ISBN: 978-93-88901-64-2

RESEARCH TRENDS IN SCIENCE AND TECHNOLOGY VOLUME I

EDITORS

DR. ROHIT SRIVASTAVA

DR. PREETI MAHAWAR

DR. MAINAK BANERJEE

DR. SAMIR M. BAGADE

Bhumi Publishing, India

First Edition: July 2023

Research Trends in Science and Technology Volume I

(ISBN: 978-93-88901-64-2)

Editors

Dr. Rohit Srivastava

Department of Chemistry,

St. Andrew's College,

Gorakhpur, Uttar Pradesh

Dr. Preeti Mahawar

Department of Biotechnology,

Faculty of Agricultural Sciences,

Madhav University, Abu Road, Rajasthan

Dr. Mainak Banerjee

Department of Zoology,

RKDF University,

Ranchi, Jharkhand

Dr. Samir M. Bagade

Department of Physics,

Arts & Science College,

Pulgaon, Wardha, Maharashtra

Bhumi Publishing

July 2023

First Edition: July, 2023

ISBN: 978-93-88901-64-2

Published by:

Bhumi Publishing,

Nigave Khalasa, Kolhapur 416207, Maharashtra, India

Website: www.bhumipublishing.com

E-mail: bhumipublishing@gmail.com

Book Available online at:

https://www.bhumipublishing.com/book/

PREFACE

In the ever-evolving landscape of science and technology, knowledge is a beacon that illuminates the path to progress. The pursuit of understanding and innovation has been the driving force behind the remarkable advancements that have shaped the world we live in today. As we embark on a new era, it becomes increasingly crucial to navigate through the diverse and dynamic currents of research to discern the trends that will define our future.

"Research Trends in Science and Technology" represents a collective effort to explore and elucidate the cutting-edge developments that are shaping the fields of science and technology. This book is an assembly of insightful chapters contributed by leading experts, researchers, and visionaries, all of whom share a common passion for unraveling the mysteries of the universe and harnessing the power of technology for the betterment of humanity.

In this volume, we delve into a broad spectrum of disciplines, ranging from fundamental sciences such as physics, chemistry, and biology to the transformative fields of artificial intelligence, nanotechnology, and biotechnology. By curating a diverse selection of research trends, we aim to showcase the interdisciplinary nature of modern scientific inquiry and the interconnectedness of technological breakthroughs.

We believe that knowledge should be shared and disseminated freely, fostering a collaborative spirit that transcends geographical and disciplinary boundaries. As such, "Research Trends in Science and Technology" serves as a platform for disseminating the latest discoveries, ideas, and perspectives that shape the course of human progress.

We extend our heartfelt gratitude to all the contributors who have dedicated their expertise and passion to enrich this compilation. Their invaluable insights and visionary outlooks have made this endeavor possible.

We hope that this book will inspire readers, whether they are students, researchers, policymakers, or curious minds, to embrace the spirit of inquiry and embark on their own explorations. By staying attuned to the latest research trends and leveraging collective knowledge, we can collectively chart a course towards a more sustainable, equitable, and innovative future.

Editors

TABLE OF CONTENT

USER INTERFACE: AN OVERVIEW

Sumit Chopra, Deepak Kumar, Gagandeep Singh and Anchal Nayyar

Department of Computer Science & Engineering,

GNA University, Phagwara, Punjab, India

Abstract:

A User interface (UI) may be a component of a framework that capacitates as a mediator between the client and the framework, permitting the client to associate with the framework more effectively. A user interface is everything with which the end user interacts physically, perceptually, and mentally to utilize the system. The user interface is the system itself for the end user. As a result, one of the foremost critical quality variables for surveying the overall quality of any code is system usability. The objective of the client interface plan is to set up a characteristic discussion grouping that permits the client and machine to trade the messages required to total a certain work. The client interface contrasts from one framework to another and from one client to another. We discovered some problems in building an effective user interface in this work. All these issues are thoroughly covered with relevant instances.

Keywords: User Interface, Models of User Interface, Interactive Design, Visual Design

Introduction:

The User Interface (UI) is the point of human-computer interface and communication in a gadget. Desktop screens, consoles, mice, and other indicating gadgets are illustrations of this. It may to relate to how a client interatomic with website or program. As a result of the expanding dependence of numerous businesses on online and portable apps, a few undertakings are underscoring UI to move forward the client involvement [1].

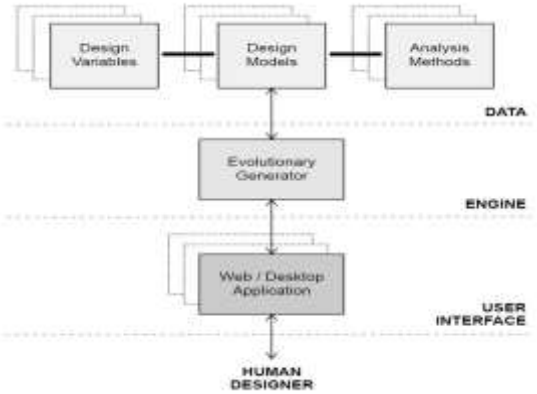


Figure 1: Layered architecture representing data, engine, and user interface layers

Types of User Interfaces

Graphical User Interface (GUI)

A Graphical User Interface (GUI) could be a set of unmistakable, intelligent components for computer applications. A graphical UI shows information-conveying and action-representative objects for the client to associate with. When the client interatomic with the things, their color, estimate, or perceivability alter [2].

Command Line Interface (CLI)

To communicate with computers and run programs, a text-based client interface (UI) known as a Command-Line Interface (CLI) is used. Command-line client interfacing is regularly alluded to as comfort client interfacing and character client interfacing. CLIs take command input from the console; the computer executes the commands entered at the command incite.

Menu-Driven Interface

A Menu-Driven Interface shows a list of menu choices from which a client may explore an online site or computer program. A menu-driven interface, which may be a component of a graphical client interface, has points of interest and drawbacks [3].

Voice User Interface

Voice-activated client interfacing Individuals communicate with them by talking to them. The larger part of savvy associates, such as Alexa on Amazon gadgets and Siri on iPhones, are VUIs [4]. Figure 2 shows how voice user interfaces work.

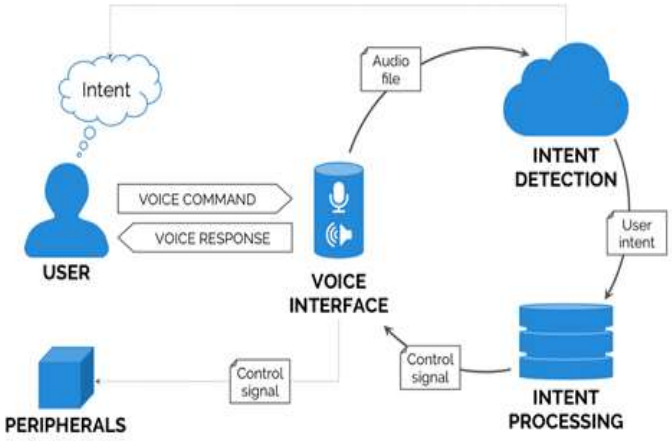


Figure 2: Voice User Interface

Dark User Interface

A program include that shows a client interface with light-colored things on a dark-colored foundation is known as dim mode. This UI plan, frequently known as 'night/light-on-dark mode/theme' or basically 'dark UI,' may be a variety on the normal 'light mode' UI. Dull

mode has recently been embraced by applications such as Facebook, WhatsApp, Instagram, and Gmail, as well as entire working frameworks such as Apple's iOS 13 and Microsoft's Windows 10.

Dim mode may be chosen by clients for assortment of reasons. One reason is that they discover dull UIs are tastefully charming. Another thought is eye consolation, thinks about propose that using a dull UI, especially in low-light circumstances, might limit visual weariness. Additionally, a few individuals like dull UI since the swoon light it transmits is less troublesome to their circadian design. Finally, a dim UI can be useful since it brings down contraption control utilization. Given these central focuses, it appears up coherent and because it was beneficial for program engineers to connect dim mode [5][6]. A dim UI, on the other hand, might have an unfavourable effect on the conduct of its clients. All through history, light and obscurity have had capable suggestions. Maybe related, mental ponders have found that light and obscurity impact numerous diverse sorts of human conduct. In sparkling light, for outline, clients make more profitable and more moral choices than in melancholy light. Living in dim or sparkling light might additionally impact improve insight and food utilization. In dim lighting, players may play longer and take more threats than in shining lighting. Dull and dim lighting can progress inventive yield, though encompassing brightness can make people more enthusiastic.

Conversational User Interface

The field of information technology of intelligent assistants has increased significantly in recent years due to technological advances in the artificial intelligence’s field and due to the increasing number of people. Opportunities like this are the best way to replace old and old graphics users. Because this method of interaction started to become popular since it can provide users information. Information is the answer to various questions, but more importantly, it helps control other related information The number of virtual assistants is estimated to be over 8 billion (which is right current population of the world) [7]. Basically, a conversational interface describes any form of entity that is used to interact via text. I am chatting here. Users control the order of conversations. Its content is compared to a graphical user interface (GUI) where most of the same information is arranged in the same way. Another notable feature is the fact that apps are now customizable. For users, the tone and even speed of speaking is important, so users use such technology Recognize the exchange of statements with your assistant in a more personal way [8]. So, someone using something like the interface finally sees them as friends and close friends, adding that they are no longer simple computers. They are innate human abilities and characteristics such as personality, emotions or logical thinking. Such a good example is Blind Square, which provides navigation instructions.

Gesture-Based Interfaces

In virtual reality (VR) games, for example, users interact with 3D design areas by moving their bodies.

Table 1: Comparison of Dark Mode vs Light Mode User Interface

Comparison	Dark Mode UI	Light Mode UI
Visual Appeal	Generally considered more visually appealing due to the high contrast and sleek appearance	Can appear less visually striking, but can also be less distracting and more soothing
Eye Strain	May cause less eye strain and fatigue due to reduced glare and blue light	May cause more eye strain and fatigue, especially in bright environments
Battery Life	May help save battery life, especially on OLED screens	Does not have a significant impact on battery life
Accessibility	May be more accessible for users with visual impairments, as the high contrast can make content easier to see	May be more accessible for users with cognitive or neurological disabilities, as it can be less visually overwhelming
Context	Can be more appropriate for certain contexts, such as low-light environments or artistic and creative applications	Can be more appropriate for certain contexts, such as business and productivity applications or educational settings
User Preference	Ultimately comes down to personal preference and may vary depending on individual tastes and needs	Ultimately comes down to personal preference and may vary depending on individual tastes and needs

Issues in designing user interfaces

In recent days, the field of digital electronics, system design and development has seen significant developments. Availability of mobile devices with advanced features i.e., mobile phones, net pads, laptops etc. is a boon to the user community. Moreover, thedecreasing cost and better quality of these digital devices have made these systems available to people from almost every stratum of society. Thus, the number of users is increasing significantly. There are several sorts of systems and users, each with its own set of capabilities and problems. The problems of

creating user interfaces for these systems have become complicated and crucial concerns as the number of various users has grown [9].

Models of user interfaces

User models

The user's knowledge of how the gadget may be utilized to execute activities and achieve goals is referred to as a user model. Good user models enable the user to establish appropriate techniques for common chores as well as solutions for somewhat different or even unique jobs. Urban System in Geography user interface designers employ a variety of ways to show acceptable models to users [10].

Implementation models

Understanding how things operate is the foundation of the technological paradigm. It is an obvious option if the mechanism is basic and transparent. If subsidies steer a person in the correct direction, suggest the proper action, and the implications of action are obvious, the user's highly intelligent model. The execution worldview indeed grants the client to repair gear, such as the yard door I fair had to bargain with. Shockingly, human-computer intelligent as often as possible show themselves through an innovation worldview in terms of program working. As a result, the client must learn how the application works in arrange to utilize it legitimately. It is also quite useful after acquiring a mental model [11]. A software might even be modified by the user to match new demands or preferences. However, the cost of implementing the model will be prohibitively expensive for most of us. It is preferable to highlight a functioning model for completing tool-specific tasks [12].

Borrowed models

A straightforward strategy of showing the client with a demonstrate of how an apparatus performs is to draw a parallel to the user's apparatus, which he as of now knows how to utilize. Since the known and obscure are comparable, the client may utilize it instinctively without understanding equipment mechanics or program. The desktop metaphor is the most well-known paradigm. Implicit comparison happens when the topic of the comparison, according to the idea of metaphor. The metaphor is based on tenor and vehicle sharing certain features [13].

Task-oriented model

A key concept in task-oriented models is that if a great device with a conventional interface is accessible, it may be rapidly, readily, and naturally trained to use. Notwithstanding of how the contraption works, interface components and activities center on the user's objective. Cooper's chapter "Master of the Records" has the foremost broad cases of contact between center technology-based interface plan and z interface design's view of the user's work.

Consider any basic graphical user interfaces "file" menu. The alternatives displayed to the client are centered on record organization, specifically the administration of the duplicate spared on disk and the duplicate dynamic in Smash [14]. Numerous users' application programs never made a mental show that precisely captures the connect between these two 'copies" yin and yang. They shouldn't, either, since the user's part is to make useable chapters.

These clients would advantage from the reexamined adaptation interface, which conceals the record administration assignment (a computer execution issue) and speaks to a single record that the client 'seems' to control from initiation to completion. From a task-oriented point of view, the "record" menu ought to be supplanted by an "archive" menu where clients can discover choices that coordinate current objectives that are a visit and fundamentally portion of report development [15].

What Does a user interface designer do?

All the screens that comprise a digital user interface, as well as the individual items on those panels, are designed by user interface designers. As a result, they consider both the general arrangement of each individual screen as well as how all the individual screens work together. Their objective is to design user interfaces that look fantastic, correctly represent the brand, and are simple and enjoyable to use [16].

User interface designers are usually concerned with:

i. Colors and images
ii. Typography
iii. Distance
iv. The visual design
v. Animation
vi. Responsive design
vii. Accessible and inclusive design

1. Why is user interface important?

The user interface is very important in meeting customer expectations and running your website efficiently. A well-designed user interface with contrasting images, linear design, and responsiveness enables good interaction between users and programs, application, or machines. When planning a client interface for your site, it is basic to consider the user's desires for availability, visual request, and convenience. Conversion rates on your site will rise if you mix excellent aesthetics with responsiveness in a way that anticipates and then satisfies user requests [17].

2. Interactive design vs visual design

2.1 Interactive Design (ID)

Interactive design (ID) components endeavor to turn detached peruses into dynamic members by giving occurrences of client interaction. In case the client is kept in intellect whereas creating the client interface (UI), the interaction and execution of specific operations that fulfill client demands will be progressed [18]. Furthermore, well-designed interactive UIs may "learn" to anticipate potential issues and address them before they have a negative expression on user. Examples include buttons, toggles, and social- share tools [19].

2.2 Visual Design

It is basic to emphasize your website's visual esteem. Color, differentiate, typeface, video, and photo components are utilized in effective plan to pull in guests and make it simpler for them to studied. It also works with, rather than against, the material to produce a logical, intuitive flow of functioning. Examples include Mobile optimization, contrast, color, white space, and typography [20].

3. Which one UI or UX is better?

Both UI and UX plan are well-paying and in-demand callings. Which one you select will be decided by your objectives and interface. If you are interested, enjoy diversity, and enjoy problem solving, user experience design might be the career for you. Consider creating user interfaces if you are a creative thinker with a strong aesthetic sensibility.

Conclusion:

The success of a product's marketing strategy can be assessed by the level of user interface design. If the end user finds the product difficult to understand and use, even a brilliant product may fail. A simple to use user interface makes the product easy to use, which ultimately boosts user adoption. It is necessary for the early stages of development. When you look at the larger picture, it is clear why developing user interfaces is so important. It is what determines whether firms succeed or fail. It is the method that people interact with your website and how they find out about your company. You shouldn't take this one aspect of your functionality for granted.

References:

1. Bodker, S. (2021). *Through the interface: A human activity approach to user interface design*. CRC Press.
2. Johnson, J. (2020). *Designing with the mind in mind: simple guide to understanding user interface design guidelines*. Morgan Kaufmann.

