional study areas of smart city concept with political, economic, social and technological factors. An eminent issue in computational analysis is the assimilation of big data. Studies have projected strategies supported numerous criteria, say entropic, a tropical, parametric, etc. As several factors and variables lie beneath the system's drivers are projected to explain smart city contexts through the varied interlinked large amount of data and networks.

Ramaswamy R. & Madakam S. (2013) found that in India, administration of the cities usually faces up to large number of key issues, like unplanned development, unorganized market of real estate, poor infrastructural facilities, insufficient health services etc. Thus the implementation of smart cities project can be a way out for partitioning these issues. Report of IBM Institute of Business Review suggest that as many people migrating from rural to urban, India needs to create 500 smart cities in upcoming 20 years.

Praharaj S. (2019) offers the statement of need of novel strategies for smart city policymakers for acknowledging diverse cultures and community needs. Author adds to scholarly debates in two aspects. First, meticulous set of evidence as bridge to socioeconomic performance and evolution of cities to become smart is provided. Second, urban and regional disciplines reveal regional political and cultural factors determine how cities perform.

Angelidou M. (2014) analysed three set of tools those ingrates the framework of strategic planning for creating smart cities. (i) Strategic Roadmap Toolkit, leads to analyzing the process to plan and implement smart city strategy (ii) Principles' Toolkit, leads to analyzing managerial, strategic and operational principles for smart city strategy (iii) Index of Weaknesses and Mitigation, leads to analyzing probable obstacles in a way of smart city mission and how they can be mitigated.

Bholey M. (2019) described that successive plans in India for the most part appear as if a direct response to rising urban wants of the day. The Grater Hyderabad Municipal Corporation (GHMC) for instance has provided app-based answer to find nearest public toilets as well as to observe the cleanliness and other sweeping issues. Delhi Metro's DMRC app helps to spearhead digital transformation is additionally taking part in a significant role in up urban public service delivery in recent times. Recognizing the nature of the problem and offering solutions by potentially making a natural process between design, technology and innovation.

Gupta K. & Hall R. (2017) found that city size influences the priorities of citizens indicating the perception of the smart cities in India. Smart city concept in the context of India can be analyzed through three separate data sources (a) citizen survey (b) vision statement of smart city and (c) a list of planned smart city projects.

FRAMEWORK OF THE STUDY

This paper initially reflects need of the study and followed by objectives of study. It then describes the fundamental idea of smart city mission. Typology of the same and its execution is then explained.

NEED OF THE STUDY

Rumours and fundamental updates of Smart City Mission are flashed through different platforms. But comparison of allotted funds and used for actual execution, analysis to strategy, components remain unheard to many. Thus, this is the ideal time to get into the intensity of this topic and imbibe its interior details. Consequently, the study offers constructive insights for both practitioners and scholars fascinated in smart city initiatives.

Study is also needed to answer the question whether the legal and moral obligations regarding implantation of sustainable development goals can be justified or not for India in concentration of Smart City Mission.

OBJECTIVES

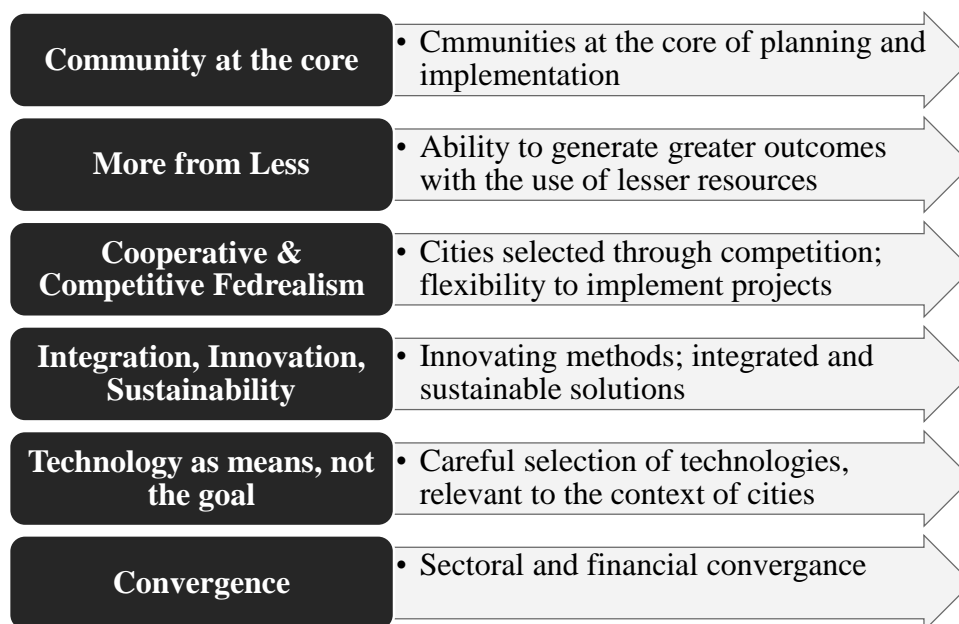
- To know the actual amount of projects or work completed and how much amount of money being invested for the same under smart city mission
- To get the idea about in near future how much amount of work would be completed on the basis of work orders are issued data.
- To establish to correlation between vital indicators for the building of Smart City and actual execution made

ABOUT SMART CITY MISSION (SCM)

The Smart Cities Mission is a ground-breaking and pioneering initiative by the Government of India to impel economic growth and perk up the quality of life of people by facilitating regional development and harnessing technology as a way to create smart upshot for citizens.

There is no existence of specific template or standard definition of Smart City. However, in context of India, following six principles are considered as base for all cities.

Fig 1: Six principles of Smart City in terms of India



(Source: smartcities.gov.in)

The Mission is functioned as a Centrally Sponsored theme. Central Government provides support to the extent of Rs. 48,000 crores over five years i.e. on an average Rs.100 crores per city annually. An equal amount on an identical basis is to be provided by the State/ULBs.

It has been proposed that execution of 5,151 projects have been done under Smart City Mission for all 100 selected cities and it will be worth Rs. 2, 05,018 crores. In terms of sources of the fund, distribution is envisaged as follows:

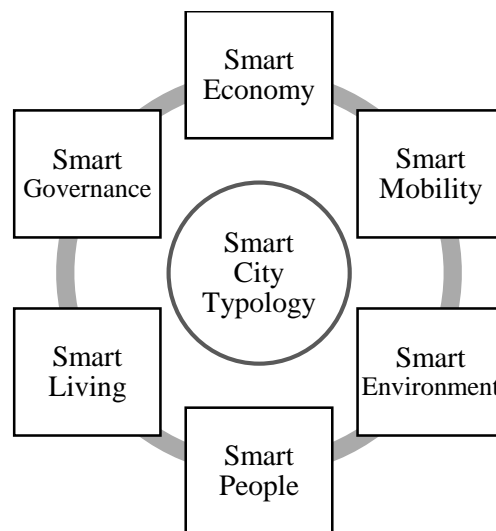
Table 1: Allocation of Funds in terms of amount and percentage

Sources	Amount	Contribution in terms of Percentage
Central and State government	Rs. 93,552 crore	45%
Convergence funding from other missions of Central and State Government and ULBs	Rs. 42,028 crore	21%
Fund from PPP	Rs. 41,022 crore	21%
Loans/Debt	Rs. 9,843 crore	4%
Own sources	Rs. 2,644 crore	1%
Other Sources	Rs. 15,930 crore	8%

SMART CITY TYPOLOGY

Giffinger et al. (2007) have developed and distinguished six dimensions - smart economy, smart mobility, smart environment, smart people, smart living, and smart governance in their model 'European Smart Cities' under global smart city indicator framework.

Fig 2: Typology of Smart City - Six indicators of Smart City Initiatives



CORRELATION ESTABLISHMENT AMONG TYPOLOGY OF SMART CITIES AND ACTUAL EXECUTION

SMART ECONOMY

Smart Economy is considered as the fundamental requirement for building up the smart community. For the purpose of achieving smart growth, sustainable growth and intensive growth in the creation of smart city; there are number of indicators which can be connected with smart economy dimensions. i.e. entrepreneurial activities, production function, research and development, economic infrastructure, GDP, flexibility in labour markets etc.

Mapping of this indicator is difficult in terms of smart city mission as urban revitalization tool, as the data of per city GDP is not targeted for the analysis. But government is continuously trying to motivate start-ups to boost up entrepreneurial activities.

SMART MOBILITY

Smart Mobility focuses on enabling the opportunity for smooth movement within the state and outside the state. In other words it is considered as the technology based transportation. Key indicators for smart mobility are local accessibility, national and/or international accessibility, safe, sustainable and innovative ICT infrastructure based transport system. Transport and mobility domains create exclusive demand of urban traffic control and traffic management system.

In Gandhinagar city, Variable Messaging Display (VMD) boards project implemented across the city under smart city mission. In Surat city, Integrated Traffic and Mobility Administration Centre (IT-MAC), with the help of it real time vehicle location and passenger details can be gathered.

SMART ENVIRONMENT

Smart Environment stresses upon nurturing and protecting our natural resources by considering these smart indicators – pollution, attractivity of natural resources, environment protection, and sustainable resource management. With a view to focusing on sustainability, city must exercise on implementation of green efforts, eco-friendly production and other activities; water ways, sewer, green spaces etc.

SMART PEOPLE

Smart people dimension is needed because they are the main drivers for establishing positive impact on other five dimensions. The indicators for the same are qualification, creativity, flexibility, social and ethnic plurality, open mindness and affinity to lifelong learning. In short, it resembles creating smart social and human capital in the city.

SMART LIVING

Smart Living dimension is significantly kept for the purpose of creating quality of life of the people. For that, indicators are cultural facilities, education facilities, health, safety and housing quality, touristic activity and social cohesion.

The working on Smart City Mission is plotted in the convergence with other government schemes like, AMRUT, Swachh Bharat Mission, Hriday, Skill Development etc. Such schemes show the effectiveness towards smart living in the cities.

SMART GOVERNANCE

Smart Governance has these indicators for smart city creation – participation in decision making process, transparency in governance, public and social services, political strategies. It is also needed in community to have ICT based public services and e-governance.

In actual term, it raises the need of declaring what and how much work is proposed and actually done should be revealed. The true test of it starts with application and transparency in governance while working on smart city mission. ICT based motive can be achieved as official website of smart city mission and other official portal of urban development justifies such progressive amount of data in reference with smart city mission.

Execution and Effectiveness Marked During the Implementation of Smart City Mission in Gujarat State

For the selection of cities and for funding purpose on the basis of area development strategy under the program of the Ministry of Urban Development (MoUD) has followed competition based method. Total

5 rounds process was conducted for the selection of smart cities. For Gujarat state, detail is given in following table.

Table 2: Selection status of Smart Cities of Gujarat

City	Winner of which round	Out of how many cities	Rank
Ahmedabad	1 st Round	20	6 th
Dahod	4 th Round	30	22 nd
Gandhinagar	4 th Round	30	9 th
Rajkot	4 th Round	30	3 rd
Surat	1 st Round	20	4 th
Vadodara	3 rd Round	27	27 th

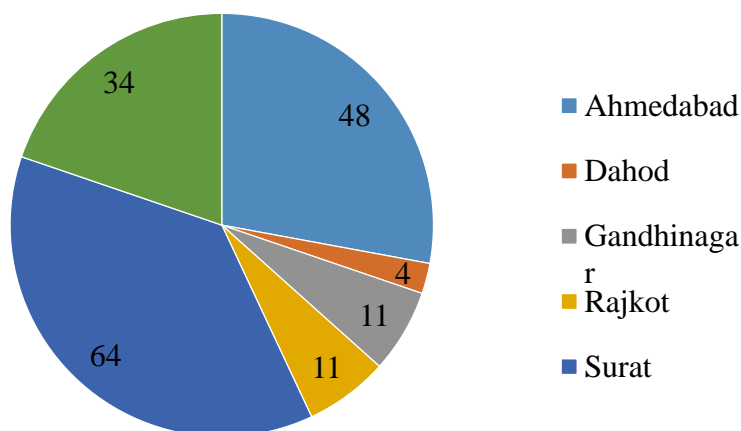
(Data compiled by Author)

Data have been collected from official government website of Smart City Mission. Following first table throws the light on number of projects has been completed by each smart city. This data shows the progress updates till 31st March, 2021. It shows that total 172 projects have been completed under Smart City Mission in Gujarat state. Highest completion of project credit goes to Surat with 64 number of projects.

Table 3: No. of projects completed and amount associated with it in Gujarat

Smart City	Work Completed under Smart City Mission	
	Projects	Amount (Rs. Crore)
Ahmedabad	48	1518.28
Dahod	4	2.83
Gandhinagar	11	231
Rajkot	11	100
Surat	64	1598
Vadodara	34	902
Total	172	4352.11

Fig 3: Projects Completed under Smart City Mission in Gujarat State



Idea of the amount used to complete these projects by each city can be received from following chart.

After the discussion of work completion in terms of number of projects and amount used for those projects, following table shows the data of tender issued for respective number of projects and amount associated with it (in Rs. Crore).

Fig 4: Amount (Rs. in crores) of work completed

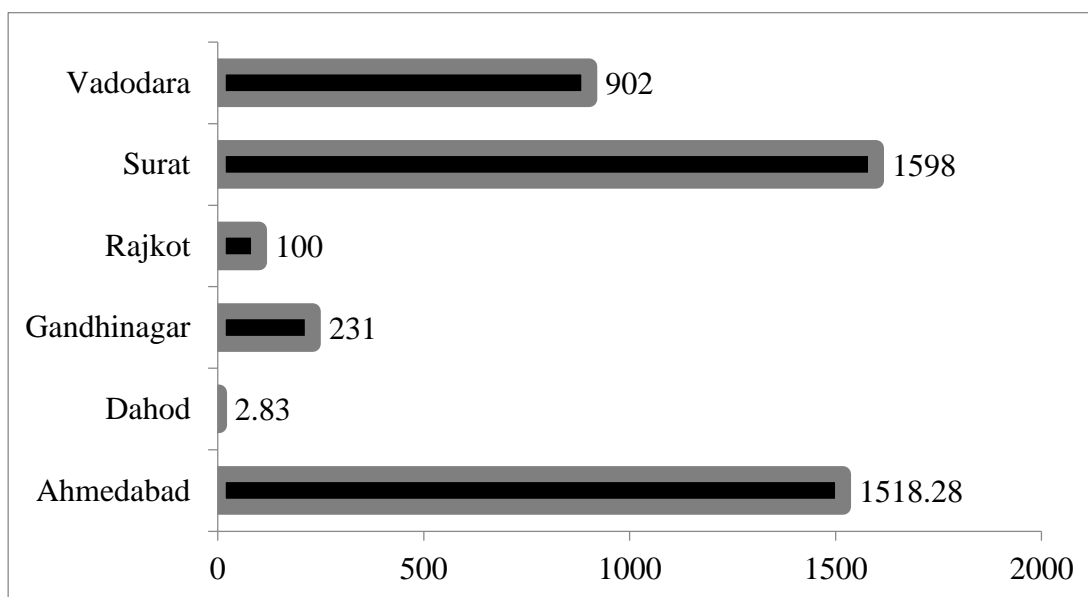


Table 4: Tenders and work order issued No. of projects completed and amount associated with it in Gujarat under Smart City Mission

Smart City	Tender Issued		Work Order Issued	
	Projects	Amount (Rs. Crore)	Projects	Amount (Rs. Crore)
Ahmedabad	4	627.14	25	4932.68
Dahod	9	353.44	12	560.88
Gandhinagar	33	1223	25	1090
Rajkot	36	3003	28	1537
Surat	87	3676	82	3164
Vadodara	54	2280	52	2123
Total	223	11162.58	224	13407.56

From the above mentioned table we can say that Surat city has the secured higher position in terms of highest number of tender and work order issued for projects and reverse to that Dahod has secured lower position in terms of lowest number of tender and work order issued for projects.

ANALYSIS AND DISCUSSION

Smart Cities Mission promotes the idea to make the community advanced which offer core foundation, feasibility and convenience to environment in the way of using smart solutions. The data justifies the basic idea that projects which are not yet started show large amount. It suggests that the task which started with the aim of completing within five years does not seem to be completed within prescribed timeline.

For Gujarat state, to cover six cities as smart cities by the end of financial year 2021, total 172 projects have been completed with the amount of Rs. 4352.11 crore. However, work orders are issued for 224 projects with the amount of Rs. 13407.56 crore.

Challenges Faced During the Implementation of Smart City Mission in Gujarat State

If urban revitalization generates benefits to the society and country under smart city mission then, implementation and management must be done correctly. But in current pattern it creates many barriers like; city densities are increasing. Another issue is religious community based violence and riots; such type of environment creates fear in the minds of citizens. Furthermore, during the implementation period entire world had to face the crisis of pandemic same with Gujarat state. In fact, more urbanization leads to creation of more slums as migration ratio increases but urban government fails to provide sufficient house blocks leads to extension of slums. Notwithstanding, it adds pressure to the base of resources and raises the demand of water, sanitation, energy, education, healthcare services. Subsequently, social, economic and environmental problems have turned into closely interlinked.

CONCLUSION

In this paper insight has been taken regarding smart cities mission for the selected six cities of Gujarat state out of 100 cities of India. It is assumed that successful implementation and effectiveness of projects will lead to better life of citizens and better future of Gujarat state. Because of various reasons, cities are significantly challenged to improve their competitiveness. Hence, to boost up urban revitalization, smart city initiatives required to be implemented with total effectiveness. Smart City Initiatives re-consolidates dominance to state governments and transfer power away from local institutions.

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Prototyping Socio Economic Contributory Model of Faith Based Social Entrepreneurial Organization: A Case of Shree Santram Samadhi Sthan

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Abstract

Faith, compulsion, miracles, and the readiness to change the world are the drivers of social enterprise. Even though the goals of religion and social enterprise are not always coextensive, several religious dimensions underlie social entrepreneurship, including institutions, high-trust networks, motivation and leadership discourse. A nascent area of inquiry known as “Spiritual Capital” is an emerging field of study that considers the advantages of faith on entrepreneurial efficacy. Social enterprises are a part of the entrepreneurial spectrum and have been under intense focus over the last many years. Moreover, within the social enterprise subgroup exists social enterprises engaged in trading activity as a result of faith and a broader view on capitalist economic thought. They are referred to as Faith-Based Social Enterprises. Furthermore, many social entrepreneurs have stated that their faith and the support from groups of devotees seeing them through in starting their social enterprise initiatives. This study sought to explore “How the capacity of FBSOs (Faith Based Social Organizations) could strengthen Social and Economic Contribution”. The case study of Shree Santram Samadhi Sthan (Located in Nadiad, Gujarat, India) identified and engaged with Faith based social activities to understand the model of their operandi for suggesting capacity for similar prospective organization.

Keywords: Social Entrepreneurship, Faith Based Organization, Socio Economic Contributory Model.

INTRODUCTION

A Faith-based organization is an organization whose values are based on faith and/or beliefs, which has a mission based on social values of the particular faith, and which most often draws its activists (leaders, staff, volunteers) from a particular faith group.

Faith-based organizations vary in size from a group composed of a few believers to global religions and broad inter-faith networks. They encompass a range of faith identities and motivations, with diverse degrees of knowledge of, willingness and capacity to observe humanitarian principles.

Faith-based organizations are a term used here to describe a broad range of organizations influenced by faith. They include religious and religion-based organizations / groups / networks; communities belonging to a place of religious worship; specialized religious institutions and religious social service agencies; and registered or unregistered non-profit institutions that have a religious character or mission.

Local faith communities consist of people who share common religious beliefs and values, and draw upon these to carry out activities in their respective communities. They are often providers of first resort in humanitarian emergencies, mobilizing and providing support through their membership and faith networks. Their members are often unpaid volunteers who act because their faith calls upon them to do so. They may or may not be aware of basic humanitarian principles.

Faith-based and secular humanitarian organizations have a long history of responding to people in need and today are important players in the international community's response to emergencies. In many parts of the world, faith-based organizations (FBOs) play a critical role in processes of

development, delivering a variety of services to the public and asserting themselves as important actors in the field of human development.

In many developing countries, including India, the significant societal contribution has been observed. FBOs are therefore significant actors in processes of development at multiple societal levels and in various contexts (Marshall, 2001; Shelledy, 2002; Clarke, 2005; Hovland, 2005).

Faith-based humanitarian organizations share many characteristics with their secular counterparts and are influenced by the same political, social and economic contexts. However, there are two characteristics which set faith-based humanitarian organizations apart from most secular humanitarian organizations: they are motivated by their faith and they have a constituency which is broader than humanitarian concerns.

In spite of this, the contribution of faith-based organizations has largely been ignored in the discourse of international development and is seen in isolation from mainstream secular thought and practice. According to Marshall (2001), this neglect of religion can be attributed to the largely secular nature of development theory as well as its foundation in 'modernization' theories, which emphasize the decreasing role of religion in modern societies.

Faith-based organisations (FBOs) are attracting increasing attention within development circles as being closer to the poor, more efficient and cost-effective, and more sensitive to people's spiritual needs than secular NGOs.

Faith Based Organizations (FBOs) occupy a considerable space in the domain of development in most parts of the world. Their involvement in development activities is vast and diverse, ranging from service provisioning like education and health to conflict resolution. Social science research in the recent past has attempted to address questions such as interrelationships of values, organisational characteristics and performance of FBOs, their similarities and dissimilarities with other secular NGOs and advantages and disadvantages in improving living conditions of people. While some argue FBOs have advantages in particular circumstances; are closer to the poor and have more positive outcomes than those of secular NGOs, apprehensions regarding the very ideological propaganda (religious and political) inherent in the development agenda of certain FBOs also exist.

Despite apparent commitment to secular political and development models, over the last six decades in India, the presence of religion in the public sphere has expanded. While religious organizations' involvement in welfare and charitable activities has a long history, the objectives of the religious reform movements and faith-based organizations that emerged during the colonial era were to strengthen their respective faith communities, drawing clearer boundaries between them, fighting against perceived 'social evils', and gaining legitimacy vis-à-vis the colonial state. The nationalist struggles and coming of independence significantly changed this social context. After independence, a state-centred development model, while it did not displace religious organizations from some of their traditional spheres of operation, deterred further growth in the numbers of FBOs.

The new communitarian and religious consciousness that has emerged since the 1980s has, however, resulted in growing numbers of FBOs that participate in the so-called 'secular spheres', including education, health and community development. Little systematic information is available on the extent and characteristics of these organizations and their activities. This preliminary study therefore sought to 'map' the scale and characteristics of FBOs and to provide an overview of their engagement in development activities in contemporary India. Limited resources led to a focus on the Case of such closer to the poor, more efficient and cost-effective, and more sensitive to people's spiritual needs and truly secular in its nature organization named as "Shree Santram Samadhi Sthaan" popularly known as Shree Santram Mandir.

LITERATURE SURVEY

Aschauer (1989) work spurred research on the effects of public infrastructure. He found that public infrastructure was an important input into the national production function, and argued for greater spending on public capital. After this, large numbers of empirical studies on the effects of public infrastructure were spawned. However, the findings from empirical search also prompted some controversies. Because it is difficult to find a consensus, mainly due to the uses of different data, varying estimation techniques, variable types of infrastructures and peculiar geographic scales of analysis

These infrastructures provide the basic framework for a nation to support essential public services in order to get higher economic growth and a better quality of life. In this research, literature on infrastructure just focuses on the “physical infrastructure”.

Infrastructure affects rural development through many channels, such as improved agricultural productivity, increased rural nonfarm employment, and rural migration into urban sectors. However, the role of infrastructure has not been paid enough attention in the literature due to lack of reliable data on various infrastructure indicators. By using newly available detailed data on rural infrastructure from the Agricultural Census and other official sources, this paper uses a traditional source accounting approach to identify the specific role of rural infrastructure and other public capital in explaining productivity difference among regions, throwing new lights on how to allocate limited public resources for both growth and regional equity purposes.

It is assumed that the effect of infrastructure on productivity depends on the various types of public infrastructure. Different categories of basic infrastructure may not have the same kind of impact on output since they are thought to pursue different purposes: local infrastructure enhances economic activity in the area where they are located, whereas transport and communication infrastructure may produce both positive benefits in the area where they are located and spill overs to other regions. These spill overs can be either positive or negative. The positive spill overs would be caused by the connectivity characteristic of most transport public capital. This network characteristic supposes that any piece of a network is related and subordinate to the entire network, increasing the interrelationships between regions. Hence, part of the infrastructure benefits (if they really exist) would be felt beyond the limits of the region where it is located. Alternatively, the negative spill over would arise from factor migration, in the sense that transportation infrastructure in one region could have a negative effect in those other regions that are the region's closest competitors for labour and mobile capital. In this chapter we will check which of these two hypotheses on the spill over effect of transport infrastructure is prevalent in the case of the Spanish regions. Additionally, we will also obtain conclusions on whether the link between growth and public capital depends on the level of economic development in the region under consideration, on the amount of the existing public capital stocks and the way infrastructure is articulated in its location relative to other factors. If the results indicate that there appear to be decreasing returns for public capital, we will be able to conclude that it is a factor with a threshold level which, once reached, reduces returns. In other words, infrastructure may have a significant role during part of the period under analysis but with a decreasing trend in time so that it

RESEARCH METHODOLOGY

Objective

The purpose of the research is to view Faith-based organizations and their impact in society. This study will view how Faith-based organizations are related to their involvement relating to persons with disabilities and their contributions to reducing social concerns in state of Gujarat. The goal of this study is to support the mission of Faith-based organizations in working towards recovery, in developing programs that will offer individuals enhancement for various areas of their lives, and in

simply helping to improve the quality of life. The objective of this study is to examine the Socio-demographic study of FBO Coverage by Shri Santram Samadhi Sthaan

Scope of a Study

In a country like India, faith plays a big part in constructing cultural, sociological and personal behaviour. Around 99 percent Indians choose to label themselves as belonging to a particular religion according to Census reports. Faith has a critical role to play in the advancement of basic human rights for children.

One way to assess the scope and scale of FBOs is to compare their activities with the activities of other nonprofit organizations. How do the activities and contributions of FBOs and nonprofit service organizations compare? This comparative approach could take place at a variety of levels. A local network approach would allow us to assess the comparative contributions within a neighborhood or a city (Wuthnow, 2000). These comparisons could be further disaggregated by the type of social problem being addressed. These data would allow us to draw conclusions about the scope and scale of specific FBO activities in comparison to other nonprofit organizations. The research outcome can also frame a prototype model, for replication of same by other FBOs. The lack of information at this level represents an additional gap in our knowledge about FBOs and their societal contribution.

Moreover, with a multitude of faiths like Hinduism, Islam, Christianity, Sikhism, Jainism, Buddhism and many more tribal faiths, India is a country made of people with strong identification to their faiths. With their extraordinary moral authority and power, faith-based organisations (FBOs) are able to influence thinking, foster dialogue, and set priorities for members of their communities. In this study, only one FBO is studied namely: Shri Santram Samadhi Sthaan.

Research Design

Type of Research Design

The research will be carried out using quantitative (descriptive) and qualitative research designs.

Source of Data

For precise identification of pertinent issues, both the secondary as well as primary research will be carried out. Secondary data sources will be used. Secondary data will comprise of journals / articles, books, internet, periodical, newsletters, magazines and reports from various agencies, newspapers and organized databases among many will form part of the same.

Data Analysis and Interpretation

Quantitative data analysis will be carried out by using various statistical methods and the qualitative aspects will be analyzed through 'Data Labels' and 'Experiences' shared by the respondents / beneficiaries.

MODEL SPECIFICATION

Theoretical economic background

Although there is consensus on the need for a certain level of infrastructural provision, once this level is reached, different results and conclusions are obtained. In this regard, some authors do not deny the existence of a link between publicly provided inputs and economic growth, but do not find evidence for it. For instance, Holtz-Eakin (1994) and Garcia-Milà et al. (1996) criticize the initial findings on positive infrastructure effects in the US case on econometric grounds, presenting estimations of regional production functions that use standard techniques to control for state-specific characteristics, revealing essentially a zero role for public capital. Furthermore, Cribfield and Panggabean (1995) using a neoclassical growth model observe that public capital has a weak effect on growth in per capita product of US metropolitan economies both by means of indirect action (factor markets) and by direct action (rates of public investment). Ciccone and Hall (1996) reach the same conclusion when explaining differences in labour productivity across US states in a model that accounts for spatial density effects.

On the other hand, Martin and Rogers (1995) and Holtz-Eakin and Lovely (1996) have highlighted the mechanism by which infrastructure affects firms and markets. Through the construction of general equilibrium and Krugman type models, their findings reveal that public infrastructure has no direct effect on increasing aggregate productivity, but alters it through increases in the number and variety of manufacturing establishments, concluding that infrastructure plays a subtle role in changing the relative attractiveness of location for firms. Besides, according to the results obtained in the Martin and Roger's study, a larger infrastructural endowment will not necessarily enhance convergence, due to the different effect of domestic and international infrastructures on industrial location. Improvements in domestic infrastructure in a poor region will always bring firms to those regions (mainly when the cost is assumed by a third party). However, firms will tend to relocate in high activity regions when international public capital is improved and when poor regions have a low level of domestic infrastructure. Therefore, in early stages, the use of public investment to deepen an integration process may increase disparities, since regions with weak competitive positions may be adversely affected (Rietveld, 1995).

The Organization: Shree Santram Samadhi Sthaan

Santram Mandir is a famous temple situated in Nadiad, Gujarat, India. It is home to Santram Maharaj who is a holy figure in Gujarat. It is very famous for spiritual as well as social activities for the needy too. The Santram mandir runs trusts for humanitarian activities like Eye Hospital, Physiotherapy Center, Dispensary, Radiology Center, Pathology & Laboratory as well as various other services which is countless.

The Pagoda Architectural Model of Development

A pagoda is a tiered tower with multiple eaves, built in traditions originating as stupa in historic South Asia. And further developed in East Asia or with respect to those traditions, common to Nepal, China, Japan, Korea, Vietnam, Myanmar, India, Sri Lanka and other parts of Asia. Some pagodas are used as Taoist houses of worship. Most pagodas were built to have a religious function, most commonly Buddhist, and were often located in or near viharas. In some countries, the term may refer to other religious structures. In Vietnam and Cambodia, due to French translation, the English term pagoda is a more generic term referring to a place of worship, although pagoda is not an accurate word to describe a Buddhist vihara. The modern pagoda is an evolution of the stupa which originated in ancient India. Stupas are a tomb-like structure where sacred relics could be kept safe and venerated. The architectural structure of the stupa has spread across Asia, taking on many diverse forms as details specific to different regions are incorporated into the overall design. (Refer Annexures for Model 1 & 2).