3. Zaina, L. A. M., Fortes, R. P. M., Casadei, V., Nozaki, L. S., & Paiva, D. M. B. (2022). Preventing accessibility barriers: Guidelines for using user interface design patterns in mobile applications. *The Journal of Systems and Software*, *186*(111213), 111213. doi:10.1016/j.jss.2021.111213
4. Wiklund, M., Davis, E., Trombley, A., & Edwards, J. (2021). Sources of User Interface Design Guidance. In *User Interface Requirements for Medical Devices* (pp. 129–134). doi:10.1201/9781003029717-12
5. Wiklund, M., Davis, E., Trombley, A., & Edwards, J. (2021). Our User Interface Design Tips. In *User Interface Requirements for Medical Devices* (pp. 135–184). doi:10.1201/9781003029717-13
6. Wang, X., Xue, C., Sun, T., Liu, J., & Fu, X. (2021, September 27). Mobile screen-based user interface design guideline for panoramic VR in shopping scene. *Proceedings of the 23rd International Conference on Mobile Human-Computer Interaction*. Presented at the MobileHCI '21: 23rd International Conference on Mobile Human-Computer Interaction, Toulouse & Virtual France. doi:10.1145/3447526.3472055
7. Spyridakis, I. (2021). Cross-cultural user interface design in a global marketplace: Building appreciation for diversity, equity, and inclusion. *2021 ASEE Virtual Annual Conference Content Access Proceedings*. Presented at the 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference. doi:10.18260/1-2—36882
8. Foster, E. C. (2021). User Interface Design. In *Software Engineering* (pp. 237–254). doi:10.1201/9780367746025-17
9. Jingar, M., Lindgren, H., & Blusi, M. (2021). Exploring limitations of user interface design to understanding the gap between technology and seniors. *Studies in Health Technology and Informatics*, *281*, 931–935. doi:10.3233/SHTI210315
10. Murad, C., Munteanu, C., Cowan, B. R., Clark, L., Porcheron, M., Candello, H., … Ku, A. (2021, May 8). Let's talk about CUIs: Putting conversational user interface design into practice. *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*. Presented at the CHI '21: CHI Conference on Human Factors in Computing Systems, Yokohama Japan. doi:10.1145/3411763.3441336
11. Bunian, S., Li, K., Jemmali, C., Harteveld, C., Fu, Y., & Seif El-Nasr, M. S. (2021, May 6). VINS: Visual Search for Mobile User Interface Design. *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. Presented at the CHI '21: CHI Conference on Human Factors in Computing Systems, Yokohama Japan. doi:10.1145/3411764.3445762

12. Mangla, V. (2021). HCI with User Interface Design. *International Journal for Research in Applied Science and Engineering Technology*, *9*(4), 1313–1322. doi:10.22214/ijraset.2021.33933
13. Belikova, S. A., & Institute of Computer Technologies and Information Security, Southern Federal University. (2021). Method for user interface design based on integration-variable concept model. *Informatization and Communication*, 61–63. doi:10.34219/2078-8320-2021-12-3-61-63
14. Oladapo, H., Owusu, E., & Chakraborty, J. (2021). Effects of culturally tailored user interface design. In *Lecture Notes in Networks and Systems*. *Lecture Notes in Networks and Systems* (pp. 845–853). doi:10.1007/978-3-030-80091-8_100
15. Park, H. (2021). A study on user interface design based on Geo-infographic and augmented reality technology. In *Communications in Computer and Information Science*. *Communications in Computer and Information Science* (pp. 364–368). doi:10.1007/978-3-030-90176-9_47
16. Sanctorum, A., Rukonic, L., & Signer, B. (2021). Design requirements for recommendations in end-user user interface design. In *Lecture Notes in Computer Science*. *End-User Development* (pp. 204–212). doi:10.1007/978-3-030-79840-6_14
17. Costanza-Chock, S. (2020, October 20). Design Justice and User Interface Design. *Proceedings of the 33rd Annual ACM Symposium on User Interface Software and Technology*. Presented at the UIST '20: The 33rd Annual ACM Symposium on User Interface Software and Technology, Virtual Event USA. doi:10.1145/3379337.3422379
18. Okamoto, T., Kambe, H., & Koizumi, H. (2020). A user interface design method based on quantitative evaluation of mental model. *IEEJ Transactions on Electronics Information and Systems*, *140*(6), 609–619. doi:10.1541/ieejeiss.140.609
19. Reddy, G. R., Blackler, A., Popovic, V., Thompson, M. H., & Mahar, D. (2020). The effects of redundancy in user-interface design on older users. *International Journal of Human-Computer Studies*, *137*(102385), 102385. doi:10.1016/j.ijhcs.2019.102385
20. Varma, A. G. (2020). Observing user interface design patterns for websites from a user-experience Point-of-View. *International Journal of Advanced Trends in Computer Science and Engineering*, *9*(2), 1981–1985. doi:10.30534/ijatcse/2020/167922020

DIGITAL TRANSFORMATION IS RESHAPING THE WORKFORCE

Sindu Padmanabhan

Bharathiar University, Coimbatore

Corresponding author E-mail: divyasn@yahoo.com

Introduction:

The COVID-19 pandemic has significantly impacted the way we work, accelerating the adoption of digital technologies and the concept of a digital workforce. To contain the spread of the virus, organizations worldwide have implemented remote work policies. This shift has necessitated the use of digital tools and technologies to facilitate collaboration, communication, and productivity. Video conferencing, project management software, and cloud-based tools have become essential for remote work. The pandemic has highlighted the importance of automation in maintaining business continuity. Organizations have increasingly turned to automation technologies like robotic process automation (RPA) and artificial intelligence (AI) to streamline processes, reduce manual work, and ensure operational resilience. Tasks that were previously performed by human workers are now being automated, leading to the emergence of a digital workforce. Many companies have accelerated their digital transformation efforts in response to the pandemic. They are adopting digital technologies to digitize and optimize their operations, customer interactions, and supply chains. This transformation often involves the integration of digital workforce components, such as AI-powered chatbots for customer support or machine learning algorithms for data analysis. With the physical separation caused by the pandemic, virtual collaboration tools have become indispensable for teams and organizations. Platforms like Microsoft Teams, Slack, and Zoom have experienced a surge in usage. Virtual collaboration tools enable remote teams to communicate, share files, and collaborate on projects, supporting the functioning of a digital workforce. The pandemic has underscored the need for employees to acquire new digital skills to adapt to the changing work landscape. Organizations are investing in upskilling and reskilling initiatives to help employees develop the competencies required to work effectively in a digital environment. This investment aims to bridge the digital skills gap and empower workers to thrive in a digital workforce. The digital workforce has led to the transformation of job roles and responsibilities. Some tasks that were previously performed by humans are now automated, freeing up employees to focus on more complex and strategic work. This shift requires employees to adapt, learn new skills, and take on roles that complement the capabilities of the digital workforce.

Overall, the COVID-19 pandemic has acted as a catalyst for the expansion of the digital workforce. Organizations are increasingly relying on digital technologies, automation, and virtual collaboration tools to ensure business continuity and productivity in the face of disruptions caused by the pandemic.

Keywords: Digital Workforce, Covid 19 Pandemic, Challenges, Pros and Cons, Transformation Strategy

Digital transformation is indeed reshaping the workforce in numerous ways. The rapid advancement of technology and the widespread adoption of digital tools and systems have significant implications for how work is performed, the skills required, and the overall structure of organizations.

Automation technologies and AI are increasingly being used to streamline and automate repetitive tasks. This has the potential to reduce the need for certain manual jobs while creating new roles focused on managing and leveraging these technologies. AI also has the potential to augment human capabilities, leading to new opportunities for collaboration between humans and machines (Wuest *et al.*, 2020). Digital transformation has enabled remote work to become more prevalent and feasible. Advancements in communication and collaboration tools, cloud computing, and high-speed internet have made it easier for employees to work from anywhere, leading to a rise in remote and flexible work arrangements. This trend has expanded the talent pool for businesses, allowed for better work-life balance, and opened up opportunities for global collaboration.

Digital transformation is driving a shift in the skills required in the workforce. As technology evolves, there is a growing demand for workers with expertise in data analysis, cybersecurity, artificial intelligence, machine learning, and other digital skills. This necessitates a focus on reskilling and upskilling the existing workforce to ensure employees have the necessary competencies to adapt to new roles and responsibilities. Digital tools and platforms facilitate collaboration and knowledge sharing across teams and departments. This has led to the emergence of more collaborative and agile work environments, where cross-functional teams work together to solve complex problems. Digital transformation enables real-time communication, project management, and document sharing, fostering a culture of collaboration and innovation.

Digital transformation has given rise to entirely new job roles and industries. Roles such as data scientists, user experience designers, digital marketing specialists, and cybersecurity analysts have become increasingly critical. Moreover, emerging industries such as virtual reality, augmented reality, blockchain, and the Internet of Things (IoT) have created new opportunities for employment and entrepreneurship. With the abundance of data generated by digital systems,

organizations can now make more informed decisions based on data analysis and insights. This has led to a growing demand for professionals who can interpret and leverage data to drive business strategies and outcomes.

Digital workforce transformation strategy

Digital workforce transformation refers to the process of leveraging digital technologies to enhance the efficiency, productivity, and effectiveness of a workforce. It involves reimagining how work is performed, enabling employees to collaborate seamlessly, automating repetitive tasks, and leveraging data and analytics to make better decisions. Developing a digital workforce transformation strategy involves several key steps

Start by evaluating your organization's existing workforce, processes, and technologies. Identify pain points, inefficiencies, and areas that could benefit from digital transformation. Determine the desired future state of your workforce. Define clear goals and objectives for the transformation strategy. This could include improving employee productivity, enhancing customer experiences, or increasing operational efficiency. Gain buy-in from top-level executives and key stakeholders. Ensure they understand the benefits of digital workforce transformation and are committed to supporting the initiative. Create a detailed plan outlining the steps required to achieve the transformation goals. Break it down into manageable phases, each with specific deliverables, timelines, and resource requirements (Alrasheedi *et al.,* 2022).

Identify the digital skills and capabilities needed for the transformed workforce. Provide training and upskilling opportunities to ensure employees are equipped to leverage new technologies effectively. Implement digital tools and platforms that facilitate seamless collaboration and communication among employees. This could include project management software, virtual meeting tools, and enterprise social networks. Identify tasks and processes that can be automated using technologies like robotic process automation (RPA), artificial intelligence (AI), and machine learning (ML). Also, explore opportunities to augment human capabilities with these technologies (Candace *et al.,* 2015).

Leverage data analytics to gather insights and make informed decisions. Implement systems and processes to collect, analyze, and interpret data effectively. Establish key performance indicators (KPIs) to track the progress and impact of the digital workforce transformation. Continuously monitor and measure the outcomes to identify areas for improvement.

Implement a change management program to help employees adapt to the new ways of working. Communicate the benefits, provide training and support, and address any resistance or concerns. Iterate and Evolve: Digital workforce transformation is an ongoing process.

Continuously evaluate the strategy, gather feedback, and make adjustments as needed. Stay updated on emerging technologies and industry trends to remain competitive.

The world has changed. The exponential growth of productivity, information sharing, mobility, and collaboration is reshaping the business world faster and more pervasively than at any other time in history. Uber, Airbnb, and Netflix are just a few examples of how the pace of innovation has created a new competitive landscape where size is no longer protected against smaller, faster, and more agile companies.

Remember that every organization's digital workforce transformation strategy will be unique, and tailored to its specific goals, challenges, and industry. It's essential to align the strategy with the organization's overall business objectives and ensure it addresses the needs and aspirations of both employees and customers.

The 4 Ps of successful digital workforce transformation

The "4 Ps" framework for successful digital workforce transformation provides a concise way to remember the key elements that contribute to a successful transformation. These four Ps are:

Purpose: Clearly define the purpose and objectives of the digital workforce transformation. This involves identifying the desired outcomes, such as increased productivity, improved customer experience, cost savings, or competitive advantage. Having a clear purpose helps align the transformation efforts and guide decision-making throughout the process.

People: Focus on the people aspect of transformation. Engage and empower employees at all levels of the organization, ensuring they understand the goals, benefits, and impact of the transformation. Provide training and upskilling opportunities to equip employees with the digital skills required for the new ways of working. Foster a culture of collaboration, innovation, and continuous learning to drive engagement and ownership.

Process: Evaluate and redesign business processes to align with digital technologies and maximize efficiency. Identify bottlenecks, eliminate redundant steps, and automate repetitive tasks through the use of technologies like robotic process automation (RPA). Streamline workflows, improve data flow, and enhance cross-functional collaboration. The goal is to leverage digital tools to optimize processes and drive operational excellence.

Platforms: Select and implement the right digital platforms and technologies to support the transformation. This includes enterprise software, cloud services, collaboration tools, data analytics platforms, and other technologies that enable automation, data-driven decision-making, and seamless communication. Choose platforms that are scalable, secure, and aligned with the organization's long-term goals. Integration and interoperability between platforms are also crucial for a cohesive digital ecosystem.

By focusing on these four Ps—Purpose, People, Process, and Platforms—organizations can ensure a holistic and well-rounded approach to digital workforce transformation. It helps align the strategic objectives, engage employees, optimize processes, and leverage appropriate technologies, leading to a successful transformation journey.

Pros of digital workforce

Digital technologies and automation can perform tasks at a faster pace and with greater accuracy than human workers. By leveraging the capabilities of a digital workforce, organizations can streamline processes, reduce errors, and achieve higher productivity levels. Implementing a digital workforce can lead to cost savings for businesses. Automation can reduce labor costs by replacing repetitive, manual tasks with automated processes. It also reduces the need for physical infrastructure and facilities associated with traditional work environments. Digital workers can operate around the clock without the limitations of human work shifts. This enables organizations to provide services and support to customers and clients at any time, leading to improved customer satisfaction and increased business opportunities (Beňo, 2021).

Digital workers can be easily scaled up or down based on demand. Organizations can quickly adjust their digital workforce to accommodate fluctuations in workload without the need for hiring or layoffs. This flexibility allows businesses to respond rapidly to changing market conditions Digital workforce technologies generate vast amounts of data that can be analyzed and used to gain valuable insights. These insights can help organizations make informed decisions, identify trends, improve processes, and enhance overall business performance (Berman, 2012).

Cons of digital workforce

The implementation of a digital workforce may lead to job displacement for certain roles that can be automated. This can result in unemployment and a need for workers to acquire new

skills to remain relevant in the job market. There may be a skills gap between the capabilities of the digital workforce and the skills possessed by the existing workforce. Implementing a digital workforce requires upfront investments in technology infrastructure, software, and training. Organizations may need to allocate significant resources to integrate and optimize digital technologies, which can be a barrier for smaller businesses or those with limited budgets.

Relying heavily on digital technologies means organizations become more susceptible to technical issues, such as system failures, cybersecurity threats, and data breaches. Organizations need to invest in robust cybersecurity measures and contingency plans to mitigate these risks. While digital workforce technologies offer efficiency, they often lack the human touch. In certain industries or tasks, human interaction and empathy are essential. The absence of human-to-human interaction may result in decreased customer satisfaction or limited problem-solving capabilities in complex situations.

The capabilities of the digital workforce are contingent on the technology being used. Some tasks may still require human judgment, creativity, or adaptability, which current digital technologies may not fully replicate. This can limit the scope of automation and the potential benefits of a digital workforce. It's important to note that the impact of a digital workforce can vary across industries, organizations, and specific use cases. While the advantages can be significant, the implementation of a digital workforce should be approached with careful consideration of the specific needs and challenges of each organization.

Biggest digital transformation challenges in 2023

While digital transformation offers numerous benefits, organizations often face several challenges along the way. Here are some common challenges associated with digital transformation:

One of the significant challenges is resistance from employees who are accustomed to traditional ways of working. Change can be unsettling, and employees may fear job loss or

struggle to adapt to new technologies and processes. Many organizations have outdated legacy systems and infrastructure that are not compatible with new digital technologies. Integrating and modernizing these systems can be complex and time-consuming. Digital transformation requires a workforce with the necessary digital skills and expertise. However, organizations often face challenges in recruiting and retaining talent with the right skills, such as data analysis, cybersecurity, AI, and machine learning

Digital transformation relies heavily on data, but organizations must ensure proper data management, privacy, and security. Protecting sensitive customer information and complying with data protection regulations can be challenging, particularly as data volumes grow. Digital transformation often requires significant cultural and organizational changes. Siloed departments, hierarchical structures, and resistance to collaboration can impede progress. Building a culture that embraces innovation, agility, and collaboration is crucial. Implementing digital transformation initiatives can be costly, especially for smaller organizations with limited budgets. Allocating resources and securing budgetary support for technology investments, training, and infrastructure upgrades can be a challenge. Scaling digital initiatives across the organization can be complex, particularly if there are multiple systems, processes, and departments involved. Integrating various technologies, platforms, and data sources to create a cohesive digital ecosystem requires careful planning and execution (Brunetti *et al.*, 2020).

Digital transformation aims to improve the customer experience. However, meeting evolving customer expectations can be challenging. Organizations must identify and address pain points, provide personalized experiences, and ensure consistency across digital channels. Successfully driving digital transformation requires strong leadership and effective change management. Leaders need to communicate the vision, inspire and engage employees, and overcome resistance to ensure the transformation is embraced and sustained. The digital landscape is constantly evolving, with new technologies and trends emerging regularly. Keeping up with the latest advancements, evaluating their relevance to the organization, and making informed technology choices can be challenging.

Overcoming these challenges requires careful planning, effective communication, strong leadership, and a focus on continuous learning and adaptation. Organizations must be agile and adaptable, continuously monitoring progress and adjusting strategies to address challenges as they arise (Shahi *et al.*, 2021).

Overall, digital transformation is reshaping the workforce by introducing new technologies, altering job requirements, enabling remote work, fostering collaboration, and creating new job roles and industries. To thrive in this evolving landscape, organizations and

individuals must adapt, embrace lifelong learning, and cultivate digital skills to remain competitive and seize the opportunities presented by digital transformation.

References:

1. Berman, Saul J. (2012). Digital transformation: opportunities to create new business models. Strategy & Leadership, 40(2), 16–24. doi:10.1108/10878571211209314
2. Candace J. Gibson, Ph.D., CHIM; Kelly J. Abrams, MPA, CHIM; and Gail F. Crook, CHE, Health Information Management Workforce Transformation: New Roles, New Skills and Experiences in Canada CHIM 2015 https://library.ahima.org/doc?oid=301180
3. Chinmay Shahi, Manish Sinha (2021). Digital transformation: challenges faced by organizations and their potential solutions International Journal of Innovation Science.
4. Federico Brunetti, DominikT. Matt, Angelo Bonfanti, Alberto De Longhi, Giulio Pedrini, Guido Orzes Digital transformation challenges: strategies emerging from a multi-stakeholder approach The TQM Journal ISSN: 1754-2731,21 July 2020
5. https://kissflow.com/digital-transformation/digital-transformation-challenges/
6. https://www.bdodigital.com/insights/digital-transformation/digital-workforce-transformation-strategy
7. https://www.consultancy.eu/news/5920/how-the-future-of-work-the-workforce-and-the-workplace-is-changing
8. https://www.digitalhumans.com/blog/what-is-a-digital-workforce-five-essentials-youll-need-to-know
9. https://www.weforum.org/agenda/2018/09/what-employees-today-future-really-want-personalization/
10. Michal Beňo Vol 5 (2021) The Advantages and Disadvantages of E-working: An Examination using an ALDINE Analysis Emerging Science Journal (ISSN: 2610-9182) Vol. 5, Special Issue "COVID-19: Emerging Research", 2021
11. Naimah Saeed Alrasheedi, David Sammon & Stephen McCarthy (2022). Understanding the characteristics of workforce transformation in a digital transformation context Pages 362-383. https://doi.org/10.1080/12460125.2022.2073636
12. Wuest, Thorsten Romero, David Cavuoto, Lora A. (2020). Empowering the Workforce in Post–COVID-19 Smart Manufacturing Systems, Volume 4, Issue 3

NOVEL DRUG DELIVERY SYSTEMS

P. Selvakumar*[1] and P. Satheesh Kumar[2]

[1]Department of Chemistry,

Nehru Institute of Technology, Coimbatore, Tamilnadu, India

[2]Department of Chemistry,

Dr. N. G. P. Institute of Technology, Coimbatore, Tamilnadu, India

*Corresponding author E-mail: drselvakumar05@gmail.com

Abstract:

Now day's recent advancements in the technology have made novel drug delivery systems (NDDS) to open the doors in various techniques like protection from toxicity, enhancement in stability, improved bioavailability of dosage formulations and protection from physical and chemical degradation. NDDS have also gained the importance by increasing the therapeutic value. The present article gives information regarding various novel techniques used for improving safety, efficacy and application of novel formulation where the main goal for developing such delivery systems is to minimize drug degradation and loss, maintain the drug concentration in therapeutic range for longer period of time, to prevent harmful side effects and to increase bioavailability.

Keywords: Novel drug delivery systems, bioavailability, therapeutic range and drug degradation

Introduction:

Drugs are administered into the body by various methods. The method of drug delivery has a crucial effect on its efficacy and efficiency and so does drug concentration. So it is very necessary to give the optimum concentration of drug to a patient otherwise it can lead to sub-therapeutic or toxic effects. The recent advances made with the understanding of parameters like pharmacokinetic and pharmacodynamic characteristics of drugs can play a huge role in the development of optimal drug delivery systems as they offer a rational approach. New drug delivery strategies often called drug delivery systems have come up and they are based on the approaches from different subjects like pharmaceutics, chemistry and molecular biology etc. and they work on controlling pharmacokinetics, pharmacodynamics and immunogenicity etc. To reduce drug loss, potentiate drug availability and to prevent dangerous side effects novel drug delivery systems are being used [1].

A novel drug delivery system comprises a medical device or dosage form or technology to carry the drug inside the human body. The conventional drug delivery system involves serious limitations in terms of higher dosage required, toxicity and adverse effects etc. So, novel drug systems have been developed to overcome the limitations of the conventional drug delivery systems by targeting a site specific region to achieve the therapeutic effect thereby reducing the side effects or toxic effects. They include processes based on both physical and biochemical mechanisms [2]. Physical mechanisms are also called controlled drug delivery systems. They include electron transport, diffusion, osmosis, dissolution and erosion. The biochemical mechanisms are liposomes, gene therapy, monoclonal antibodies etc.

Advantages of novel drug delivery systems:

- The efficacy of drug is increased
- Delivers drug to the target site so it is site specific
- Drug is protected from physical and chemical degradation
- Enhancement of solubility and stability
- Bioavailability is increased
- Better patient compliance is delivered
- Reduction in toxicity or side effects
- Enhancement of pharmacological activity
- Sustained delivery of drug
- Improved tissue macrophages distribution [3, 4].

Types of novel drug delivery systems

The various types of novel drug delivery systems include [5]:

1. Phytosomes

Phytosomes are lipid compatible molecular complexes which are composed of “phyto” which means plant and “some” meaning cell-like that are formed by complexing the polyphenolic phytoconstituents in the molar ratio with phosphatidyl choline. Phytosomes are new herbal drug delivery systems which are advanced and better equipped as they are well absorbed and utilized to produce better results than those produced by conventional herbal extracts [6].

Advantages

- They show better results than conventional products
- The absorption of active ingredients is improved in phytosomes
- The phytosomes also show good stability and improves percutaneous absorption.

2. Liposomes

Liposomes are phospholipid -based colloidal vesicular structures in which hydrophilic core is entirely enclosed by membranous lipid bilayer's. Liposomes are concentric bilayered structures made of amphipathic phospholipids and depending on the number of bilayer, liposomes are classified as multilamellar (MLV), small unilamellar (SUVs), or large unilamellar (LUVs). They range in size from 0.025-10 μm in diameter. The size and morphology of liposomes are regulated by the method of preparation and composition. Liposomes are used for delivery of drugs, vaccines, and genes for a variety of disorders. They are widely used for cancer treatment and reduces its side effects like nausea, vomiting and hair loss as they deliver the molecules to the target site as the drug can be encapsulated thereby protecting healthy cells from toxicity. Another important use of liposomes is they also act as drug carriers by carrying the drugs to their site of action. Liposomes in both modified and unmodified forms are able to change the course of pharmacokinetic parameters of the drugs. Modified liposomes also have huge applications in targeting various drugs to the organs like heart, liver, kidney, lungs and bones [7, 8]. Examples: Amphotericin B, daunorubicin and cytarabine.

Advantages

- These are the most extensive and explored drug delivery system
- Ease of preparation
- They are site specific
- Good biocompatibility
- Non-toxic and non-immunogenic
- Bind with specific ligands flexibly [9].

3. Nanoparticles

Nanoparticles are amorphous or crystalline solid substances varying in the size range 10-200 nm. They adsorb or encapsulate the drug and protect it from chemical and enzymatic degradation. They are potential drug delivery devices due to their wide applications in the controlled release of drugs, in targeting particular organ/or tissue, as carriers of DNA in gene therapy, and in their abilities to deliver proteins peptides and genes through pre-oral route. There are different types of nanodevices and they can be classified as nanotubes, nanowires, nanocantilevers, nanoshells, quantum dots, nanopores, gold nanoparticles and bucky balls [10, 11].

Advantages

- Delivers directly to the site of action
- Increased efficacy and therapeutic index

- Enhanced pharmacokinetic effect
- Low drug dose is sufficient
- Drug delivery is uniform
- Administration through different routes is possible
- Producible with various sizes, compound surface properties [12].

4. Microspheres

Microspheres are small spherical free flowing particles composed of biodegradable proteins or synthetic polymers with diameter in the range 1-1000 μm. These are also called microparticles or microcapsules. The materials used for making microspheres include the polymer of natural synthetic origin and also modified natural substances. Synthetic polymers employed as carriers materials are methyl methacrylate, acrolein, lactide, glycolide and their co-polymers, ethylene vinyl acetate and polyanhydrides etc. The natural polymers used for the purpose include albumin, gelatin, starch, agarose, collagen & polydextran etc. They are used in antimalarial drugs, as efficient carriers in delivering of drugs, for targeted drug delivery to tumour cells etc [13, 14].

Advantages

- Microspheres provide constant and prolonged therapeutic effect
- Reduces the dosing frequency and thereby improve the patient compliance
- Better drug utilization will improve the bioavailability
- Reduce the incidence or intensity of adverse effects
- Microsphere morphology all owes a controllable variability in the degradation and drug release [15].

5. Ethosomes

They are developed by a mixture of phospholipid and highly concentrated ethanol. This carrier is important and it penetrates deeply into the skin and improves the drug delivery into deeper layer of skin and in blood circulation. They are very helpful in the topical delivery of alkaloids in the form of gel and cream. They show increase in their permeability through the skin by fluidizing the lipid domain of the skin. Unstable nature and poor skin penetration are the limits of ethosomes [16].

Advantages

- They improve transdermal delivery of drug through skin
- They help in the delivery of large amounts of diverse groups of drugs.
- Ethosomes are administered in semisolid form resulting in improvement in patient's compliance [17].

6. Niosomes

Niosomes are multilamellar vesicles formed from non-ionic surfactants of the alkyl or dialkylpolyglycerol ether class and cholesterol. Niosomes are widely used as an alternative to liposomes and behave in-vivo like liposomes, and they offer certain advantages over them prolonging the circulation of entrapped drug and altering its organ distribution and metabolic stability. Nonionic surfactants vesicles are prepared by the incorporation of components containing non- ionic surfactants. However, they may also be prepared with various ionic amphiphiles such as dicetylphosphate and stearylamine. The vesicles forming non-ionic compounds are mainly alkyl ether lipids that are further divided into two classes based on nature of their hydrophilic head groups, i.e., alkyl ethers in which the hydrophilic head group consists of repeat glycerol subunits, related isomers or larger sugar molecules, and those in which the hydrophilic head group consists of repeat ethylene oxide subunits. In addition, alkyl esters, amides and fatty acids, and amino acids compounds also from vesicles [18, 19].

Advantages

- Decreases drug induced toxic side effects
- Increasing the anti-tumor efficacy of various anti neoplastic agents
- The drug is targeted to its desired site of action and/or to control its release
- Various types of drug deliveries can be possible using niosomes like targeting, ophthalmic, topical and parentral.

7. Resealed erythrocytes as drug carriers

Erythrocytes are the most abundant cells in our body. Erythrocyte is red blood cell (RBC). Erythrocyte is biconcave discs, anucleate filled with haemoglobin, a protein that functions in gas transport. It contains the plasma protein spectrin. Healthy adult male contains 4.5 millions/μmL of erythrocytes where as healthy adult female contains 4.8 millions/ μmL. Immature RBC are called “reticulocytes.” Erythrocytes are biocompatible, biodegradable, possess very long circulation halflives and they can be filled with a variety of biological substances using physical and chemical methods for delivery of drugs [20]. Drug loaded erythrocytes or carrier erythrocytes are one of the growing and potential systems for delivery of drugs and enzymes. In this the drug is broken down and is entrapped into erythrocytes and they are resealed and resultant carriers are then called as “resealed erythrocytes”. Upon reinjection the drug loaded erythrocytes serve as slow circulation depots targets the drug to reticulo-endothelial system [21].

Properties of resealed erythrocytes:

- It should be biocompatible and less toxic

- Should be able to carry broad spectrum of drug
- Should be stable during storage
- The drug should be released at the target site
- It should be physico -chemically compatible with drug [22].

Advantages

- They are non-immunogenic in nature
- No chemical modification of the drug and the substance to be entrapped is required
- It is biodegradable in nature
- Systemic activity of the drug is prolonged
- Isolation of erythrocyte is easy and larger amount of drug can be encapsulated in small volume of cells
- Targeting the drug within the reticulo-endothelial system is possible.

Disadvantages

- There is a possibility of clumping of cells and dose dumping
- Not suitable for highly polar and non-diffusible drugs
- The technique is not very economic
- They have a limited potential as carrier to non-phagocyte target tissue [23].

8. Hydrogels

Hydrogels are three-dimensional, hydrophilic and polymeric networks capable of imbibing large amounts of water or biological fluids. They are used to regulate drug release in reservoir-based, controlled release systems or as carriers in swellable and swelling-controlled release devices. They are divided into three types- based on preparation methods like co-polymeric hydrogel, stimuli sensitive hydrogels like temperature sensitive and pH sensitive hydrogels and based on mechanism of drug release like diffusion or swelling controlled [24, 25].

Advantages

- Hydrogels are easily modified
- Possess wide degree of flexibility
- They are biodegradable and biocompatible.

9. Transdermal drug delivery system

Transdermal drug delivery system is defined as self-contained, discrete dosage forms, when applied to the intact skin, deliver the drug through the skin at controlled rate to the systemic circulation. Transdermal drug delivery system established itself as an integral part of novel drug delivery systems; drug delivery via the transdermal route is an interesting option because transdermal route is convenient and safe. It avoids problems such as gastrointestinal

irritation, metabolism, variations in delivery rates and interference due to the presence of food. It is also suitable for unconscious patients. The technique is generally non-invasive and aesthetically acceptable, and can be used to provide local delivery over several days. Slow penetration rate, lack of dosage flexibility and restriction to low dosage drugs are certain limits of this delivery system [26, 27].

Advantages

- Avoids first pass metabolism and enhances therapeutic efficacy
- Avoidance of gastro intestinal incompatibility
- Predictable and extended duration of activity
- Improves physiological and pharmacological response
- Termination of therapy is easy at any point of time
- Greater patient compliance due to elimination of multiple dosing profile
- Provides suitability for self-administration of dosage form [27].

Conclusion:

Novel drug delivery system is a combination of advance technologies and new dosage forms which are far better than the conventional dosage forms. Good utilization of the NDDS not only helps in reducing the repeated administration to overcome non-compliance, but also helps to increase the therapeutic value by reducing the toxicity and increasing the bioavailability, and so on which leads to an improvement in the overall healthcare system in the country. Application of these novel techniques have led to enhanced bioavailability, reduced toxicity, sustained release action and protection from gastrointestinal fluids which cannot be obtained through conventional drug delivery system due to large molecular size, poor solubility and degradation in gastrointestinal media.

References:

1. Bhagwat R.R. and I.S. Vaidhya, (2013). “Novel Drug Delivery Systems: An Overview”, International Journal of Pharmaceutical Sciences and Research., vol. 4, no. 3, pp. 970-982.
2. Reddy P.D. and D. Swarnalatha, (2010). “Recent advances in Novel Drug Delivery Systems”, International Journal of Pharmaceutical Technology and Research., vol. 2, no. 3, pp. 2025-2027.
3. Akash B.and S. Ravindranath, (2019). “A Review on Novel Drug Delivery System: A Recent Trend”, Journal of Drug Delivery & Therapeutics., vol. 9, no. 3, pp. 517-521
4. Ziaie, B. *et al.* (2004). “Hard and Soft Micro machining for Biomems: Review of Techniques and Examples of Applications in Microfluidics and Drug Delivery”, Advanced Drug Delivery Reviews., vol. 56, no. 3, pp. 145-72.

5. Jain, N. K. (2002). "Controlled and Novel Drug Delivery", CBS Publishers and Distributers, New Delhi, 4th edition, pp. 236-237.
6. Amin T. and S.V. Bhat, (2012). "A Review on Phytosome Technology as a Novel Approach to Improve the Bioavailability of Nutraceuticals", International Journal of Advancements in Research and Technology., vol. 1, no. 3, pp. 1-15.
7. Gaurav, T. *et al.* (2012). "Drug Delivery Systems: An Updated Review", International Journal of Pharmaceutical Investigation., vol. 2, no. 1, pp. 2-11.
8. Rajan Verma K. and Sanjay Garg, (2001). "Current Status of Drug Delivery Technologies and Future Directions", Pharmaceutical Technology On-Line., vol. 25, no. 2, pp. 1–14.
9. Kharat A.and P. Pawar, (2014). "Novel Drug Delivery System in Herbals", International Journal of Pharmaceutical, Chemical and Biological Sciences., vol. 4, no. 4, pp. 910-930.
10. Soppimath, K.S. *et al.* (2001)., "Biodegradable Polymeric Nanoparticles as Drug Delivery Devices", Journal of Controlled Release., vol. 70, no. 1-2, pp. 1-20.
11. Agnihotri, S.A., *et al.* (2004). "Recent Advances on Chitosan-Based Micro and Nanoparticles in Drug Delivery", Journal of Controlled Release., vol. 100, no. 1, pp. 5-28.
12. Paolicelli, P. *et al.* (2009). "Chitosan Nanoparticles for Drug Delivery to the Eye", Expert Opinion on Drug Delivery., vol. 6, no. 3, (2009). pp. 239-253.
13. Vaibhav, R.*et al.* (2016). "Microspheres: A Promising Drug Carrier", Journal of Drug Delivery & Therapeutics., vol. 6, no. 3, pp. 18-26.
14. Kumar, A. *et al.* (2011). "Microencapsulation: As a Novel Drug Delivery System", Internationale Pharmaceutica Sciencia., vol. 1, no.1, pp. 1-7.
15. Sree Giri Prasad, B. *et al.* (2014). "Microspheres as Drug Delivery System – A Review", Journal of Global Trends in Pharmaceutical Sciences., vol. 5, no. 3, pp. 1961–1972.
16. Jaiswal, P.K. *et al.* (2016). "Ethosome: A New Technology used as Topical & Transdermal Delivery System", Journal of Drug Delivery & Therapeutics., vol. 6, no. 3, pp. 7-17.
17. Prabhakar V. and S. Saurabh, (2014). "Liposomes: An Overview", Journal of Drug Delivery and Therapeutics., vol. 1, pp. 47-55.
18. Madhav N.V.S. and A. Saini, (2011). "Niosomes: A Novel Drug Delivery System", International Journal of Research in Pharmacy and Chemistry., vol. 1, no. 3, pp. 498-511.
19. Pagar K.R. and V.K. Sarika, (2019). "A Review on Novel Drug Delivery System: A Recent Trend", Asian Journal of Pharmacy and Technology., vol. 9, no. 2, pp. 135-140.
20. Deshmukhe A.and S. Shetty, (2010). "Resealed Erythrocytes: A Novel and Promising Drug Carrier", International Journal of Pharmaceutical Science and Research., vol. 8, no. 8, pp. 324- 325.

21. Villa, C. H. *et al.* (2017). "Erythrocytes as Carriers for Drug Delivery in Blood Transfusion and Beyond", Transfusion Medicine Reviews., vol. 31, no. 1, , pp. 26-35.
22. Gupta, A. (2010). "Cell Based Drug Delivery System through Resealed Erythrocyte: A Review", International Journal of Pharmaceutical Sciences and Drug Research., vol. 2, no. 1, pp. 23-30.
23. Yang, V.C. *et al.* (2010). "Erythrocyte Encapsulated L- Aspaginase for Enhanced Acute Lymphoblastic Leukaemia Therapy", U.S. Patent 20100284982, Nov 11.
24. Byrne, M.E. *et al.* (2002). "Molecular Imprinting within Hydrogels", Advanced Drug Delivery Reviews., vol. 54, pp. 149-161.
25. Muller Goymann, C.C. (2004). "Physicochemical Characterization of Colloidal Drug Delivery Systems such as Reverse Micelles, Vesicles, Liquid Crystals and Nanoparticles for Topical Administration", European Journal of Pharmaceutics and Biopharmaceutics., vol. 58, no. 1, pp. 343-356.
26. Arunachalam, A.*et al.* (2010). "Transdermal Drug Delivery System: A Review", Current Pharma Research., vol. 1, no.1, pp. 70-81.
27. Sharma, B. *et al.* (2011). "Sonophoresis: An Advanced Tool in Transdermal Drug Delivery System", International Journal of Current Pharmaceutical Research., vol. 3, no. 3, pp. 89-97.