I Social and Cultural Services

- 1 Shree Santram Bhojanalaya "Annapurna"
- 2 Shree Santram Garbh Sanskar Kendra
- 3 Shree Santram Muktidham (Smashaan Gruha)
- 4 Shree Santram Ashti visarjan Service
- 5 Shree Santram Viklang sahay kendra
- 6 Shree Santram Sivan class kendra
- 7 Shree Santram Jyotish Karyalaya
- 8 Shree Santram Relief Activities for Natural Calamities
- 9 Shree Santram Help of grocery to Needy People / Hospitals
- 10 Shree Santram Atithi Gruh (Guest House)

- 11 Shree Santram Suvichar Lekhan
- 12 Shri Santram Natural Disaster relief services
- 13 Shri Santram Astrology Office
- 14 Shri Santram Pankharni Hash

II Educational Services

- 15 Shree Santram Shishu Vaatika
- 16 Shree Santram Vidhyalaya
- 17 Shree Tapovan Vidyapith
- 18 Shree Narayan Computer Center
- 19 Shree Santram Hostel
- 20 Shree Santram Shishu Kendra
- 21 Shree Santram Vanvasi Hostel
- 22 Shree Santram Gurukulam (formally known as Baal Sanskar Kendra)

III Healthcare Services

- 23 Shree Santram Eye Hospital
- 24 Shree Santram Physiotherapy and Healthcare Center
- 25 Shree Santram Radiology and Imaging Center
- 26 Shree Santram Pathology Center
- 27 Shree Santram Dispensary
- 28 Shree Santram ECG Department
- 29 Shree Santram Honorary Doctors Department
- 30 Shree Santram Dental Department
- 31 Shree Santram Ayurveda Department
- 32 Shree Santram Homeopathy Department
- 33 Shree Santram Medical Store
- 34 Shree Santram Center for Various Health Related Diagnosis / Surgical Camps
- 35 Shree Santram Oxygen Bank
- 36 Shree Santram Ambulance Service
- 37 C C Patel General Hospital Sojitra
- 38 Shree Santram Polio Foundation
- 39 Shree Santram Funeral Van

IV Religious and Spiritual Development Activities

- 41 Akhand Naam Sankirtan (Raam Dhun)
- 42 Shree Vishnu Divya Sahastra Naam Paath (Daily)

- 43 Satsang on Shree Ram Charit Manas
- 45 Satsang on Pad Sangrah
- 46 Satsang on Vishnu Sahastra Naam
- 47 Satsang by Various Spiritual Discoursed People
- 48 Shree Ram Charit Manas (Four Times a Year)
- 49 Dwadash Varshiya Shree Vishnu Sahastra Naam Anushthaan
- 50 Sundar Kaand Paath
- 51 Shree Santram Bhajan Spardha (Competition)
- 52 Shree Santram Geeta Gyan Prachar Satra

CONCLUSION

The relationship between public infrastructure investment and economic growth has always been an eye-catching issue. Taking the investment policy as the background, this paper aims to examine the effect of infrastructure investment on economic growth. Both theoretic and practical analysis indicates that infrastructure capital stock exerts a positive impact on economic growth and it will increase long-term economic growth rate, which could verify the appropriateness of the current “infrastructure-stressed” investment policies of the Indian government. The development of the public infrastructure can contribute widely in educational, regional, medical and religion areas for a long period like most other developing countries. The religion organization can take lead like Shree Santram Samadhi Sthaan for contribution in boosting the economy by imparting effective usage of religion infrastructure as public infrastructure

FUTURE STUDY REFERENCE

The further study can measure the quantifiable measures of contribution in different Contribution by Shree Santram Samadhi Sthaan

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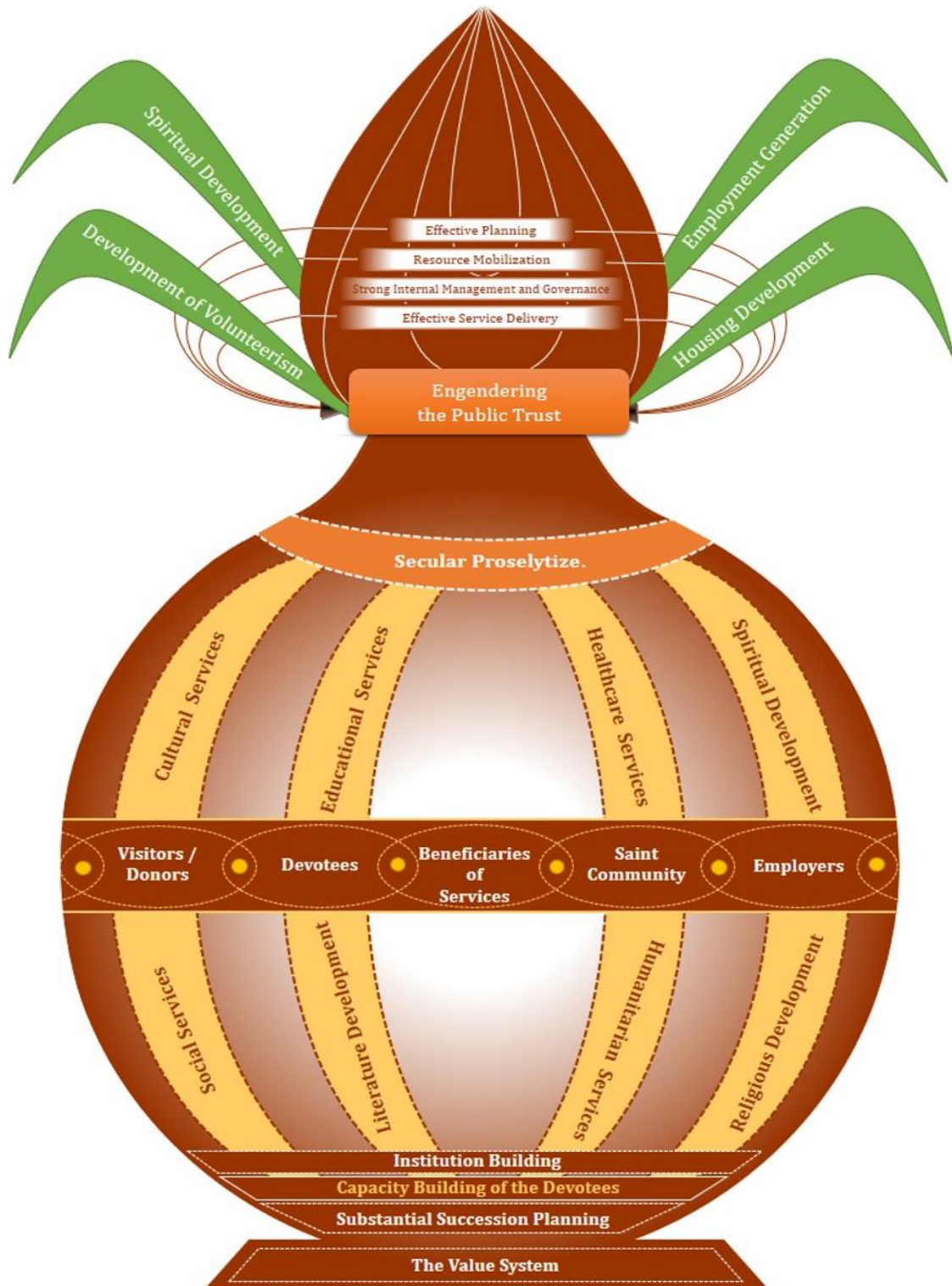
ANNEXURES

[Model 1 - The Pagoda Architectural Model of Development]



The Kalash Model: A Prototype Socio Economic Contributory Model of Faith Based Social Entrepreneurial Organization

[Model 2 - Contributory Model of Shree Santram Samadhi Sthaan]



A Study of Relationship between Organisational Cooperation and Knowledge Management Practices in Higher Educational Institutions: A Case of Gujarat State

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ABSTRACT

Progress of Knowledge Economy has necessitated the organisations to focus on knowledge management. Knowledge management is the process of creating, storing, and transferring, applying and evaluating knowledge for making it available at the right time to the right people. Knowledge creation, transfer and application remains human centric in their approach and hence cooperation within organisational members play a significant role in knowledge management. The current study focuses on studying the relationship between organisational cooperation and knowledge management practices as perceived by the teaching staff of Higher Educational Institutions in Gujarat State. The results of the study shows that all the practices of knowledge management are positively correlated to cooperation among individuals. Implications based on the conclusions are discussed.

Keywords: Cooperation among Individuals, Knowledge Management, Knowledge Creation, Knowledge Storage, Knowledge Transfer, Knowledge Application, Knowledge Evaluation, Higher Educational Institutions

INTRODUCTION

Cooperation as the mixture of acts involving social interface, synchronization in goal-setting and accomplishment, and communication (Argyle & Lu, 1991), is a widely acknowledged psychological organizational concept. Organizational Cooperation (OC) will influence how the organization can successfully adjust to changes in the environment, be well located in inter-organizational networks and be flexible in production or services, to cope with environmental constraints (Schalk & Curseu, 2010). Cooperation must be encouraged, as it establishes “much of the value-creation opportunities within an organization” (Gratton, 2005).

Current organizational life stresses effective cooperation practices in KM, to boost performance (Xu & Bernard, 2013). Further research is necessary on collaborative networks as determining factor of the way knowledge flows (Singh, 2005). Interpersonal networks and social ties among workers impact the way knowledge is spread in the organization (Ahmadi et al., 2011). Employees in organizations work in groups, teams and projects. Strategies must be built in order to increase socialization and trust amongst team members (Ribiere & Walter, 2013), crucial requirements for cooperation.

One of the main persuasive factors on the successful knowledge sharing within organization is the existence of an organizational culture that supports the operative sharing of knowledge (Probst 1998, Bullinger 1998). According to major studies on Knowledge Management or Organizational Learning, culture is a key barrier to accomplishment in related initiatives. (The conference Board, 2000)

Efficient knowledge sharing needs grounds of trust between involved parties. The notion of trust has long been a studied phenomenon with respects to its role in the context of business. As early as 1964, Simmel (In McAllister, 1995) argued that trust is essential if there is neither full knowledge nor full ignorance, and researchers have long sought after an omnipotent and universal definition of the term.

For the current study, researcher considers cooperation within the institutes as an independent variable. The researcher aims at studying the relationship between cooperation within institutes and different factors of knowledge management (knowledge creation, knowledge storage, knowledge transfer, knowledge application and knowledge evaluation).

BACKGROUND OF THE STUDY

Organisational Cooperation is a contemporary concept that focuses on the increasing coherence between individuals and teams. Similarly, Knowledge Management (KM) supplements the organisational management in all sectors of business and human activity. Most of the processes needed for knowledge management are sensitive to cooperation and the way both concepts relate to each other is significant in understanding the organisations and encouraging better performance.

Knowledge epitomizes the primary resource for people, organisations and society (Ahmadi, Selsele, & Ahmadi, 2011) and it is a “critical ingredient”, which must be seized and set into habits, customs, practices and procedures (Desouza, 2004, p. 5). Knowledge is sometimes created by humans individually and sometimes it is created by social interactions among humans (Davenport & Prusak, 1998). Knowledge is created from multiple emotional, cognitive and behavioural elements and is seen to be asset of the organisation (Bodrožić & Stepanović, 2012; Davenport & Prusak, 1998; Durst & Edvardsson, 2012).

Knowledge cannot be managed unless the employees in the organisation cooperate with each other. It is in this background for the current study, researcher considers cooperation within the institutes as an independent variable. The researcher aims at studying the relationship between cooperation within institutes and different factors of knowledge management (knowledge creation, knowledge storage, knowledge transfer, knowledge application and knowledge evaluation). The present study aims to deepen understanding of the relationship between organizational cooperation (OC) and knowledge management (KM) in a sample of people working in higher educational institutions.

STATEMENT OF THE PROBLEM

For the Higher Educational Institutions, their survival and growth depends on how the knowledge is created, shared, utilized and evaluated in their organisational systems. In the 21st century, knowledge is power. An organisation which can manage knowledge will be effective in the longer run and will be able to create a competitive edge. The creation of new knowledge does not takes place in isolation. It takes place when people in the organisation interact with each other with trust and when they cooperate with each other for creating something new.

So far many studies have been conducted on organisational cooperation and knowledge management too separately, but there is no such evidence that such a study is conducted to find out the relationship between the two constructs. So the current study intends to study the relationship between organisational cooperation and knowledge management practices in higher educational institutions.

OBJECTIVES OF THE STUDY

The primary objective of the study is to study the relationship between organisational cooperation and knowledge management practices in higher educational institutes. In order to achieve the primary objectives following specific objectives are examined:

- To assess the level of cooperation within the institutes.
- To assess the knowledge management practices in higher educational institutes.
- To find the relationship between organizational cooperation and knowledge management practices.

STATEMENT OF THE HYPOTHESIS

Based on the objective of the study the following hypothesis is formulated:

H₀: There is no significant correlation between cooperation between individuals in an educational institution and different factors of knowledge management (Knowledge Creation, Knowledge Storage, Knowledge Transfer, Knowledge Application and Knowledge Evaluation).

H_a: There is a significant correlation between cooperation between individuals in an educational institution and different factors of knowledge management (Knowledge Creation, Knowledge Storage, Knowledge Transfer, Knowledge Application and Knowledge Evaluation).

SIGNIFICANCE OF STUDY

The importance of knowledge management in higher educational institutions has gained more interest during the last decade. However, at the advent of the entrepreneurial economy and knowledge society, there has emerged a new social class that Drucker refers to as “knowledge workers” (Kelloway & Barling, 2000), whose principal function is the generation of knowledge. This generation of knowledge is supported by cooperation within the knowledge workers. Unless the organisations are able to create a culture of trust where the employees are ready to cooperate with each other, the organisations will not be able to achieve their goals in the knowledge economy.

The recommendations made at the end of the study would be helpful in designing the future course of actions for higher educational institutions w.r.t. knowledge management.

SCOPE OF THE STUDY

The study is limited to the higher educational intuitions of Gujarat State. The study is only focused on finding out the relationship between organisational cooperation and knowledge management practices. The study is focused only on the responses of teaching staff in higher educational institutions. Responses of teaching staff to the statements raised in the questionnaire are analysed to arrive at conclusions.

REVIEW OF LITERATURE

Cooperation is defined by **Argyle (1991)** as “acting together, in a coordinated way at work, leisure, or in social relationships, in the pursuit of shared goals, the enjoyment of the joint activity, or simply furthering the relationship”. In organizations **Marcus and Le (2013)** stressed working with others for common goals and pointed out circumstances such as sharing information and helping one another to finish certain tasks. **Smith, Carroll, and Ashford (1995)** distinguish cooperation’s focus on the communication within individuals, groups and organizations, and the consequent psychological associations either for common gain or benefit. These authors state that cooperative associations can be formal or informal, contingent on whether they involve contractual responsibilities and formal structures of control, or adaptable provisions that define parties’ assistances.

Deutsch (2001), in his theory of Cooperation and Conflict Resolution, showed that cooperative groups will distinguish from competitive groups in some ways: more effective communication and approval among members; more friendly and accommodating group discussions; more effort synchronization, work division, alignment through task achievement, more direction when discussing, and higher productivity; a greater sentiment of agreement and confidence in each other’s ideas and value for the group, and a better sense of resemblance in values and beliefs. Also, cooperation leads to the perception of conflict as a problem to be solved jointly and collaboratively.

According to **García (2009)** to implement KM HEIs must take into consideration some actions that will insure the effectiveness of the system. They are: (i) to have a strategy for developing the knowledge management system, (ii) to communicate to organizational members that information technology and knowledge management are different, (iii) to consider is training organizational members regarding the benefits of knowledge management and how it can contribute to improving their performance, (iv) to promote the concept of being a community of practice, since this activity helps them share knowledge and organizational learning, (v) to create knowledge culture that includes collaboration and the design of devices that allow the knowledge to be accessible to all people in the organization. Knowledge Management System in Higher Education Institution could boost the efficiency, effectiveness, and

quality of graduates who can satisfy the employers' need in the entry level of employability in their future (Ramakrishnan & Yasin, 2012). But, KMS efforts are not sustainable unless the organization implements a means of enhancing individual learning through the individual's own contributions (Ramakrishnan & Yasin, 2012).

RESEARCH METHODOLOGY

Research Setting: All the leading higher educational institutes in Gujarat were chosen as the setting of this research. This included graduate, professional and post graduate institutes in the state.

Research Design: Descriptive and diagnostic research designs are used in the study due to the nature of the study. Descriptive research, also known as statistical research, describes data and characteristics about the population or phenomenon being studied. Diagnostic research design helps to find out the relationships between two variables.

Sampling and Sample Size: The sampling unit for this study were faculty members, HODs, Deans and Principals in higher educational institutes. The sampling units may belong to any stream of education as all institutes offering UG, PG and Professional Courses are a part of the population. The Google form link of the questionnaire was sent to around 2500 faculty members of Gujarat State. Out of them 648 respondents filled in the complete form.

Data Collection: Looking at various benefits of questionnaire method, objectives of the study and the nature of data to be collected, the study used questionnaire as an instrument for collecting primary data. The questionnaire was designed by the researcher which included 55 statements. The structured questionnaire had statements which were to be rated on Likert five point scale. These statements were carefully framed keeping in mind previous studies.

Tools for Analysis: The statistical tools used for the analysis of the research questions of this study were Descriptive Statistics, Frequency Distributions, and Correlation Analysis.

DATA ANALYSIS AND INTERPRETATION

To fulfil the first objective descriptive statistics for Organisational Cooperation Scores are found with the help of MS Excel. The mean Organisational Cooperation is 5.17. The possible range of mean was between -16 to 16.

Table 1: Descriptive Statistics of Organisational Cooperation

Mean	Standard Error	Median	Mode	Standard Deviation
5.169753	0.200269	6	6	5.098008

To fulfil the second objective descriptive statistics for Knowledge Management Scores are found with the help of MS Excel. The mean Knowledge Management is 33.80. The possible range of mean was between -94 to 94.

Table 2: Descriptive Statistics of Knowledge Management

Mean	Standard Error	Median	Mode	Standard Deviation
33.80864	1.183839	37	50	30.13561

Keeping the third objective in mind a hypothesis is formed.

H₀: There is no significant correlation between cooperation between individuals in an educational institution and different factors of knowledge management (Knowledge Creation, Knowledge Storage, Knowledge Transfer, Knowledge Application and Knowledge Evaluation).

H_a: There is a significant correlation between cooperation between individuals in an educational institution and different factors of knowledge management (Knowledge Creation, Knowledge Storage, Knowledge Transfer, Knowledge Application and Knowledge Evaluation).

To test this hypothesis correlation is found out between cooperation between individuals in an educational institution and different factors of knowledge management (Knowledge Creation, Knowledge Storage, Knowledge Transfer, Knowledge Application and Knowledge Evaluation).

Table 3: Correlation between Cooperation within Institutes and Factors of Knowledge Management

	<i>Organisational Cooperation</i>
Organisational Cooperation	1
Knowledge Creation	0.62522964
Knowledge Storage	0.576622512
Knowledge Transfer	0.552761267
Knowledge Application	0.631010525
Knowledge Evaluation	0.491780477

Table 3 shows the Pearson's correlation coefficients between cooperation between individuals in an educational institution and different factors of knowledge management (Knowledge Creation, Knowledge Storage, Knowledge Transfer, Knowledge Application and Knowledge Evaluation). Pearson's correlation indicated that all factors of knowledge management are positively correlated with cooperation between individuals in an educational institution. Further the strength of correlations of factors of knowledge management differs from each other. Knowledge Creation ($r = .625$), Knowledge Storage ($r = .577$), Knowledge Transfer ($r = .553$), Knowledge Application ($r = .631$) and Knowledge Evaluation ($r = .492$) are moderately and positively correlated with cooperation between individuals in an educational institution. Here all correlations are found to be significant at 0.01 level of confidence.

FINDINGS AND CONCLUSIONS

The primary objective of the study was to study the relationship between organisational cooperation and knowledge management practices in higher educational institutes.

Table 3 shows the Pearson's correlation coefficients between cooperation among individuals in an educational institution and different factors of knowledge management (Knowledge Creation, Knowledge Storage, Knowledge Transfer, Knowledge Application and Knowledge Evaluation). Table 3 shows that all factors of knowledge management are positively correlated with cooperation among individuals in an educational institution. Further, the strength of correlations of factors of knowledge management differs from each other. The strength of correlations between cooperation within institutes and Knowledge Creation ($r = .625$) is found to be most. Thus, it can be concluded that if individuals within an institute cooperate with one another, it positively impacts knowledge creation of that institute the most. The strength of correlations between cooperation within institutes and Knowledge Evaluation ($r = .492$) is found to be least among the factors of knowledge management. It somewhere sounds fair also as cooperation within individuals may not affect the way knowledge is evaluated by the organisations. But, still it is found that the correlation is positive and significant enough to conclude a relationship between cooperation within institute and knowledge evaluation.

Secondary objectives included measuring the level of organisational cooperation and knowledge management practiced by the respondents. Our analysis of data revealed that the level of organisational cooperation is found to positive but it is quite low (Table 1). In tune with organisational cooperation, knowledge management scores are also found to be positive but they are not significantly high (Table 2).

IMPLICATIONS AND RECOMMENDATIONS

Findings revealed that all factors of knowledge management are positively correlated with cooperation between individuals in an educational institution. The strength of correlations between cooperation within institutes and Knowledge Creation was found to be most. So, benefits of cooperation within institutes should be communicated to all the faculty members as a win-win situation for all.

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“RELIGIOUS HUB –A Perfect Destination for All the Religions”- A Business/Start-up Plan

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Abstract

With the rapid urbanization, by 2020 the retail growth & the digital drive are widely initiated by the government. By this the customers are benefited in terms of lower prices, wide variety & convenience. Also due to the Pandemic situation people are mostly switching to virtual shopping through desktops or laptops or widely by their mobile phones. By this, we had come up with an idea to sell the Religious goods/products on an online platform, whereby the customers can find all the goods from a single platform which covers all the religion's, and which also results into saving time, easily comparing of things & also convenient as well as safe at time. The plan undertakes feasibility check, financial analysis, marketing plan likewise...under which we will be providing all the kinds of religious products of all the religions and with the ease for the customers we will be connecting through an application. Hope this can be a great success start-up plan especially in this era of pandemic where people are more into converting towards the digital era and this will be a great advantage to us. Due to the modernization, more people are nowadays coming into Start-ups business and more specifically E-Commerce Businesses, thereby increasing the competitors. While analysing the feasibility of our plan we also analyze the local as well as global competitors in order to survive and lead in the Market.

Keywords: Start-up, Religious Goods, Innovation, Leadership, Entrepreneurs, E-Commerce.

INTRODUCTION

A Business idea is a concept that can be used for financial gain that is usually centered on selling of the product or the service that can be offered for money. An idea is the base of the pyramid when it comes to the business as a whole. It should also be **Innovative, Unique, and Problem Solving & Profitable as well**. It is linked to its creator who identifies the Value Proposition in order to enter into the market and to gain the competitive advantage.

The **USP (Unique Selling Proposition)** is the factor which makes a company or the product stands out from its competitors. It is created through the element of being first to the market. As analyzing the current pandemic scenario and as being tech-savvy, the E-commerce businesses are growing at a rapid face right now. We are thinking of starting an “**Ecommerce Business for Selling of Religious Goods**” by launching an app named “**RELIGIOUS HUB**”. This is an idea to sell religious goods relating to different religions on an online platform whereby people over here can get the different goods/objects relating to worship or conducting the religious purpose activities.

UNIQUE IDEA/INNOVATION AS OF

The unique idea behind this business idea is that:-

- People can be able to get the Religious good at their doorsteps.
- They can be able to get all types of things on a single platform.

- Due to the pandemic situation they need not to go to the markets and take the risks.
- The comparison variety and the others things between different products can be made available.
- There is less availability of such online retailing of religious things on an e-commerce platform until now.

LITERATURE REVIEW

Ranjani Ayya (Nov 26, 2017), she has practiced of conducting devotees & their practices with the use of technology. Basically the company provides information on astrology & numerology and also helps organize Pujas & all. Her main component was to win the trust of customers. Investors are sure start-up in religious & spirituality are good business propositions. Therefore in this age of technology & the current pandemic the goods availability on e-commerce platform can be beneficial.(Ayya R. , The article on practice of conducting devotees & their practices with the use of technology., 2017)

Aarti Rahul Sharma (July 8, 2016), the entrepreneurship boom has been a lot of novel start-ups in the recent years. Hundreds of entrepreneurs have built amazing business from health to food, groceries to education etc... by this “Aaduishakti” is a new entrant, whereby it can create a marketplace or model for astrologers, tarot card readers, vastu experts etc... this will give customers numerous choices & sense of reliability.(Sharma, 2016)

Samikah Majumdar (June 6, 2018), in his article has been explained the facts about religion in India. India is home to 1.4 billion people, for most Indians, faith is important. Due to its population growth of world’s largest religions, it is a religiously pluralistic & multiethnic democracy, high levels of government restrictions on religion, having high level of religion-related social hostilities. Therefore from this it is concluded that in India people do believe & spend, conduct practices for the same.(Majumdar, 2018)

Hindustan times (may 02, 2020), which says about the effect of COVID-19 on the religious pattern, where they are trying to stay connected with devotees who keep on calling for performing Puja & all keepers of the faith, & perform & book all the things online at different states all over the India accordingly, in this pandemic where technology is a blessing from god & can conduct the practices at any face of time.(Hindustan time, 2020)

Debolina Biswas (Nov, 2018), the author described the importance of religion in our life and how the startup can help the people in fulfilling these requirement by bringing to the doorstep of people. Many startups have been stated in recent years to help people to celebrate festival in style, offer Puja to temples you might be not able to visit.”EPUJA” company help the people to book local priest who perform the Puja on their behalf and send them Prasad in mail.(Biswas, 2018)

Sanchita Dash (Aug, 2017), the paper analyzed the opportunity of bringing spirituality to digital. With the advent of digitalization, startup have come up with newer ideas to make sure that people from the comfort of their home not only book tickets for religious travel but also receive information of various cultural events like inauguration of Ram mandir and order Religious items like Prasad and many more.(Dash, 2017)

Shephali Bhatt (July 2016), the authors expressed that how people are connected to spirituality and room for the startup who sell their gods to customers. Startup like “SHUBH PUJA” arranges not only Puja and pandit but also help people in terms of astrology, numerology and vastu etc. such startups are gaining momentum and receiving \$40 billion from big entrepreneurs’ as they have brand and has created image in minds of people like “Shubhkart”.(Bhatt, 2016)

Sutrishna Ghosh (March, 2019), the author expressed that faith and spirituality might be the oldest known practices to mankind, but application of technological tools like AI is new. Born of experience in deep tech and consumer spaces, online platforms not only carve a niche for itself but also serve time poor generation. In these hustle bustle life people prefer more online spiritual than offline.(Ghosh, 2019)

J Vignesh (Feb, 2018), the author expressed how the artificial intelligence can help the people experience of being present virtually who are stretched for time, senior citizens who wish to participate in various religious ceremonies “VIRTUAL DARSHAN” .Such facilities have eased the life of people and this pandemic has increased the users of such platforms.(Vignesh, 2018)

RESEARCH METHODOLOGY

Objectives

- To start an app “**RELIGIOUS HUB**” whereby people can place order online for the religious goods.
- To satisfy the customer’s needs in this period of pandemic.
- To provide satisfactory and good experience to our customers.
- To be the best player amongst the leading ecommerce market serving religious goods.
- To create awareness about our app to the people through various social media marketing.

Mission & vision statement

- **Mission:**
“To spread the roots of spirituality in every corner of the world.”
- **Vision:** “To be one of the leading spiritual Tech-savvy Company; Providing Good and Qualitative range of varied products to the customers at every corner around the world.”

Research design

A research design is the set of methods and procedure used in collecting and analyzing measures of variables specified in problem research. The design of the study defines the study type and sub-type, research hypothesis, dependent and independent variable etc. Here in the study the design used is **descriptive research design**, whereby the gathering, analyzing and presenting collection can be done.

Future expectations

- For our business plan firstly we will be available for the selling of the religious goods at large variety in the products for Ahmadabad locally. And the products that are to be purchased from the businessmen, wholesalers at the prescribed quantity.
- And as after period of 2-3 years we are expecting to cover other nearby and in accordance to India level we will be covering mostly the metro-cities and the religious pilgrims like Mathura, Nathdwara, Rishikesh etc....where the end-users are large in numbers.
- The other expectation is regarding the products i.e. those products that are being purchased from other businesses but after we will be having our own **In-House Production & Warehouses** which ultimately will lead to cost-effective and also the stocks can be maintained large at and more working capital can be maintained. Moreover regarding to funding, our expectations are also to receive the funding from Angel investors, Venture Capitalist and to take our business one step ahead in line with new opportunities and trends.

Beneficiaries

- Senior citizen who needs religious goods in day to day life can get the goods online in this pandemic situation.
- People who are busy in hustle bustle life and cannot get time to purchase goods physically can get the goods delivered at their home.
- People can compare the prices from physical stores and can also get the benefit of discounts, coupons etc.
- Here the consumer will find all the types of good at a common platform and thus which can help them to buy at a convenience.

Limitations

- Creating the awareness about the app and the online retailing business may be hard in initial stage.
- Lack of secondary data also acts as a limitation.
- As the time period is less, it also acts as a limitation.
- Initially we are covering only the local market i.e. only for Ahmedabad, so less customers in context to that can also be a limitation.

MARKET ANALYSIS

Market analysis is very important part for any business plan. It is useful to demonstrate both your expertise in your particular market and the attractiveness of the market from a financial standpoint. A market analysis is a quantitative and qualitative assessment of a market. So for this we had done a **Primary Survey**, by making a Questionnaire to check the feasibility for the same and then it is to be distributed among the peoples. From this the analysis is to be done on the basis of same.

Result

1. Do you buy Religious Products Online? Do you like/prefer to buy religious products online?

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Maybe	9	18.0	18.0	18.0
No	15	30.0	30.0	48.0
Yes	26	52.0	52.0	100.0
Total	50	100.0	100.0	

From the above chart we can interpret that **52%** of respondents would like/prefer to buy religious goods online while only **30%** of respondents would like to buy from local shops.

2. State your level of satisfaction: Overall Reliability

Case Processing Summary

	N	%
Valid	49	98.0
Cases Excluded	1	2.0
Total	50	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.679	13

- a. List wise deletion based on all variables in the procedure.

The data is reliable.