IMPROVING POWER QUALITY: ISSUES AND SOLUTIONS

Prabha A[1], Themozhi G*[2] and Balamurugan S. M[3]

[1]Kings College of Engineering, Pudukkottai

[2]Department of EEE, AMET Deemed University, Chennai

[3]Department of EEE, Sri Venkateswara College of Technology, Chennai

*Corresponding author E-mail: gthemozhivijayakumar@gmail.com

Abstract:

Power quality refers to any problem with the power supply that result in utility or end-user electrical equipment failing or malfunctioning. Aberrations in voltage, current, or frequency may be present due to this problem. Today's increasingly linked culture makes it necessary, not optional, to lessen the impact of power quality. Electrical utilities are needed to supply uninterrupted, clean electric energy to modern data management (ISP) and communications centers, telecommunications networks, industrial, commercial, and institutional power systems, as well as microwave relay towers that feed data. Power outages are extremely expensive and can have a negative impact on a company's bottom line. A typical electrical load can be impacted by a wide range of power quality issues, including voltage fluctuations, voltage sags, under-voltage, voltage swells, over-voltage, voltage transients, surge currents, voltage interruptions and outages, harmonic voltage distortion, harmonic content distortion, low power factor, electromagnetic interference (EMI / RFI), and voltage notching. Waveform measurements can be used to detect the majority of harmonic problems, which can then be followed by measurements of the harmonic spectrum, power information, voltage and current magnitudes, etc. Employees with extensive experience in electrical engineering and maintenance are aware of how crucial it is to identify, track down, and address power quality and grounding problems in order to keep structures and power distribution systems operating properly. This article covered the most recent data regarding problems with power quality, power factor, power conditioning, electronic device technologies, power quality businesses, power analyzers, and power quality applications, as well as alternative remedies.

Introduction:

The degree to which the voltage, frequency, and waveform of a power supply system conform to specified requirements is referred to as electric power quality. A stable supply voltage that stays within the prescribed range, a steady AC frequency near to the rated value, and a smooth voltage curve waveform are all indicators of good power quality (which resembles a

sine wave). In general, power quality can be defined as the compatibility between what comes out of an electric outlet and the load hooked into it. [1] The phrase refers to the electric power that powers an electrical load as well as the load's ability to perform effectively.

There are numerous ways in which electric power might be of poor quality, as well as numerous causes of such power. The electric power industry consists of energy generation (alternating current power), transmission, and finally distribution to an electricity metre installed at the end user's premises. The electricity is then routed through the end user's wiring system until it reaches the load. The intricacy of the infrastructure used to transport electric energy from point of production to point of consumption, combined with variations in weather, generation, demand, and other factors, creates several opportunities for supply quality to be compromised.

While "power quality" is a convenient term for many, the term actually describes the quality of the voltage rather than power or electric current. The current demanded by a load is mostly unregulated, and power is just the movement of energy.

The quality of electrical power can be expressed as a set of parameter values, such as: Service continuity, Magnitude variation in voltage, Voltage and current transients, Harmonic content in AC power waveforms. It's helpful to think of power quality as a compatibility issue: is the equipment connected to the grid compatible with the grid's events, and is the power given by the grid, including the events, compatible with the connected equipment? Compatibility issues always have two solutions: either clean up the power or make the device more durable.

Good and poor power quality

A power source that is constantly available, always within voltage and frequency tolerances, and has a pure noise-free sinusoidal wave shape is referred described as having ‘Good power quality’. 'Poor power quality' defines any supply that deviates from this ideal; whether or not the divergence is significant relies on the installation's purpose, equipment design, and installation design.

Power quality problems

Problems with power quality can be broadly categorized into the following categories such as Voltage drops, Micro-interruptions, Prolonged pauses, Spikes in voltage, Voltage surges, Distortion of harmonics

Voltage sags

A reduction in the usual voltage level of 10 to 90% of the nominal rms voltage at the power frequency for durations ranging from 0, 5 cycle to 1 minute. The main causes of voltage sag include transmission or distribution network faults, consumer installation faults, connection of heavy loads, and start-up of large motors. The implications of microprocessor-based control

system will cause process stoppage, disconnection and loss of efficiency in electric rotating machines.

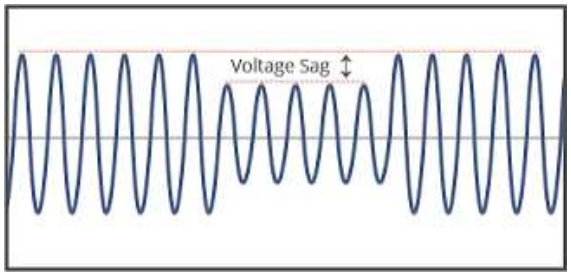


Figure 1: Voltage Sag

Micro interruptions

Micro interruptions are described as total electrical supply outages lasting from a few milliseconds to one or two seconds. Micro interruptions are caused by the opening and automated reclosing of protective devices, insulation failure, lightning, and insulator flashover. Micro interruptions cause protection mechanisms to trip, information to be lost, data processing equipment to malfunction, and sensitive equipment to stop working (such as ASDs, PCs, PLCs).

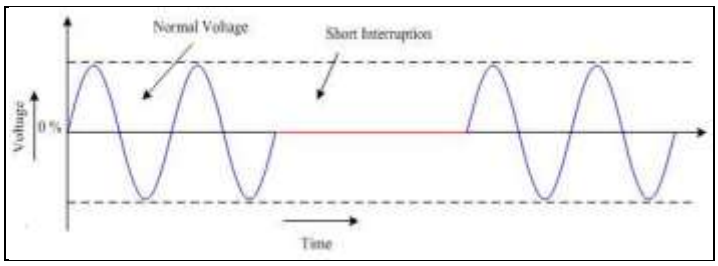


Figure 2: Micro Interruptions

Voltage spikes

Voltage spikes are very fast variations in voltage that last from a few microseconds to a few milliseconds. Lightning, switching of lines or power factor correction capacitors, and disconnection of heavy loads are all causes of voltage spikes. The effects include component and insulating material destruction, data processing errors or data loss, and electromagnetic interference.

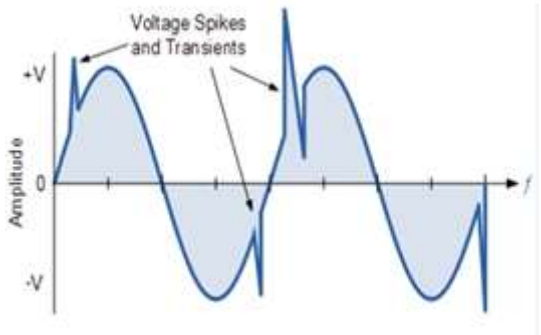


Figure 3: Voltage Spikes

Harmonic distortion

Voltage and current waveforms are non-sinusoidal. Harmonic distortions are waveforms that correspond to the sum of several sine-waves with varied magnitude and phase and have frequencies that are multiples of the power-system frequency. Harmonic distortion are caused by classic sources such as electric machines operating above the knee of the magnetization curve (magnetic saturation), arc furnaces, welding machines, rectifiers, and DC brush motors, as well as modern sources such as all non-linear loads such as power electronics equipment including ASDs, switched mode power supplies, data processing equipment, and high efficiency lighting.

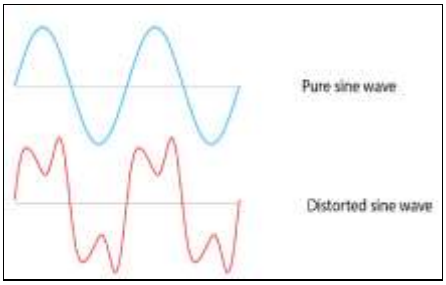


Figure 4: Harmonic Distortion

Harmonic distortion causes increased likelihood of resonance, nuisance tripping of thermal safeguards, electromagnetic interference, increase in losses, and loss of efficiency in electric machines (e.g. 5th harmonic).

Resolutions to power quality issues

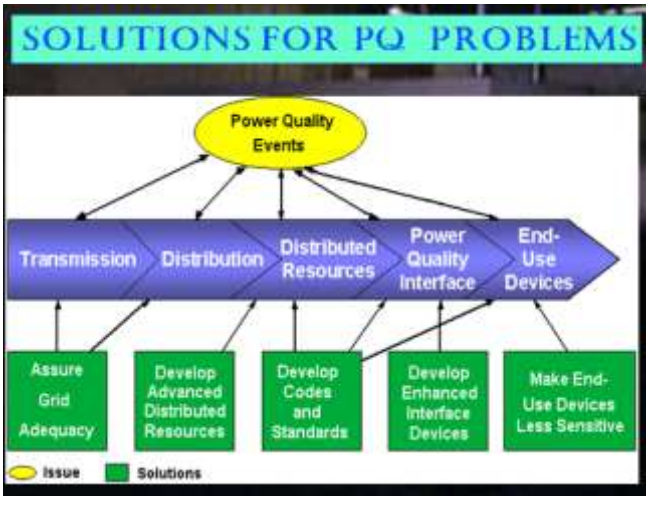


Figure 5: Solutions to Power Quality Problems

Grid adequacy

Many PQ issues have their roots in the T&D network. Many PQ issues can be avoided by having a high level of redundancy, cleaning the insulators, trimming the trees next to the power lines, and having a properly planned and maintained grid.

Distributed resources

Distributed resources play a vital role in power quality improvement. Example distributed generation and energy storages.

Distributed generation

Critical loads are supplied with "clean power" using this technique, which isolates them from grid-related problems. Backup generators ensure that critical loads receive electricity during extended power outages. Combining electrochemical batteries UPS with a diesel generator is the most typical approach. Currently, several manufacturers are starting to provide this combination of a flywheel and a diesel generator as a popular option.

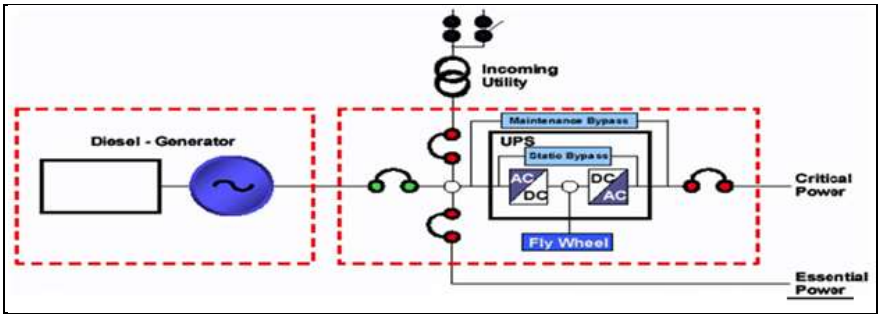


Figure 6: Distributed Generations

Distributed resources – energy storage systems

In low PQ environments, energy storage solutions, usually referred to as restorative technologies, are employed to give electric loads the ability to ride through.

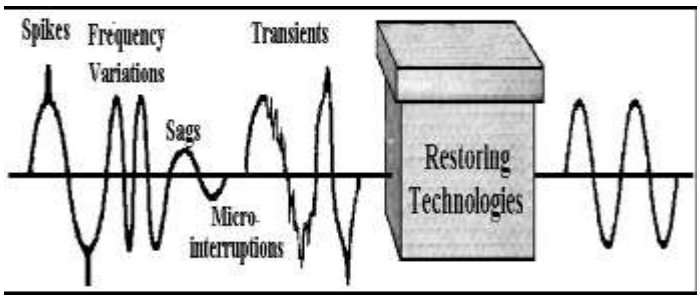


Figure 7: Energy Storage Systems

Flywheel

The technologies that have brought our society to the point where it is now possible to manage the electrical network are known as energy storage systems (ESSs). The world is fascinated by the ESS technology because of its stability, management of voltage and frequency lags, improvement in power quality, and balance in supply and demand. However, despite being one of the more traditional ESS, flywheel ESS (FESS) has developed a reputation for being environmentally friendly and capable of megajoule-level energy storage.

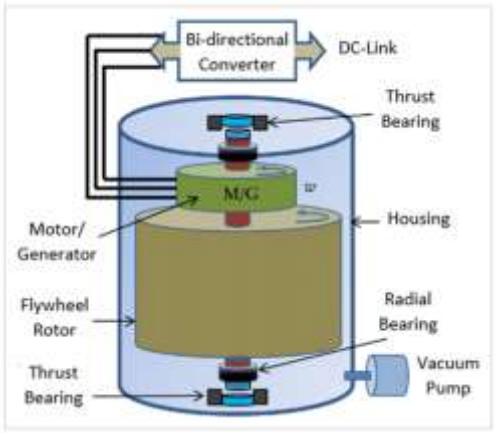


Figure 8: Flywheel

Supercapacitors

The supercapacitor is ideal for energy storage that undergoes frequent charge and discharge cycles at high current and short duration. And also it has simple charge methods, that is no full-charge detection is needed or no danger of overcharge. They can operate under much higher temperature.

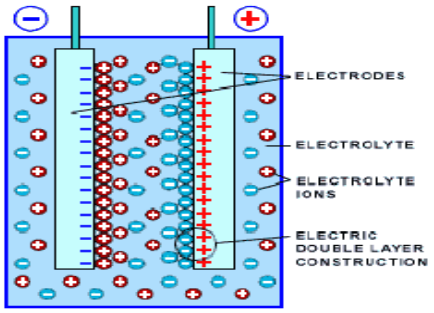


Figure 9: Supercapacitors

Superconducting Magnetic Energy Storage (SMES)

A coil constructed of superconductor material, which has a high power density, a very quick response, and is highly expensive, stores energy in its magnetic field.

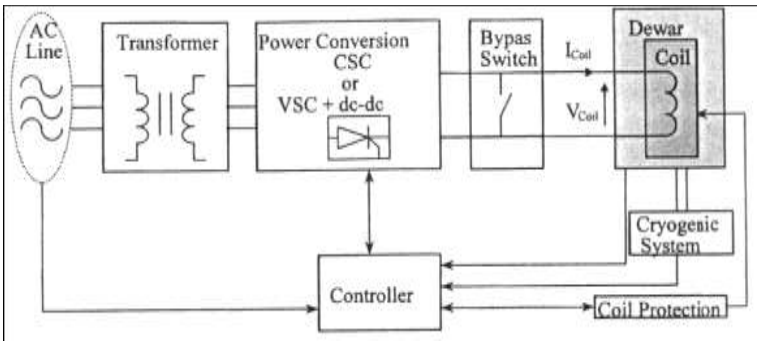


Figure 10: Superconducting Magnetic Energy Storage (SMES)

Codes and Standards

Most relevant standards:

CBEMA curve

The CBEMA curve, which gives the duration and magnitude of voltage fluctuations that may be tolerated, is frequently used to describe data-processing equipment's tolerance to voltage variations.

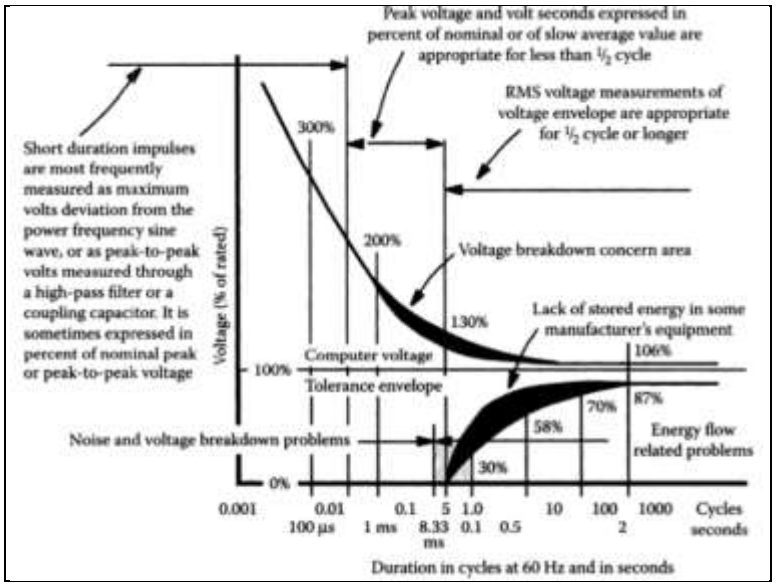


Figure 11: CBEMA Curve

ITIC curve

The ITIC and CBEMA curves both serve the same function. **The ITIC curve has better defined voltage and duration levels for detection and graphing of voltage events**. The Revolution has the capability to detect and record each type of anomaly based on the ITIC regions. The ITIC curve indicates where IT equipment such as computers, servers, power distribution units, programmable logic controllers and telecommunication equipment is expected to operate properly within the middle “no interruption in function region” portion of the curve

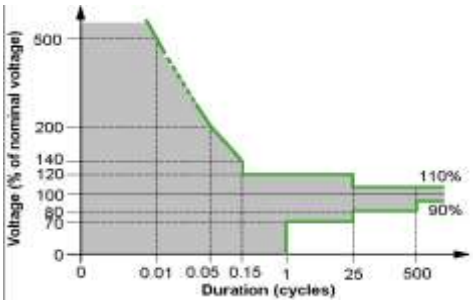


Figure 12: ITIC Curve

- IEC 61000
- EN 50160:2001

- IEEE standards
  - 519-1992 →Harmonics
  - 1100-1992 →Powering and grounding sensitive equipment
  - 1159-1992 →Monitoring power quality
  - 1250-1995 →Service of sensitive equipment

These norms and standards outline our duties as well as those of our electric consumers in order to maintain excellent electric service. They also assist in identifying the voltage range needed to operate equipment efficiently, which is crucial for the dependable and effective operation of sensitive electronic loads.

Enhanced Interface Devices

One can separate the loads from disturbances resulting from the grid by using the appropriate interface devices. Several of the improved interface devices include:

A. Dynamic Voltage Restorer

In series with the load, a dynamic voltage restorer (DVR) functions as a voltage source. At the load terminals, the DVR's output voltage is maintained roughly constant.

B. Transient Voltage Surge suppressors (TVSS)

In order to prevent transient voltage from damaging sensitive loads, transient voltage surge suppressors (TVSS) are employed

C. Noise Filters

To keep undesired frequency current or voltage impulses (noise) from damaging sensitive equipment, noise filters are utilised.

D. Static VAR Compensators

Rapid voltage regulation is accomplished by static VAR compensators (SVR) using a reactor and capacitor combination.

E. Harmonic Filters

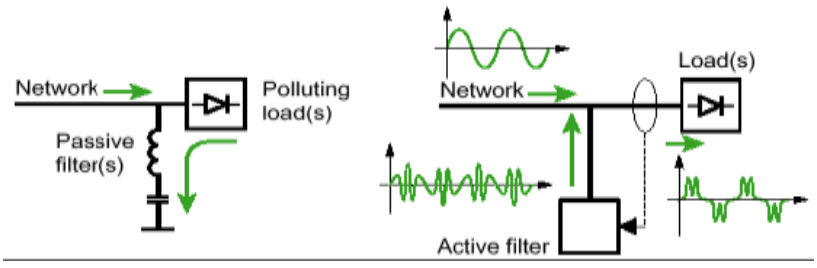


Figure 13: Harmonic Filters

Unwanted harmonics can be reduced using harmonic filters. Passive filters and active filters are two categories into which they can be separated. A low impedance link to the frequencies of the harmonics that will be dampened by passive components makes up passive

filters (left) (inductors, capacitors and resistors). Active filters (right) analyze the load's current usage and generate a current that cancels the harmonic current the load produces.

Make end-use devices less sensitive

Making end-use devices less susceptible to PQ disruptions is typically a more cost-effective solution than purchasing equipment to address these issues. Some steps to improve equipment resistance: power supplies should be upgraded with a bigger capacity capacitor; Utilize cables with more substantial neutral conductors; transformers that derate.

Conclusions:

For the smooth operation of contemporary society, high-quality electric power must be readily available. While some industries are content with the calibre of the power supplied by utilities, others have higher standards. The most demanding customers must take steps to stop the problems in order to avoid the significant losses associated with PQ issues. The choice of less sensitive equipment among the many measures can be crucial. When even the most durable equipment is impacted, additional steps must be taken to prevent PQ issues, such as installing restorative technology, FACTS devices, distributed generation, or an interface device.

References:

1. Von Meier and Alexandra (2006): Electric power systems: a conceptual introduction. John Wiley & Sons. p. 1. ISBN 9780470036402.
2. Galli A.W. *et al.* (1996). Exploring the power of wavelet analysis. IEEE Computer Applications in Power Volume: 9, Issue: 4 : pp: 37 – 41.
3. Ribeiro M.V. *et al.* (2001). An enhanced data compression method for applications in power quality analysis.27th Annual Conference of the IEEE Industrial Electronics Society. Vol. 1: pp. 676–68.
4. Ribeiro M.V. *et al.* (2004). An improved method for signal processing and compression in power quality evaluation. IEEE Transactions on Power Delivery, Vol. 19 (2): pp.464–471.
5. Jan Kraus et al (2009). "Lossless encodings and compression algorithms applied on power quality datasets". 20th International Conference and Exhibition on Electricity Distribution, pp. 1–4.
6. Hossain E. *et al.* (2018). Analysis and Mitigation of Power Quality Issues in DG Systems Using Custom Power Devices, Vol.6: pp. 16816-16833.
7. Singh Rajendra (2022). Different Power Quality Issues of the Energy Power System with Their Analysis and Mitigation Techniques, ECS Transactions, Vol.107, No. 1

RADIATION AND ITS IMPACT: UNDERSTANDING THE SCIENCE AND HEALTH RISKS

Kulshrestha Himani*[1], Jadoun Singh Pratap Surya[1],

Asthana Shobhit[2] and Singh Akhand Pratap[1]

[1]Maharishi University of Information Technology, Lucknow, India

[2]School of Engineering and Applied Sciences, Bennett University, Greater Noida, India

*Corresponding author E-mail: himanikul01@gmail.com

Abstract:

Radiation is a ubiquitous presence in our environment, with living organisms constantly exposed to cosmic rays from space and natural radioactive sources near the Earth's surface. Understanding the nature of radiation and its impact on biological systems is of paramount importance. This book provides a comprehensive exploration of radiation, focusing on its types, interactions with matter, biological effects, and mechanisms of cellular damage. Additionally, radioprotection, the practice of mitigating the harmful effects of radiation, is discussed in detail.

Introduction:

Living organisms exist in a radiation environment, constantly bombarded by various forms of radiation from both cosmological and earthly sources. Radiation encompasses the movement of atomic and subatomic particles, as well as waves such as X-rays, heat rays, and light rays. It can be classified into ionizing and non-ionizing radiation based on its ability to dislodge electrons and cause harm to biological molecules.

Ionizing radiation poses a greater health risk to individuals as it can alter the fundamental structure of atoms in cells, particularly DNA molecules. This type of radiation includes alpha particles, beta particles, and gamma rays, each with distinct characteristics and potential dangers. Alpha particles are positively charged particles emitted during radioactive disintegration and can be particularly hazardous if inhaled. Beta particles, composed of smaller electrons, can cause damage to human skin and tissues. Gamma rays, powerful electromagnetic energy released during radioactive decay, exhibit great penetrating capability and interact with matter through processes like the photoelectric effect, Compton scattering, and pair creation.

The biological effects of gamma radiation are of significant interest, as it can induce DNA damage, oxidative stress, and inflammation within cellular systems. The severity of these effects depends on the dose, duration of exposure, and physiological state of the cells. Radiation

exposure can lead to a range of consequences, including acute cell damage and long-term stochastic health risks such as an increased likelihood of cancer development.

Cellular damage by gamma radiation occurs through two primary mechanisms. Firstly, ionization of water molecules within the body generates free radicals, initiating disruptive chain reactions that can result in significant DNA damage. Secondly, gamma radiation can directly collide with DNA molecules, ionizing and damaging them. These mechanisms contribute to the adverse effects of radiation on cellular structures and functions.

To mitigate the harmful effects of radiation, radioprotection strategies are crucial. Radioprotection aims to prevent or reduce radiation-induced damage to normal tissues. It involves the use of radioprotectors, which are agents delivered before or during radiation exposure to decrease the damage caused to biological molecules. Radioprotectors act as antioxidants, scavenging free radicals and protecting cells and tissues from oxidative stress. Understanding the mechanisms of radioprotection is vital for developing effective strategies to mitigate the harmful effects of radiation exposure.

In this chapter, we explore the fascinating world of radiation and its impact on biological systems. We delve into the types of radiation, their interactions with matter, and the biological consequences they entail. Furthermore, we discuss radioprotection as a means to safeguard against radiation-induced damage and explore the mechanisms through which radioprotectors exert their beneficial effects. By expanding our knowledge of radiation and radioprotection, we aim to contribute to the development of strategies that promote the health and well-being of individuals in the face of radiation exposure

Radiation

Radiation is a ubiquitous presence in our environment, encompassing the movement of atomic and subatomic particles as well as waves such as X-rays, heat rays, and light rays. It surrounds us both from cosmic sources and natural radioactive substances found near the Earth's surface. Additionally, everyday devices such as the sun, microwaves, and radios emit radiation (Morgan *et al.*, 2003).

Radiation sources

There are various sources of radiation that impact our daily lives. Cosmic rays, originating from outer space, constantly bombard the Earth. Natural radioactive sources, like radon gas, exist in the Earth's crust and contribute to our radiation exposure. Furthermore, we encounter radiation from common devices and technologies, such as X-ray machines, nuclear power plants, and consumer electronics (Kargas *et al.*, 2003).

Classification of radiation

Radiation can be classified into two broad categories: ionizing and non-ionizing, based on its energy level and interaction with matter. Ionizing radiation possesses enough energy to dislodge electrons from atoms, leading to the creation of charged particles and potential damage to biological systems. Examples of ionizing radiation include X-rays, gamma rays, and alpha and beta particles. Non-ionizing radiation, on the other hand, has insufficient energy to remove electrons from atoms and primarily interacts with matter by transferring heat energy. This category includes radio waves, microwaves, and visible light (Lawrence and Rosenberg, 2008).

Health risks associated with ionizing radiation

Ionizing radiation presents significant health risks due to its ability to cause ionization and potentially disrupt cellular structures, particularly DNA molecules. One of the main concerns is the risk of cancer development. Ionizing radiation can damage DNA, leading to mutations that may initiate the uncontrolled growth of cells, which is a hallmark of cancer. Additionally, high doses of ionizing radiation can have immediate acute effects on cells and tissues, causing direct damage and cell death. Long-term exposure to lower levels of ionizing radiation also increases the probability of stochastic effects, such as cancer, as the likelihood of DNA damage accumulates over time (Zhang *et al.*, 2012).

Understanding the risks associated with ionizing radiation is crucial for establishing safety guidelines, implementing appropriate protection measures, and developing strategies to minimize exposure. It is essential to conduct thorough research and studies to evaluate the health effects of radiation exposure and explore methods for mitigating its potential harm.

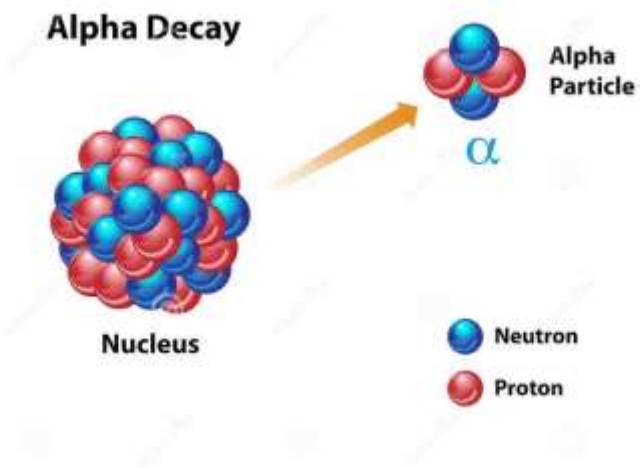
Types of ionizing radiation

1. **Alpha particles**

Alpha particles are positively charged particles consisting of two protons and two neutrons, essentially equivalent to a helium nucleus. They are emitted during the radioactive decay of certain substances, such as uranium and radon. Due to their large size and positive charge, alpha particles have a limited range and are easily stopped by a few centimeters of air or a sheet of chapter. However, they can pose a significant danger when inhaled or ingested.

Dangers of alpha particles

When alpha particles are inhaled or ingested, they can deposit their energy within the body's tissues, particularly in the lungs or other organs. This localized deposition of energy can cause significant damage to surrounding cells and DNA, increasing the risk of developing cancer. Therefore, precautions must be taken to prevent inhalation or ingestion of alpha-emitting substances.

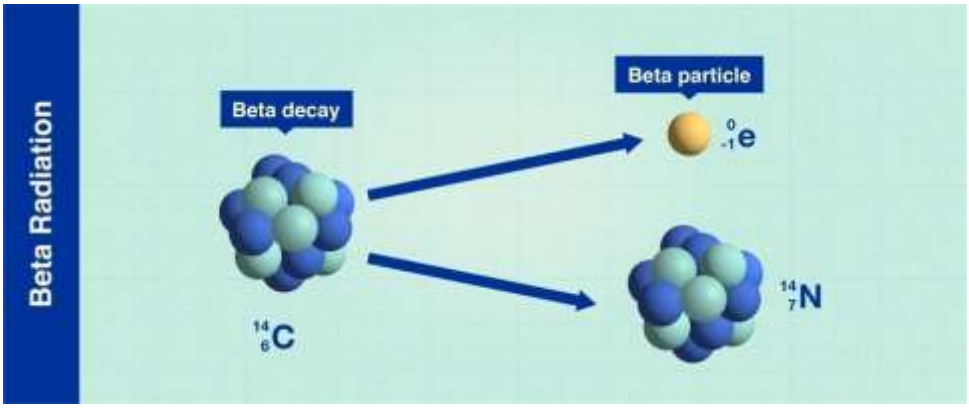


2. Beta Particles

Beta particles are high-energy electrons (β-) or positrons (β+) emitted during the process of beta decay, which occurs when a neutron in the nucleus of an atom is converted into a proton or vice versa. Beta particles are smaller and lighter than alpha particles, and they possess greater penetrating power. They can travel several feet in air and penetrate deeper into human tissue compared to alpha particles (Zhang *et al.*, 2012).

Effects of beta particles on human tissue

When beta particles interact with human tissue, they can ionize atoms and molecules along their path. This ionization process can cause damage to cellular structures and DNA. The extent of tissue damage depends on factors such as the energy of the beta particles, the duration of exposure, and the tissue's sensitivity. Beta particles can lead to skin burns, radiation dermatitis, and potential damage to deeper tissues (Claus *et al.*, 2005).



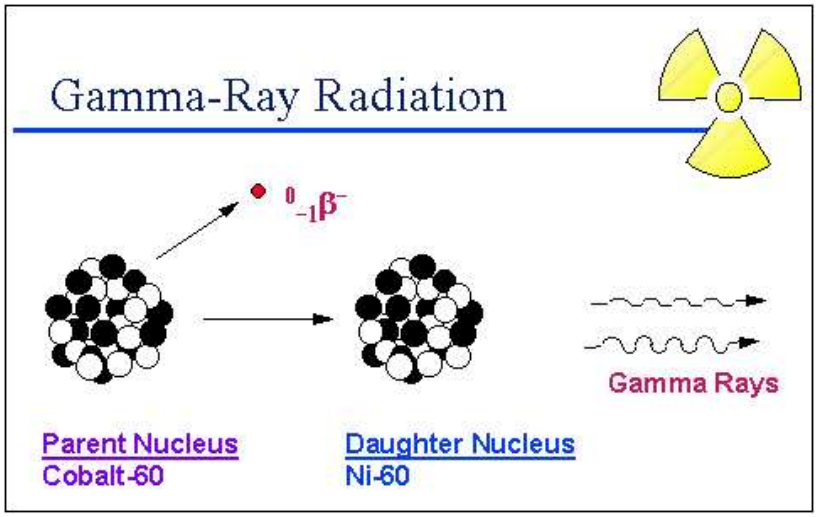
3. Gamma rays

Gamma rays are electromagnetic radiation of extremely high energy and short wavelength. They are produced by the nucleus of an atom during radioactive decay processes. Unlike alpha and beta particles, gamma rays have no mass or charge, making them highly

penetrating and capable of traveling long distances through air and other materials (Claus *et al.*, 2005).

Properties and interaction with matter

Gamma rays have tremendous penetrating power, enabling them to pass through most substances, including human tissue. They can interact with matter through three primary processes: the photoelectric effect, Compton scattering, and pair production. In the photoelectric effect, gamma rays transfer all their energy to an electron, resulting in the ejection of the electron from an atom. Compton scattering involves the scattering of gamma rays by electrons, causing a reduction in photon energy. Pair production occurs when high-energy gamma rays convert into matter, producing an electron-positron pair [Chen (2014).



Interaction of gamma radiation with matter:

Photoelectric effect

The photoelectric effect is an interaction process between gamma rays and matter. When a gamma ray photon encounters an atom, it may transfer all its energy to an electron in one of the atom's inner shells. This interaction causes the electron to be ejected from the atom, resulting in the creation of an ionized atom and a free electron. The energy carried by the gamma ray is entirely absorbed by the electron, leading to the ionization of the atom and potentially causing subsequent ionization events (Morgan *et al.*, 2003).

Consequences of the photoelectric effect

The photoelectric effect can have significant consequences in biological systems. When gamma rays interact with atoms in living tissue, the ejection of electrons can lead to the creation of free radicals, which are highly reactive and can initiate chain reactions within cells. These reactions can disrupt cellular structures and DNA, potentially resulting in genetic mutations and

other harmful effects. The photoelectric effect plays a role in the biological damage caused by gamma radiation (Kargas *et al.,* 2003).

Compton scattering

Compton scattering is another interaction mechanism between gamma rays and matter. In this process, a gamma ray photon collides with an electron in an atom. The collision causes the gamma ray to scatter in a different direction, while the electron recoils and gains kinetic energy. The energy of the scattered gamma ray is reduced compared to its initial energy due to the transfer of energy to the recoiling electron (Lawrence and Rosenberg, 2008).

Description and energy reduction in compton scattering

Compton scattering involves the transfer of energy and momentum between the gamma ray and the electron. The scattered gamma ray has a lower energy and longer wavelength compared to the incident gamma ray. The amount of energy reduction depends on the scattering angle and the energy of the initial gamma ray. Compton scattering is one of the primary processes through which gamma rays lose energy as they interact with matter [Zhang *et al.* (2012).

Pair creation

Pair creation is a unique phenomenon that can occur when high-energy gamma rays interact with matter. In this process, a gamma ray photon converts its energy into mass, resulting in the creation of an electron-positron pair. The gamma ray must have sufficient energy to satisfy the conservation of energy and momentum requirements for the creation of the particle-antiparticle pair (Karagas *et al.,* 2003).

Transformation of gamma rays into electron-positron pairs

During pair creation, the gamma ray photon is transformed into an electron and a positron. These particles carry equal and opposite charges. The energy of the gamma ray is divided between the two particles, with each particle acquiring a portion of the original gamma ray's energy. Pair creation is a process that occurs in high-energy environments, such as in nuclear reactions or near dense materials.

Biological effects of gamma radiation:

Penetrating capability and external risk

Gamma radiation possesses a high penetrating capability, enabling it to pass through most substances, including human tissue. This characteristic allows gamma rays to interact with cells and tissues throughout the body. While alpha and beta particles have limited ranges, gamma radiation can travel long distances and affect organs and tissues far from the radiation source.

Consequently, gamma radiation is considered an external risk, as it can impact the body from outside sources (Morgan *et al.,* 2003).

Acute consequences of high doses

Exposure to high doses of gamma radiation can have immediate and direct acute consequences on biological systems. The damage caused by such high-dose exposure is primarily attributed to the ionization of atoms and molecules within the body. When gamma rays interact with water molecules, ionization occurs, leading to the creation of free radicals. These free radicals can initiate disruptive chain reactions, causing significant damage to cellular structures and DNA (Kargas *et al.,* 2003).

The acute consequences of high-dose gamma radiation exposure can include severe cell damage, tissue injury, and immediate health effects such as radiation sickness. The severity of these effects depends on the dose and duration of exposure. High-dose radiation exposure requires prompt medical attention and appropriate treatment to mitigate the immediate consequences (Lawrence and Rosenberg, 2008).

Stochastic health risks associated with low exposure levels

Stochastic health risks refer to the probability of developing health effects, particularly cancer, as a result of exposure to radiation. While high-dose radiation exposure is more likely to cause immediate damage, long-term exposure to low levels of gamma radiation can also pose health risks. As the exposure level increases, so does the likelihood of developing cancer.

The primary mechanism through which low levels of gamma radiation can induce cancer is through DNA damage. Even though a single cell contains trillions of atoms, a significant alteration in its structure requires a high amount of radiation. However, over time, repeated exposure to low levels of gamma radiation increases the probability of DNA damage and genetic mutations, which can lead to the development of cancer (Zhang *et al.,* 2012).

It is important to note that the stochastic health risks associated with low exposure levels are probabilistic, meaning that they are based on statistical probabilities rather than certain outcomes. These risks emphasize the need for radiation safety measures, dose monitoring, and adherence to radiation protection guidelines to minimize the potential long-term health effects (Karagas *et al.,* 2003).