3. Would you like to shift your buying behavior of religious goods from physical from to online in period of covid?

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Maybe	17	34.0	34.0	34.0
No	5	10.0	10.0	44.0
Yes	28	56.0	56.0	100.0
Total	50	100.0	100.0	

From the chart we can interpret that **56%** of people would like to shift their buying from physical to online, while only **10%** would not like to shift, **34%** chances are there that they may swift towards the online market.

So from the above analysis we can derive the level of feasibility of our business plan from the survey made through questionnaire and from this the certain % of usage and the preference can be known of the sample customers as our primary survey.

Competition:

The competitors here that we will face are the present players who are selling similar products in an online platform. Therefore in order to get better outcome we have made various strategies and innovations to overcome the competition.

List of some competitors

- Akhbari brothers (Rajkot)
- Sri Sai Pooja Samagri (Mumbai)
- Ahmedabad Catholic Online
- Puja Giri
- Global Retailers like **Amazon, Flip kart, Shop clues etc...**

These are some of the local websites that are running which includes sales of mainly Hindu religious products and one is in Christian's religious product. So in that case in our app "**Religious Hub**" we will be selling all the religion's spiritual products at a particular place/platform.

INFRASTRUCTURE

In our business plan the Infrastructure facilities that can be needed are like:

- Application
- Warehouse
- Courier Service tie-ups

ABOUT APPLICATION Under this there are general guidelines and frameworks that will make your business suitable for running ecommerce. It is a standard like technical tools, legal and regulatory frameworks, and the involvement of service providers. Under this we will we launching an app named "**RELIGIOUS HUB**". For this there are some of the legal formalities that are to be made.

Application infrastructure components may include things like servers, data storage, networking, application monitoring, and logging capabilities, and application security services.

App launching:

- There is a onetime fee of \$25 by which a developer can open an account, loaded with functions and control features.
- After this payment this app will be uploaded on **Google Play store** for free. All for that we need to fill out the required credentials and we are good to go.
- The merchant account then will allow us to manage and examine the app sales, thereby.



- After this the IT person will be handling the detailing and orders and updated relating to the app and then the things will be informed to us. By this way a supply chain will be made and it will be easy in managing the same.

WAREHOUSE

The location of the warehouse would be preferred in the midst of the city so that it can be easy for us to do such transactions in least cost and the least time thereby.

Need for the warehouse

- Managing inventory, equipment, and safety.
- Keeping products secure.
- Better organization of products.
- Time Saving.

Thus, Good inventory and warehouse management for your online store can help you save money and time while meeting customer expectations.

COURIER SERVICES TIE-UPS

Here, as our business plan is for Ahmedabad so we will approach the local courier companies like:

- Shree Anjani Courier services pvt. Ltd.
- Shree Maruti courier services pvt. Ltd.
- Dtdc courier.
- The professional couriers.
- Speed post couriers.

These courier companies will be picking the products from the warehouse and then will ship them to the customers as per the area. For this we had thought of adding **Rs. 40-50** of the delivery charge on the order that are below Rs. 499 and above than that there will be zero delivery charges. And most of the other sites that are already into the market are making as same charges while some are charging too high as per their norms and conditions thereby.

PRODUCT DETAILING

The products are the actual thing which is considered as the value or the goodwill of any kind of business. So here are some of the detailing related to the products that we will be selling on our e-commerce platform, which consists of all the kind of products related to every religion.

Product's Segmentation

It is divided as per the religions and accordingly the different kind of products will be available on the Religious Hub app.

Religions Covered:-

1. Hindu
2. Muslim
3. Christian
4. Jainism
5. Buddhist
6. Sikhism
7. Taoism

Products available

- **(Hinduism)** the products lists are like **Holy books, Chunaris, Dhoop, Diya, Incense sticks, Malas, Pooja thali, Idols, Wagha, Gems stones, Mataji Garba etc...**
- **(Christianity)** the products used by them in worshipping are like, **holy books, candle, Cross pendants and wall hangings, Locketts, Rosary etc...**
- **(Muslim)** In our business plan we sell various products of Muslim religion like **Prayer caps, holy books, Churners, Attars etc.**
- **(Sikh)** In our business plan we sell various products of Sikh Religion like **Turban, Rumala, Chaur Sahib, Kada etc.**
- **(Jainism)** In our business plan we sell various products of Jain religion like **Muhapatti, Holy books, Jain Mala, Mahavir swami idol etc.**
- **(Judaism)** In our business plan we sell various products of Judaism religion like **Locketts, Menorah etc...**

So, these are example of the products and its detailing that we will be selling in our business plan of online retailing of all the religious products. As considering our plan we will be covering every single products relating to every religions so this are some of the examples from the whole. And rest all the product can be visible in the app –**“Religious Hub”**.

LEGAL REQUIREMENTS

Before starting our venture the most important thing to be considered is fulfilling Legal requirements, failing which can lead the business in vulnerable situation. Various things are to be considered before starting the business such as:-

- Formation of company
- Memorandum of Association
- Articles of Association
- Non-Disclosure agreement
- Trademark
- Applying for License

For our venture we will form the private company “Religious Hub Pvt Ltd” having 2 members i.e. Meghna and Veena. Also we will apply for the license to sell the products online Under Gujarat Government policy. As we will sell our products on our App we are also required to pay one time fees of \$25 by which developer can open an account and get it register on play store. Such legal requirements are required to be fulfilling before we start our business.

The Trademark will also be registered on the company logo



FINANCIAL PLAN

For our report we had made the estimated statements for the 3 years from the commencement of the business and the analysis had been done on the same.



Table 1: Projected Income Statement fiscal (2021-2023)

Revenues	2021-2022	2022-2023	2023-2024
Grants	100,000	200,000	300,000
Sales	600,000	700,000	800,000
Advertising	4000	8000	13000
Total Revenue	704,000	908,000	1,113,000
Expenses	2021-2022	2022-2023	2023-2024
Web-Design	36,000	36000	40000
Salaries	160,000	160,000	200,000
Rent	150,000	150,000	150,000
Advertising Expenses	20,000	20,000	22,000
Courier Expense	70,000	100,000	150,000
Electricity	25,000	25,000	25,000
Interest Expenses	52,500	52,500	52,500
Packaging Expense	60,000	75,000	80,000
Printing charges	10,000	10,000	10,000
Depreciation on furniture	10,000	9,000	8,000
Other Expenses	15,000	18,000	20,000
Total Expenses	608,500	655,500	757,500
Net Surplus	95,500	252,500	355,500

Table 2: Balance Sheet for the year end 2021-2023

Assets	2021-2022	2022-2023	2023-2024
Non-Current assets			
Furniture	100,000	90,000	81,000
Intangible assets	13,500	13,500	13,500
Total non-current assets	113,500	103,500	94,500
Current assets			
Inventories	298,500	370,000	490,000
Trade receivables	450,000	575,000	615,000
Cash & Cash Equivalents	30,000	30,000	30,000
Other bank balances	400,000	400,000	400,000
Other current assets	63,500	84,000	84,000
Total current assets	1,242,000	1,459,000	1,619,000
Total assets	13,55,500	15,62,500	17,13,500
Liabilities	2021-2022	2022-2023	2023-2024
Capital Contribution			
A. Equity Capital(30,000 shares 10 each)	300,000	300,000	300,000
B. Preference Share	-	-	-
Total Share Capital	300,000	300,000	300,000
Add: Net Surplus	95,500	252,500	355,500
	395,500	552,500	655,500
Non-Current liabilities			
Borrowings	700,000	700,000	700,000
	700,000	700,000	700,000
Current liabilities			
Trade Payables	250,000	300,000	350,000
Other Current liabilities	10,000	10,000	8,000
	260,000	310,000	358,000
Total Equities & Liabilities	13,55,500	15,62,500	17,13,500

Table 3: Imaginary Budget for the year 2021-2022

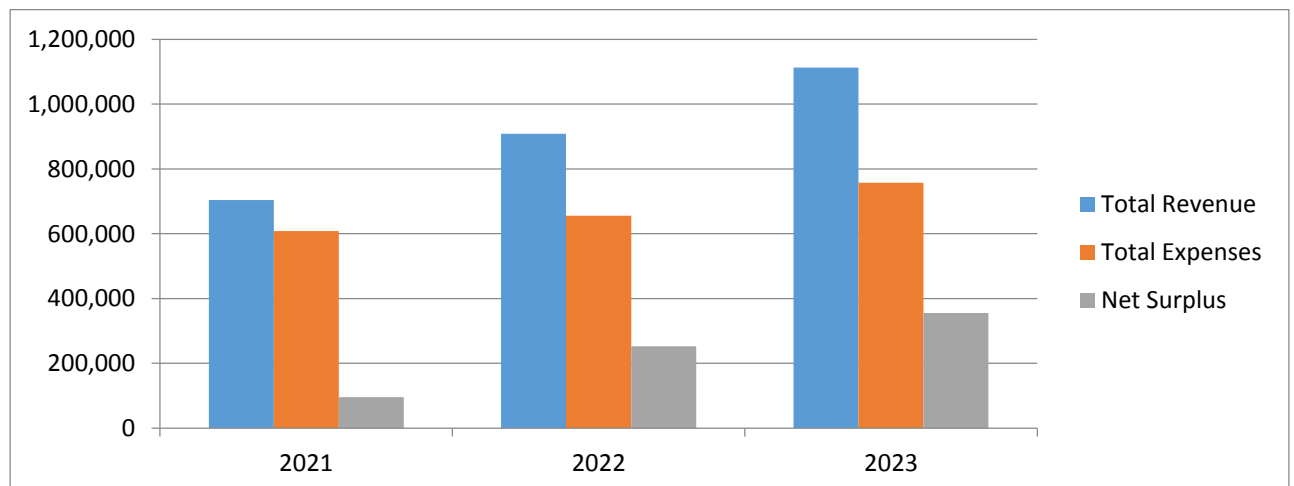
Religious Hub		Business startups cost	
Funding	Estimated	Actual	Under/Over
Investor funding			

Owner 1	150000	150000	-
Owner 2	150000	150000	-
Total Investment	300000	300000	-
Loans	700000	700000	-
Total funding	1000000	1000000	-
Costs	Estimated	Actual	Under/Over
Web-Design	36000	45000	(9000)
Salaries	160000	160000	-
Rent	150000	160000	(10000)
Adv Expenses	20000	25000	(5000)
Courier Expenses	70000	65000	5000
Electricity	25000	25000	-
Interest Expenses	52500	52500	-
Packaging Expenses	60000	50000	10000
Printing Charges	10000	8000	2000
Depreciation	10000	10000	-
Other Expenses	15000	18000	(3000)
Total Expenses	608500	618500	(10000)

Net Surplus analysis

From the year of commencement to next 3 years the surplus has been increasing at a good percent and in a profitable manner.

Fig 1: Net Surplus Analysis



Interpretation

The above chart shows the bars for Revenues, Expenses & Surplus. In the startup phase the revenue was 704000 and the expenses were 608500, which lead to the profit of 95500 and then it substantially increased by 20%, thereby proving that our business has the potential to earn good revenue initially and then to continue by such in the future to grow and survive in the competitive era.

MARKETING AND DISTRIBUTION PLANNING

MARKETING

The marketing plan details the strategy that a company will use to market its products to customers. For this various things are necessary they are like:

ADVERTISEMENT AND PUBLICITY

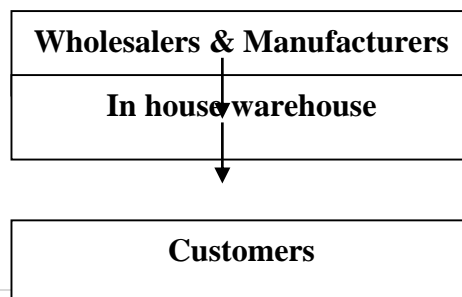
Every business plan is incomplete without advertising and publicity. Advertisement helps the business to reach to the people and promote their product and brand. By choosing correct medium, business can easily engage with their customers and can create brand awareness in their minds. With the aim to provide the goods and services to a large number of customers and to promote our products, we have made collaboration with Religious Platforms like “**Jalaram Mandir**”, “**Guru Gobindsingh Gurudwara**”. Also in this current era of digitalization in pace with latest trends we would also be having Social-media advertisement on platforms like Instagram and face book. Also we made tie up with various websites for the advertisement of our products.

Ways of Advertisement

- **Social Media Advertisement:**
Social media advertisement is the most efficient medium to connect to a large number of people. With this view in mind we have created “**Religious Hub**” page on Instagram and Face book to reach to the millions of people. And also on the websites relating to the spiritual activities or may be booking of the tickets and all, on such sites we will be making pop-up advertisement of the app & its availability.
- **Display Advertisement:**
To promote our products and brand we have made tie up with various OTT platforms like religious app, Amazon, and Flip kart for display advertisement. Also on the T.V in the religious channels it can be made available.
- **Print Media Advertisement:**
To bring awareness among people about our App as well as our products we will also advertise in Consumer and Trade Magazines as well as Direct Mail. Mails are the best way to stay connected with our clients.
- **Seo Sighting:**
Seo is the practice of bringing traffic to our websites/apps through organic search results. With the help of Seo our business can increase its sales as well as can create brand in market.

Distribution Plan

The distribution channel in our business plan “Religious Hub” is as under:



As mentioned above, we will be directly purchasing the goods from the wholesalers & manufacturers and then we will store it in the warehouse and then as per the order arrives the goods will be made delivered to the final customers. By this way the distribution plan is short and well precise so that the inventory can be well maintained.

OPERATIONAL PLAN

The operational plan is nothing but the overall planning of all the operations that are to be carried out in the business plan & details the what, when, who, how long, with what, and how much of company activities. As and before starting of the business there are lots of operations may be the small or the bigger one but it should be decided in an appropriate manner.

There are different plans that are to be made in regarding to the:

- Firstly, the business is started by the Meghna and Veena so, they are the owner/CEO of the company named **“Religious hub”**.
- As our business is in startup phase all the activities of the business will be managed by its Founders Veena and Meghna from home only, currently we are working from home but in near future we will set up our office depending on the growth of our business.
- What the activities of the business are, when those activities occur, who is responsible for various tasks, how long each activity will occur, what tools or equipment are required, and how much time and funding are needed.
- We have backend team who will process our orders and deliver them on time.
- Also we have rented one godown for the storage of our products. We have also planned to collaborate with Religious platforms like “Guru Gobind Singh Gurudwara”, “Jalaram Mandir” to promote our business and reach to the maximum customers.

FINDINGS OF THE BUSINESS PLAN

The Findings are the overall analysis of the Research Study made, and it is seen what all are the measures that have been done, and what are the loopholes that have to be rectified all are mentioned here:

- Today the world is moving fast and becoming digitalization, people prefer to purchase the goods online. The research helped us to identify our competitors, their strength and weakness, newer opportunities for our business, success rate of our business.
- Literature review helped us to analyze that there is lot of opportunities available in ecommerce business for selling religious Goods. Many startups like “EPUJA” helped the people to book local priest online as well as receiving Prasad at their home.
- Any business is incomplete without market survey, with the help of primary survey we found out that 56% of people preferred to shift their buying from physical to online especially in this period of pandemic.
- Also the pilot study helped us to understand the price of the products of the competitors and benefits available to the customers. This helped to analyze the market thoroughly as well as to know the success rate of our business. The study helped us to frame the marketing strategies to compete with our competitors and bring more customers to our App **“RELIGIOUS HUB”**.
- The research helped us to analyze the funding requirement for our business and sources of funds as well as the return generated by the business. It helped us to focus on each and every aspect of cost required by the business to successfully reach the product to the customers.
- Also we identified the risk associated with the business and worst situations like natural calamities that can affect our business and lead to loss.
- We also analyzed the legal requirements of our business and requirements required to be fulfilled to launch our App.
- The research helped us to identify our target audience and create the brand awareness of our products in their mind, through segmentation and targeting.
- From our analysis we found that our business can generate 20% in a period of 2 years thereby proving that our business has the potential to earn good returns in near future.

- The main focus of our study is the competitors. The research helped us to find not only local competitors but also global competitors having products similar to our products and strategies adopted by them.

CONCLUSION

The making of the business plan helped us to have a good insight about all the areas that we need to work upon before starting the actual business plan. As our business plan is on e-commerce platform whereby we the owner of the app named **“Religious Hub –a perfect destination for all the religions”** are serving the spiritual goods consists of all the religion from the pin to plane. As the name suggest our specialty of what we are into.

For this we had done all the legal requirements, what is the Feasibility check of the business plan, who are our competitors and what all the marketing strategies and the needs to be carried out in order to be known in the market. And also the financial analysis of the business has been made for 3 yrs based on the assumption of the current environment and availability. Other than that we had also gather various sources of gathering the funds in the initial stage and to progress in further.

By this way step by step all the plans and things have been decided and been made in order to get the blueprint of our business plan and to assure its feasibility that how far it is realistic. In our Comprehensive Project, we had been blessed with our faculty guide **Dr. Hetal Vyas** where she had helped us so much to our plan the best and expressed her knowledge regarding the start-up plans and success, which gained us much help.

For this business plan as we had come up with the app which has been prepared by the 2 IT persons which can properly specify what exactly we are into and the availability of the products and its prices and so on. Hope this can be a great success start-up plan especially in this era of pandemic where people are more into converting towards the digital era and this will be a great advantage to us.

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Dr. Tanvi Pathak
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Dr. Tanvi Pathak is an assistant professor for Accounts and Finance at Faculty of Management, GLS University. She holds a doctorate degree in the area of economics with an overall experience over a decade in academics. Her area of interest includes Financial Management, Managerial Economics and International Financial Management. She has authored several research papers in national and international journal.

New Normal in Management

COVID-19 outbreak, has come with challenges of its own kind, which are new for everyone. Businesses are being challenged with how to ensure business continuity. The conference aims to cover research conducted to assess the impact of the emerging trends, digital technologies, financial challenges and the difficulties faced in human resource management.

The pandemic has taught us the capability of generating, processing and managing more data and information than ever before. The process has evolved the teaching and learning process as well as the decision making process in all aspects. With digital learning, teaching and learning experiences have progressed to be more efficient and collaborative. By upscaling and accelerating the adoption of distance and online education across the world, the Covid-19 pandemic has demonstrated the importance of rethinking the educational process. In this massive collective experience of change, the role of the educational institutions, teachers, learners, their families and communities is rapidly transforming. As a result, new challenges for researchers have emerged that need to be addressed.

This book is a compilation of research papers discussing how the businesses need to go beyond mere crisis management and identify hidden opportunities of new sources of revenue. It acknowledges the fact that in this kind of environment, revenue is not going to be there for sure. It could be muted. The book address the fact a-one-size-fits-all approach wouldn't work in these tough times. In the new normal, company management need to have a more humane approach and not a "command and control" approach. The book thus deliberates on the general management challenges faced by businesses today and how to tackle them.



The Institution of Engineers (India)

A Century of Service to the Nation

36th

National Convention of Chemical Engineers

&

National Conference

on

**Frontier Technologies for
21st Century's Process Industries**

March 06-07, 2021

Organized by

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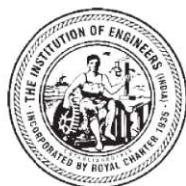
Chemical Engineering Division, IEI

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Proceedings



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- Paper ID: IE29** : *novel three parameter activity coefficient model*
Authors: Sivaprakash B, D Nirubamaa, I Purushothaman, V Vandhana
- 1155 hrs – 1205 hrs** : **Title:** *Isothermal and isobaric VLE prediction from a novel activity coefficient model for binary systems*
Paper ID: IE27 **Authors:** Sivaprakash B, Agastinraj T, Rakesh E, Santhosh Kumar S
- 1205 hrs – 1220hrs** : **Discussion (Q&A)**
- Technical Session–IV** : **Theme: Industrial Waste Treatment and Utilization**
Chairman: Prof Tapas Modal, IIT Guwahati
Session Coordinator: Dr Bimal Das, NIT Durgapur
- 1220 hrs – 1230 hrs** : **Title:** *Synthesis of Coal Fly Ash Based Adsorbent for the Sequestration of Heavy Metals from Effluent - Sustainable Approach for Waste Water Treatment*
Paper ID: IE11 **Authors:** Divya Tirva, Ritesh R Palkar, Latesh B Chaudhari
- 1230 hrs – 1240 hrs** : **Title:** *Extraction, Adsorption and Optimization of Chitosan (from Prawn Shells) in the study of Removal of Copper ions*
Paper ID: IE07 **Authors:** P Mallika Rani, D Anjali, M Shiva Naresh, S Manikanta, N Manoj Yadav, S Krishnaveni
- 1240 hrs – 1250 hrs** : **Title:** *Experimental Investigation in Making Low Cost Concrete from Paper Industry Waste*
Paper ID: IE12 **Authors:** D Sakthivel, S Ramesh Kumar, E Vellaingiri
- 1250 hrs – 1300 hrs** : **Title:** *Experimental Investigation of Industrial Wastewater by using Dragon Peel*
Paper ID: IE16 **Authors:** S Ramesh Kumar, D Sakthivel, E Vellaingiri
- 1300 hrs – 1315hrs** : **Discussion (Q&A)**
- 1315 hrs – 1400 hrs** : **LUNCH BREAK**



Synthesis of Coal Fly Ash based Adsorbent for the Sequestration of Heavy Metals from Waste Effluent – A Sustainable Approach for Wastewater Treatment

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ABSTRACT

The Coal Fly Ash (CFA) is a promising industrial by-product generated from coal based combustion power plants and other relevant sources as well. In order to focus the sustainable approach and to highlight the diverse applications of CFA, the synthesis of zeolite as a cost-effective adsorbent is an emerging field. It's mineralogical composition, unique ion-exchange framework, and sorption property make zeolite a preferable adsorbent for the treatment of waste effluent. In this research work, an attempt is made to investigate modifications in the physio-chemical properties of zeolite and its utilization for the treatment of heavy metals such as Zn²⁺ and Ni²⁺ ions. A novel efficient mesoporous adsorbent (NaP1 types zeolite) was synthesized by adopting the hydrothermal synthesis method. It has been observed that color has reduced from 240 Pt-Co units to 6 Pt-Co units and pH dropped from highly alkaline range 9.5 to 7.5, COD is considerably reduced from 2300 mg/L to 600 mg/L. The experimental study reports the potential for the simultaneous removal of Zn²⁺ and Ni²⁺ ions with adsorption efficiency of 97% and 99% respectively. The objective of this research work is to develop a techno-economic feasible solution for the recycling and utilization of CFA. This approach not only suppresses the pollution index but also contributes towards achieving the sustainable development goal (SDGs).

Keywords : Coal fly ash; Synthesized zeolite; Adsorption; Heavy metals; Zinc; Nickel.

INTRODUCTION

In current scenario, the proper clearance of coal fly ash primarily from any coal-based power plant is a prime concern. In India, due to large use of sub-bituminous coal with high ash content (30-50%) contributes to a huge quantity of fly ash. The fly ash generated, accounted as raw material for few processes as per the desired requirements. There are few processes, which facilities the use of fly ash as raw material viz., concrete manufacturing and for other potential applications in the construction industry. In most of the situations the fly ash is simply dumped on the landfill sites. As per the rough statistics, more than 90 million tons of fly ash is being generated annually in India, and it covers almost 65000 acres of land which is being covered by the ash ponds. Moreover, the proper disposal of fly ash

is a concern for the industries. Due to the lack of proper disposal options, a huge quantity of ash has posed a great hazard to the ecosystem. In order to mimic the hazard to the ecosystem, the waste coal fly ash can be utilized in many processing applications. One of the attractive applications is synthesis of zeolite, which has created a positive impact towards sustainable development. The different research group has identified the fly ash as a fascinating raw material for synthesizing zeolite, since it has a high content of reactive materials like aluminosilicate. The important aspect in this process is not only to convert the fly ash into zeolites but also to eliminate the disposal issue. This capability represents the potential into a marketable commodity for the waste material which is generated from most of the thermal power plants. In this research article, the research group



has investigated the synthesis of zeolite synthesis from waste coal fly ash. This work also highlights the reaction mechanism of zeolitization, and proper usage of the product obtained. The sodium hydroxide is used as an alkali source in this hydrothermal synthesis process. The desired properties of the material synthesized is characterized using the physical properties such as surface structure, crystal structure, cation exchange capacity (CEC) and ion exchange properties.

EXPERIMENTAL

Material

The main raw material, coal fly ash (CFA) sample was collected from the electro precipitator of Atul limited, Valsad. The composition analysis of the CFA shows the presence amorphous phase (mainly SiO_2 , Al_2O_3) as well as the crystalline phase (mainly quartz and mullite). An X-ray Fluorescence (XRF) (Rigaku X-ray spectrometer model- ZSX mini 2) spectrometer was employed for the quantitative chemical analysis of the sample to reveal the elements (as the oxide by wt. %) present in it. The ratio of $\text{SiO}_2/\text{Al}_2\text{O}_3$ is 1.92 and this type of fly ash belongs to high Al and low $\text{SiO}_2/\text{Al}_2\text{O}_3$ ratio fly ash. Zeolite synthesized from a low $\text{SiO}_2/\text{Al}_2\text{O}_3$ ratio holds

greater porosity, higher cation exchange capacity, and selective adsorption of polar molecules. The composition analysis of CFA consumed in the current investigation is presented in **Table 1**.

Table 1: Composition analysis of CFA by XRF

Components	Composition (wt. %) of fly ash
Na_2O	1.87
MgO	0.60
Al_2O_3	26.65
SiO_2	51.29
P_2O_5	0.24
Na_2O	1.87
Fe_2O_3	3.73
SO_3	0.26
K_2O	0.79
CaO	2.58
TiO_2	1.67
Cr_2O_3	0.09
MnO	0.05

SrO	0.02
Y_2O_3	0.01
ZrO_2	0.55

Synthesis of Zeolite from CFA

In this work, hydrothermal alkaline fusion; a very cost effective and efficient process has been adopted for the synthesis of zeolite. In this process, in order to eliminate the larger chunks; the raw CFA undergone size separation in a BSS Tyler sieve (80 mesh size). The raw material is then subjected to calcination at 600°C for 2 hours. In this process, the unburnt carbon and volatile matter present in the CFA eliminated. The modifications of the properties interms of enhancement in the activity of zeolite formation, thermal stability, and acidity of zeolite; the calcined CFA is further treated by hydrochloric acid. The elimination of the oxides of iron and aluminum from CFA was observed in this stage.

In continuation to the steps prescribed, acid treated CFA was then mixed with sodium hydroxide in a pre-determined ratio and fused at different temperature from 550-650°C for 1 h. In this work, the NaOH/Fly ash ratio was varied from 1.0 to 1.5. The mixture obtained is then cooled to room temperature and transformed into slurry by adding water. The slurry was then stirred for several hours at room temperature and then kept for ageing at 90°C for 18 hours without any disturbance. The resultant mixture was then allowed to cool down and then it was subjected to a wash of distilled water several times to remove excess sodium hydroxide ($\text{pH} < 10$). The desired product is then filtered. In later stage, the mixture was then dried. The schematic representation of the is as shown in **Figure 1**.

The maximum amount of product is achieved in 18 h using an optimum activation NaOH/fly ash ratio of 1.3. This process consumes large amount of water and it also requires the long activation periods. The use of lower activation solution/fly ash ratio led to less water consumption to a drastic reduction in the activation time.

CHARACTERIZATION

X-Ray Deffraction (XRD)

The qualitative and quantitative XRD analysis (**Figure 2 (a)**) of the raw fly ash used in this study was carried out. The foremost crystalline phases in the ash were quartz (SiO_2), Mullite ($3\text{Al}_2\text{O}_3 \cdot \text{SiO}_2$) with a small amount of



magnetite and hematite. The quartz had the most intense peak at 27 degrees 2θ the most intense peak of quartz was observed. On the other way, the less intense peaks on the XRD patterns were identified as a mullite, hematite and magnetite. Apart from this, the fly ash contained an amorphous glassy phase give rise to broad hump in the region between 21 and 35 degrees 2θ as indicated in the XRD spectra.

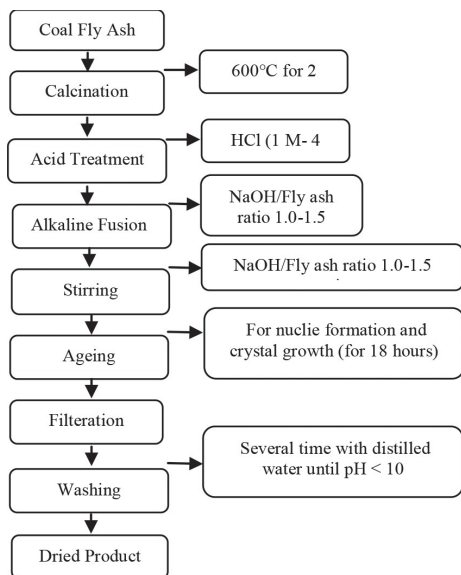


Fig. 1 Process flow diagram of synthesis of zeolite by hydrothermal fusion method

The zeolite formation step, suggests the conversation of more refractory quartz, mullite, hematite and magnetite phases. The desired product has been observed in terms of the major zeolite phase, after the activation of fly ash with NaOH solution along with the hydrothermal synthesis of zeolite Na-P1 (with the strongest peak at $27^\circ = 2\theta$). It shows the desired variation with respect to the variables like yield, depending on the experimental conditions. Along with this zeolite product, hydroxysodalite crystallized as a trace phase.

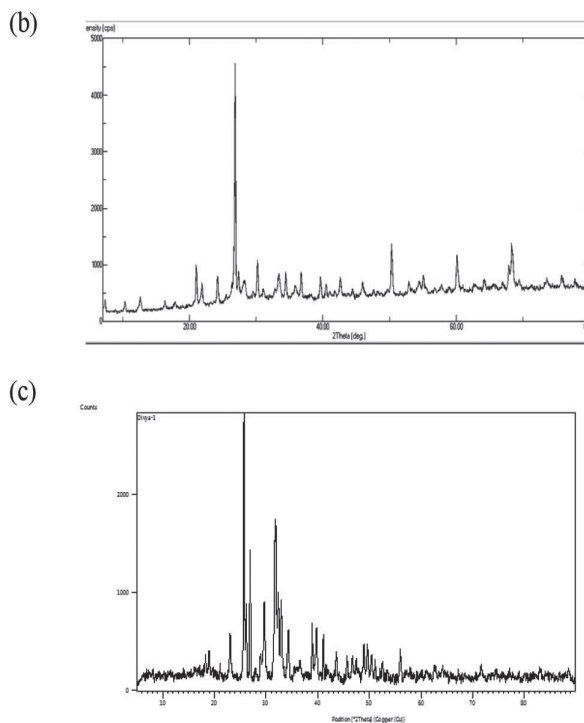
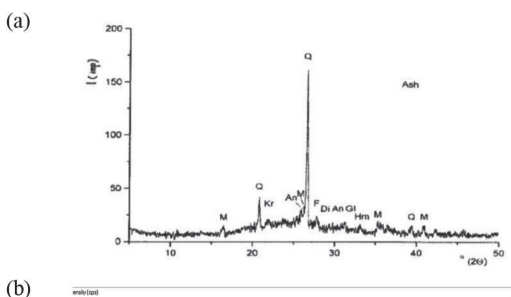


Fig. 2 (a) X-Ray diffraction pattern of Coal Fly Ash (Q – quartz, M–mullite, Hm– hematite, F – feldspars, Kr – crystobalite, Di – diopside, Gl – gehlenite, An – anhydrite), (b) Synthesized zeolite: ageing time 6 hours, (c) Synthesized zeolite: ageing time 18 hours.