Mechanisms of cellular damage by gamma radiation:

Ionization of water molecules and creation of free radicals

When gamma radiation interacts with living tissue, one of the primary processes involves the ionization of water molecules. Gamma rays have sufficient energy to remove electrons from

water molecules, resulting in the creation of highly reactive ions. This ionization process generates free radicals, which are molecules or atoms with unpaired electrons.

Free radicals are highly unstable and reactive due to the presence of unpaired electrons. They initiate chain reactions by reacting with nearby molecules, including lipids, proteins, and DNA. This chain reaction of free radical formation can lead to significant damage to cellular structures, including membranes, proteins, and genetic material (Morgan *et al.,* 2003).

Formation of reactive ions and interaction with tissues and cells

The ionization of water molecules by gamma radiation generates reactive ions, such as hydroxide (OH-) and hydronium (H3O+) ions. These ions can readily interact with tissues and cells, further contributing to the production of free radicals and oxidative stress.

Hydroxide ions (OH-) have an unpaired electron, making them highly reactive. When they come into contact with tissues and cells, they react with molecules, including DNA, proteins, and lipids, causing additional damage and the generation of more free radicals. This process can disrupt cellular functions and contribute to the development of various health effects [Kargas *et al.* (2003).

Direct collision with dna molecules and ionization

Gamma radiation can directly collide with DNA molecules, resulting in the ionization and subsequent damage of this crucial genetic material. When gamma rays interact with the DNA molecule, they can dislodge electrons from atoms within the DNA, leading to ionization and the formation of charged particles.

The ionization of DNA molecules can cause structural changes, breaks in the DNA strands, and the formation of DNA adducts. These alterations can disrupt the normal functioning of DNA, interfere with replication and transcription processes, and potentially lead to genetic mutations. The direct interaction of gamma radiation with DNA is a critical mechanism through which it can induce long-term genetic damage and contribute to the development of cancer and other radiation-related diseases (Lawrence and Rosenberg, 2008).

Radioprotection

Radioprotection is the term used to describe the protection against the harmful effects of radiation. The International Commission on Radiological Protection (ICRP) has proposed a system of radioprotection to mitigate radiation damage to the human body. Radioprotectors are compounds, either chemical or herbal, designed to decrease the damage caused by radiation to normal tissues. These agents are delivered prior to or at the time of irradiation to prevent or reduce the harmful effects of radiation. Radioprotectors operate as antioxidants, neutralizing free radicals and reducing oxidative damage. They can act as scavengers, protecting cells and tissues

from radiation-induced harm. There are both endogenous and exogenous antioxidants that play a role in radioprotection (Deousky *et al.*, 2015).

Mechanisms of radioprotection

After exposure to ionizing radiation, free radicals are generated through the radiolysis of water in the body. To prevent damage caused by these free radicals, it is necessary to neutralize them. Radioprotection mechanisms include the action of free radical scavengers and repair through hydrogen donation to target molecules. Radioprotectors act by reducing the formation and reactivity of free radicals, thereby minimizing the extent of damage to cellular structures.

References:

1. Aharmian F, Akhperjanian A, Barrio J, Bernlohr K, Borst H, Cortina J, Gotting N. (2001). The Tev energy spectrum of Markarian 501 measured with stereoscopic telescope system of HEGRA during 1998 and 1999. APJ., 546:898.
2. Chen M; (2014). Radiation protection and regulations for the nuclear medicine physician. Elsevier, 44:215-228
3. Desouky. O, Ding.N, Zhou.G. (2015). Targeted and non-targeted effects of ionization research.247-254.
4. Grupen Claus, Cowan G, Eidelman SD, Stroh T. (2005.) Astroparticle physics. Springer; p.109.
5. Hamada N, Fujmichi Y. (2014). Classification of radiation effects for dose limitation purposes: History, current situation, and future prospects. J. Radiat. Res.; 55[zhang *et al.* 2012]:629–640
6. Karagas MR, Stannard VA, mottLA, Slattery, MJ, Spencer SK and WeinStock MA (2002). Use of tanning devices and risk of Bessel cell and squamous cell skin Cancers.Jnatl cancer INST 9(224-226).
7. Lawrence T and Rosenberg S (eds) (2008). Cancer: Principle and practice of oncology. Philadelphia, PA: Lippincott Williams and Wilkins.
8. Willian F. Morgan *et al.* (2003). Non targeted and delay effect of exposure to ionizing radiations: II. Radiation-induced genomic instability and bystander effects in vivo, clastogenic factors and transgenerational effects.radiation research 159.581-596
9. Zhang M, Qureshi AA, Geller AC, frazier, L hunter DJ and Han J. (2012). use of tanning beds and incidence of skin cancer. J clin oncol 30:1588-1593.

TRANSDERMAL DRUG DELIVERY SYSTEM (TDDS): AN OVERVIEW

Dilsar Gohil*, Dev Panchal, Varunsingh Saggu, Cyril Sajan,
Krupa Joshi, Kinjal Patel and Rajesh Maheshwari
Department of Pharmacy,
Sumandeep Vidyapeeth Deemed to be University,
Piparia, Vadodara, Gujarat, India 391760
*Corresponding author E-mail: gohildilsar9624@gmail.com

Abstract:

Transdermal drug delivery system (TDDS) provides a means to sustain drug release as well as reduce the intensity of action and thus reduce the side effects associated with its oral therapy. Transdermal drugs are self-contained, discrete dosage form. It delivers a drug through intact skin at a controlled rate into the systemic circulation. The skin offers an accessible and convenient site for the administration of medications. To this end, the field of transdermal drug delivery, aimed at developing safe and efficacious means of delivering medications across the skin, has in the past and continues to garner much time and investment with the continuous advancement of new and innovative approaches. This chapter details the progress and status of the transdermal drug delivery field and describes numerous pharmaceutical developments, its generation, which have been employed to overcome limitations associated with skin delivery systems. Advantages and disadvantages of the various approaches are detailed, rationally; the conventional routes of medication delivery have many inherent limitations, which could potentially be overcome by advanced drug delivery methodologies such as transdermal drug delivery (TDD).

Keywords: Transdermal, drug delivery, Parts, Generations,

Introduction:

Topical remedies anointed, bandaged, rubbed or applied to the skin are likely to have been usedsince the origin of man, with the practices becoming evident with the appearance of written records, such as on the clay tablets used by the Sumerians (Kramer, 1963). Ancient Egyptians used oil (e.g. castor, olive and sesame), fats (mainly animals), perfumes (e.g., bitter almond, peppermint and rosemary) and other ingredients to make their cosmetic and dermatological products (unguents, creams, pomades, rouges, powders, and eye and nail paints) (Forbes, 1955). The mineral ores of copper (malachite: green) and lead (galena: dark grey) were used to prepare kohl, a paste used to paint the eyes [1].

Transdermal drug delivery has made an important contribution to medical practice, but has to fully achieve its potential as an alternative to oral delivery and hypodermic injections. First-generation transdermal delivery systems have continued their steady increase in clinical use for delivery of small, lipophilic, low-dose drugs. Second-generation delivery systems using chemical enhancers, nonactivational ultrasound and iontophoresis have also resulted in clinical products; the ability of iontophoresis to control delivery rates in real time provides added functionality. Third-generation delivery systems target their effects to skin's barrier layer of stratum corneum using microneedles, thermal ablation, and microdermabrasion, electroporation and cavitation ultrasound. Microneedles and thermal ablation are currently progressing through clinical trials for delivery of macromolecules and vaccines, such as insulin, parathyroid hormone and influenza vaccine. Using these novel second- and third-generation enhancement strategies, transdermal delivery is poised to significantly increase its impact on medicine [2].

The transdermal delivery route is an alternative for the oral and hypodermic route of drug delivery. The major advantage of this route is the patient compatibility compared to the other routes. It also bypasses the first pass metabolism, directly reaches into the systemic circulation, and thus gives faster onset of action. In the past few years, the transdermal drug delivery has played major role in the health care management and have gained a boost in providing better therapeutic action. For thousands of years people have placed substances on skin for therapeutic action and in the modern times, there are number of topical formulations that have been developed for medical condition.

The first transdermal preparation was a three-day patch, which was used to deliver scopolamine in motion sickness, which was approved for treatment in United States in the year 1979. A decade later nicotine patches were developed which boosted the usage of transdermal drug delivery. Transdermal drug delivery system (TDDS) represents the most attractive method because of its low rejection rate, excellent ease of administration, and superb convenience and persistenceamong patients.

TDDS could be applicable in not only pharmaceuticals but also in the skin care industry, including cosmetics. Because this method mainly involves local administration, it canprevent local build-up in drug concentration and nonspecific delivery to tissues not targeted bythe drug [3].

Advantages of TDDS

1. Avoid First pass metabolisms of drug.
2. Avoid gastrointestinal incompatibilities.
3. Self-medication is possible.
4. Duration of action gets extended and predictable.
5. Minimized the Unwanted side effects.

6. Maintained Drug plasma concentration.
7. Number of doses get reduces which improve patient compliance.

Therapeutic value of many drugs get increased by avoiding problems associated with druglike-lower absorption, GI irritation, decomposition due to hepatic first pass metabolism [4].

Disadvantages of TDDS

1. TDDS is not recommended, for high dosage drugs.
2. Drugs with large molecular sizes are hard to be absorbed.
3. It is possible that the skin will get irritated, and the reaction will be hypersensitive
4. It is impossible to manufacture a drug with a long half-life.
5. Transdermal drug delivery systems cannot achieve high drug levels in the blood.
6. Ionic medicines cannot be delivered by a transdermal drug delivery method [5].

Transdermal drug delivery system (TDDS) provides various merits over conventional drug delivery systems such as oral delivery and injections including avoidance of hepatic first pass metabolism, reduction of pain, and possible sustained release of drug. Still, transdermal passage of molecule is tedious due to less permeability of stratum corneum (SC), the outermost layer of the skin. In its intact state, the skin is a formidable barrier, resistant to chemicals and tissue-harmful ultraviolet rays and virtually impenetrable to the life-threatening microorganisms. The stratum corneum (SC) develops a thin, tough, relatively impermeable membrane, which usually provides the rate-limiting step in transdermal drug delivery system. To overcome this barrier function chemical permeation enhancers (CPEs) are used that facilitate the absorption of permeate through the skin by temporarily decreasing the impermeability of the skin [6].

Different parts of TDDS

A transdermal therapeutic system is essentially a multilaminate structure that is composed offollowing constituents:

1. Drug
2. Polymer matrix
3. Penetration enhancers
4. Adhesives
5. Backing membrane
6. Release linear [7].

1. Drug

Transdermal route of administration cannot be employed for all types of drugs. It depends upon optimal physicochemical properties of the drug, its biological properties. In addition, consideration of the pharmacokinetic and pharmacodynamics properties of drug is necessary [8].

2. Polymer

Polymers are the backbone of a transdermal drug delivery system. Systems for transdermal delivery are fabricated as multilayered polymeric laminates in whicha drug reservoir or a drug–polymer matrix is sandwiched between two polymeric layers: an outer impervious backing layer that prevents the loss of drug through the backing surface andan inner polymeric layer that functions as an adhesive and/or rate-controlling membrane [9].

Polymer	Category	Role
Gelatine	Natural	Base, Adhesive
Na alginate	Natural	Base, Adhesive
Gum tragacanth	Natural	Adhesive
Hydroxyl propyl cellulose	Semi Synthetic	Base, Adhesive
Polyvinyl alcohol	Synthetic	Base, Adhesive
Polyethylene	Synthetic	Linear, backing

3. Adhesives

The adhesive is a crucial component of all transdermal delivery patches, and pressure-sensitiveadhesives. Clearly, the adhesive must:

- Stick to the skin for the patch's lifetime
- Be non-irritating and no allergenic as it may be in place for up to 7 days
- Be compatible with the drug and other excipients and
- Allow the patch to be removed painlessly without leaving adhesive residue on the skinsurface [10].

4. Backing membrane

It protects the patch from the outer environment. The backing layer should be impermeable todrug and penetration enhancers. It does a function of holding the entire system and protects drug reservoir from atmosphere. The commonly used backing materials are polyesters, aluminized polyethylene terephthalate and siliconized polyethylene terephthalate [11].

5. Release liners

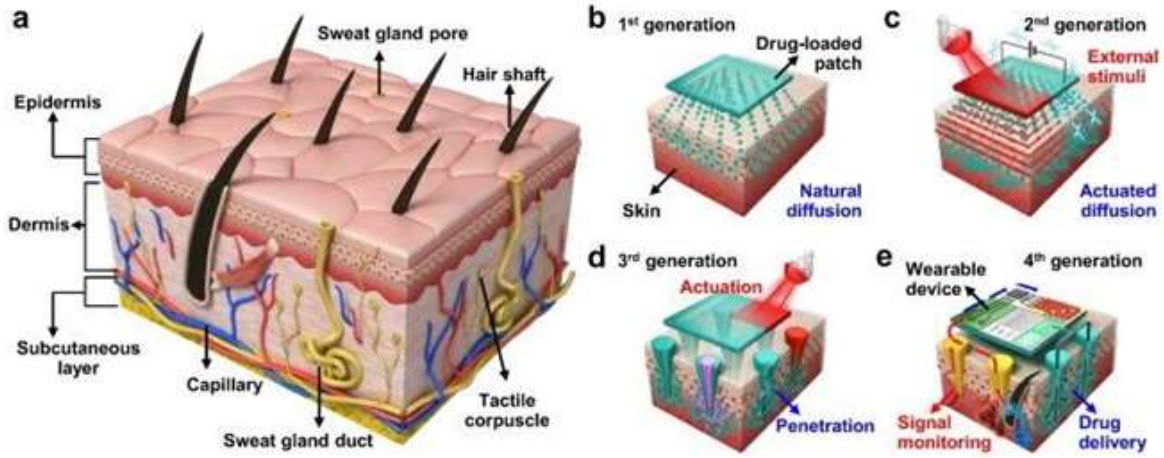
The release liner has to be removed before the application of transdermal system, and it prevents the loss of the drug that has migrated into the adhesive layer during storage. It also helps to prevent contamination. It is composed of a base layer, which may be non-occlusive or

occlusive, and a release coating layer made of silicon or Teflon. Other materials include polyesters; foil, Mylar and metallizedlaminate [12].

Different generations of TDDS

There are Four generations of TDDS according to the advancement of the TDDS, which are as follows.

- First Generation
- Second Generation
- Third Generation
- Fourth Generation



First generation TDDS

The first generation of simple transdermal patches emerged during the early 1970s. Following the first approval from the U.S Food and Drug Administration (FDA) for the use of scopolamine patch for motion sickness, approximately 19 patches including nicotine, menthol,and estradiol are commercially available to date. However, the number of drugs that are suitable for patch formulation is severely limited because of the physiological barrier of the epidermis. The vast majority of the first-generation transdermal drugs are highly lipophilic with partition coefficients greater than 104, small particle sizes, and molecular weights no more than 400 Da.

The research on the first generation of transdermal drug delivery systems focused on tailoring the physicochemical properties of chemical drugs. Drugs for transdermal delivery are either selected or modified to have a high partition coefficient and a low molecular weight for facile diffusion through the skin barrier [13].

Second generation TDDS

The second-generation transdermal delivery strategies seek to maximize the permeability ofthe drug to the skin using chemical enhancers or external energy sources without damaging the structure of the skin. Chemical enhancers facilitate the drug to penetrate the skin by interacting with the proteins comprising the skin and by increasing the drug solubility

The second generation of transdermal delivery systems recognizes that skin permeability enhancement is needed to expand the scope of transdermal drugs. The ideal enhancer should be,

1. Increase skin permeability by reversibly disrupting stratum corneum structure,
2. Provide an added driving force for transport into the skin and
3. Avoid injury to deeper, living tissues. Enhancement methods developed in this generation, such as conventional chemical enhancers, iontophoresis and non-cavitation ultrasound [13].

Third generation TDDS

Third generation methods including chemical enhancers, microneedles, thermal ablation and ultrasound [31]. Technologies used by transdermal devices can be divided into passive or active methods based on whether an external source of energy is used for skin permeation enhancement. Passive methods include use of chemical enhancers, emulsions and lipid assemblies. Chemical methods are relatively easy to incorporate into transdermal patches and can be used to deliver varying dosage amounts by changing the application area. However, these methods may have a lag time up to hours and thus cannot be easily adapted for rapid onset or time varying delivery, which may be needed for drugs such as insulin. Increasing numbers of academic and industrial researchers are focusing on transdermal devices with active mechanisms for skin permeation (Brown et al., 2006). A similar trend is seen in the type of systems that have entered the transdermal market in the last decade, and those under clinical development (Gordon and Peterson, 2003; Brown et al., 2006). These active methods of skin permeation enhancement include jet injectors, iontophoresis, electroporation, ultrasound, microneedles [14].

Fourth generation TDDS

Personalized therapy is distinguished from conventional medical treatments by its ability to optimize the treatment based on each individual's pathophysiological conditions. Establishment of personalized therapy requires systematic control of the administered dose based on an accurate real-time observation of the patient's physiological parameters to determine the progression of disease and efficacy of the drug. In response to an increasing need for personalized treatment, the advanced transdermal delivery system empowered by soft bioelectronics has been spotlighted as a strategy for the next generation drug delivery method.

The TDDS has not fully developed still but there are certain Physical and Chemical Enhancers/Methods, which are used to enhance the drug penetration through the skin and obtain better therapeutic action. However, the penetration of drugs across the skin and their percutaneous delivery are limited by the barrier function of the enormously organized structure of Stratum corneum (SC).

The principle transport mechanism across mammalian skin is by passive diffusion through primarily the trans-epidermal route at steady state or through Trans appendage route at initially, non-steady state. The factors, which affect the permeability of the skin mainly the stratum corneum, are classified into following categories:

1. Physicochemical properties of the penetrant.
2. Physicochemical properties of the drug delivery systems.
3. Physicochemical and pathological conditions of the skin [15].

Conclusion:

During the past decade, the number of drugs formulated in the patches has hardly increased, and there has been little change in the composition of the patch systems. Modifications have been mostly limited to refinements of the materials used. The reason is the only a limited number of drugs fit the molecular weight, and potency requirements for transdermal absorption.

A rich area of research in recent years has been focused on developing transdermal technologies that utilize mechanical energy to increase the drug flux across the skin by either altering the skin barrier (primarily the stratum corneum) or increasing the energy of the drug molecules. These so-called “active” transdermal technologies include iontophoresis (which uses low voltage electrical current to drive charged drugs through the skin), electroporation (which uses short electrical pulses of high voltage to create transient aqueous pores in the skin), sonophoresis (which uses low frequency ultrasonic energy to disrupt the stratum corneum), and thermal energy (which uses heat to make the skin more permeable and to increase the energy of drug molecules). Even magnetic energy, coined magnetophoresis, has been investigated as a men’s to increase drug flux across the skin. However, subjective and objective analysis of these devices is required to make sure both scientific, regulatory and consumer needs are met.

The devices in development are more costly and complicated compared to conventional transdermal patch therapies. In addition, effects of the device on the skin must be reversible, since any permanent damage to the SC will result in the loss of its barrier properties and hence its function as a protective organ. Regulatory bodies will also require data to substantiate the safety of the device on the skin for either short or long-term use. Thus, for any of these novel drug delivery technologies to succeed and compete with those already on the market, their safety, efficacy, portability, user-friendliness, costeffectiveness and potential market has to be addressed.

References:

1. Pastore MN, Kalia YN, Horstmann M, Roberts MS. (2015). Transdermal patches: history, development andpharmacology. British journal of pharmacology. 172(9):2179-209.

2. Prausnitz MR, Langer R. (2008). Transdermal drug delivery. Nature biotechnology. 26(11):1261-8.
3. Jeong WY, Kwon M, Choi HE, Kim KS. (2021). Recent advances in transdermal drug delivery systems: Areview. Biomaterials research. 25(1):1-5.
4. Durga KN, Bhuvaneswari P, Hemalatha B, Padmalatha K. (2022). A Review on Transdermal Drug DeliverySystem. Asian Journal of Pharmacy and Technology. 25;12(2):159-66.
5. Soni A, Dua JS, Prasad DN. (2022). Article Reviewing Transdermal Drug Delivery System. Journal of DrugDelivery and Therapeutics. 15;12(1):176-80.
6. Ali S, Shabbir M, Shahid N. The structure of skin and transdermal drug delivery system-a review. Res. J. Pharm. Technol. 2015 Feb 28; 8:103-9.
7. Gaikwad AK. (2013). Transdermal drug delivery system: Formulation aspects and evaluation. Comprehensive Journal of Pharmaceutical Sciences. 1(1):1-0.
8. Kandavilli S, Nair V, Panchagnula R. (2002). Polymers in transdermal drug delivery systems. Pharmaceutical technology. 26(5):62-81.
9. Aulton ME. (2017). Powders, granules and granulation. Aulton's Pharmaceutics E-Book: The Design andManufacture of Medicines. 7:476.
10. Kesarwani A, Yadav AK, Singh S, Gautam H, Singh HN, Sharma A, Yadav C. (2013). Theoretical aspectsof transdermal drug delivery system. Bull. Pharm. Res. 3(2):78-89.
11. Sahu K. (2021). Transdermal Drug Delivery System: A Review Article 24 September 2021/0 Comments.consultant. 24:0.
12. Lee H, Song C, Baik S, Kim D, Hyeon T, Kim DH. (2018). Device-assisted transdermal drug delivery. Advanced drug delivery reviews. 1;127:35-45.
13. Seah BC, Teo BM. (2018). Recent advances in ultrasound-based transdermal drug delivery. International journal of nanomedicine. 13:7749.
14. Prausnitz M, Gill H, Zarnitsyn V, Sullivan S, Lee J, Choi S. (2008). Microscale device for transdermal delivery. International. J. Pharma. 2008.
15. Alexander A, Dwivedi S, Giri TK, Saraf S, Saraf S, Tripathi DK. (2012). Approaches for breaking the barriers of drug permeation through transdermal drug delivery. Journal of controlled release. 28;164(1):26-40

CROP RESIDUE BURNING IN INDO-GANGETIC PLAINS AND ITS IMPACT AND MANAGEMENT

Manisha*, Pardeep Phogat, Govind Prasad, Rakesh Kumar and Pritam Kumari
Chaudhary Charan Singh Haryana Agricultural University,
Hisar, Haryana 125004
*Corresponding author E-mail: manisha.agron@gmail.com

Introduction:

Residue management is the emerging challenge for environmental protection as well as sustainable growth of Indian agriculture. India is producing copious amount of crop residue that is manageable. But at present, either due to lack of any viable and systematic approach or poor adoption rate to deal with crop residues lead to burning of residues in the field, which leads to huge nutrient loss besides deteriorating environment and human health. Combine harvesting, lack of traditional use of crop residues, intensive cropping systems, lack of buyers for straw and to ensure the timely sowing of the next crop are the main factors driving residue burning without any obstacle in farm operation due to unkempt straw. Farmers are forced to burn the straw because it takes long interval to manage loose straw mechanically in order to ensure a smooth sowing of the following crop in standing stubbles. Earlier it occurred on a small scale so policymakers did not pay much attention to field burning of crop residue (FBCR), but nowadays it is recognised as a serious agricultural pollutant that has an adverse effect on environment and human health which contributes to global warming because it releases greenhouse gases during combustion. Due to this unhealthy practice, people in NW India experience severe smog problems during the crop harvesting seasons and soil fertility is also severely affected. In the dearth of suitable and economically viable alternative, farmers are still bounded to follow this practice as it is otherwise a big problem for farmers. Therefore, we need on-farm and post-harvest management of crop residues either by adjustment in the cropping system, modification in machineries, educating farmers and utilizing residues in the industries and power generation. In this chapter, several efforts have been built up to cover major aspects related to crop residue management in different cropping systems of India.

What is crop residue?

Crop residues are the materials present in the form of leaves, stalks, stems, seeds, etc. which left over after a crop harvest. The quantity of crop residue depends on method of tillage operations, type and growth period of crop and method of harvesting.

Field residues

The residues left in the field after the harvesting of main crop are called field residues. When these left in the field as well as buried into the soil, lead to increase in water holding capacity, control erosion and nutrients supply.

Post-harvest residues

Post-harvest residues are the materials that left after processing which are used as animal feed and soil amendments. Ex- husk, seeds, molasses, bagasse, etc.

Production of crop residue in India:

Table 1: Production and surplus of residue in India [1]

Crop group	Crop	Gross Potential (MT)	Surplus potential (MT)
Cereals	Rice	154	43.5
	Wheat	131.1	28.4
	Maize	35.8	9
	Pearl millet	24.3	5.1
	Sorghum	17.6	3.5
	Other	4.9	0.6
Total		**367.7**	**90.1**
Oilseeds	Mustard and rapeseed	12.7	4.9
	Soyabean	13.5	4.6
	Groundnut	17.0	3.0
	Sunflower	3.8	0.6
	Other	1.8	0.6
Total		**48.8**	**14.3**
Pulses	Tur (arhar)	7.2	1.4
	Gram	6.4	1.6
	other	4.3	2.1
Total		**17.9**	**5.1**
Sugarcane	Sugarcane	110.6	55.7
Horticulture	Banana	41.9	12.3
	Coconut	18.0	9.7
	Arecanut	1.5	0.5
Total		**61.4**	**22.5**
Others	Cotton	75.4	46.9
	Jute	3.9	0.4
Total		**79.8**	**47.3**
Gross		**686.0**	**234.5**

Agriculture has a great role in the overall economy of India. In various agro-ecological regions of India, a varied range of crops are cultivated across the majority of land with prominent quantity of crop residue (non-economical plant parts) that are left in the field. After being used in alternatives such as animal bedding, cattle feed, fuel, organic manure etc., nearly 234 million tonnes/year (*i.e.* 30%) of gross residue generated in India is available as surplus. This enormous amount of crop residue has economic value. Approximately 500-550 million tonnes (Mt) of crop residue are produced on-farm and off-farm annually from the production of 110 Mt of wheat, 122 Mt of rice, 26 Mt of millets, 71 Mt of maize, 141 Mt of sugarcane, 28 Mt of pulses and 8 Mt of fibre crops (jute, mesta, cotton).

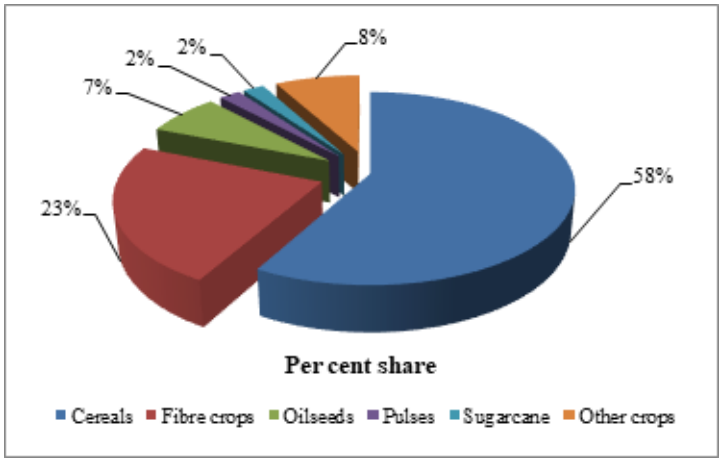


Figure1: The percent share of unutilized residues in total residues generated by different crops in India [2]

Disposal of residue across India

Across India, crop residue is being used differently depending on the region and its socio-economic status, number and type of cultivated crops per year, etc. Usually, growers use crop residues for fuel, fodder, feed, cattle sheds, packaging, etc. or to sell landless households or middle men for further selling. Rice straw in southern India is used in boilers for parboiling rice and for domestic fuel whereas, in northern India a huge amount is burnt on-farm by farmers. As like, sugarcane leftovers are used for either feeding cattle or burnt on-farm for ratoon crop and groundnut residues are burnt in brick and lime kilns. Cotton, oils seed crops, pulses, chillies, coconut shell and jute residues are used as domestic fuel. Rice stubble is mostly subjected to on-farm burning across the country, especially after the introduction of modern combine harvesters. The enormous amount of wheat residue is consumed for cattle feeding and domestic fuel. Unlike wheat, millets and corn stalk are relatively hard, and therefore not much suitable for fodder. Among all the crops, cereals are the highest contributor of surplus residues which are often in-situ burnt. In addition, peanut stems and shells are used for domestic and industrial fuel, respectively.

Table 2: State-wise total crop residue generated and residue burnt in India [3]

Crop Residue Generated									
State	**Rice**	**Wheat**	**Maize**	**Mustard**	**Groundnut**	**Sugarcane**	**Coarse cereal**	**Cotton**	**Total residue burnt**
Andaman & Nicobar	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Andhra Pradesh	9.89	0.00	2.42	0.01	1.19	3.71	3.09	1.05	5.00
Arunachal Pradesh	0.29	0.01	0.11	0.07	0.00	0.02	0.16	0.05	0.16
Assam	6.3	0.03	0.13	0.48	0.00	0.57	0.15	0.91	1.94
Bihar	10.94	7.24	3.94	0.25	0.00	6.18	4.24	1.35	8.29
Chhattisgarh	10.68	0.23	0.47	0.05	0.09	0.4	0..56	0.04	3.10
Dadra & Nagar Haveli	0.04	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Delhi	0.02	0.12	0.00	0.00	0.00	0.00	0.01	0.64	0.10
Goa	0.15	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.04
Gujarat	2.56	3.88	1.17	0.87	6.22	5.67	3.02	0.28	4.81
Haryana	5.91	16.36	0.03	2.39	0.01	3.9	1.70	0.43	10.51
Himachal Pradesh	0.19	1.00	1.15	0.01	0.00	0.01	1.29	0.03	1.02
J&K	0.76	0.67	0.79	0.06	0.00	0.00	0.87	0.11	0.79
Jharkhand	5.10	0.60	0.83	0.50	0.06	0.00	0.92	0.12	1.93
Karnataka	3.46	0.24	4.85	0.00	0.83	12.99	8.23	0.54	8.45
Kerala	0.58	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.16
Lakshadweep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Madhya Pradesh	5.61	25.42	4.89	2.32	0.74	2.24	7.43	0.66	11.77
Maharashtra	4.13	2.66	5.05	0.01	0.83	24.80	10.26	0.01	11.81
Manipur	0.57	0.01	0.09	0.06	0.00	0.00	0.09	0.07	0.20
Meghalaya	0.27	0.00	0.06	0.02	0.00	0.00	0.07	0.05	0.11
Mizoram	0.08	0.00	0.01	0.00	0.00	0.02	0.01	0.04	0.04
Nagaland	0.45	0.01	0.20	0.07	0.00	0.00	0.00	0.00	0.17
Odisha	11.05	0.00	0.30	0.01	0.11	0.16	0.40	1.86	3.18
Puducherry	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Punjab	15.38	23.29	0.65	0.11	0.00	3.39	0.74	1.1	19.45
Rajasthan	0.60	12.73	2.02	9.2	2.25	0.23	10.50	0.04	7.65
Sikkim	0.03	0.00	0.1	0.01	0.00	0.00	0.00	0.00	0.03
Tamilnadu	3.15	0.00	1.4	0.00	1.16	9.01	2.10	0.85	4.11
Telangana	6.87	0.01	3.9	0.01	0.67	0.98	4.32	0.61	4.15
Tripura	1.08	0.00	0.03	0.02	0.00	0.00	0.03	0.11	0.30
Uttar Pradesh	18.26	42.59	2.23	2.17	0.17	66.50	6.10	2.32	34.38
Uttarakhand	0.84	1.25	0.05	0.03	0.00	3.07	0.48	0.12	1.44
West Bengal	20.31	1.22	1.03	1.25	0.35	0.74	1.13	1.71	6.44
All India	**145.65**	**139.58**	**37.91**	**19.97**	**14.69**	**144.67**	**67.90**	**15.10**	**151.58**

In Indo-Gangetic plains (IGP), intensive cropping system is adopted which leads to burning of crop residues, as it is the easiest and most economical option to get rid of it because of short period available for sowing of next crop. Use of crop residue are not limited to purpose of animal feeding and fuel for domestic, but also includes soil mulching, bio-manure, thatching for rural homes and industrial use. Despite its benefits, farmers burn a significant portion of the crop residues on-farm so that the succeeding crop can be sown on clear field. Mechanized farming coupled with lack of skilled farm labour and high cost; further support the on-farm burning of crop residues. Irrigated areas where multiple crops are grown annually and areas adjoining to the NCR has experienced intensive residue burning of rice, wheat, cotton, maize, millet, sugarcane, jute, rapeseed-mustard and groundnut. Nowadays, the demand of crop straw for cattle feed and industrial purpose have increased across the India due to excessive in-situ burning of residues.

Why farmers go for straw burning?

Residue burning is believed to raise productivity of soil and shortens harvesting time by a couple of days which helps in timely sowing of succeeding crop. It is the easiest as well as quickest way to get rid of huge amount of crop residue due to less labour-intensive and there is no additional financial burden on farmers as it involves no transportation or disposal costs. In case of rice-wheat cropping system, farmers dispose the residue through burning to clear the field for smooth operation of farm machineries mainly for seed bed preparation. In paddy cultivation, coarse varieties (non-basmati) are more offender for burning issues than the fine-grained varieties (basmati) because of higher price of basmati rice in international market and also due to their lower yield farmers go for manual harvesting instead of combine harvesting to reduce the losses [4]. Straw of basmati rice is also used for animal feeding with green fodder due to high palatability than coarse varieties. Demand for basmati rice straw in the dry areas of country makes it possible for local buyer to purchase it from farmers' fields and after proper chopping, it can supply as per demand in spite of its bulky nature. Farmers also claim that burning helps to kill deleterious pest hibernating under residues and un-decomposed wheat straw of previous season float on standing water and uproots newly transplanted rice seedling under blowing air.

State agriculture departments of Punjab and Haryana suggest farmers about residue incorporation in the soil by using machinery, but their concern about this advisory is that it increases the cost of cultivation. Generally, farmers go for deep ploughing and laser land levelling once in 3 or 4 years. But as per advisory, every year deep ploughing becomes necessary to incorporate residues and followed by land levelling which is not economical. Farmers not prefer to feed their dairy animals with rice straw due to the lack of sufficient nutrients needed to

maintain high milk production level. The reasons for burning of residues also include high transport cost, long time required in composting and no other economically viable alternate uses.

Effects of stubble burning

Environmental effects: The most adverse environmental effects of crop residue burning incarnate the emission of greenhouse gases (GHGs) that contributes to global climate change. In addition to that, enhanced levels of particulate matter (PM) and other air pollutant those cause health hazards, loss of agricultural diversity and the deterioration of soil fertility are main effects. The burning of the crop stubbles in open field influences soil fertility, soil biota and also erode the soil nutrients.

Air pollution: Crop residue burning produces various air pollutants like CO, NH_3, NO_X, SO_X, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), non-methane organic compound (NMHC) and PM. These pollutants lead to the loss of organic carbon, nitrogen and alternative nutrients, which otherwise might have preserved in soil. In Punjab, approximately 0.92 Mt of CO, 22 Mt of CO_2 and 0.03 Mt of SO_2 is generated from around 15 Mt of rice residues on an annual basis [5]. According to a study, GHG's account for 91.6% of total emissions caused by the burning of 98.4 Mt of crop residue and the remaining 8.4% are CO, NO, NMHCs and SVOCs. Burning of stubbles also leads to emission of aerosols. The PM released from the burning of crop residues is 17 times higher than that of the emissions from several other sources like industrial waste, motor vehicles, waste incineration, etc.

Human health: Incomplete combustion of crop residues produces polycyclic aromatic hydrocarbons (PAHs) that are a group of more than 100 toxic chemicals which are mutagenic or carcinogenic in nature. Carcinogenic nature of the PAHs can be perspicuous by the fact that out of total 200 compounds tested, 25% were delineated tumerogenic and about 30% of these were PAHs. PAHs are highly lipid soluble in nature and penetrate in bronchial epithelium cell of lungs where metabolism takes places and causes severe respiratory disorders such as asthma, pulmonary fibrosis and lung cancer.

Crop residue management:

Important options for farmers to manage crop residues includes baling, removing them for use as animal feed and bedding, incorporating them into the soil in situ with tillage and completely or partially leaving them on the surface as mulch using zero or reduced tillage. Bails of crop residue can also be used for production of chapter and ethanol, bioconversion and engineering applications. Rice straw has no economic value and due to scarcity of labour, farmers hesitate to invest in cleaning the field by using a chopper. This practice also requires another operation and increases cost of cultivation. Farmers in NW India find out burning as the

cheapest and easiest way to dispose large load of residues for sowing of wheat crop in a short time after rice harvesting. Nowadays, more than 80% of total rice straw produced annually is being burnt by the famers during October last to mid-November.