Scanning Electron Microscopy (SEM)

The scanning electron micrographs of the coal fly ash and the synthesized zeolite are shown in **Fig. 3 (a)** and **Fig. 3 (b)** respectively. From the SEM images of untreated fly ash and synthesized zeolite it is evident that, the absence of spherical particles in synthesized zeolite indicates the high conversion of amorphous phase to crystalline phase. The synthesized zeolite possess distorted octahedral structure

BATCH EXPERIMENTS TO REMOVE HEAVY METALS FROM WATER USING ZEOLITE SYNTHESIS

Zeolite synthesized from experiment used to treat waste water containing Ni^{+2} and Zn^{+2} Heavy metals. 1 gm of zeolite synthesized were rinsed 6 to 7 times with distilled water and dried in oven before they were mixed with waste water in beaker.

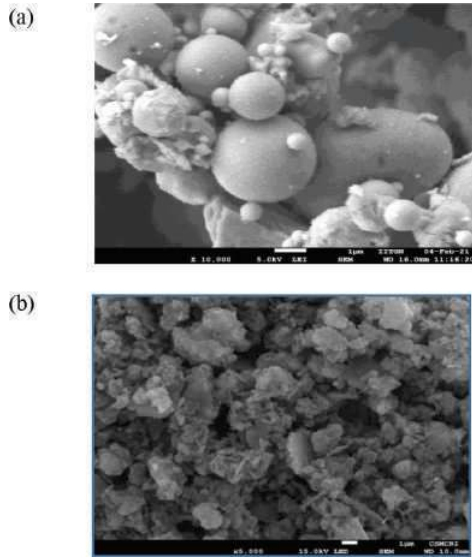


Fig. 3: Typical SEM micrographs (a) Coal fly ash (Untreated), (b) Synthesised Zeolite

The waste waters of various heavy metals concentration ranging from 5 mg/lit to 100 mg/lit were prepared by dissolving analytical reagent grade $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$ and $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$. The beakers were shaken for 10 min containing different grades of zeolite sample such as 1, 1.5, 2, 2.5, 3, 3.5 and 4 gm with the prepared waste water sample.

RESULTS AND DISCUSSION

Following conclusion can be drawn from the results of batch experiments:

1. The synthesized zeolite removes more than 97% and 87% heavy metals of 5 mg/lit and 100 mg/lit NiSO_4 sample respectively and adsorption equilibrium reaches at 10 min for adsorption. The graph is shown in Fig 4 and Fig 5.

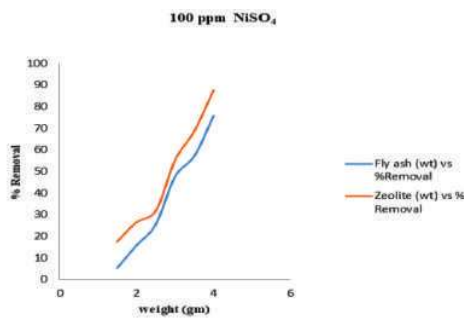


Fig. 4: Effect of NiSO_4 on % removal of heavy metals with reference to the fly ash and Zeolite weight

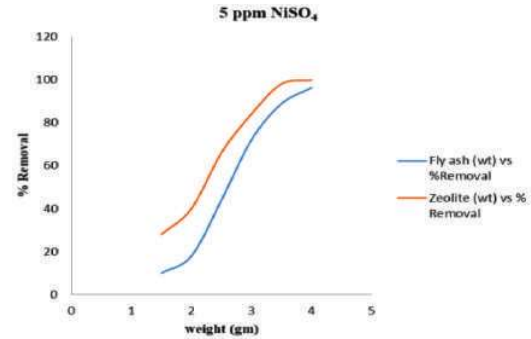


Fig. 5: Effect of NiSO_4 on % removal of heavy metals

2. It removes more than 99% heavy metals from 5 mg/lit ZnSO_4 sample and its take about 10 min for adsorption when zeolites synthesized are used to treat waste waters containing heavy metals. The graph is shown in Fig 6.

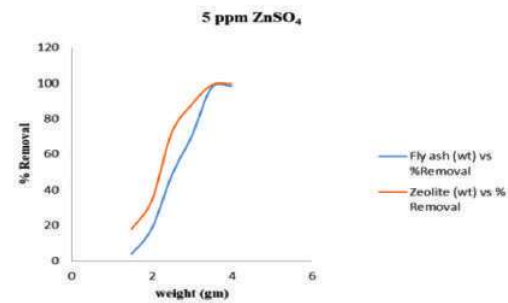


Fig. 6 Effect of ZnSO_4 on % removal of heavy

3. The removal rate increases with the increases in the amount of zeolites used in experiment. It is obvious that for waters of same solution concentration $\text{Ni}+2$ removal rate increases with increase of zeolite amount from 1 gm to 4 gm. The Observation relating the amount of zeolites when it was more than 1 gm; the removal rate in mentioned in the Table 2 and Table 3.

Table 2: Treatment of NiSO_4 100 PPM solution using fly ash and synthesized zeolite

Fly ash			Synthesized Zeolite		
Flyash wt (gm)	Filtrate ppm	% Removal	Zeolite wt (gm)	Filtrate ppm	% Removal
1.5	94.6	5.4	1.5	82.2	17.5
2	84.2	15.8	2	73.5	26.5
2.5	74.5	25.5	2.5	68.3	31.7
3	52.4	47.6	3	44.8	55.2



3.5	42.8	57.2	3.5	31.2	68.8
4	24.3	75.7	4	12.3	87.7

Table 3: Treatment of NiSO₄ 5 ppm solution using fly ash and synthesized zeolite

Fly ash			Synthesized Zeolite		
Flyash wt (gm)	filtrate ppm	% Removal	zeolite wt (gm)	filtrate ppm	% Removal
1.5	4.5	10	1.5	3.6	28
2	4.1	18	2	3	40
2.5	2.8	44	2.5	1.7	66
3	1.4	72	3	0.8	84
3.5	0.56	88.8	3.5	0.1	98
4	0.19	96.2	4	0.012	99.76

Table 4: Treatment of ZNSO₄ 5 ppm solution using fly ash and synthesized zeolite

Fly ash			Synthesized Zeolite		
Flyash wt (gm)	filtrate ppm	% Removal	zeolite wt (gm)	filtrate ppm	% Removal
1.5	4.8	4	1.5	4.1	18
2	4.1	18	2	3.3	34
2.5	2.6	48	2.5	1.4	72
3	1.5	70	3	0.6	88
3.5	0.12	97.6	3.5	0.05	99
4	0.08	98.4	4	0.02	99.6

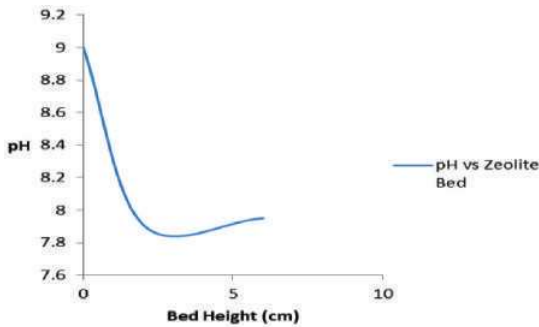


Fig. 7: Effect of pH on bed height

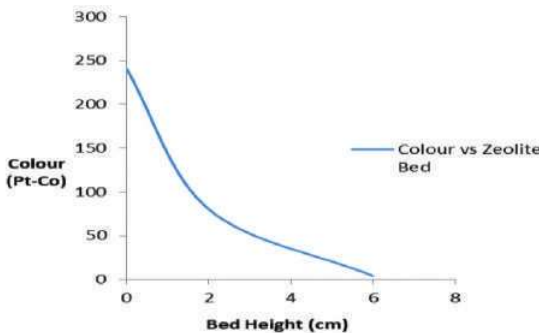


Fig. 8: Graph of Colour vs zeolite bed height

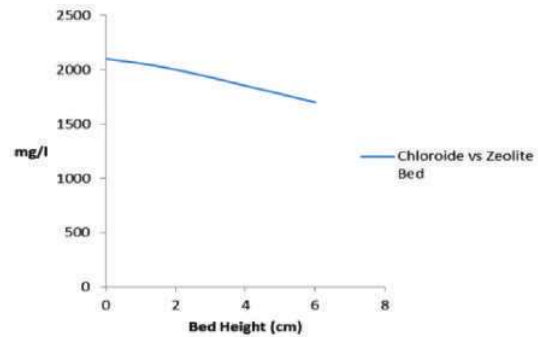


Fig. 9: Graph of Chloride vs Zeolite bed Height

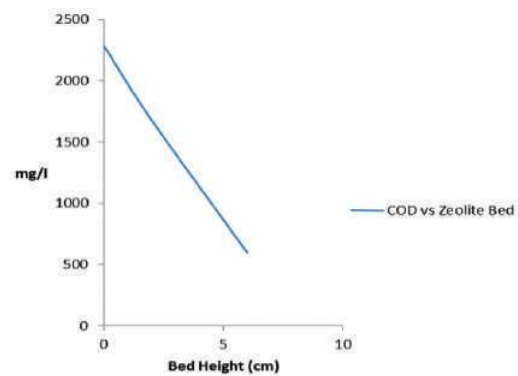


Fig. 10: Graph of COD vs Zeolite bed Height

Table 5: COD analysis data

Sr No	Sample	Volume of sample (ml)	Burette reading (ml)	COD (mg/l)
1	Blank	-	14.1	-
2	Untreated water	1.4	12.5	2285
3	Bed height (2 cm)	2.5	12	1680
4	Bed height (6 cm)	2	13.5	600

Table 6: Chloride analysis data

Sr No	Sample	Burette reading (ml)	Dilution Factor	Chloride mg/l
1	Blank	0.5	1:10	-
2	Untreated water	4.7	1:10	2099.32
3	Bed height (2 cm)	4.5	1:10	1999.36
4	Bed height (6 cm)	3.9	1:10	1699.45



Table 7 : Treatment final result data

Sr No	Sample	pH	Color Pt-Co	COD mg/l	Chloride mg/l
1	Untreated Water	9	240	2285	2099.32
2	Bed height (2 cm)	7.91	80	1680	1999.36
3	Bed height (6 cm)	7.95	4	600	1699.45

CONCLUSION

Since, we are concerned of growing atmospheric pollution, coal fly ash is one of the source. Though there are number of sources contributing to the deterioration of the environment, one must utilize the waste and should mould it into desired product or raw material. The concept of waste to best is utilized in this present work. The idea of contributing to sustainable development was the prime objective of this work.

The product developed and analysis shows the significant applications. The desired changes in term of morphological structures has been observed in this research work and it supports the use of waste fly ash a potential source for waste water treatment. The experiments were conducted shows the modifications in the properties of zeolitic material formed and it primarily depends upon the treatment conditions along with concentration of raw materials. The proposed technological solution allows to achieve a high level of fly ash conversion into high purity zeolite material Na-P1 in a very effective and efficient way. The fly ash analysed in this work characterized by a low Si to Al ratio, it supports the successful synthesis of zeolites with low Si content (NaP1), which display high ion-exchange capability and a large volume of pores. The optimal condition for synthesis observed are; at 600°C; 3 M NaOH solution and 6-8 hours of fusion time NaP1 zeolite is formed. The synthesized zeolite-NaP1 was tested for heavy metal contaminated impure water and results were observed that it is highly efficient in the removal of heavy metal cations Ni^{+2} and Zn^{+2} by exchangeable Na^+ cations. Further work is still needed to examine the effect of the variation in the raw materials and operating conditions on properties of zeolite.

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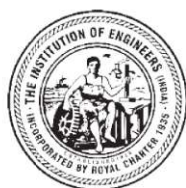
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- Paper ID: IE29** : *novel three parameter activity coefficient model*
Authors: Sivaprakash B, D Nirubamaa, I Purushothaman, V Vandhana
- 1155 hrs – 1205 hrs** : **Title:** *Isothermal and isobaric VLE prediction from a novel activity coefficient model for binary systems*
Paper ID: IE27 **Authors:** Sivaprakash B, Agastinraj T, Rakesh E, Santhosh Kumar S
- 1205 hrs – 1220hrs** : **Discussion (Q&A)**
- Technical Session–IV** : **Theme: Industrial Waste Treatment and Utilization**
Chairman: Prof Tapas Modal, IIT Guwahati
Session Coordinator: Dr Bimal Das, NIT Durgapur
- 1220 hrs – 1230 hrs** : **Title:** *Synthesis of Coal Fly Ash Based Adsorbent for the Sequestration of Heavy Metals from Effluent - Sustainable Approach for Waste Water Treatment*
Paper ID: IE11 **Authors:** Divya Tirva, Ritesh R Palkar, Latesh B Chaudhari
- 1230 hrs – 1240 hrs** : **Title:** *Extraction, Adsorption and Optimization of Chitosan (from Prawn Shells) in the study of Removal of Copper ions*
Paper ID: IE07 **Authors:** P Mallika Rani, D Anjali, M Shiva Naresh, S Manikanta, N Manoj Yadav, S Krishnaveni
- 1240 hrs – 1250 hrs** : **Title:** *Experimental Investigation in Making Low Cost Concrete from Paper Industry Waste*
Paper ID: IE12 **Authors:** D Sakthivel, S Ramesh Kumar, E Vellaingiri
- 1250 hrs – 1300 hrs** : **Title:** *Experimental Investigation of Industrial Wastewater by using Dragon Peel*
Paper ID: IE16 **Authors:** S Ramesh Kumar, D Sakthivel, E Vellaingiri
- 1300 hrs – 1315hrs** : **Discussion (Q&A)**
- 1315 hrs – 1400 hrs** : **LUNCH BREAK**



Synthesis of Coal Fly Ash based Adsorbent for the Sequestration of Heavy Metals from Waste Effluent – A Sustainable Approach for Wastewater Treatment

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ABSTRACT

The Coal Fly Ash (CFA) is a promising industrial by-product generated from coal based combustion power plants and other relevant sources as well. In order to focus the sustainable approach and to highlight the diverse applications of CFA, the synthesis of zeolite as a cost-effective adsorbent is an emerging field. It's mineralogical composition, unique ion-exchange framework, and sorption property make zeolite a preferable adsorbent for the treatment of waste effluent. In this research work, an attempt is made to investigate modifications in the physio-chemical properties of zeolite and its utilization for the treatment of heavy metals such as Zn²⁺ and Ni²⁺ ions. A novel efficient mesoporous adsorbent (NaP1 types zeolite) was synthesized by adopting the hydrothermal synthesis method. It has been observed that color has reduced from 240 Pt-Co units to 6 Pt-Co units and pH dropped from highly alkaline range 9.5 to 7.5, COD is considerably reduced from 2300 mg/L to 600 mg/L. The experimental study reports the potential for the simultaneous removal of Zn²⁺ and Ni²⁺ ions with adsorption efficiency of 97% and 99% respectively. The objective of this research work is to develop a techno-economic feasible solution for the recycling and utilization of CFA. This approach not only suppresses the pollution index but also contributes towards achieving the sustainable development goal (SDGs).

Keywords : Coal fly ash; Synthesized zeolite; Adsorption; Heavy metals; Zinc; Nickel.

INTRODUCTION

In current scenario, the proper clearance of coal fly ash primarily from any coal-based power plant is a prime concern. In India, due to large use of sub-bituminous coal with high ash content (30-50%) contributes to a huge quantity of fly ash. The fly ash generated, accounted as raw material for few processes as per the desired requirements. There are few processes, which facilities the use of fly ash as raw material viz., concrete manufacturing and for other potential applications in the construction industry. In most of the situations the fly ash is simply dumped on the landfill sites. As per the rough statistics, more than 90 million tons of fly ash is being generated annually in India, and it covers almost 65000 acres of land which is being covered by the ash ponds. Moreover, the proper disposal of fly ash

is a concern for the industries. Due to the lack of proper disposal options, a huge quantity of ash has posed a great hazard to the ecosystem. In order to mimic the hazard to the ecosystem, the waste coal fly ash can be utilized in many processing applications. One of the attractive applications is synthesis of zeolite, which has created a positive impact towards sustainable development. The different research group has identified the fly ash as a fascinating raw material for synthesizing zeolite, since it has a high content of reactive materials like aluminosilicate. The important aspect in this process is not only to convert the fly ash into zeolites but also to eliminate the disposal issue. This capability represents the potential into a marketable commodity for the waste material which is generated from most of the thermal power plants. In this research article, the research group



has investigated the synthesis of zeolite synthesis from waste coal fly ash. This work also highlights the reaction mechanism of zeolitization, and proper usage of the product obtained. The sodium hydroxide is used as an alkali source in this hydrothermal synthesis process. The desired properties of the material synthesized is characterized using the physical properties such as surface structure, crystal structure, cation exchange capacity (CEC) and ion exchange properties.

EXPERIMENTAL

Material

The main raw material, coal fly ash (CFA) sample was collected from the electro precipitator of Atul limited, Valsad. The composition analysis of the CFA shows the presence amorphous phase (mainly SiO_2 , Al_2O_3) as well as the crystalline phase (mainly quartz and mullite). An X-ray Fluorescence (XRF) (Rigaku X-ray spectrometer model- ZSX mini 2) spectrometer was employed for the quantitative chemical analysis of the sample to reveal the elements (as the oxide by wt. %) present in it. The ratio of $\text{SiO}_2/\text{Al}_2\text{O}_3$ is 1.92 and this type of fly ash belongs to high Al and low $\text{SiO}_2/\text{Al}_2\text{O}_3$ ratio fly ash. Zeolite synthesized from a low $\text{SiO}_2/\text{Al}_2\text{O}_3$ ratio holds

greater porosity, higher cation exchange capacity, and selective adsorption of polar molecules. The composition analysis of CFA consumed in the current investigation is presented in **Table 1**.

Table 1: Composition analysis of CFA by XRF

Components	Composition (wt. %) of fly ash
Na_2O	1.87
MgO	0.60
Al_2O_3	26.65
SiO_2	51.29
P_2O_5	0.24
Na_2O	1.87
Fe_2O_3	3.73
SO_3	0.26
K_2O	0.79
CaO	2.58
TiO_2	1.67
Cr_2O_3	0.09
MnO	0.05

SrO	0.02
Y_2O_3	0.01
ZrO_2	0.55

Synthesis of Zeolite from CFA

In this work, hydrothermal alkaline fusion; a very cost effective and efficient process has been adopted for the synthesis of zeolite. In this process, in order to eliminate the larger chunks; the raw CFA undergone size separation in a BSS Tyler sieve (80 mesh size). The raw material is then subjected to calcination at 600°C for 2 hours. In this process, the unburnt carbon and volatile matter present in the CFA eliminated. The modifications of the properties interms of enhancement in the activity of zeolite formation, thermal stability, and acidity of zeolite; the calcined CFA is further treated by hydrochloric acid. The elimination of the oxides of iron and aluminum from CFA was observed in this stage.

In continuation to the steps prescribed, acid treated CFA was then mixed with sodium hydroxide in a pre-determined ratio and fused at different temperature from 550-650°C for 1 h. In this work, the NaOH/Fly ash ratio was varied from 1.0 to 1.5. The mixture obtained is then cooled to room temperature and transformed into slurry by adding water. The slurry was then stirred for several hours at room temperature and then kept for ageing at 90°C for 18 hours without any disturbance. The resultant mixture was then allowed to cool down and then it was subjected to a wash of distilled water several times to remove excess sodium hydroxide ($\text{pH} < 10$). The desired product is then filtered. In later stage, the mixture was then dried. The schematic representation of the is as shown in **Figure 1**.

The maximum amount of product is achieved in 18 h using an optimum activation NaOH/fly ash ratio of 1.3. This process consumes large amount of water and it also requires the long activation periods. The use of lower activation solution/fly ash ratio led to less water consumption to a drastic reduction in the activation time.

CHARACTERIZATION

X-Ray Deffraction (XRD)

The qualitative and quantitative XRD analysis (**Figure 2 (a)**) of the raw fly ash used in this study was carried out. The foremost crystalline phases in the ash were quartz (SiO_2), Mullite ($3\text{Al}_2\text{O}_3 \cdot \text{SiO}_2$) with a small amount of



magnetite and hematite. The quartz had the most intense peak at 27 degrees 2θ the most intense peak of quartz was observed. On the other way, the less intense peaks on the XRD patterns were identified as a mullite, hematite and magnetite. Apart from this, the fly ash contained an amorphous glassy phase give rise to broad hump in the region between 21 and 35 degrees 2θ as indicated in the XRD spectra.

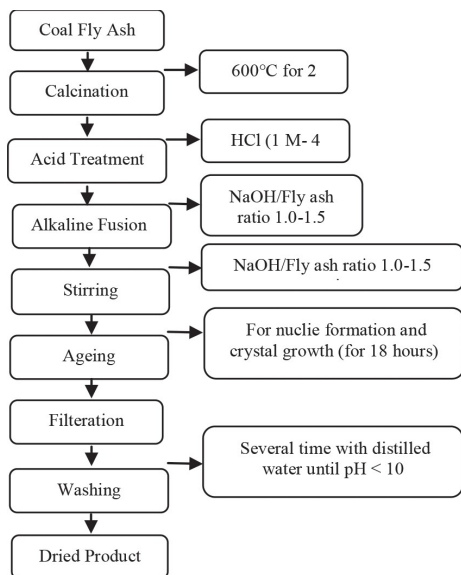


Fig. 1 Process flow diagram of synthesis of zeolite by hydrothermal fusion method

The zeolite formation step, suggests the conversation of more refractory quartz, mullite, hematite and magnetite phases. The desired product has been observed in terms of the major zeolite phase, after the activation of fly ash with NaOH solution along with the hydrothermal synthesis of zeolite Na-P1 (with the strongest peak at $27^\circ = 2\theta$). It shows the desired variation with respect to the variables like yield, depending on the experimental conditions. Along with this zeolite product, hydroxysodalite crystallized as a trace phase.

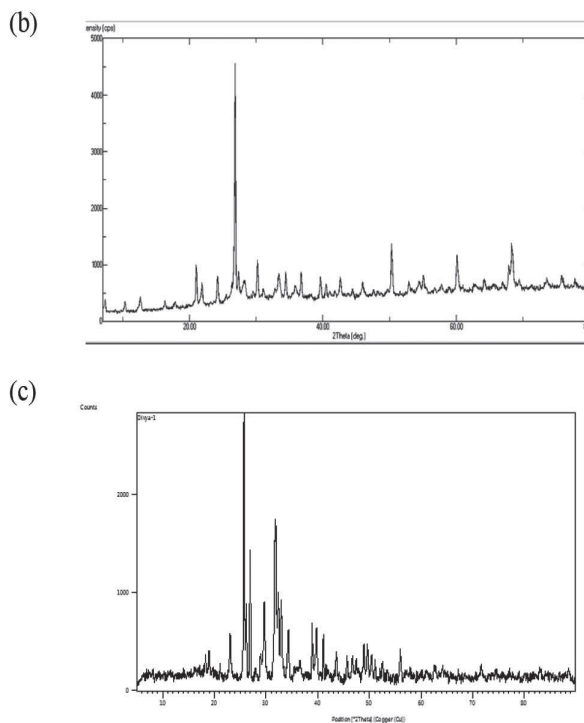
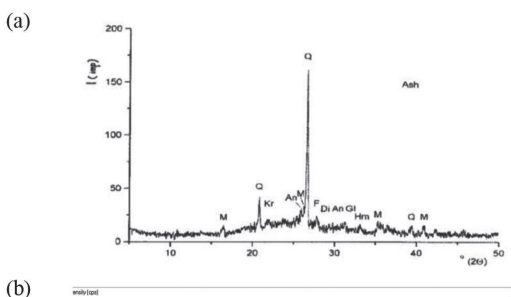


Fig. 2 (a) X-Ray diffraction pattern of Coal Fly Ash (Q – quartz, M–mullite, Hm– hematite, F – feldspars, Kr – crystobalite, Di – diopside, Gl – gehlenite, An – anhydrite), (b) Synthesized zeolite: ageing time 6 hours, (c) Synthesized zeolite: ageing time 18 hours.

Scanning Electron Microscopy (SEM)

The scanning electron micrographs of the coal fly ash and the synthesized zeolite are shown in **Fig. 3 (a) and Fig. 3 (b)** respectively. From the SEM images of untreated fly ash and synthesized zeolite it is evident that, the absence of spherical particles in synthesized zeolite indicates the high conversion of amorphous phase to crystalline phase. The synthesized zeolite possess distorted octahedral structure

BATCH EXPERIMENTS TO REMOVE HEAVY METALS FROM WATER USING ZEOLITE SYNTHESIS

Zeolite synthesized from experiment used to treat waste water containing Ni^{+2} and Zn^{+2} Heavy metals. 1 gm of zeolite synthesized were rinsed 6 to 7 times with distilled water and dried in oven before they were mixed with waste water in beaker.

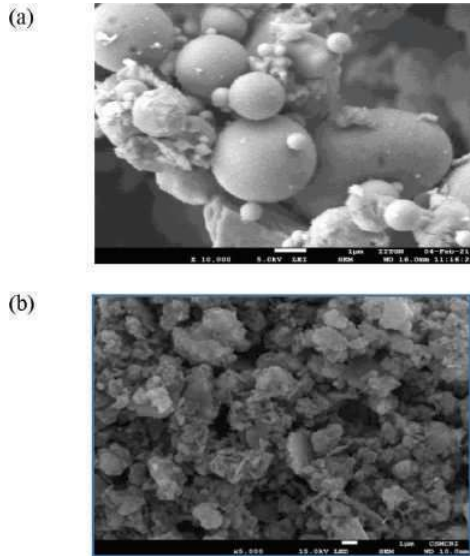


Fig. 3: Typical SEM micrographs (a) Coal fly ash (Untreated), (b) Synthesised Zeolite

The waste waters of various heavy metals concentration ranging from 5 mg/lit to 100 mg/lit were prepared by dissolving analytical reagent grade $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$ and $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$. The beakers were shaken for 10 min containing different grades of zeolite sample such as 1, 1.5, 2, 2.5, 3, 3.5 and 4 gm with the prepared waste water sample.

RESULTS AND DISCUSSION

Following conclusion can be drawn from the results of batch experiments:

1. The synthesized zeolite removes more than 97% and 87% heavy metals of 5 mg/lit and 100 mg/lit NiSO_4 sample respectively and adsorption equilibrium reaches at 10 min for adsorption. The graph is shown in Fig 4 and Fig 5.

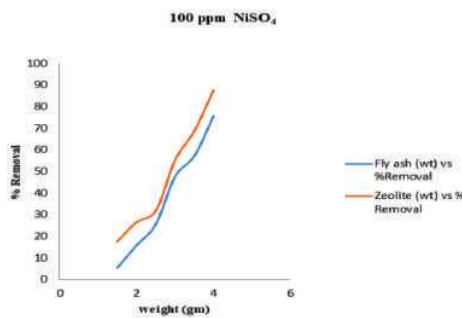


Fig. 4: Effect of NiSO_4 on % removal of heavy metals with reference to the fly ash and Zeolite weight

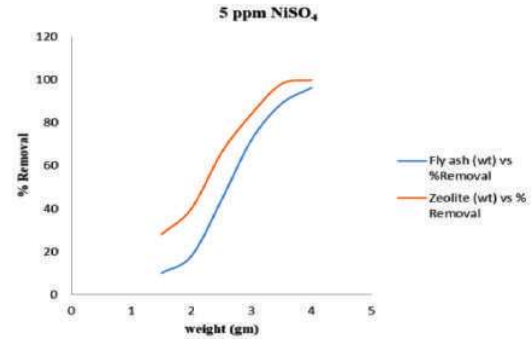


Fig. 5: Effect of NiSO_4 on % removal of heavy metals

2. It removes more than 99% heavy metals from 5 mg/lit ZnSO_4 sample and its take about 10 min for adsorption when zeolites synthesized are used to treat waste waters containing heavy metals. The graph is shown in Fig 6.

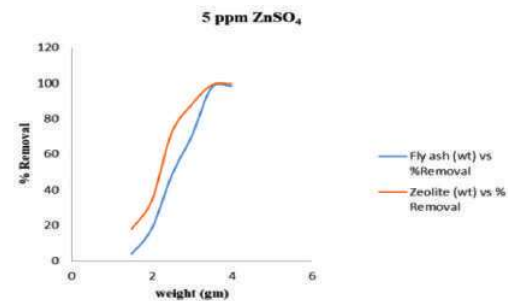


Fig. 6 Effect of ZnSO_4 on % removal of heavy

3. The removal rate increases with the increases in the amount of zeolites used in experiment. It is obvious that for waters of same solution concentration $\text{Ni}+2$ removal rate increases with increase of zeolite amount from 1 gm to 4 gm. The Observation relating the amount of zeolites when it was more than 1 gm; the removal rate in mentioned in the Table 2 and Table 3.

Table 2: Treatment of NiSO_4 100 PPM solution using fly ash and synthesized zeolite

Fly ash			Synthesized Zeolite		
Flyash wt (gm)	Filtrate ppm	% Removal	Zeolite wt (gm)	Filtrate ppm	% Removal
1.5	94.6	5.4	1.5	82.2	17.5
2	84.2	15.8	2	73.5	26.5
2.5	74.5	25.5	2.5	68.3	31.7
3	52.4	47.6	3	44.8	55.2



3.5	42.8	57.2	3.5	31.2	68.8
4	24.3	75.7	4	12.3	87.7

Table 3: Treatment of NiSO₄ 5 ppm solution using fly ash and synthesized zeolite

Fly ash			Synthesized Zeolite		
Flyash wt (gm)	filtrate ppm	% Removal	zeolite wt (gm)	filtrate ppm	% Removal
1.5	4.5	10	1.5	3.6	28
2	4.1	18	2	3	40
2.5	2.8	44	2.5	1.7	66
3	1.4	72	3	0.8	84
3.5	0.56	88.8	3.5	0.1	98
4	0.19	96.2	4	0.012	99.76

Table 4: Treatment of ZNSO₄ 5 ppm solution using fly ash and synthesized zeolite

Fly ash			Synthesized Zeolite		
Flyash wt (gm)	filtrate ppm	% Removal	zeolite wt (gm)	filtrate ppm	% Removal
1.5	4.8	4	1.5	4.1	18
2	4.1	18	2	3.3	34
2.5	2.6	48	2.5	1.4	72
3	1.5	70	3	0.6	88
3.5	0.12	97.6	3.5	0.05	99
4	0.08	98.4	4	0.02	99.6

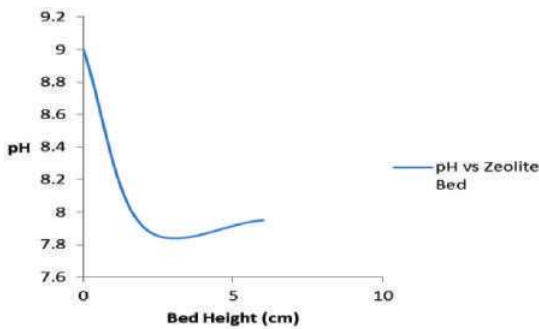


Fig. 7: Effect of pH on bed height

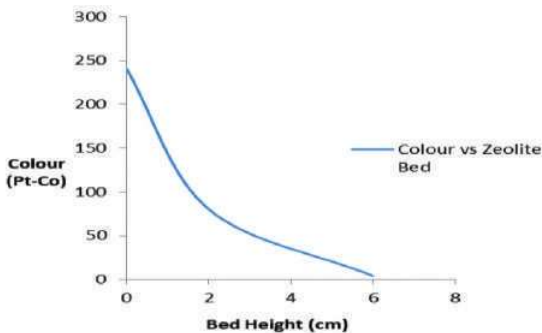


Fig. 8: Graph of Colour vs zeolite bed height

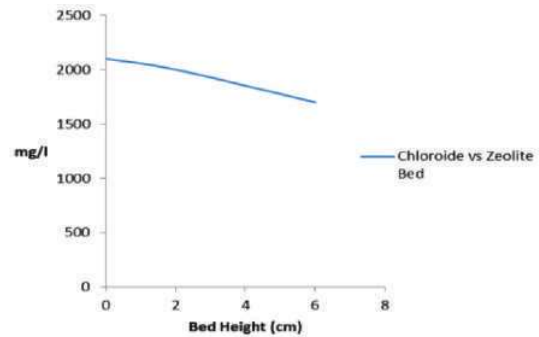


Fig. 9: Graph of Chloride vs Zeolite bed Height

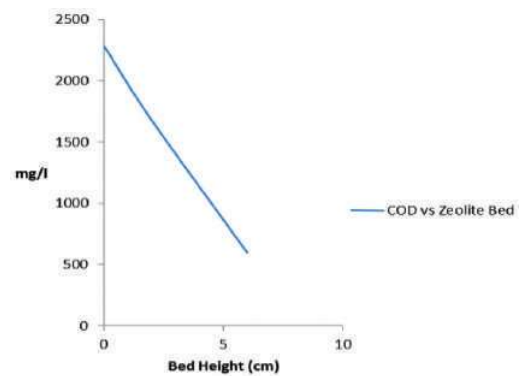


Fig. 10: Graph of COD vs Zeolite bed Height

Table 5: COD analysis data

Sr No	Sample	Volume of sample (ml)	Burette reading (ml)	COD (mg/l)
1	Blank	-	14.1	-
2	Untreated water	1.4	12.5	2285
3	Bed height (2 cm)	2.5	12	1680
4	Bed height (6 cm)	2	13.5	600

Table 6: Chloride analysis data

Sr No	Sample	Burette reading (ml)	Dilution Factor	Chloride mg/l
1	Blank	0.5	1:10	-
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3	Bed height (2 cm)	4.5	1:10	1999.36
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Table 7 : Treatment final result data

Sr No	Sample	pH	Color Pt-Co	COD mg/l	Chloride mg/l
1	Untreated Water	9	240	2285	2099.32
2	Bed height (2 cm)	7.91	80	1680	1999.36
3	Bed height (6 cm)	7.95	4	600	1699.45

CONCLUSION

Since, we are concerned of growing atmospheric pollution, coal fly ash is one of the source. Though there are number of sources contributing to the deterioration of the environment, one must utilize the waste and should mould it into desired product or raw material. The concept of waste to best is utilized in this present work. The idea of contributing to sustainable development was the prime objective of this work.

The product developed and analysis shows the significant applications. The desired changes in term of morphological structures has been observed in this research work and it supports the use of waste fly ash a potential source for waste water treatment. The experiments were conducted shows the modifications in the properties of zeolitic material formed and it primarily depends upon the treatment conditions along with concentration of raw materials. The proposed technological solution allows to achieve a high level of fly ash conversion into high purity zeolite material Na-P1 in a very effective and efficient way. The fly ash analysed in this work characterized by a low Si to Al ratio, it supports the successful synthesis of zeolites with low Si content (NaP1), which display high ion-exchange capability and a large volume of pores. The optimal condition for synthesis observed are; at 600°C; 3 M NaOH solution and 6-8 hours of fusion time NaP1 zeolite is formed. The synthesized zeolite-NaP1 was tested for heavy metal contaminated impure water and results were observed that it is highly efficient in the removal of heavy metal cations Ni^{+2} and Zn^{+2} by exchangeable Na^{+} cations. Further work is still needed to examine the effect of the variation in the raw materials and operating conditions on properties of zeolite.

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Chapter 4

Sustainable Organo-Inorganic Metal Composites for Catalytic Degradation of Industrial Persistent Toxic Substances and Energy Storage

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Abstract

Colossal quantity of wastewater contaminated with persistent hazardous substances and degradable toxic compounds to the atmosphere are generated annually. Amongst the particular pollutant, chemicals, organic dyestuffs are of a considerable significance by virtue of its applications in fibers, fabric, coloring element, printed matter and manuring production. The present chapter comprises a complete perspective of green and sustainable organic-inorganic metal nanocomposites for heterogeneous chemical curtail of precarious organic noxious tinge (Chromotrope-2R, Eosin-Y and Methylene Blue) and energy storage (H_2 and C_2H_4). The nanocomposites were designed by simple strategy adopting nanostructured porous carbon material developed from reasonable pyrolysis fuel oil (PFO) related pitch remains.

Keywords

Economical, Energy Storage, Green Heterogeneous Catalyst, Hazardous Water Pollutants, Organic Dyes

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1. Introduction

Water is a precious reservoir and not a single living creature can live without H₂O. The large quantity discharge of untreated sewage and industrial wastes are polluting the habitation and environment. Contemporary applied industries are practicing the use of organic colouring agents, pigments and dye materials globally. Polymer industry, foodstuff, garments, synthetic leather and pulp industries are the major stock holders of these significant dye materials. The pollutant clearance and toxic waste of these factories is contaminating the water and soil. Ubiquitously, environmental researchers are working on the counteraction of this colouring agent-associated waste materials and its reprocessing [1]. Methylthioninium chloride, also known as methylene blue (MB), is used in medication to treat methemoglobinemia but it is mainly promoted as a dying agent to colour cottons, wood and silk threads. The contamination of methylene blue dye is very harmful to the environmental health [2-4]. Eosin-Y is a xanthene group's red fluorescent pigment. Due to its stability, adaptability, and light absorption nature, it is broadly availed in diverse applications such as., printing, polymer production, sensitizing industry, printing ink, fluorescent dye compounds, nanomaterials, histology, and biomedical research [5-8]. The discharge of Eosin-Y effluents spoils the eco-environment system due to its deep colour and noxious properties. Its structural features, combination of carboxyl group, pyran and benzene, enables carcinogenic vulnerability as a dye waste. Thirdly, the union of aromatic ring, chromophore mono-azo (-N=N-), hydroxyl (-OH), sulfonyl (-SO₃H) functional groups composes unique dye which is represented as a Chromotrope 2R. Due to its

carcinogenic, destructive and venomous behaviour, the effluent of Chromotrope 2R causes serious environmental problems [1, 9-11]. Organic dyes in drain water experienced chemical changes, absorbs dissolved oxygen and ruins marine life. The stain and immense chemical oxygen demand (COD) of these discharges may cause serious natural problems. For future generation environment protection, it is necessary to decompose these pollutant materials. A competent lessening and curing capabilities are therefore required to discard the poisonous or cancerous pigment masses, these colouring agents are a real matter in the area of contaminated water therapy. A large number of scientific researchers have shaped firm attempts to develop various methods and techniques for elimination of dyes and persistent pollutants in drain water. Presently, diverse scientific methods are viable such as molecular concentration, solid eradication, micellar improved active penetration, micro-purification and chemical sorption on the surface of adsorbent, activated farming hard wastage, hybrid carbon matters, magnetic compounds and catalytic decomposition. Lately, several processes have been employed to eliminate or breakdown of the organic dyes from wastewater, e.g., agglomeration, sorption, catalytic redox reaction, living science processes and photocatalysis. These methods failed to produce total elimination or breakdown of organic dye pollutants; however, it offered certain hitches like partial removal, great consumption of chemicals and reagents, pricey, and creation of inferior toxic pollutants. [12]. These organic dye pollutants are chemically fragmented to smaller molecular weight, simple and readily switchable materials such as oxygenated molecules, acetic acid, propionic acid, ethanol and minerals (CO_2 , H_2O). These decomposed materials are non-toxic and can be easily released in the environment [13]. Nanostructured porous-carbon materials have exhibited huge potential for the elimination of pollutants by using progressive heterogeneous oxidation/reduction reactions. Sustainable, non-pricey and green metallic-carbon nanomaterial acquires united characteristics of basic-organic structure, metals and carbon-establishment together with the probability of customizing the activeness and preferences of nanomaterials. Addition of selective non-carbon/non-hydrogen atoms and transition metal into the nano-porous carbon framework will arouse the composite active sites. In the last decade, several reports of transition metal-associated composites have been published because of its immense fertile function as a solid-catalyst, chemical sorbent, carbon-electrode, power stockpile shell [14]. This chapter comprises a wide-ranging review of green and solid organic-inorganic metal nanocomposites for chemical breakdown of toxic organic dyes such as., Chromotrope-2R, Methylene Blue and Eosin-Y (Fig. 1) along with nanocomposite material's hydrogen and ethylene gas adsorption activity for energy storage. The nanocomposites were prepared by an easy technique using nano-sized porous carbon structure synthesized from cheaper petroleum pyrolysis fuel oil (PFO) based pitch excess. These sustainable catalysts have gigantic

prospective for the operation of purifying hetero-atom dye contaminated H₂O and it was freshly employed for novel sorption purpose as well.

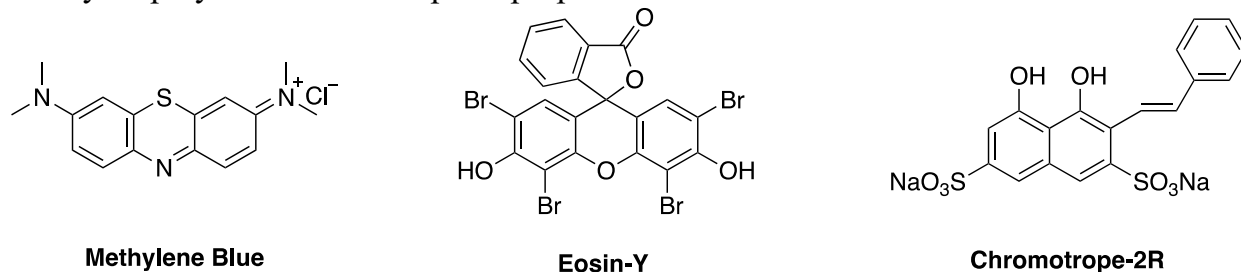


Figure 1. Chemical structures of Chromotrope-2R, Methylene Blue and Eosin-Y dyes.

2. Petroleum remnant as a carbon precursor

The world is greatly understanding the benefits of petroleum resources and its limited reserves. Low-cost petroleum pyrolysis fuel oil (PFO) is a higher boiling point multi-ring non-aliphatic hydrocarbon compound of crude oil residue that are supplied from petroleum distillation process or naphtha cracking process. Naphthalene is one of the binary-ring aromatic products and its derivatives are an essential part of various biologically important naturally occurring valuable chemicals, organic dyes and medicines [15-17]. Valuable naphthalene crystals were separated from PFO by developing innovative and economical solvent extraction methods. PFO based pitch was considered for the higher carbon content source after subsequent separation of valuable products [15, 18]. PFO pitches are applied extensively as precursors for porous carbon framework due to their finest graphitizable character, unique structural-shape, huge carbon amount, thermal flexibility and no burning remains. The particular qualities of carbon precursor are a promising applicant for the preparation of highly functioning carbon nanocomposite by applying a molding technique [19-21]. Schematic diagram of naphthalene separation and isolation of pitch as carbon precursor from PFO is shown in Fig. 2.

The nano silica ball (NSB), homogeneously uniform nano-sized silica sphere template, was prepared by the water based chemical breakdown and condensation of tetraethoxy orthosilicate (TEOS) [22]. Fresh solvent isolated PFO pitch excess was generated as per the report [15]. The prepared pitch paste (1.0 g) was taken in a rectangle-shaped ceramic crucible and heated at 140°C for half an hour until the formation of soft and highly moldable amber coloured semi-liquid. Uniform sized NSB (1.0 g) bed was mixed homogeneously with pitch fluid along with heating until the formation of dark amber coloured dust. The carbonization of the composite was carried out at 900°C in presence of

nitrogen gas atmosphere in a tubular furnace to get nano silica carbon composite (CSC) for 4 hours. The nano-silica content from CSC was removed by stirring the mixture with aqueous 10% HF solution for 24 hours. Finally, the process was succeeded by filter-separation, H₂O washing and de-moisturization at 110°C for 4 hours to achieve a black colour nano carbon cage (NCC) with great carbon turnout (0.62 g). This nano carbon cage (NCC) can be used as a porous host for direct metal doping [18]. The covalent binding of ligand or metal complex makes hybrid composite sustainable and leaching independent. Therefore, the synthesized crude oil pitch originated carbon nano-cage (NCC) was further oxidized in combined presence of N₂ and 5% O₂ gas at 698 K for deep 10 hours to secure NCC-OH. The facet -OH moiety of NCC-OH was refluxed with watery sodium hydroxide (0.1N NaOH) solution for 1 hour under maintained pH condition to form NCC-ONa (Fig. 3). All the three nanocomposites NCC, NCC-OH, NCC-ONa can be directly used as a porous host for direct metal doping or covalent bonding [1].

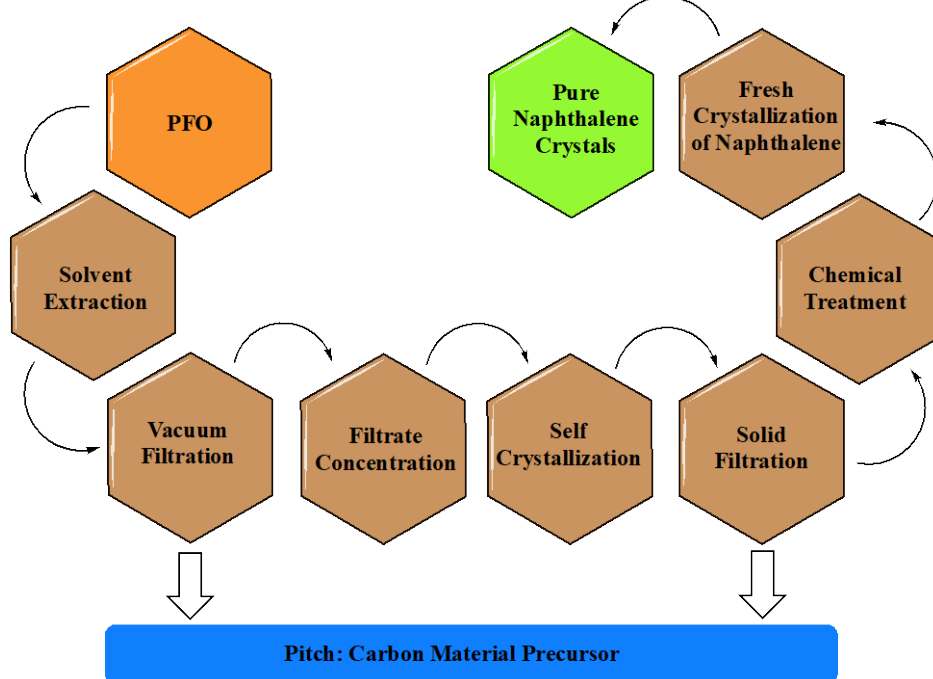


Figure 2. Schematic diagram of separation of carbon material precursor.

2.1. Organic-inorganic metal nanocomposites

Commercially, activated carbons are generally jumbled with irregular pore-sizes and they regularly have the impurities of the origin source, but nano-porous carbon materials prepared by template methods are highly ordered and have uniform pore size. The requirement of homogeneous metal carbon nanocomposites has been increased considerably in the last few years due to their broad applications in large scale industrial

adsorption, gas isolation, water cleansing and heterogeneous catalysis. In continuation of our development of organic-inorganic hybrid catalyst and chiral stationary phases [23-25], the current study will deliver a comprehensive evaluation of synthesized carbon nanocomposites of gold (**Au@NCC**), copper (**Cu@NCC**), nickel (**Ni@NCC**), potassium and manganese (**K-Mn@NCC**), phosphorous (**P@NCC**), gold-phosphorous (**Au-P@NCC**), molybdenum-vanadium (**Mo-V@NCC**), palladium (**Pd@NCC**), gold-palladium (**Au-Pd@NCC**), tungsten (**W@NCC**) and covalently bonded gold Salen nanocomposite (**Au-Salen@NCC**) and its catalytic activities along with energy storage capacity. The schematic diagram of synthetic route of all the 11 organic-inorganic metal carbon nanocomposites is given in Fig. 4. The characterization of all nanocomposites and products have been accomplished by microanalysis, ^1H & ^{13}C NMR, ^{13}C CP-MAS NMR cross polarized magic angle spinning NMR, FTIR, GC, LCMS, UV-Visible spectroscopy, fine-powdered X-ray diffraction (XRD), thermal gravimetric analysis (TGA), surface analysis, scanning electron microscopy coupled energy dispersive X-ray spectroscopy (SEM/EDS), high resolution transmission electron microscopy (TEM), inductive coupled plasma (ICP) based metal analysis, and solid reflectance UV-vis spectroscopy.

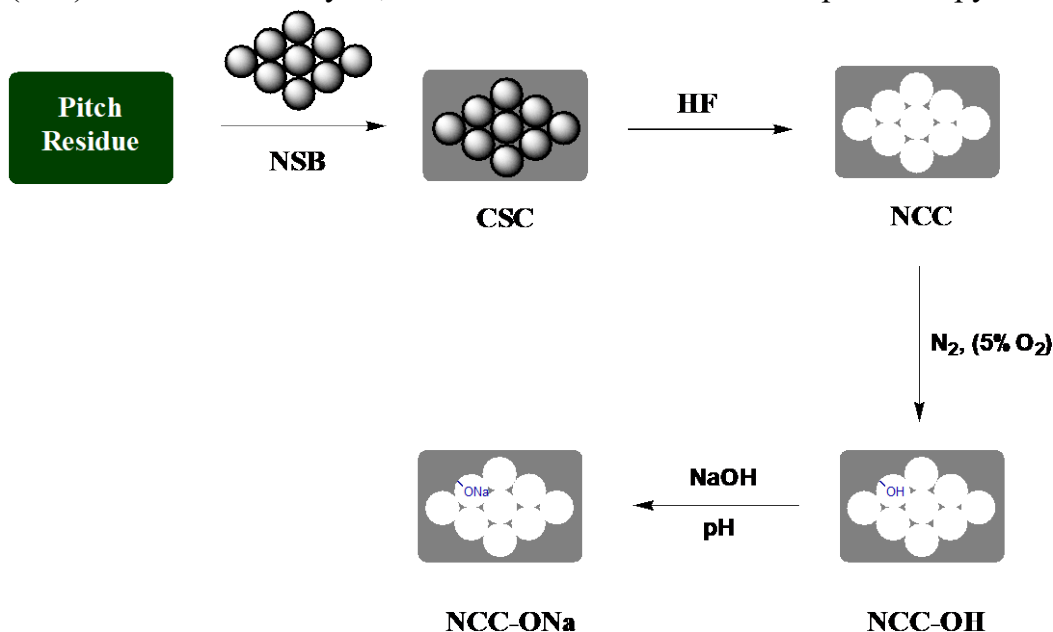


Figure 3. Synthesis route of Nano carbon cage (NCC), Hydroxy nano carbon cage (NCC-OH) and Sodium hydroxy nano carbon cage (NCC-ONa).

All eleven synthesized metal carbon nanocomposites, **Au@NCC** [26, 27], **Cu@NCC**, **Ni@NCC**, **K-Mn@NCC** [18, 27], **P@NCC**, **Au-P@NCC** [28], **Mo-V@NCC** [3], **Pd@NCC**, **Au-Pd@NCC** [29, 30], **W@NCC** [14], and **Au-Salen@NCC** [1], displays not

only the singular physico-chemical essence of involved metal and nanoporous carbon cage (NCC) but also the collective characteristics of the paired composite and the occurrence of new qualities able of promoting brand-new operations (Fig. 4).

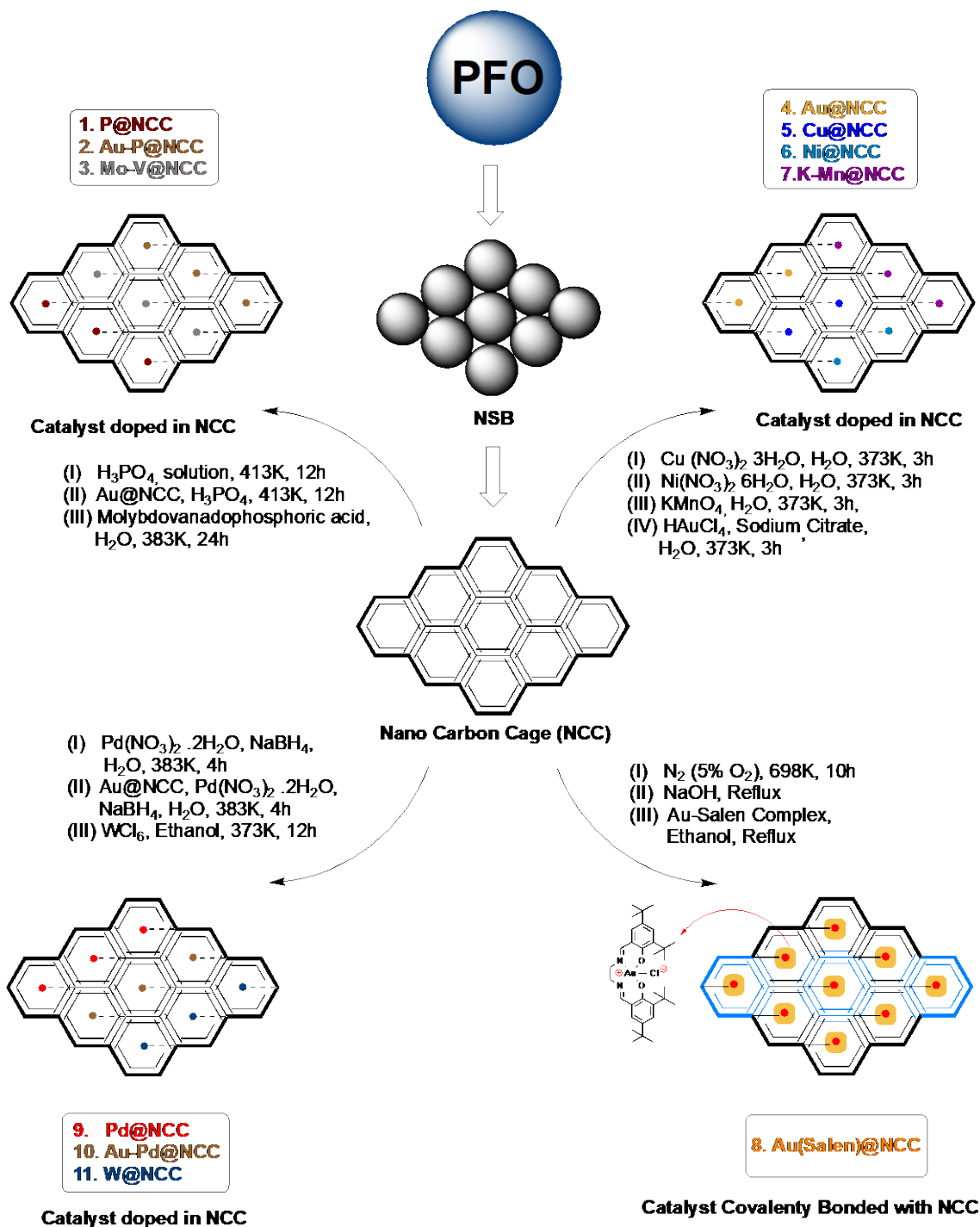


Figure 4. Synthesis route of eleven organic-inorganic metal nanocomposites 1-11.

3. Removal process of organic pollutant dyes

To expand the improved awareness of this materials, the following nanocomposites were successfully used as heterogeneous catalytic reaction of Eosin-Y, Methylene Blue, and Chromotrope-2R dyes. They were also utilized as an energy storage adsorbent for the adsorption of hydrogen gas and ethylene gas, and as an electrode for methanol oxidation reaction.

3.1 Catalytical degradation of methylene blue

The heterogeneous catalytic degradation of potentially destructive dye, methylene blue (MB), was effectively investigated by molybdenum-vanadium carbon nanocomposite (**Mo-V@NCC**). The catalytic degradation of MB dye was accomplished by taking 1 g of the recyclable nanocomposite catalyst **Mo-V@NCC** in round-based flask applying 50 ml of methylene blue solution (10^{-4} M, MB) and 50ml 30% hydrogen peroxide (H_2O_2 , 10^{-4} M). The catalytic decomposition was observed by UV-visible and FT-IR spectroscopy [3]. The full range (200-800 nm) and selective (450-800 nm) UV-vis spectra of MB decomposition are revealed in Fig. 5 and 6. The UV-Vis spectrum of MB displayed major absorbance peak at 664 nm initially. The spectrum also shown three additional key projections at 250, 297 and 665 nm because of π to π^* electron alteration of the aromatic cycle and hetero atom multi-aromatic alliance in MB. The intensity of all the peaks was getting weaker and totally disappeared after 60 min catalytic reaction run with **Mo-V@NCC** catalyst. It denotes that the hazardous pigments were absolutely fragmented into small chemical segments. An FT-IR study of MB dye decomposition is show in Fig. 7. Originally, non-catalysed MB shown characteristic peaks of C=N stretching vibration, C=C vibrations, multiple ring stretching vibrations, $\text{C}_{\text{Ar}}\text{-N}$ (the bond between the side aromatic ring and nitrogen atom) stretching vibration and N- CH_3 stretching vibrations 1601, 1544 & 1489, 1398, 1354, 1241 & 1181 cm^{-1} respectively [31]. Subsequently, original untreated MB characteristic bands were disappeared after catalytic degradation reaction which indicated the complete decomposition of pollutant dye. New additional peaks were generated at 1404, 1398 & 1225 cm^{-1} , these peaks mayhap as a result of IR-stretching vibrations of COO^- , NO_3^- and SO_4^{2-} functional groups, respectively. Additionally, new peaks confirmed the presence of carbon dioxide as a chief final product along with some acids. FT-IR spectra also supported the complete oxidative decomposition of MB like UV-vis spectroscopy. The recovered **Mo-V@NCC** was recycled and reused for several catalytical run successfully with no noticeable loss in its activity [3].

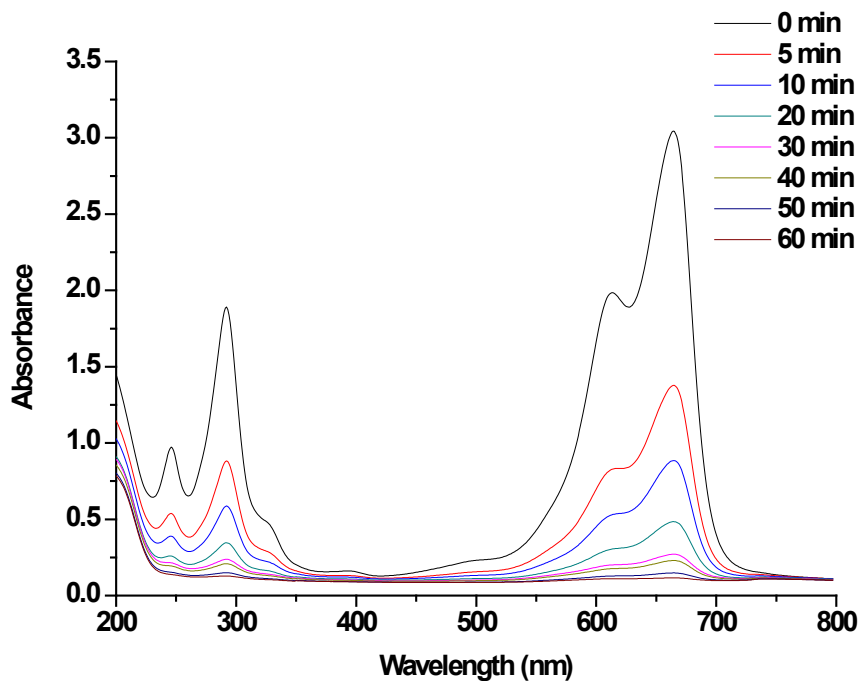


Figure 5. Full range UV-vis spectrum of MB degradation by **Mo-V@NCC**.

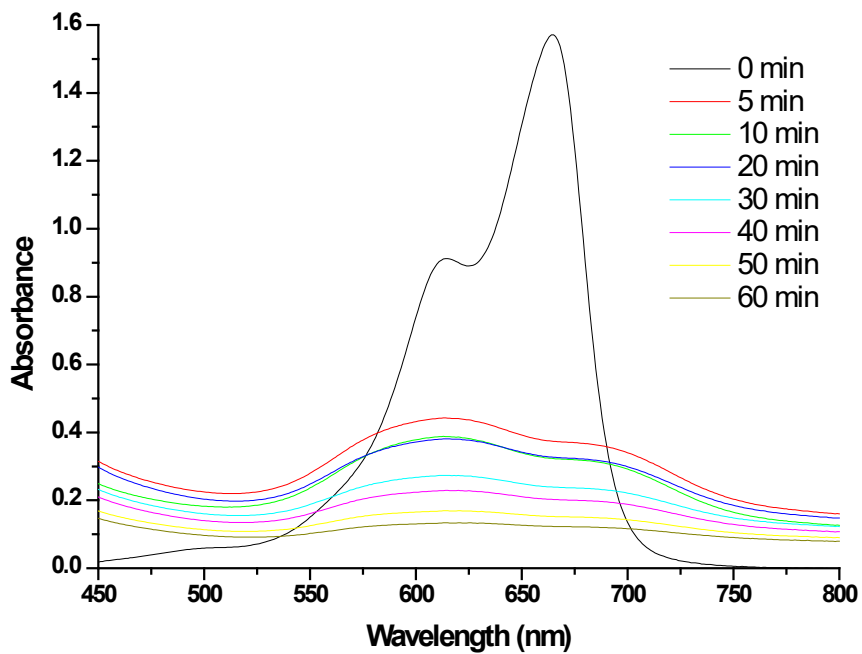


Figure 6. Selective absorption UV-vis spectrum of MB degradation by **Mo-V@NCC**.

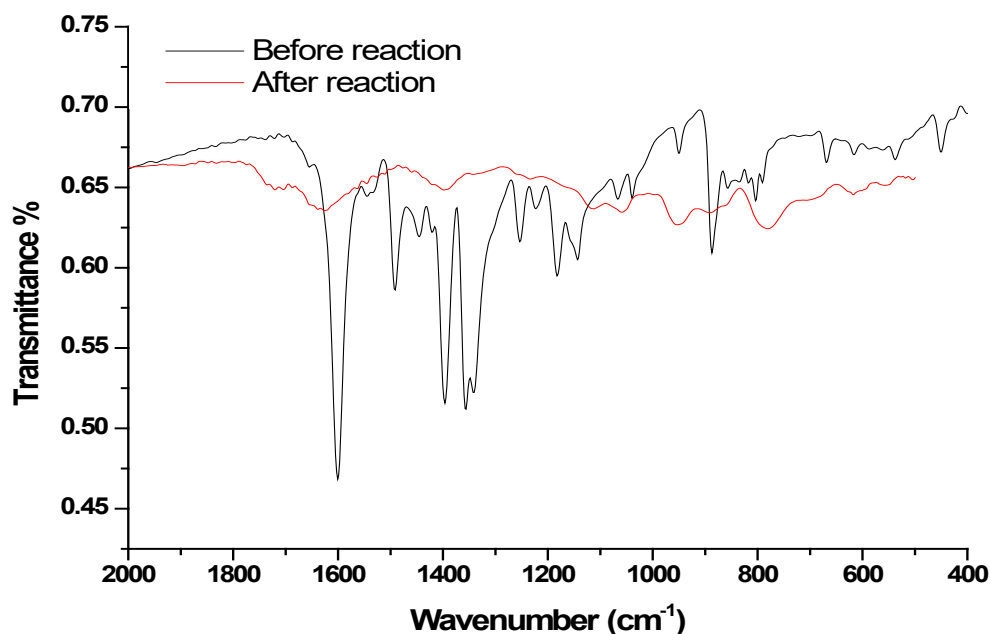


Figure 7. FT-IR spectrum of MB before and later degradation by catalysts **Mo-V@NCC**.

Moreover, the rapid adsorption ability of **W@NCC** nanocomposite to methylene blue was detected by single outing the discoloration of MB dye content. This swift adsorption characteristics of **W@NCC** lead to the new catalytic oxidation study of MB. The full range UV-Visible spectra MB degradation using **W@NCC** is shown in Fig. 8. The spectrum shown dominant absorbance projections at 665 nm and binary little absorbance peaks at 251 and 297 nm. As we have seen in **Mo-V@NCC** case, similar phenomenon of the peak intensity weakening and disappearing was observed after 25 min vigorous reaction with **W@NCC**. It suggested that the aromatic and hetero-atom multi-aromatic link of MB dye was fully destroyed and entirely fragmented into scaled-down products. The catalytic oxidation of MB using **W@NCC** was also confirmed and supported by FT-IR spectroscopy [14].

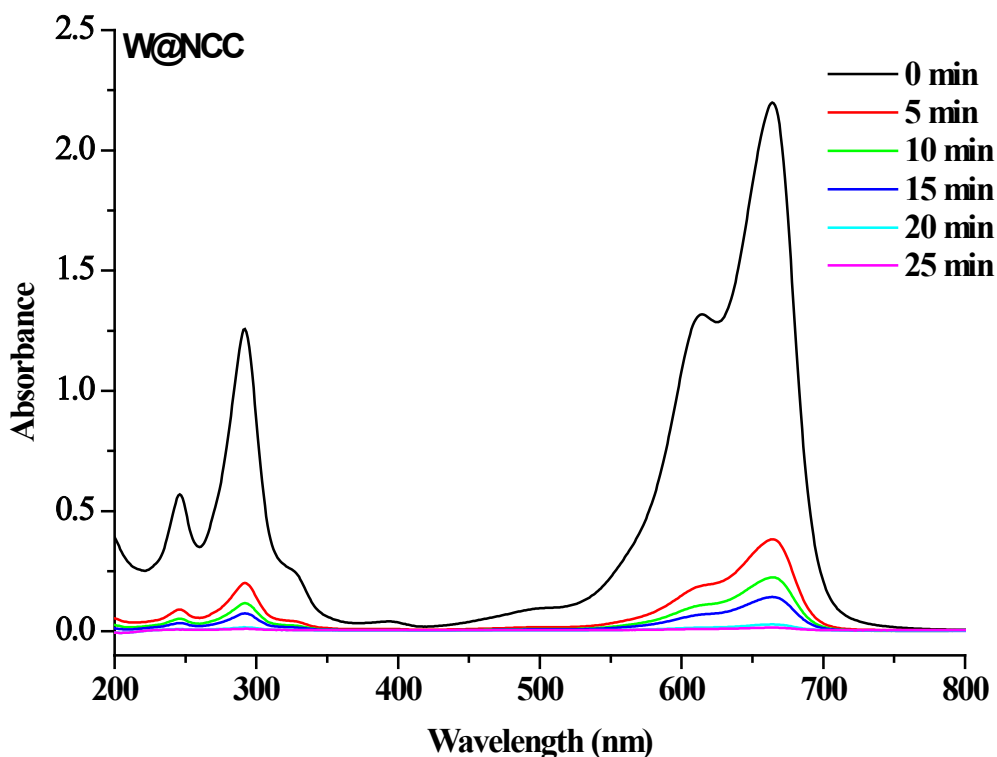


Figure 8. Full range UV-vis spectrum of MB degeneration by *W@NCC*.

3.2 Catalytical breakdown of chromotrope-2R and Eosin-Y

Jacobsen Salen Schiff base metal complexes have been largely studied because of their important catalytic activity and various organic reaction [32]. Together, several developed redox reactions of toxic waste healing have been rejuvenated amidst inexpensive, eco-friendly and huge productivity to settle the strong requirement of straight sewerage analysis. Less articles have been reported for the chemical reactionary removal Chromotrope-2R and Eosin-Y and from wastewater [1]. Au-Salen compound bonded nano-structured carbon material, *Au-Salen@NCC*, has assured the breakdown of Chromotrope-2R and Eosin-Y dyes with mild reaction modes employing modest oxidant hydrogen peroxide (H_2O_2) for Chromotrope-2R and reducing agent sodium borohydride ($NaBH_4$) for Eosin-Y and it is found to be highly significance and capable in contrast to available literature report [33].

The catalytic destruction and fragmentation of Eosin-Y lead the formation of simpler acid compounds which were further decomposed to essential mineral compounds. Gas chromatography study recognized four different products viz., (1Z,4E)-1,5-dibromo-3((Z)-

2carboxyvinyl)-6-oxohexa-1,4-dien-2-olate, 2-((2-3,6-dihydro-2H-pyran-4-yl) phenyl)2-carboxylate, 2-(2-formylphenyl)-2-carboxylate and 3,5 dibromocyclohex-5-ene-1,2,4-trione. The GC data was in support of Eosin-Y degradation mechanism [1]. These four intermediate compounds experienced subsequent decomposition to yield oxalic acid and malonic acid which were additionally degenerated to carbon dioxide and water. **Au-Salen@NCC** achieved 98.68 % degradation of Eosin Y within less than 1-hour time at room temperature and ordinary pressure, whilst other reported titanium dioxide (TiO₂) based sunlight-catalyst delivered 96 % decomposition yield under visible light treatment for 3 hours [33]. The Fig. 9 reveals the UV-vis spectrum of Eosin-Y decomposition using nanostructured **Au-Salen@NCC**. The UV-vis spectra of Eosin-Y identified main spectral-absorbance peak at 515 nm. The spectrum strongly suggests that the magnitude of spectral-absorbance bands evolved weaker as the reduction activity proceeded and peaks eliminated completely in 50 minutes.

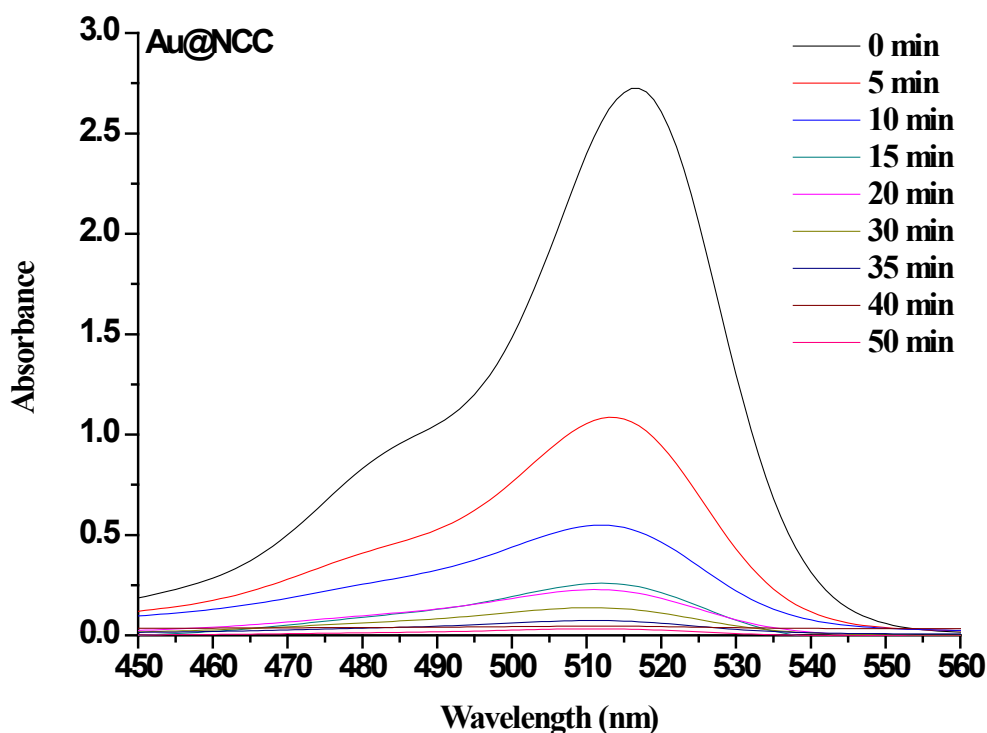


Figure 9. Full range UV-vis spectrum of Eosin-Y degeneration using **Au-Salen@NCC**.

Catalytic degradation activity of Chromotrope-2R produced few capable acidic compounds as a result of decomposition of residual functional groups such as aromatic ring, $-N = N-$, $-OH$ and $-SO_3H$ [34,35]. GC-MS analysis gave confirmative peaks for oxamic acid,

oxalacetic acid, oxalic and malonic acid as the ultimate outputs that were break-downed to carbon dioxide [1]. Proportionately, 98.8% destruction of Chromotrope-2R was done by **Au-Salen@NCC** nanocomposite in period of one hour with respect to the reported Fenton process [34]. The present catalyst **Au-Salen@NCC** and technique was found to be very efficient, and eco-friendly and time saviour for full destruction of pollutant dyes. The UV-Visible investigation spectrum of Chromotrope 2R using **Au-Salen@NCC** nanocomposite is displayed in Fig. 10. The UV-vis spectrum of Chromotrope-2R dye displayed main absorbance at 508 nm. Usually, the disappearing of major absorbance band peak with course of oxidative catalytic reaction and complete removal after 55 min.

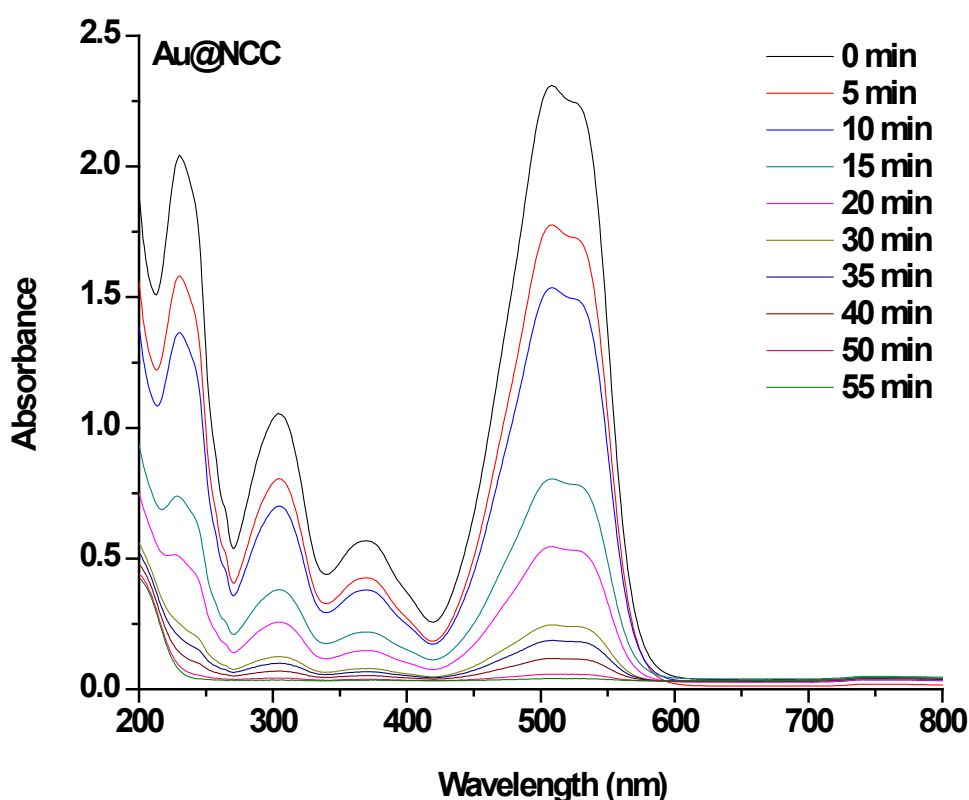


Figure 10. Full range UV-vis spectrum of Chromotrope-2R degeneration by **Au-Salen@NCC**.

The solid-catalyst optimization study of **Au-Salen@NCC** nanocomposite was conducted for both Chromotrope 2R and Eosin Y dyes (Table 1). The total conversion of dye treatment was increased reasonably during the catalyst load increment from 1, 3, 5, 8, 10 g in both the dyes. On the basis of research findings, the optimum catalyst amount (5 gL⁻¹) and

maximum conversion time (50 and 55) was found for Eosin-Y and Chromotrope-2R pigments, respectively. Recycled **Au-Salen@NCC** catalyst worked well for four repeated experiment without any leaching and performance loss. **Au-Salen@NCC** was sustainable and adequate compared to past literature reports.

Table 1. Solid-Catalyst load study on degradation of Chromotrope-2R and Eosin-Y.

Solid-Catalyst loading (g L ⁻¹)	Eosin-Y	Chromotrope-2R
	Catalytic Reaction Time (min)	Catalytic Reaction Time (min)
1	90	80
3	70	70
5	50	55
8	50	55
10	50	55

4. Adsorption and energy storage

In the instant energy consumption era, the adsorption and storage of primary gases is one of the crucial concerns for the awareness for power maintenance and undoing the earth surface warming process viz., greenhouse. Few unhealthy volatile matters are supposed to be main suppliers to acidic rainfall, hazardous air pollution and elevated temperature of world. The diminishing fossil fuel reservoir and growing substantial deterioration knowledge have started an exploration for substitute fuel-materials and zero discharge carriers.

4.1 Hydrogen (H₂) gas adsorption study

Hydrogen gas is predicted to play a major part in the forthcoming world energy equilibrium. The efficient storage of H₂ gas is a challenging condition and need for its use as a vehicle fuel. The H₂ gas running cars have good advantage over battery and petrol cars. H₂ gas can be easily produced by electrolysis of H₂O, only release from its succeeding reaction with O₂ in the energy producing phase is H₂O. and H₂ gas has the maximum energy volume (120 MJ/kg) per mass unit [27, 36]. The H₂ gas adsorption isotherms were accomplished by using gravimetric adsorption system (MSB Rubotherm) in four particular stages: black analysis, stowing and activation of specimens, buoyancy study and sorption analysis. Later, the risen mass of the specimen by virtue of H₂ gas sorption was precisely counted by utilizing MSB connected to the sampling site. Normally, 0.2~0.7 g of adsorbent was taken for adsorption experiment. Adsorption isotherms metal carbon nanocomposites

and its precursors, **Cu@NCC**, **Ni@NCC**, **K-Mn@NCC**, **Au@NCC** and non-metal pristine **NCC**, were studied to check the performance of metal-associated carbon nanocomposites. The hydrogen (H_2) gas sorption volume of nanocomposites is articulated in phrase of wt. % (mass of the hydrogen gas energy carrier/mass of the nanocomposite x 100) [27, 29].

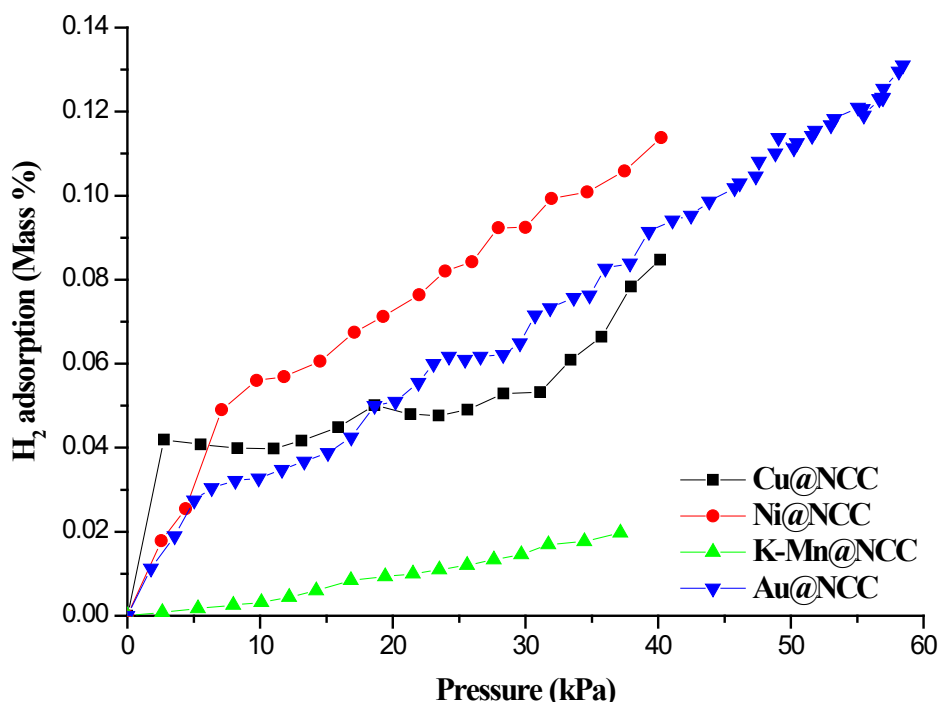


Figure 11. Hydrogen adsorption of metal carbon nanocomposites **Cu@NCC**, **Ni@NCC**, **K-Mn@NCC** and **Au@NCC**.

The hydrogen gas sorption study of pure **NCC** and its metal nanocomposites **Cu@NCC**, **Ni@NCC**, **K-Mn@NCC**, **Au@NCC** were investigated using standard gravimetric adsorption analysis. Nanocomposites **Cu@NCC** and **Ni@NCC** revealed highest H_2 gas adsorption capacity of 0.08 and 0.11 wt % around 40 kilopascal (kPa) pressure, respectively. Also, **Au@NCC** shown higher adsorption with raised pressure (0.13 wt %, 58.5 kPa). While **K-Mn@NCC** isotherm exhibited minimal H_2 gas with pressure rise (0.02 wt %, 37.1 kPa) compare to other nanocomposites (Fig. 11). Contrarily, active H_2 gas sorption was missing for pure **NCC** sample at physical force up to 5000 kilopascal (kPa) because of week or no interaction between H_2 gas and adsorbent. The anticipated target

adsorption capacity of NCC is still far lower compared to metal nanocomposites (Fig. 12). The study results revealed that the H₂ gas adsorption capacity of metal carbon nanocomposites were significance compared to pure NCC and it shown moderate to excellent hydrogen adsorption in phrase of the proportion matter captured per unit pressure. The Au-doped NCC can guide to a greater H₂ gas depository compare to pure NCC adsorbent.

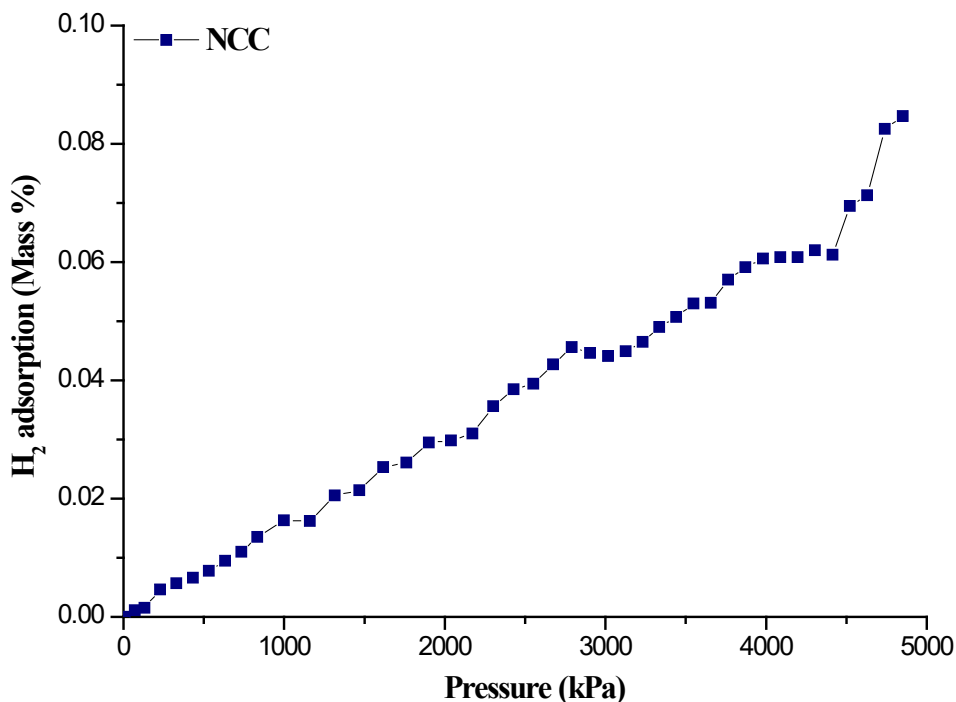


Figure 12. Hydrogen adsorption of metal carbon nanocomposite pristine NCC.

4.2 Ethylene gas adsorption study

Chemical adsorption of ethylene gas (C₂H₄) is truly significance in agricultural industry during transportation or depository, several harvested-fruits can generate ethylene (C₂H₄) gas which is capable of diminishing the character and self-survival. Lately, many experimental studies of sorption of ethylene (C₂H₄) gas on a range of active *d*-block metal composite facet have been done using new techniques. These composite materials help to maintain the freshness of the harvested products in the course of transportation and hoarding. The chemical adsorption of ethylene (C₂H₄) gas was determined on the organic-inorganic metal carbon nanocomposites in a moderate pressure auto gas sorption operation using gas chromatography (GC) at atmospheric temperatures. Typically, 0.50 gm of the

five adsorbent materials (NCC, Cu@NCC, Ni@NCC, K-Mn@NCC, Au@NCC) was placed inside a Pyrex sorption unit joined to the adsorption apparatus and exposed to a regular pre-treatment prior to ethylene gas (C₂H₄) adsorption analysis which integrated vacuum dehydrating in a vacuum desiccator and thermal revival in an oven [27].

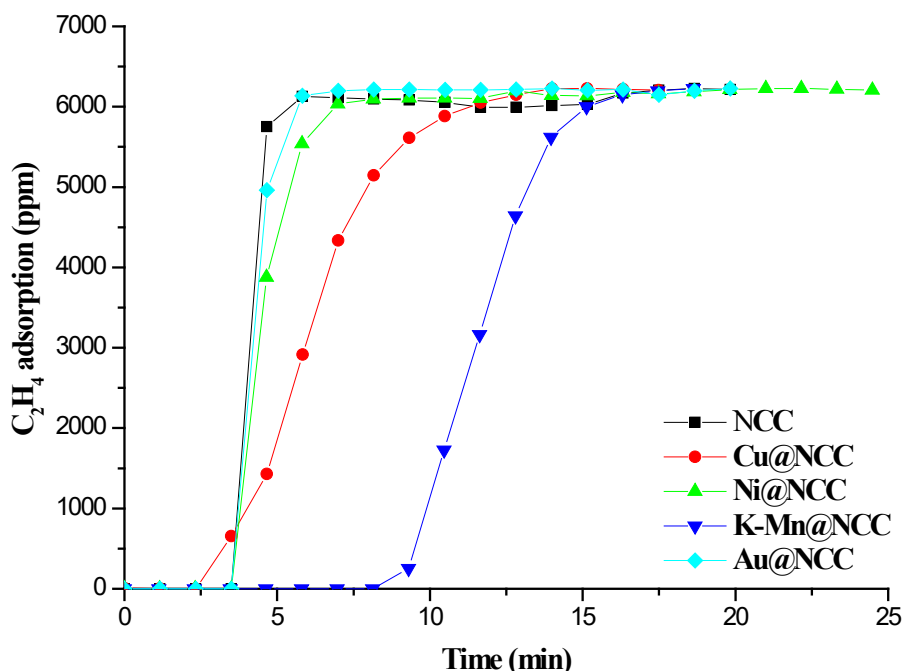


Figure 13. Ethylene adsorption of carbon nanocomposites Cu@NCC, Ni@NCC, K-Mn@NCC, Au@NCC and NCC.

The ethylene (C₂H₄) gas adsorption abilities of the carbon nanocomposites were achieved by gas chromatography (GC) analysis at atmospheric temperature. Fig. 13 depicts the ethylene adsorption visual representation of five carbon nanocomposites. The corresponding C₂H₄ gas adsorptions on the adsorbents (NCC, Cu@NCC, Ni@NCC, Au@NCC) have been raised remarkably from 0 to 6000 ppm in 3–15 min while K-Mn@NCC displayed a corresponding ethylene (C₂H₄) gas sorption growth starting with 0 to 6000 pm in around 8~15 minutes. The ethylene (C₂H₄) gas sorption was nearly identical for all five of the adsorbents and more or less steady upon sample saturation with time (Fig. 13). The metal carbon nanocomposites had a uniform pore size and a transition-metal attraction which permits the nanocomposites to bind and capture the ethylene alike tinier compounds (3.14 Å) at adsorption sites. These nanocomposites can be broadly used as

efficient and low-priced adsorbents in the time of movement and storage of harvested fruits and vegetables in order to protect the farming product quality by capturing ethylene release.

Conclusion

This chapter describes the evidence for the robust research findings carried out in recent time to project a new and improved techniques for the cleansing of water waste from organic dyes along with energy storage applications. The metal carbon nanocomposites **Au@NCC**, **Cu@NCC**, **Ni@NCC**, **K-Mn@NCC**, **P@NCC**, **Au-P@NCC**, **Mo-V@NCC**, **Pd@NCC**, **Au-Pd@NCC**, **W@NCC** and **Au-Salen@NCC** were prepared by a simple pattern method employing low-cost petroleum based pitch as the carbon creator and nano structures silica ball as hole maker. The green, recyclable and sustainable organic-inorganic metal nanocomposites were applied successfully as a solid-sustainable catalyst for degeneration of toxic organic pollutant pigments (Chromotrope-2R, Methylene Blue and Eosin-Y) and as an adsorbent for energy protection (H₂ and C₂H₄) and environment fixing.

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Review on catalytic degradation of hazardous phenolic compounds using nanocatalyst@carbon

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Abstract

Waste matter containing phenol is hazardous wastewater for the environment and human health. Researchers are working on the performance of several catalysts for phenol removal from wastewater from a long time. The review presents research survey of decomposition of phenolic compounds in the environment and water using nanocatalyst@carbon. Several processes such as Fenton and Fenton like reactions, photo Fenton reactions, wet oxidation and catalytic wet oxidation has also been thoroughly examined. Main aim of selection of catalyst for wet oxidation with particular reference to nano carbon materials has been highlighted. Nanoparticles exhibit significant promise for wastewater treatment, this review discusses trends and future prospects utilizing the sustainable applications of green-synthesized nanocatalysts and nanomaterials for the removal of phenol and its analogues from aqueous solutions.

Keywords

phenolic compounds, nanocatalyst@carbon, hazardous, wet oxidation, green catalyst

1. Introduction

Phenol and its phenolic analogues are extensively used as designer in pharmaceuticals, personal care products and industries. These manufacturing industries generate waste streams that when set free into watercourses cause environmental problems due to their high toxicity and bio-resisting in nature. Therefore, the phenolic discharge must be treated before they liberate into watercourses to protect human health and aquatic environment. Different predictable methods were applied for degradation of phenolic compounds but incapable to completely removal of the organics instead they produce secondary contaminants (Etaiw et al., 2020). Phenolic compounds are normally generated in petrochemical industries as a derivative and, furthermore, include unwanted pyrolysis oil component. Phenolic components obtainable in excess amount in the mixture form in water and are considered as severe environmental pollution. These are corrosive to combustion engines and pipes and are difficult for transformation. This openly goes ahead to the addition of phenol-rich tar in most urbanized country environments, these results in severe pollution of the environment and unnecessary resources of valued organic carbon (Nabgan et al., 2020). The wastewater treatment is still a worldwide concern. Industrial and domestic wastewater needs to be treated correctly, which involves a wastewater treatment method to accomplish an exact minimum level to meet the environmental standards. Even though, wastewater contains different kinds of organics, phenol along with its derivative compounds, constitutes a major class of water contaminants. The main reason is that even when present at lower concentrations, these compounds are highly toxic to living organisms and have therefore been listed since 1976 on the Environmental Protection Agency (EPA) priority list (Saputra et al., 2020).

Nano catalysts doped on carbon are promising catalyst in the field of heterogeneous catalysis, adsorption, wastewater treatment, radiopharmaceutical activities, and chiral resolution. Nano catalysts are on demand everywhere due to their excellent reaction performance,

advantageous recyclability, and low cost by doping on usual carbon materials. Titanium nanoparticles (TNPs) for Ni-Pt/Al nano-sized catalysts, several nano catalysts like Au(Salen)@CC nano composites, metal incorporated composite carbon materials, nanocarbon gold composite, gold phosphorus supported carbon nanocomposites, palladium, gold and gold-palladium containing metal-carbon nanoreactors were successfully used by our research group in the field of catalysis and water treatment by degrading phenolic analogues and dyes in water which usually waste products from industries and research centers. Very few other recent literatures are available in decomposition of phenols by nonmaterial.

1.1 Properties that make nanocatalyst@carbon an advantageous catalyst

Salen Schiff base-transition metal complexes and their composites have been mainly scientifically examined due to its capable use as a catalyst in a broad variety of organic transformations (Abdi et al., 2009). Transition metal nanocomposites have opened huge impact over last decade because of their opportunity in applications as a solid catalyst, adsorbent, sensor, electrode, and energy storage (Mayani et al., 2015). To develop improved care of the option of this performance, we researchers have development new heterogeneous catalyst of Au(III) Salen complex onto carbon cage prepared from pyrolysis fuel oil based pitch residue using a novel and environmental friendly approach for the catalytic degradation of carcinogenic water pollutants (Mayani et al., 2017). Transition metal supported porous carbon materials have become a potential catalyst. Recyclability of the catalysts maintains no observable loss of performance during catalytic oxidation reaction. Our research group has developed transition metal supported porous carbon materials have become a promising candidate. Palladium, gold, and gold-palladium anchored carbon composites with two different sized carbon cages (~25 and ~170 nm) were synthesized using nano-silica ball (NSB) as the template and a pyrolysis fuel oil (PFO) based pitch residue as the carbon source (Mayani et al., 2016). Porous carbon materials have some inspiring properties and can be used as templates for the production of metal-carbon nanoreactors. Reusable, low-priced, and environmental friendly metal composite carbon materials have attracted considerable interest as an opportunity to unacceptable composite materials. Considerable research has been carried out to attach metal particles, such as Au, Pt, Pd, Cu, Ni, K, Mn, and Ru to the carbon frame work for prospective applications in the field of catalysis Carabineiro et al. (2013) reported that gold nano particles on carbon nanotubes achieved a combined yield of 3.6 % from cyclohexane oxidation after 6 h reaction time. Oxidative dehydrogenation of cyclohexane and cyclohexene over supported Au, Pd, and Au-Pd catalysts has been accomplished. The hybrid carbon composites with brilliant properties have been considered to gather the demands of multiple applications. These metal-doped carbon materials have potential in the field of energy storage, heterogeneous and electro-catalysis, and material science owing their individual porous structure and surface area, nano size, mass transfer capacity, and chemical and physical properties (Mayani et al., 2016).

Pyrolysis fuel oil (PFO) residue based pitch is measured the most excellent option for the well-organized and inexpensive significant production of new template-based porous carbon networks and devices. A chemically static porous carbon cage (CC) developed from low-cost petroleum pitch as a carbon source after extraction of naphthalene crystals and silica as a template can be used as a metal host, where energetic metal particles can activate along the surface/to be filled inside the carbon framework. Many techniques available for engineering metal carbon nanoreactors (MCNRs), the modern template method and metal doping approach can exceptionally produce a wide range of different sized porous structures and well-defined morphologies with metal functionalities. MCNRs also have several added features as well as the possibility for alteration the activity and selectively of nanocomposites.

Transition-metal composites (tungsten and molybdenum) have shown great significance over the past years because of their potential in applications as a sensor, photochemical device, fuel cell for power generation, adsorbent, heterogeneous catalyst or its host. Therefore, the characteristic properties of transition-metal composites have been found to be similar to those of precious metals, such as platinum (Mayani et al., 2015). Synthesized metal-attached porous carbon materials have been newly studied extensively because of their unique porous structure, peculiar surface properties, mass transfer capability and numerous applications. Among the many methods for fabricating metal carbon nanoreactors (MCNRs), the modern template method and metal doping techniques can afford a range of porous structures with a wide range of pore sizes and well-defined morphologies with metal functionality. The sets of uniform pore sizes and adequate surface areas, as well as the addition features achieved by combining active metal particles with pristine CC, highlight the possibility of improving or encouraging the activity and selectivity of MCNRs (Mayani et al., 2014 a).

Nanomaterials are a group of special material that sticks to on purpose influencing size scales (less than 100 nm). Great attempts have established that nanomaterials based catalysts such as metal/ metal oxide nanoparticles, metal/metal oxide supported nanoparticles, and nanocarbon materials can be helpful in removing organic contaminants from wastewater successfully. Normally, metal/metal oxide nanoparticles based catalysts, mainly Fe, Cu, and Mn species contained in porous solid matrices (e.g., pillared clays, activated carbon, alumina, and zeolites), are highly favorable for catalytic oxidation process. Among those nanocarbons, carbon nano tubes (CNT) are essentially appropriate for catalytic reactions, due to pore volumes, large specific surface areas as well as individual properties. In addition, the doping of nitrogen species in CNTs make them a talented candidate in catalytic wet peroxide oxidation. $\text{Fe}_3\text{C@NCNT}$ and NiCo@NCNT were recognized to have equivalent activity to metal-based material in electrocatalysis, and the effectiveness is recognized to the graphitic carbon shells activated by those nanoparticles, which give carbons with high electron conductivity as well as satisfactory electron-transfer capacity. Novel nitrogen-doped carbon nanotubes on Fe_3C nanocrystals coated paper-like sintered stainless steel fibers (PSSF) structured catalyst ($\text{Fe}_3\text{C@NCNT/PSSF}$) was synthesized for catalytic wet peroxide oxidation of phenol (Huang et al., 2020). Carbon-metal catalyst has attracted worldwide attentions in recent years. In this hybrid structure, carbon material has outstanding conductivity and rich chemical active sites; metal species functions as the centre of catalytic reaction and plays the role of electron transport and material transfer. Carbon-metal catalyst thus showed brilliant catalytic activities toward various reactions, including photocatalysis, electrocatalysis and asymmetric catalysis (Song et al., 2017).

1.2 Phenolic compounds: Effects on ecosystem and health

Phenolic compounds are characteristic pollutants that mainly come from pharmaceutical, dye, paper factories, or many other industrial sectors. They are harmful to human health and possess high toxicity and carcinogenicity, particularly, showing resistance towards various degradation technologies. Due to such properties, they are usually selected as targeted compounds in many environmental research projects (Huang et al., 2020). The effects of water pollution are not only disturbing to people but also to animals, fish, and birds. Polluted water is unsuitable for drinking, recreation, agriculture, and industry. It decreases the visual quality of lakes and rivers. Further, contaminated water destroys aquatic life and reduces its reproductive skill. In time, it is a danger to human health. Toxicity of an organic pollutant is its normal aptitude to cause an unfavorable health effect, such as the ability to induce cancer, birth defects and other illnesses in animals and humans. Phenols can cause damage to the cells of the living organisms. It has been revealed that a long-time intake of phenols by

experimental animals lead to changes in the skin, lungs, liver, mucous membranes and in the kidneys. As an outcome of phenol dispersion through the man's skin, the skin darkens and the muscles become weak. The toxicity caused by phenols irritates such symptoms as headaches, dryness of the throat, vomiting, and diarrhea. According to other reports, phenols have cytotoxic effect on skeletal muscle and neurotoxic effect on pyramidal neurones. Phenol and its derivatives also show mutagenic effects by unbinding of the DNA helix, inhibition of DNA synthesis in the human cells, and induction of gene mutations. The ingestion of 1 g of phenol is deadly for man.

Chlorophenol is one of the most toxic water pollutants, which causes damage to the critical organs of human beings. 2-chlorophenol is exceptionally corrosive and causes skin, mouth and gastrointestinal injuries. Workers exposed to pesticides that contain chlorophenols have developed acne and mild injury to their livers. In laboratory studies, animals that received high levels of chlorophenols in food or water developed liver and immune system effects, and also weight loss. High levels of chlorophenols given to pregnant female rats in their drinking water reduced the number of babies they had, and caused low birth weights. Chlorophenols have not been shown to cause birth defects in animals. There is evidence to suggest that people exposed to chlorophenols for a long time may have slightly higher cases of cancer. 4-CP is listed as hazardous for landfill disposal. 2,4-dichlorophenol (2,4-DCP) has been described to cause lethargy, tremors and convulsions in mice while workers who made pesticides or were exposed to chlorophenols developed acne and mild liver injuries. 2,4,6-TCP, caused leukemia in rats and liver cancer in mice. It can cause severe skin and eye irritation. 4-nitrophenol is more harmful than 2-nitrophenol when given in high amounts over a short time. Skin irritation has been noted in animals that had large amounts of 4-nitrophenol applied to their skin, and eye irritation when it was applied to the eye. The nitrophenols are, however, not classified as human carcinogens (Mayani et al., 2011).

2. Several catalytic processes for decomposition of phenols by nanocatalyst@carbon

A few methods in use for decomposition of phenols are described below:

2.1 Fenton and Fenton-like processes

Fenton reaction is one of the best catalytic processes for phenol oxidation. The Fenton reagent (FR) is a mixture of hydrogen peroxide (H_2O_2) and an iron(II) salt, which is regularly used for oxidation and degradation of organic substances owing to its high oxidizing power and simplicity. The oxidation of organic substances with FR is an induced chain reaction. Koppenol and Liebman (1984) have compared some of the thermodynamic properties of $\bullet OH$ and FeO_2^+ and found both the species to be almost equally active. The extremely reactive nature of the two species has made it very difficult to control the reactions at some desired point. Because of this, the Fenton reaction has almost no control on the product selectivity and this is also the reason for limited use of Fenton reaction for wastewater treatment and similar processes. The Fenton-like reagent, which utilizes Fe^{3+} instead of Fe^{2+} is also capable of oxidizing organic substrates, but it is somewhat less reactive than Fenton's reagent. As iron (III) can be produced in applications of Fenton's reagent, Fenton chemistry and Fenton-like chemistry often occur simultaneously. Therefore, Fenton and Fenton-like reactions are generally believed to continue by similar mechanisms.

Various authors have shown that several oxidation mechanisms may exist all together challenging with each other. Which mechanism overcome is determined by the reaction conditions, such as the metal ligands, the solvent, the pH and the organic substrate to be oxidized. The active species are often indefinable in nature with relatively short life-spans, making it difficult to study their activities or separate them in experiments (Mayani et al.,

2011).

2.2 Photo-Fenton reaction

The photo-Fenton reaction has also acknowledged enough concentration as an option, well-organized and low-cost method for wastewater and soil treatment (Chaliha and Bhattacharyya, 2006). In this process, an interaction between radiations and Fenton or Fenton-like reagents creates the conditions for more efficient oxidation of organic contaminants (Pignatello, 1992). This technique has been demonstrated to be very effective in increasing the biodegradability of chlorophenols in natural and industrial waters and has been proposed as a suitable pre-treatment step in treating industrial wastewater (Fallmann et al., 1999). The photo-Fenton method has the advantage that it has high reaction rates and can be powered by sunlight. In Fenton, Fenton-like and photo-Fenton processes, hydrogen peroxide is used which much less in cost is compared to strong oxidizing agents like per sulphate. The commonly mentioned disadvantage of the photo-Fenton method is the necessity to work at low pH (in literature normally a pH below 4 is considered to be necessary), because at higher pH, ferric ions would begin to precipitate as hydroxide. Another difficulty is to remove the added iron from the management method (Klibanov et al., 1980).

2.3 Wet air oxidation (WAO)

For treating wastewater full with uncontrollable organics, oxidation reactions are to be carried out in the aqueous environment. In such reactions, the dissolved oxygen can be used to react with the organics. Wet air oxidation (WAO) is thus defined as a process of oxidizing organic matter in the presence of water. Wet air oxidation of organic compounds proceeds via a free radical mechanism initiated by the reaction of the organic substrate with oxygen. WAO is considered as an ultimate process for pretreatment of wastes that are opposing to conventional biological oxidation. In the WAO, water has been shown to behave much like a catalyst and is an integral part of the reaction and the process has the capability to oxidize waste liquors, slurries, and sludges where the oxygen demanding organic matter constitutes only a few percent of the overall waste load. The organic contaminants in water are either partially degraded by means of an oxidizing agent into biodegradable intermediates or mineralized into innocuous inorganic compounds such as CO₂, H₂O and inorganic salts, which remain in the aqueous phase. One of the main drawbacks of the WAO process is its inability to achieve complete mineralization of organics, since some low molecular weight oxygenated compounds (especially acetic and propionic acids as well as methanol, ethanol, and acetaldehyde), originally present in wastewater or build up in the liquid-phase during the oxidation process, are resistant to further transformation to carbon dioxide. Consequently, the WAO process is considered as one of the most promising and simplest techniques for partial oxidation of parent pollutants into more biologically agreeable intermediates. The efficiency of aqueous phase oxidation can be largely improved by the use of catalysts, either in the form of solids or as homogeneous catalysts (Mayani et al., 2011).

2.4 Catalytic wet oxidation (CWO)

The incorporation of a catalyst into the oxidation process has been considered mainly to reduce the operating temperature and pressure, and/or to treat pollutants that cannot be destroyed during non-catalytic liquid phase oxidation processes. Use of suitable heterogeneous catalysts, on the other hand, has the intrinsic advantage of easy separation of the solid catalyst from the reaction mixture. The heterogeneous oxidation process requires intensive contact between the catalyst surface and the organic contaminants in solution and the process of oxidation follows from adsorption of one or more reactants on the catalyst surface. The process thus involves the following steps (Bhargava et al., 2006): transport of

the reactants to the catalyst or support surface, adsorption of the reactants onto the surface, reaction between the adsorbed species on the surface, desorption of products off the surface, and diffusion of products from the surface to the bulk.

Phenol and its derivatives have been the subject of many studies in CWO. Studies on the mechanisms for oxidation of phenol require some knowledge of the short-lived intermediates as well as the final reaction products. Nano-architecture Cobalt (III) supramolecular coordination polymer based on host-guest has been obtained as an efficient catalyst for phenolic degradation (Etaiw et al., 2020). Saputra et al. (2020) explained carbon-supported manganese for heterogeneous activation of peroxymonosulfate for the decomposition of phenol in aqueous solutions. Novel nitrogen-doped carbon nanotubes encapsulating Fe₃C nanocrystals coated paper-like sintered stainless steel fibers (PSSF) structured catalyst (Fe₃C@NCNT/PSSF) was designed for continuous catalytic wet peroxide oxidation of phenol (Huang et al., 2020).

3. Reviewed results

Researchers have been delivered continuous efforts in the field of science to develop beneficial nano carbon catalysts for heterogenous catalysis and waste water treatments.

Etaiw et al. (2020) have synthesized Nano-architecture cobalt (III) supramolecular coordination polymer based on host guest recognition as a valuable catalyst for phenolic degradation. In this research works, phenol is utilized as a pollutant pattern for the catalytic degradation experiments under normal conditions (NC), NC with UV-light irradiation and NC with ultrasonic irradiation [NC=3.4x10⁻⁴ M phenol, 0.4 M H₂O₂ and 0.025 g catalyst with stirring. Kinetic study exhibited degradation of phenol to follow first-order kinetics and energies of activation of 2.5 % MnOx/ACP were obtained to be 15.0 kJ/mol 2.5 % MnOx/ACP presents significantly lower activation energy than other catalysts and would be a promising catalyst Saputra et al. (2020). Huang et al. (2000) have described Novel nitrogen-doped carbon nanotubes encapsulating Fe₃C nanocrystals coated paper-like sintered stainless steel fibers (PSSF) structured catalyst (Fe₃C@NCNT/PSSF) was designed for continuous catalytic wet peroxide oxidation of phenol. The reaction condition for catalytic degradation of phenol over Fe₃C@NCNT/PSSF composite catalyst (feed flow rate: 2 ml min⁻¹, catalyst bed height: 2 cm, temperature: 80 °C, C_{phenol}: 1 gL⁻¹ and C_{H₂O₂} : 5.1 gL⁻¹) (Table 1).

Table 1 Kinetic parameters of catalytic and photocatalytic degradation of phenol using catalyst

System/ SCP1	K _{obs} (min ⁻¹)	K _t (l mol ⁻¹ min ⁻¹)	t _{1/2} (min)	R ²	q _e (mg/g)	Time (min)	D %
1. Control experiment	0.0002	0.0005	03450	0.999	0.506	1420	34.4
2. NC without stirring	0.0051	0.0127	135.29	0.982	1.252	360	86.6
3. NC	0.0053	0.0132	130.18	0.992	1.272	350	88.0
4. NC with UV-light irradiation	0.0100	0.0250	069.00	0.986	1.324	240	96.5
5. NC with ultrasonic irradiation	0.0143	0.0357	048.25	0.984	1.391	160	98.9

[NC= 3.4 X 10⁻⁴ phenol, 0.4 M H₂O₂ and 0.025 g catalyst with stirring]

[Control experiment = 3.4 x 10⁻⁴ M phenol and 0.4 M H₂O₂ with stirring]

The UV and ultrasonic radiation-catalytic processes presented a new method of elimination of hard pollutants like phenols (Etaiw et al., 2020). Carbon-supported manganese for heterogeneous activation of peroxydisulfate has been used for the decomposition of phenol in aqueous solutions by Saputra et al. (2020). Phenol decreases with time in adsorbing and catalytic oxidation. Reaction conditions: [Phenol concentration] 75 mg/L, [Catalyst concentration] 0.4 g/L, [PMS concentration] 2 g/L, and T 25 °C.

Mayani et al. (2013) have described metal carbon nanoreactors (MCNR) samples that were made-up by (Figure 1) a nanocasting metal deposition process using pristine CC and metal nanocrystals such as gold, copper, nickel, potassium and manganese. Catalysts were well characterized by physico-chemical characterization methods (Mayani et al., 2012).

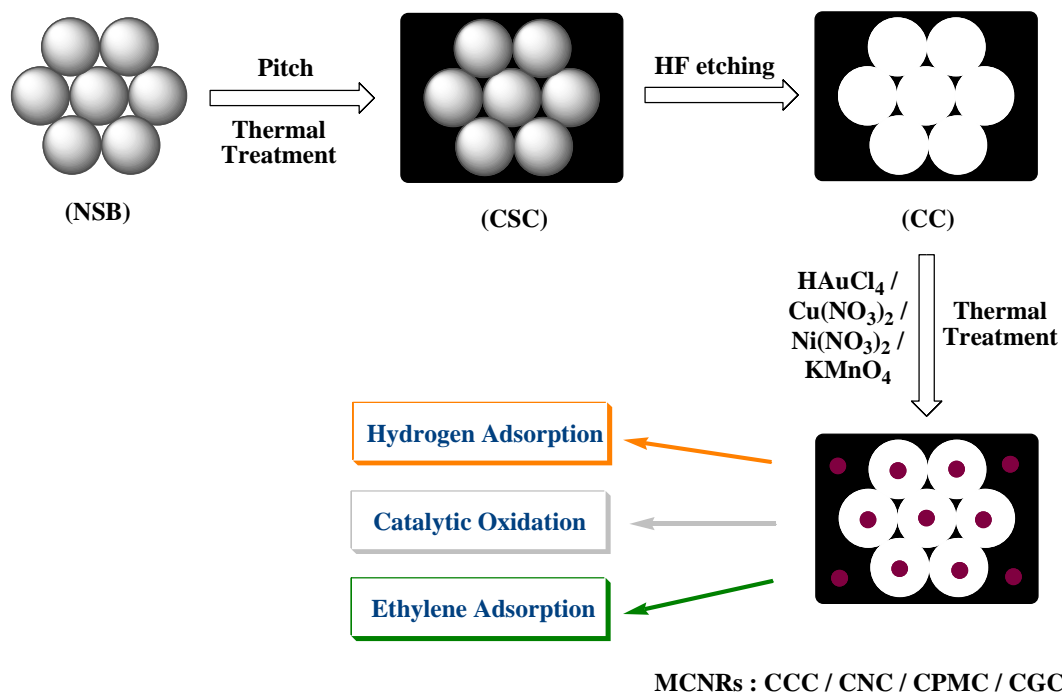


Figure 1. Schematic diagram for the synthesis of metal-carbon nanoreactors (MCNRs).

Heterogeneous catalytic oxidation of 1-phenylethanol was carried out at atmospheric pressure by solvent-free reaction condition using carbon gold composite (CGC) as an eco-friendly catalyst (Figure 2). Authors have carried out the solvent-free oxidation of 1-phenylethanol with CGC in the presence of oxygen gas at 120 °C. CGC provided the oxidation product in ~96 % yield (Table 2, entry 1). This catalytic study clearly recognized the catalytic activity to the Au supported on the CGC material and recyclability of the catalyst.

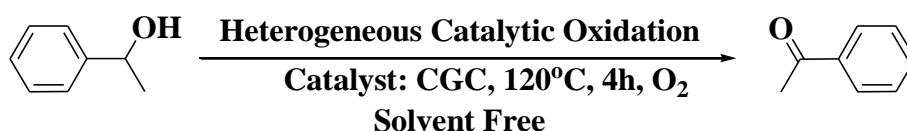


Figure 2. Heterogeneous catalytic oxidation of 1-phenylethanol using CGC.

Table 2 Heterogeneous catalytic oxidation of 1–phenylethanol using CGC and its recycling study^a

Entry	Materials ^b	Yield ^d (%)	Catalytic run
1	CGC	96	1
2	CGC	94	2
3	CGC	95	3
4	CGC	95	4
5	CC	---	---
6	CGC + MW ^c	---	---

a The reaction was carried out by using 1–phenylethanol (5.06 g) and CGC (0.1 g) in presence of O₂ at 120°C for 4 h.

b Two composite materials (CC/CGC) were used as catalyst.

c The reaction was carried out by using 1–phenylethanol (5.06 g) and CGC (0.1 g) was irradiated for 1 min in a microwave oven.

d Isolated yield after column chromatography.

These MCNRs materials are found with excellent adsorption, high catalytic conversion and reasonable stability under the authors' experimental conditions.

Mayani et al.(2014 b) have synthesized Gold Phosphorus Supported Carbon Nanocomposites (Figure 3).

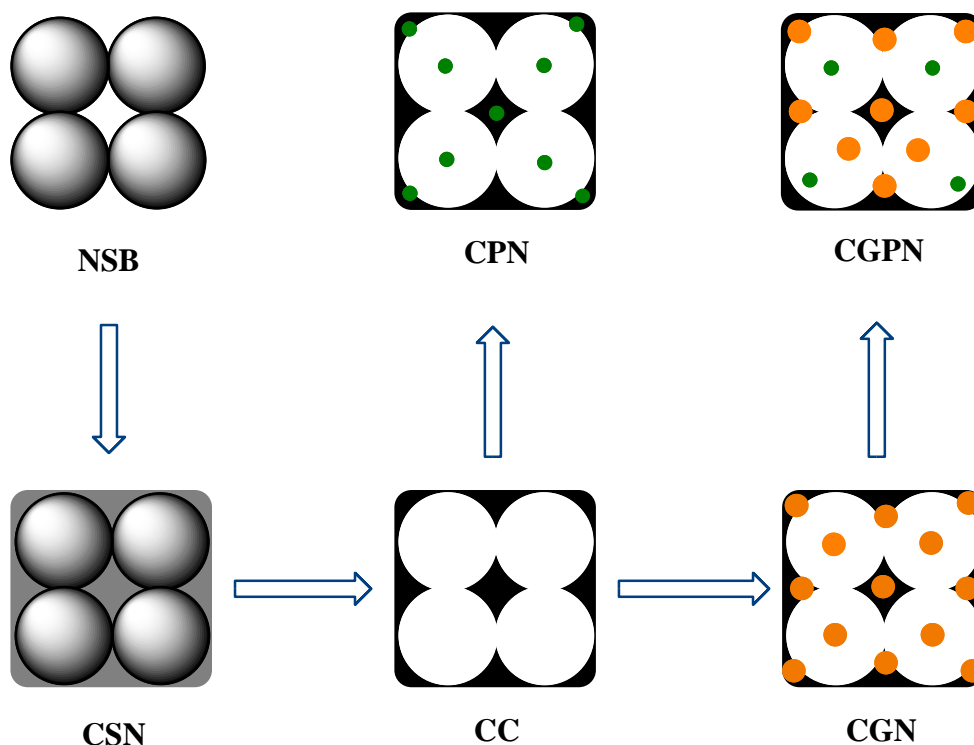


Figure 3. Schematic diagram for the synthesis of NSB, CC, CGN, CPN and CGPN.

These nanocomposite will lead to the novel applications in the field of material science with the combined property of gold and phosphorus along with carbon.

Two sized (~25 and 170 nm) porous carbon supported tungsten carbide were developed using economical petroleum residue followed by tungsten (W) doping by Mayani et al. (2015) (Table 3). Both carbon tungsten composites (CTC-25/170) showed tungsten subcarbide (W_2C) and monocarbide (WC) as the major and minor crystalline phase in X-ray diffraction, respectively. Schematic diagram has been discussed in Figure 4.

Table 3 Physico-chemical data and CV capacitance of nanocomposites.

Samples	BET Surface Area (m ² /g)	Total Pore Volume (cm ³ /g)	BJH Pore Diameter (Å)	Specific Capacitance (F/g) at Scan Rate (10~200 mV/s)				
				10	20	50	100	200
NSB-25	30	0.086	116					
CC-25	82	0.120	58					
CTC-25	69	0.107	61					
CTCE-25	---	---	---	957	873	780	590	468
NSB-170	163	0.290	71					
CC-170	212	0.857	162					
CTC-170	180	0.749	161					
CTCE-170	---	---	---	439	381	324	288	0.2

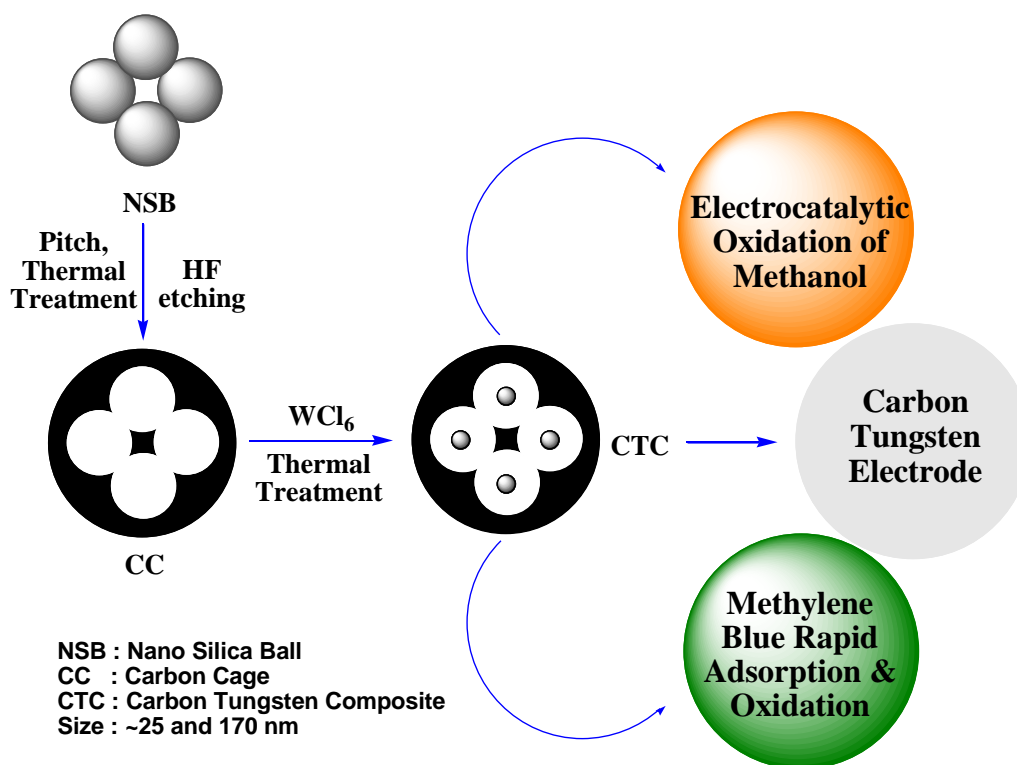


Figure 4. Schematic diagram for the preparation of NSB, CC and CTC.

Mayani et al. (2016) constructed palladium, gold and gold-palladium anchored carbon composites (CPC-25/170, CGC-25/170, and CGPC-25/170) with two different sized carbon cages (~ 25 and 170 nm) using silica spheres as the template and pyrolysis fuel oil (PFO) residue as the carbon source (Figure 5). The Pd, Au and Au-Pd doped carbon nanoreactors were well characterized. The application of catalyst in catalytic oxidation of cyclohexanol with H₂O₂ is described in Table 4.

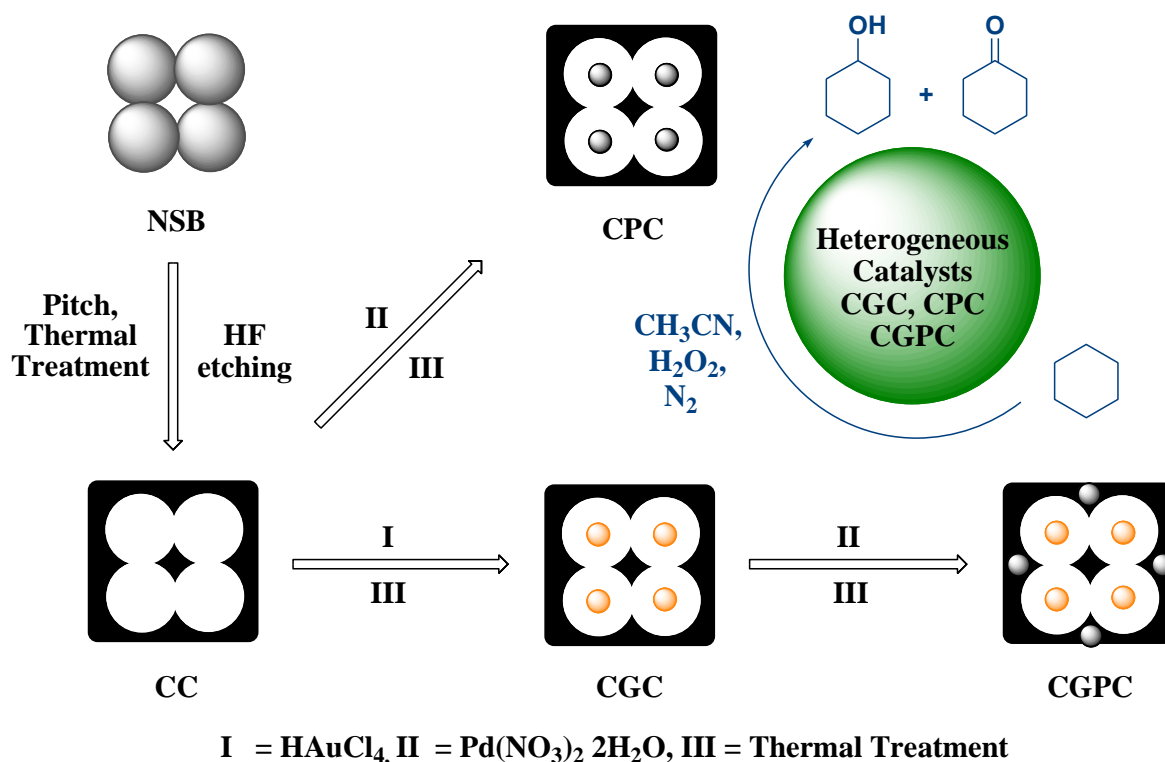


Figure 5. Schematic design for the synthesis of CGC, CPC and CGPC and its catalytic activity.

Table 4 The nanocatalyst applied in catalytic oxidation of cyclohexanol with H₂O₂ as given in table below:

Sr. No.	Catalyst	Yield (%)		
		Cyclohexanol	Cyclohexanone	Total
1.	CPC-25	---	---	---
2.	CGC-25	0.6	1.8	2.4
3.	CGPC-25	0.04	0.01	0.05
5.	CPC-170	---	---	---
6.	CGC-170	4.1	3.6	7.7
7.	CGPC-170	0.3	0.02	0.32

Reaction conditions: Acetonitrile (3.0 ml), cyclohexane (5 x 10⁻³ mol), rt, under dinitrogen, H₂O₂ 10 x 10⁻³ mol, catalyst CPC-25/170 or CGC-25/170 or CGPC-25/170: 0.1 g

Mayani et al. (2018) described new gold Salen complex doped carbon nanocomposite Au(Salen)@CC which was developed by easy methodology using nano carbon cage (CC) prepared from low-priced Pyrolysis fuel oil (PFO) residue based pitch (Figure 6).

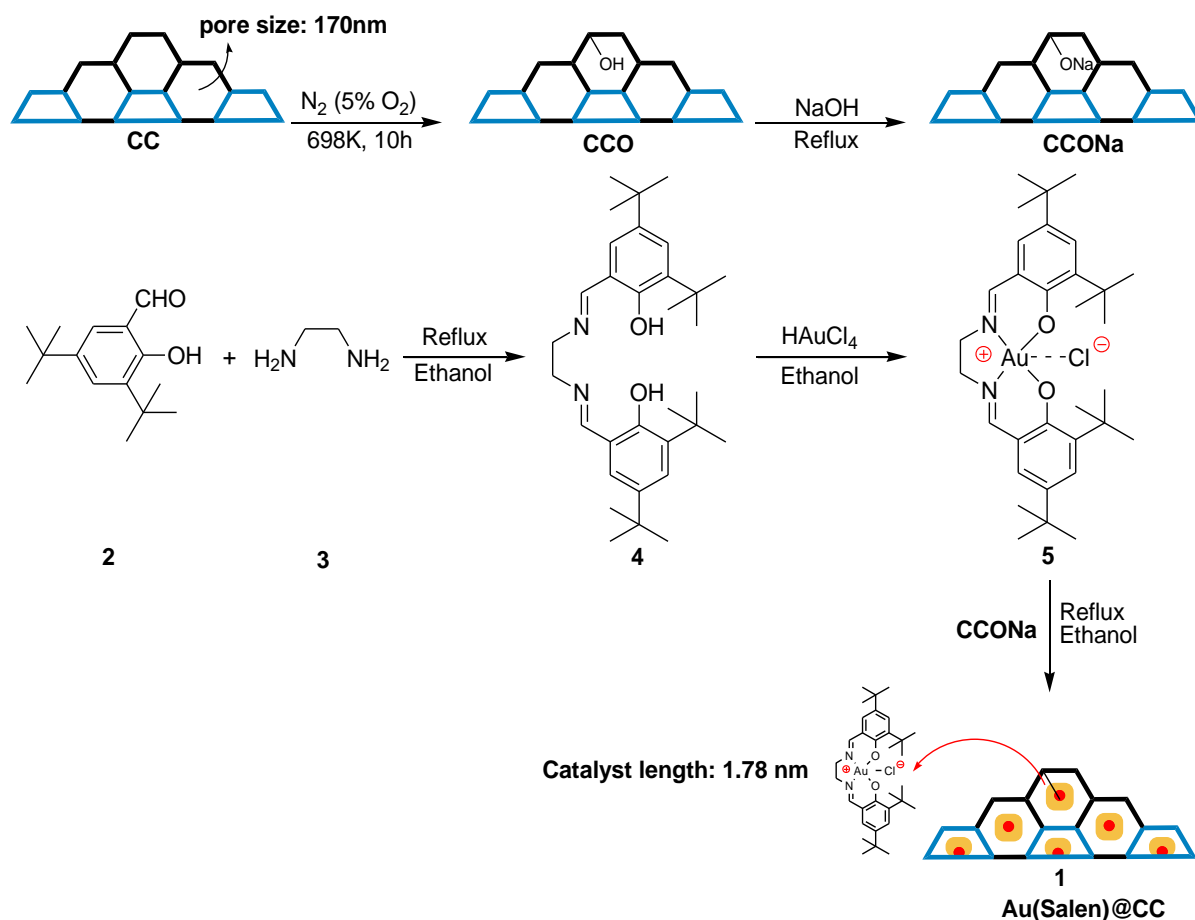


Figure 6. Synthesis path of carbon cage doped nanocomposite Au(Salen)@CC 1.

The catalyst was applied for decomposition of chromotrope 2R and Eosin-Y dyes and further works are carrying out in degradation of toxic phenolic compounds in water. It will be an advantageous and novel catalyst in the field of waste water treatment.

The eleven synthesized metal carbon nanocomposites, Au@NCC (Mayani et al., 2012 a; Mayani et al., 2013), Cu@NCC, Ni@NCC, K-Mn@NCC (Mayani et al., 2012 b; Mayani et al., 2013), P@NCC, Au-P@NCC (Mayani et al., 2014 b), Mo-V@NCC (Mayani et al., 2013), Pd@NCC, Au-Pd@NCC (Mayani et al., 2014), W@NCC (Mayani et al., 2015), and Au-Salen@NCC (Mayani et al., 2017), exhibited not only the particular physico-chemical spirit of concerned metal and nanoporous carbon cage (NCC) but also the combined characteristics of the paired composite and the happening of new behavior able of encouraging untouched procedure (Figure 7). These hybrid organic-inorganic nano catalysts have immense assurance in the field of heterogenous catalysis and water treatment (Mayani et al., March-2021).

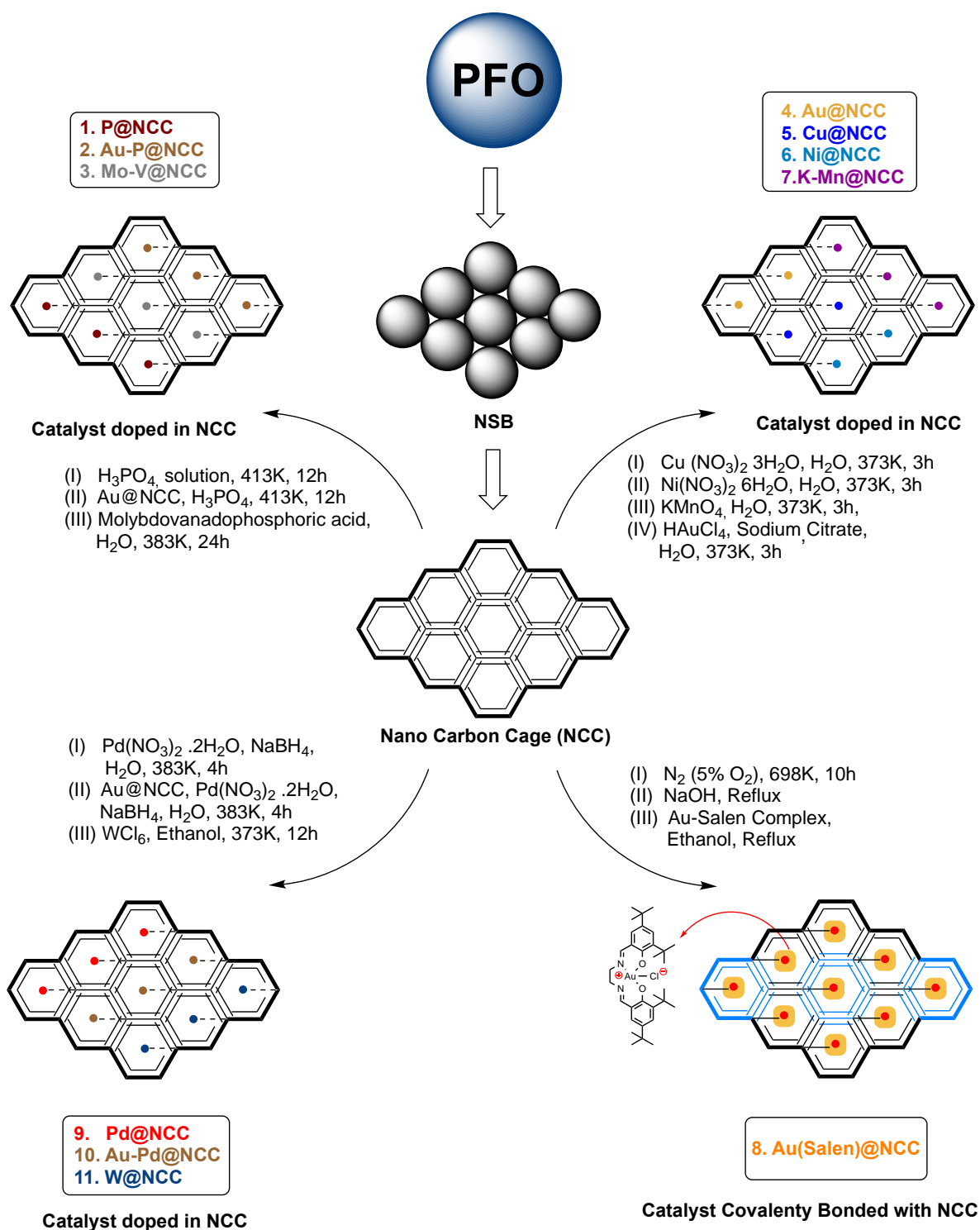


Figure 7. Synthesis route of eleven organic-inorganic metal nanocomposites 1-11.

4. Conclusions

The review illustrates the verification for the well-built research efforts approved in current point in time to develop new and improved methods of nanocatalyst@carbon synthesis and for the purification method of phenolic compounds. The best skill to be applied powerfully depends on single cases, in particular from the concentration of phenol in the stream and the co-presence of other contaminants. Scientifically quite simple methods are available.

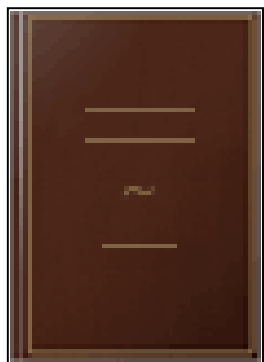
However, in more complex technologies, advanced apparatus are needed, make certainly more expensive and more complex its operation, but might result very successful in the future to decrease small concentration of pollutants. In this review, opinion of the present authors, when the concentration of phenol in wastes is small, simple techniques that can be performed are preferred choices from the ecological point of view.

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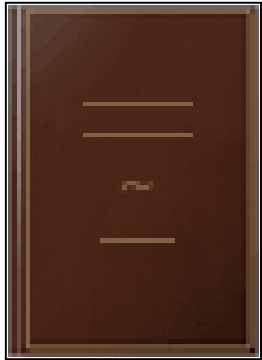
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Bioprospecting of Microorganism-Based Industrial Molecules

Chapter 4

Antiaging and Skin Lightening Microbial Products

Prabuddha Gupta, Ujwalkumar Trivedi, Mahendrapalsingh Rajput, Tejas Oza, Jasmita Chauhan, Gaurav Sanghvi

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Summary

Globally, in the last few years, there has been an increasing trend in the usage of antiaging and skin lightening products because of health awareness and the economic growth of people. Skin aging is a multifactorial process but majorly attributed by two factors, viz., extrinsic and intrinsic factors. Many compounds keep skin rejuvenate and vital for a more extended period. However, due to the toxic effect of chemical compounds, there has been an increasing demand for natural products. Natural compounds have not the only capacity to increase market capture but also have valuable properties like antioxidant and anti-allergic. In this context, it is essential to explore various natural sources for the isolation of novel commercially important compounds. Microbial diversity represents an enormous but largely underexplored biological pool, which can be exploited for the production of many commercially important compounds. From the majority of cultured microbes like bacteria, yeast, fungi, and algae, different cosmetic compounds are produced. A wide range of compounds like antioxidants, enzymes, peptides, anti-collagenase-elastase holds a promising future in the skincare segment of cosmetics. Thus, this chapter has been made to provide overall the phenomena of skin aging, consumer market demand of skincare products, and to showcase different properties of compounds produced by various microbes.

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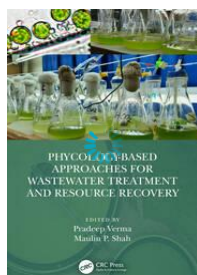
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Chapter




Biotechnological Advances for Utilization of Algae, Microalgae, and Cyanobacteria for Wastewater Treatment and Resource Recovery

By Prabuddha Gupta, Ashok Kumar Bishoyi, Mahendrapal Singh Rajput, Ujwal Trivedi, Gaurav Sanghvi

Book [Phycology-Based Approaches for Wastewater Treatment and Resource Recovery](#)(.)

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ABSTRACT

There has been a mounting concern over the conventional wastewater treatment process because of the high energy consumption, emission of greenhouse gases, and massive environmental footprint associated with this process. In recent years, there has been an advancement in the wastewater treatment process by integrating algal-based wastewater treatment with conventional wastewater treatment to make the process sustainable. Phycoremediation technology not only offers a well-designed treatment strategy by accumulating nitrogen, phosphorus, heavy metals, and toxic compounds from wastewater but also contributes towards resource recovery and recycling. The valuable biomass obtained can be used to produce biofuels, animal feed, and fertilizers, and it can be put to agricultural use, thus enhancing productivity and sustainability. This chapter explores the role of algae and cyanobacteria in the wastewater treatment process, innovation in algae growth and cultivation strategy, harvesting biomass, and downstream processing. Special emphasis is given to the progress in molecular biology, metabolomics, and other “omics” opportunities for algal biotechnology advancement.



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Nanobiotechnology

Microbes and Plant Assisted Synthesis of Nanoparticles, Mechanisms and Applications

2021, Pages 235-252

Chapter 15 - Heavy metal removal by nanobiotechnology

Aditya Saran ^a, Gaurav Sanghvi ^a, Prabuddha Gupta ^a, Mahendrapalsingh Rajput ^a, Tejas Oza ^a, Ujwalkumar Trivedi ^{a, b}[Show more](#) [Outline](#) | [Share](#) [Cite](#)<https://doi.org/10.1016/B978-0-12-822878-4.00015-8>[Get rights and content](#)

Abstract

Nanobiotechnology is an emerging era to deal with heavy metals and metalloids pollution lead by various biological and chemically nanostructured elements. The competitive efficiency and specificity of such nanostructures reside within the structural phenomena, which are influenced by the spatial arrangements of atoms that result in various geometries, such as nanotubes, nanospheres, nanocomposites, and nanoparticles. Often, these structural changes significantly modulate their physio-chemical properties that can be utilized for quenching heavy metals from the severely polluted sites. Although at a lower concentration, the heavy metals are an integral constituent of ecological chemistry, various anthropogenic activities have led to an upsurge in their concentration leading to environmental disturbances and health hazards. This chapter highlights various natural and anthropogenic sources of heavy metals and addresses their dispersion and distribution in the environment through the integration of nanotechnology with physical, chemical, and biological approaches of heavy metal remediation. Comparative studies of various nanomaterials are also an essential component of the present chapter. The discussion is centered on their pilot-scale applications, their recovery, and sustainability. Furthermore, their efficiency and limitations are outlined concluding with promising future directions.

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Keywords

heavy metal remediation; physio-chemical remediation techniques; bioremediation; nanomaterials; nanoabsorbents

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


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Vadodra Chapter

Managing People, Planet and Profit (3Ps) in COVID World

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Chapter 18

Sustainable Product Development: A Tool to Manage People, Planet and Profit in Covid World.

Dr. Rhuta Mehta¹ Ms. Nirali Karia²

Abstract

Sustainable products can be defining as those products that are offering an environmental, social and economic profits while caring for the public health and environment over their whole life cycle, from the mining and getting of the raw materials until the final disposal of the products developed.

Sustainable product development has marked its importance and presence during the pandemic time where, Covid-19 has created massive destruction and disturbance at an international level that has changed the entire socio-economic system that results in the de-globalization of almost all economic activities. Economies of all over the world have been impacted due to Covid-19 in the almost all the business including production, retail, hospitality, entertainment, aviation etc.

The purpose of this research topic is to comprehend and draw the attention towards the importance of sustainable product development, and its role as a tool to manage the 3P's i.e. People, Planet and Profit in Covid world even to identify the loopholes.

Conversation with all those founders of such products and the organizations, it has been observed that such entrepreneurs, even after working hard, are facing the resistance while putting their sustainable products in market. The issue is not related to the

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development or manufacturing of sustainable products, but it is about the lack of awareness among people about such products.

Introduction

In the perspective of the preface provided by the Charter of the United Nations, development is defined as the endorsement of social progress and enhanced quality standards of living in the larger autonomy. This extensive explanation of development is convoluted by adding the adjective "sustainable". The earliest meaning of sustain is to support, or to uphold the course of or to keep into being. Where the one more meaning is to provide with food and drink, or the necessities of life. Still another definition is to endure without giving way or yielding. The point to emphasize here is that the term 'sustainability' has ideological and political content as well as ecological and economic content. There is a struggle, worldwide, to determine how 'sustainable development' or 'sustainable capitalism' will be defined in the discourse on the wealth of nations (ibid., p. 153).

Popular mythology suggests that there is mostly one environmental movement, that it began with Earth Day in 1970, and that it is mainly concerned with preserving extra-urban nature (wilderness). Improved environmental performance of products and services has lately become one of the major tactical and operational targets of producers. This is because of the influences from different stakeholders including government, consumers, societies and the business partners. Markedly, diverged producers differently executed their environmental practices for sustainable product development depending on various driving factors such as customer awareness about it, legislation, economical reimbursement and competitive strategies, etc.

During the time of covid, we have lately realized that few practices of living the life followed by our ancestors were something important which were directly and indirectly affecting and was

playing a role in maintaining our health as well as the environment. The practices that were so normal and regular in the early days have now turned into something called innovation and or maybe we can call it the trend of living life today. Sustainable product development in that case is now becoming a tool to manage the people, planet and profit in the times of covid. Like there were lot many people who lost their jobs during covid and then there were the other few whose business came to an end due to covid. In such a time, the products that were made out of certain things which aren't harmful to the society and were under the head of sustainable products; played its role and such organizations grew pretty in these times. Like it was quite a normal thing to use the cow dung as a "dhup" (incense stick) in the earlier times, but covid now taught our generation to use it as one of the best ways to improve your breathing and maintain immunity.

Literature review:

One of the most recent developments in the emergence of the concept of "sustainable product development" which deals with elementary demands, essential product functions, and the system in which product function, the nature, availability, and selection of resources, and the distribution of those resources among nations and generation. In the last ten years, many companies all over the world have become aware of the fact that both economically and ecologically, proactive policies and preventive measures are far more attractive than after-the-event and end-of-pipe technologies. As a result, the 'pollution prevention' concept became increasingly popular (J.C. Van Weenen, 1995)

Waste is generally meant for discarding because it acts as a source of pollution (Pongracz & Pohjola 2004). However, if it is used in any other process such as feedstock it may be considered as a co-product (Brown 2003). For example; In India, 69.9% population resides in rural areas (The Hindu 2011), where a cow is major cattle

and generates 9 – 15 kg dung/day (Werner, et al. 1989; Brown 2013).

The need for introducing environmental requirements into the design and development of new products has already been discussed for more than a decade (Pezzoli K., 1997). Environmental requirements are mainly considered as an unavoidable "must", which generates additional design constraints and increases the cost (Bhamra TA 1999, Borland 1998, Fiksel J. 1996)

Current practices of product development in manufacturing companies are still predominately based on traditional cost/profit models (Asiedu Y, 1996) aiming at the high quality of product at a low cost and high profit. Users learn about products, their environmental, societal, and economic impacts and their use, and environmental aspects of changes in consumer behavior, and they develop ideas on how to influence corporate strategies. It is argued that too close a link to customers may hinder innovations as the company may only pay attention to current customers (Christensen and Bower, 1996, Danneels 2003) resulting in a strong niche orientation. (Brockhoff, 1997,1998)

Objectives of the study

1. To understand the significance of sustainable products and their' design development for people, the planet, and profit.
2. To understand the purpose and process adopted by the various companies for sustainable product development.

Research methodology

Qualitative research has been carried out to fulfill the stated objectives. Through telephonic interviews of ten entrepreneurs engaged in sustainable product development and production, the required data has been collected. Interpretation is based on researchers' own perception and understating.

Analysis

Research Analysis included the details collected from those companies, which included their product line, financial support, and source, inception idea about the start-up and their customer pool.

1. **Gaukriti** is the inventor of India's first handmade recyclable paper out of cow dung. These papers consist of seeds of vegetation that will grow in plants of Tulsi, Gander, Cumin, and such plants after being dumped.

Product line by Gaukriti: This company has come up with innovations in more than 70 products which include bags, bangle box, calendars, diaries, envelopes, and wedding cards and so on. During the hard times of covid, they also came up with masks made out of cow dung papers including the vegetation seeds too. Before the festival of Raksha Bandhan arrives, they also start manufacturing the rakhis made out of cow dung which are plantable too.

Interview Gist:

In our conversation with Mr. Bhimrao Sharma, we analyzed that the production of such an innovative product as cow dung paper was not an easy task. The idea behind coming up with such a product was protecting the cows from not being taken care by the owners while she is not giving milk and the second was protecting the environment. We came to know that there are times when cows stop giving the milk or give the least milk than its average capacity, during such times the cow owners either leave the cow or stop feeding the cow in the same amount that it needs on its daily basis. This is why, there were lot many cows found on the road who were not getting proper food and shelter. By coming up with a concept of making papers from cow dung, cow now became a monetary source even when she is not giving milk. Hence, the least owners now let their cows run on the road.

Talking about the manufacturing of paper; along with cow dung, cotton waste is also the other raw material that is used. Out of 40

Kgs of cow dung and the basic raw material, 100 Kgs of paper is manufactured at the unit of Gaukriti. While in the normal papers, 24 trees are cut down to manufacture at least 1000 kgs of paper. At the same time, the paper made at Gaukriti has 12 types of different seeds including fruits and vegetables which are suitable to grow in every different weather and soil condition.

The main reason Mr. Bhimrao highlights about least acceptance and sale of such products in our market is the lack of awareness among people about such products. There could be various ways that he suggests to push such products in the market and the government can play a big role in it, but we haven't reached there yet and so, most of the products that are manufactured are exported to other countries.

Resources: The main raw material for manufacturing these papers is cow dung which is bought by Gaukriti at the rate of Rs. 10 per kg from different cow owners. Along with that the cotton waste is also bought and the seeds of different vegetation are also added in these papers which makes the papers recyclable.

Customer Pool: In our conversation with Mr. Bhim rao, we analyzed that as such there are no fixed and major customers to their business. The handicraft stores can be a great medium to sell such things but still, there is the least acceptance of keeping such products even at the stores. The main selling at present is done through online mediums like Amazon and Flipkart. Other than that, a maximum of products are exported to different countries like USA and Italy.

1. **MKV Enterprise** is a manufacturer and a supplier of Areca Plates, Bagasse plates, earthenware, Bamboo products, Fiber products, and Organic products. They are leading merchant and trade exporters of such sustainable products.

• **Product line by MKV Enterprise:** The product range offered by MKV Enterprise is as below:

1. **Areca products** include bowls, cups, rectangle plates, round plates, areca-shaped bowls, and square plates.
2. **Bagasse products** include bowls, containers, meal trays, and plates.
3. **Earthenware products** include biryani pots, cooking pots, clay cups, glass, flower pots, frying pan, ice cream pots, kitchen sets, long handle pots, diyas, rice cooker, S type pots, serving bowls, water filters, water jug, and water pot.
4. **Bamboo products** include bowls, glass, mugs, utensils, water bottles and water glasses.
5. **Coconut shell products** include coconut shell agapai, incense stick stand, bird feeder, bowls, designed bowls, forks, earrings, candle holder, hair clips, ice cream bowl, gift box, oval cups, salad cups, soup cups, semi-polished cups, spoons, teacups, and wine glasses.
6. **Banana leaf** is the other product altogether that is exported to Arabian countries.

Interview gist:

In a conversation with Mr. Kamal Venu, we analyzed that maintaining and offering such a large range of products is not easy, but still taking inspiration from his father; he is working to take this organization to a height. He tried and collects the maximum range of such sustainable products under him so that such customers don't have to keep searching in market for finding these products. There are very few organizations in India that are working hard to bring such products among us, make them available easily among us, and MKV Enterprise is one such among them.

The organization is particularly in the manufacturing of Earthen and Areca products, the other products are bought from different manufacturers and provided at this same platform for the ease of customers.

The thing we analyzed and discussed here again was the lack of awareness and acceptance for using such products in the Indian market and so the maximum of the products are exported to the countries like Europe, Australia, Israel, Canada, the US and other Arabian countries.

Customer Pool: As in the case of Gaukriti, the major customers are not Indians but the people in other countries so the export amount is higher than the local buying.

1. **Other companies:**

The other companies that we were able to understand and know about were:

1. **Plantable** – This is into the making of recyclable papers with seeds providing a range of papers, diaries and wedding invitations.
2. **Fabrefine** – This is into recycling the old jeans into items like handbags and other accessories for females.
3. **Earthen** – This is into manufacturing the products like plates, bowls and spoons out of the palm leaves.
4. **Dinearth** – This is into manufacturing tableware and crockery out of sugarcane bagasse pulp without any plastic or wax coating.
5. **Greenvale eco-products** – This is into manufacturing the products like plates and bowls from sugarcane wastage.
6. **Champs Agro Unit** – This is into the manufacturing of eco-friendly handicraft items out of banana fiber like papers, gift boxes, dairy covers, and other products from palm fibers, and jute wine bags.
7. **Green-o-Tech India** – This is into collecting the paper waste and converting it into stationery products. The other initiative we would mention about them is they plant one tree on recycling of every 100kg of paper waste.
8. **Ecoware** – This is into manufacturing the products like bowls, boxes, cups and plates out of common crop waste.

Discussions

From this research study, we analyzed and understood that there are many organizations and the entrepreneurs behind such organizations that are working on developing sustainable products and their' manufacturing and selling. And to our surprise, we came to know that most of the products are that are manufactured by such units are exported only. And in our conversation with such entrepreneurs, we realized that they are into exporting such products just because there is least awareness of such products in our country. The other thing that we realized is, there are least efforts by the government for pushing such products in the market. India is and has always been rich in terms of agricultural products and major sustainable products are from agricultural by-products and other such things. So we have options always open for such products but it is just the lack of awareness of using such products in our market and such products are in-demand in foreign markets and so are exported in maximum numbers.

Implications of the study:

With this research study, we analyzed that there are lot many organizations coming up with the manufacturing of sustainable products with a motive to protect Mother Nature and the interest of our future generations. We as responsible humans shall support such business organizations by using such products a maximum of times. Such organizations bring up not only innovations in products but are also generating more employment opportunities. The profit is not only earned in terms of monetary resources but also the environment is protected and nothing can be a better profit than protecting the nature for future.

As seen, we always try and imitate the foreign markets and style of living and habits, we also saw that maximum products are exported from our country and then people from our country are inquiring there for such products, but never took care of looking in our own

country for such products. For now, exporting the products in maximum is good, as the earning comes into foreign currency and so ultimately our economy gets support and growth. But we must also focus on the point that we shall not earn compromising on our health and not taking care of the environment that we live in. We as researchers of this study will like to make points to the future entrepreneurs that; the coming generation will be more careful and concerned about protecting the environment and start using such products and promoting such products. Jumping into innovating and bringing such products in the market right now may seem difficult, but we are sure that the future of such products is going to be the brightest.

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An Assessment of GHG Emission Reduction by Using Renewable Energy and Energy Efficient Processes



Kosha Navnit Vaishnav and Ritesh Ramesh Palkar

Abstract Nowadays, consumer prefers product and services from companies which adhere the principle of sustainability and operation with Sustainable Commitments. The main objective of this study is the reduction of GHG emission by the use of Renewable Energy and Energy Efficient processes and equipment. Detailed assessment of an energy profile and GHG emission is to be carried out from different micro, small and medium scale industries and lack of data monitoring found to be a major drawback. Energy efficiency interventions based on techno-economic analysis of the prevailing electricity tariff, fuel cost and conservation of operating hours includes improved performance, better insulation, reduction in the consumption of resources such as water, fuel and energy, efficient operation and better energy management with proper monitoring system. Renewable energy interventions result in potential saving of 10–12% of electrical energy by replacing the conventional pumps with the solar water pump as it gives remarkable savings with average payback period of 3–9 months according to the study. According to the Solar supplier/vendors, investing in this asset have their own pros and cons with investment classes and payback period with the inclusion of technical specifications, warranty/guaranty periods, maintenance and service, quality assurance plan and special offers/intensives. Some suggestions for the same such as CAPEX Model, OPEX Model and Off-site Model are given by solar suppliers and vendors. This could be the step towards the low carbon pathway and efficient use of renewable energy to get the maximum possible benefit from the same.

Keywords Renewable energy · Solar pumps · Energy efficient processes · GHG emission · Low carbon pathway

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