***In-Situ* Incorporation**: Although there are other alternatives to crop residue burning, currently farmers have only two choices: either incorporate the crop residue into soil or to burn it directly in the field. Generally, farmers do not favour in situ incorporation because the stubble takes a long time for degradation into the soil. According to the Department of Agriculture (Punjab), less than 1% of farmers execute in situ incorporation of crop residues. However, the yield of succeeding crop was significantly lower if the rice residues added immediately before sowing; due to inorganic nitrogen immobilization and it adversely affect availability of nitrogen. In few studies, 30 days before wheat sowing rice residues was incorporated in the soil during the first 1-4 years and the wheat yield was found to decrease. According to an experiment incorporation of rice residues in the soil could be the best alternative practice [6]. A six-year study period revealed that the production of subsequent wheat and rice crops was not adversely affected if the rice residue was incorporated into the soil between 10 to 40 days before the sowing of the wheat crop. Paddy straw was added into the soil three weeks before the sowing of wheat and yield increased significantly in clay loam soil as compared to sandy loam soil. By allowing enough time, between its incorporation and the sowing of wheat crop, rice straw can be managed successfully in situ and help to avoid N deficiency due to N mobilisation. Only a small number of farmers have opted to use in situ rice straw incorporation as a burning alternative due to its high cost, labour and energy requirements. Incorporating rice residue also causes a 2-3 week delay in wheat sowing. In wide row planting method, in situ incorporation of sugarcane trash conserve buffer soil temperature, soil moisture and also increase yield [7]. Peanut residue incorporation enhances crop yield, nitrogen yield and water use efficiency of summer peanut-winter wheat cropping system [8].

Mulching: It refers to protective soil cover either with sawdust, polythene, compost or chapter to control weeds, erosion, and evaporation and to enrich soil. Generally, before the field ploughing, biomass transferred from the field and then the biomass returned back to the prepared field. During plant establishment, the soil is saturated or flooded and weeds are managed by herbicides. Some farmers use relay crops to sow rice in wheat fields before mixing harvests. During the rice crop, the standing wheat stubble gradually decays. In order to save water and enhance nitrogen performance, a system for rice production covers the soil under non-flooded conditions with soil covered by rice straw during development, but the yield of grain was often lower than in flooded rice. A reduced or no-tillage system makes it fairly easy to preserve the

residue on the soil like mulch by merely holding it onto the field after harvesting, when the residue does not need to be removed and added until tillage. Its potential for conservation depends on the presence of crop wastes used as mulch. This mulch gives the soil surface a layer of protection that is very effective at stopping soil erosion and also improves the ecology of the soil. It has two possible productivity levels. First, the mulch tends to stabilise and occasionally even enhance crop yield. Secondly, it also implies changes to input usage efficiency and factor substitution.

Composting: It is a biological process in which organic waste is converted into compost using microorganisms under controlled aerobic conditions and finally, used as a fertilizer. This technique is majorly used for the management of off-field residues where the compost generated is not returned to the field, while it can also be implemented in fields (in situ composting). In situ, rice straw is stacked up at threshing locations as an instance of composting, where the straw progressively decomposes, largely aerobically, and then the compost can be dispersed into the soil as a fertilizer at the start of the next season. The disadvantages of this process include the creation of ideal habitat for rodent pests and the undesirable existence of immobilised residual nitrogen. Another type of in situ composting practised in China is the burial of wheat or barley leftovers in ditches parallel to the rice transplant. Crop residue can be composted alone or in combination with other organic resources like animal manure. The resulting compost can then be collected and used as a fertiliser in the soil. Composting technique necessitates labour input but does not entail financial investment nor advanced machinery and infrastructure, which might be especially appealing to small farms with adequate manpower resources.

Vermicomposting: It is the non-thermophilic biodegradation process of organic material through the interaction between earthworms and microorganisms, whereby organic material residuals are rapidly fragmented into much finer particles by passing them through a grinding gizzard while maintaining nutrients. Earthworms thereby reduce quantity of human pathogens, which is similar to the impact achieved by increasing the temperature in traditional composting, but vermicomposting is generally faster. Compared to conventional composting system (as commonly used in country to manage crop residues and other related wastes), vermicomposting often results in mass reduction, shorten time for processing, high levels of humus with reduced phytotoxicity. Vermicomposting with earthworms is an eco-biotechnological method that converts complicated organic compounds into a stabilised humus-like product. The source of this decrease in C/N ratio during vermicomposting process could be attributed to microbial respiration, in which carbon is lost as CO_2, resulting in an increase in the proportion of total nitrogen in the medium. Earthworms speed up the mineralization process and turn manures into

castings with more nutritional value and humification than standard composting methods. Vermicompost made from agricultural leftovers had a better biological status than manure or crop residue used directly. The impacts of different crop residues as a base substrate on the final vermicompost fertiliser were variable.

Zero-tillage: It has been adopted on a significant area in the Rice-Wheat cropping system in Indo-Gangetic Plains with positive impacts on wheat growth, profitability and resource use efficiency. Crop residues could not be managed in no-till systems using tine-type openers. Loose straw collects in the seed drill furrow openers, the seed metering drive wheel loses traction and seed planting depth is non-uniform owing to repeated lifting of the instrument under heavy trash conditions. The potential benefits of no-till can only be fully realised if it is practised continually and the soil surface is covered by at least 30% crop leftovers.

Happy seeder machine although crop residue retained in the field plays a positive role in reducing environmental pollution caused by stubble burning and recovering soil quality. Sowing of wheat in the field with rice residue retained was a challenge until the development of a happy seeder machine recently. The 'Happy Seeder,' which combines stubble mulching and drilling in a single device, is a potential new approach in which stubble is cut and gathered before seeding, and the cut stubble is then deposited as mulch behind the seed sower. According to the National Academy of Agricultural Sciences (2017), rice residue can be managed by concurrent use of a super straw management system (SMS) fitted with combines and turbo happy seeder. Sowing of wheat with Happy Seeder has an operating cost 50–60% lower than that with a traditional seeder.

Baling and removing the straw: Surplus straw from agriculture may be used for a number of useful purposes such as livestock feed, fuel, bedding materials, composting for mushroom cultivation and as mulch for vegetables, orchards and other crops.

Bioenergy: Bioenergy production from crop residues is another promising residue management method. Crop residues, for example, can be used to produce liquid biofuels, which is the conversion of biomass to bio-power or electricity or liquid fuel. The most common biofuel made from crop residues is cellulose-based ethanol, which is made by enzymatically breaking down the polysaccharide in straw into its component sugars, which are then fermented into ethyl alcohol. Direct combustion of straw alone (direct firing) or mixed with another fuel (co-firing) generates biopower. Another alternative to direct combustion is gasification, in which straw is gasified by air or steam to produce a fuel-gas mixture of N_2, H_2, CO and CO_2, which is then burned to generate electricity. Bioenergy can also be produced from crop residues through anaerobic digestion, which produces biogas, primarily CH_4, which is collected and burned to produce electricity. Using cattle and buffalo manure and crop residues as feedstock, anaerobic

digestion was used to produce biogas, which was accompanied by the production of organic fertilizer. In a study, mixed agricultural waste (e.g., potato peels, lettuce leaves, and pea peels) and livestock manure to produce biogas, and it was discovered that the co-feedstock of manure and lettuce leaves yielded the highest CH_4 and biogas production yields of 6610.2 and 1,23,55 mL, respectively [9]. Uttar Pradesh produces the most surplus residues (40 MT), followed by Maharashtra (31 MT) and Punjab (28 MT), which can be used to produce bioenergy. According to previous findings, the state ranking ranges from lowest in western Bengal (679 MJ) to highest in Punjab (16,840 MJ).

Rice straws are the poorest in protein and contain the highest percentage of crude fibre of any feeding material. They are relatively low in P and available Ca, as well as trace elements, but contain a lot of silica. Their digestible crude protein content is practically nil, while their total digestible nitrogen content is approximately 40%. Straws are never fed to livestock in Western countries, but are used as bedding materials. Rice straw is valuable to Asian farmers. The harvested paddy is transported to a centralised location on or off the field for threshing, which separates the grain from the straw. In China, North Vietnam, Eastern India, Bangladesh, and Nepal, where complete removal of rice straw from fields is very common, there is a high demand for straw as fodder. Rice straws, which contain 70% carbohydrate by dry weight, are a potential source of energy for ruminants. Crop residue can be removed from the field, composted alone or in combination with other organic materials from the farm, such as animal wastes, and then returned to the soil as manure for the rice crop. In India, the traditional passive composting method simply involves stacking crop residues in piles or pits to decompose over time. A few turnings can shorten the time required, which slightly improves passive aeration. Chinese rural composting methods, which use turnings and aeration holes, produce output in 2–3 months. Composting requires labour, but it does not require capital, sophisticated infrastructure or machinery. Composting technology is most likely beneficial to small farmers who do not have manual labour constraints. Rice residues from 1 ha of land yield approximately 3.2 tonnes of nutrient-rich manure as FYM.

Roof thatch: Resource-constrained rice farmers cover bamboo roofs with long rice straw (90-130 cm). Roof thatch has a lifespan of about two years, depending on the amount of rain, the slope of the roof, the type of straw used (cultivars), and the silicon content. Rice straws with fine grain last longer as roof thatch. Harvesting and threshing methods are critical in determining the quality of rice straw for thatch use. If properly dried, bundled, and stacked, hand cut rice straw is ideal for roof thatch. Roof thatch is typically made every 2-3 years, alternately before the onset of the monsoon. Straw roof thatch becomes cooler in the summer and warmer in the winter. This

is very beneficial to farmers, but one disadvantage is that it is highly flammable in the event of a fire.

Table 3: Existing and emerging in-field residue management practices in rice cropping systems in different regions of South Asia [10]

Region	Cropping system	Existing residue management practices and (amount of residue returned per year, t/ha)	Emerging residue management options and (amount of residue that could be returned per year, t/ha)
Trans- and Upper IndoGangetic Plain	Rice–wheat	Incorporation of rice and wheat stubble remaining in the field (~1)	Mulching with rice straw in no-till wheat (5–7) Incorporation of straw and stubble of combine harvested rice in wheat (5–7) Incorporation of combine harvested wheat straw and stubble in rice (1–2)
Middle- and Lower IndoGangetic Plain	Rice–wheat Rice–oilseed Rice–pulses Rice–jute–rice Rice–vegetable Rice–vegetable– rice	Incorporation of stubble remaining in the field (~1) Rice straw mulch in vegetable production (1–2)	Mulching with rice straw in no-till wheat (~5) Incorporation of manually harvested or combine harvested wheat straw and stubble in rice (~1)
Non-Indo-Gangetic Plain (Terai of Nepal, Bihar, and Uttranchal)	Rice–wheat Rice–wheat–pulses	Incorporation of rice and wheat stubble (~1)	Mulching of rice residues in wheat (~4)
South India	Rice–rice Rice–rice– rice Rice–pulses	Incorporation of rice stubble (~1)	Incorporation of rice straw and stubbles (~4)

Paddy straw mushroom: Tropical mushroom cultivation is the simplest way to use agro-waste in the shortest amount of time while also producing high-quality food with a high proportion of essential amino acids. Straw is an excellent mushroom substrate. There are numerous edible mushroom species (*Volvariella volvacea*, *Agaricus volvaceus*, *Amanita virgata*, and *Vaginata virgata*) grown on rice straw throughout East and South-East Asia. Mushroom is known by various names in China, the Philippines, Thailand, Vietnam, Bangladesh and India. Mushrooms are grown in coastal states such as Kerala, Tamil Nadu, Odisha, West Bengal, and Assam in India. This mushroom can thrive at higher temperatures (28-35°C). It grows quickly, so the cropping cycle is very short (30 days) and the mushroom yield is about 10-15% of the dry substrate. Straw mushroom is an excellent source of amino acids, which may supplement protein deficiencies in Asian diets. Rice straw mushrooms are simple to grow, inexpensive and require little space and investment. They are a healthy food that sells well in the market.

Transport packaging: Paddy straw is also widely used as a low-cost packaging material, particularly for the packaging of fruits and furniture in Indian cities. Rice straw packaging must be dry, clean and free of live insects, soil, farces, prohibited or restricted seeds, other plant material, animal debris and other quarantine risk materials.

Benefits of crop residue management [11]:

1. Crop residue returns organic matter to the soil, where it is retained through a combination of physical, chemical and biological activities, including nutrient cycling, that interact and affect soil quality.
2. Retention of crop residues can affect soil pH because the direction of change in soil pH is related to the chemical composition of the residue and soil properties.
3. Cation exchange capacity (CEC) is an indicator of soil fertility because it measures the soil's ability to hold cations for exchange with the soil solution. Soil residue retention raises soil organic matter content, which raises the pH-dependent CEC of the soil.
4. The addition of crop residues can affect the crop's nitrogen availability. N mineralization can occur when legume residues with a low C/N composition are added, whereas cereal residues with a high C/N composition can temporarily immobilise N during the decomposition process. The retention of residue has been shown to increase the concentration of P in the top soil.
5. Retaining crop residue can improve soil structure through a variety of mechanisms, including (1) increasing soil aggregation by adding organic matter to the top soil, (2) protecting soil aggregates from raindrop impact, and (3) preventing compaction caused by raindrop impact. Residue retention has been demonstrated to slow down runoff and

reduce evaporation, contributing to greater soil water content and resilience in drought-prone areas.

6. It has been observed that leaving residues on the soil surface reduces daytime soil temperature. This effect is beneficial in hot, tropical climates because soil temperature may be too high for optimal plant growth, whereas it can be detrimental in cooler climates.
7. Crop residue incorporation increases soil temperature and aeration, creating favourable conditions for microorganisms and increased contact between them and the residues, resulting in faster decomposition rates and overall SOC loss.
8. Larger soil fauna, particularly soil macrofauna like earthworms, play an important role in the soil environment as well. Because of their effects on the soil ecosystem, earthworms are referred to as ecosystem engineers. They have a direct impact on the C and N cycles because they consume, store and cycle nutrients through their biomass.

However, depending on their ecological niche, residue retention can have varying effects on earthworms, as tillage may benefit endogeic (horizontal-burrowing) earthworms if residue is incorporated into the soil, providing a food source. Given the fact that many farmers use crop residues as their primary source of livestock feed, use for fodder may provide a greater short-term economic benefit than retention for soil fertility maintenance. Depending on the climatic factors, a portion of crop residue can still be retained for soil health benefits in some cases. The benefits vs. costs of residue retention in mixed crop-livestock systems are determined by the value of crop residue as soil amendment vs. feed.

Government policies to tackle residue burning [12]:

Stringent measures to reduce crop burning and further regulate crop waste management necessitate the involvement of relevant government agencies. The Government of India made several attempts to introduce and educate the agricultural community about best agricultural waste management practises through government-initiated projects. Environmentalists and government officials also convened numerous forums and developed proposals to reduce crop residue burning and promote the use of alternative sustainable management methods. Following laws govern crop residue burning: Section 144 of the Civil Procedure Code (CPC) to prohibit paddy burning; The Air Prevention and Control of Pollution Act, 1981; The Environment Protection Act, 1986; The National Tribunal Act, 1995; and The National Environment Appellate Authority Act, 1997. The National Green Tribunal (NGT) has taken stringent measures to limit crop residue burning, particularly in the states of Rajasthan, Uttar Pradesh, Haryana and Punjab. Biogas plants are a progressive step taken by the Indian government to

reduce crop burning and pollution. Biogas technologies have been popular since the 1970s and the National Biogas and Manure Management Program-off grid biogas power generation program-runs several programmes to provide renewable energy for electricity generation, cooking and lighting. The government implemented these programmes as part of its "waste to energy mission." This is also part of India's climate change action plan. Large industrial biogas plants can produce 5000 m^3 of biogas per day. Nearly 400 off-grid biogas power plants with a combined capacity of 5.5 MW have been built. In India, there are currently 56 biogas-based power plants in operation, with the majority of them located in the states of Maharashtra, Kerala and Karnataka. Small family biogas plants capable of producing 1 to 10 m^2 biogas per day have also been introduced in rural areas. Ministry of New and Renewable energy has installed nearly five million family biogas plants as part of the biogas development programme.

Recent technological advancements have made it possible to use paddy straw and other crop residues other than dung and vegetable waste for biogas generation in an integrated approach. It has been reported that the establishment of a biogas plant in Fazilka, Punjab, along with commercial farms and processing units is a novel green energy initiative. Using bio-methanation technology, these plants generate biogas from rice straw. The biogas plant, which has been certified by prestigious academic institutions such as the Indian Institute of Technology, Delhi and the Punjab Agricultural University, produces approximately 4000 m^3 of biogas from 10 tonnes of agricultural waste. A 12 MW rice-straw power plant in another biogas enterprise can consume 120,000 tonnes of stubble collected from nearly 15,000 farmers. These private enterprises provided approximately 700,000 jobs to the farming population. Crop burning has been reduced but not completely stopped as a result of some of the measures implemented by government agencies and the private sector.

National Plans and Policies:

The Indian government recently directed the National Thermal Power Corporation (NTPC) to use crop residue pellets (nearly 10%) in place of coal for power generation. Farmers received a monetary return of approximately Rs. 5500 per tonne of crop residue as a result of this. These lucrative measures have yet to be implemented and farmers can profit from them. The Indian government oversees a few bio-composting initiatives. The Rashtriya Krishi Vikas Yojna (RKVY), State Plan Scheme of Additional Central Assistance, which was launched in August 2007, is a government initiative as part of the Government of India's 11th Five Year Plan. This scheme established eight demonstration and training projects in villages throughout the Azamgarh and Marinath Bhanjam districts of eastern Uttar Pradesh. A total of 456 farmers received training in agro-waste bio-conversion and bio-compost production. These large-scale

efforts helped farmers gain economic benefits. In addition to the foregoing, India's Ministry of Agriculture recently developed a National Policy for Crop Residue Management (NPMCR). The NPMCR's primary goals are as follows:

1. To prevent the loss of valuable soil nutrients and to diversify crop residue uses in industrial applications, promote technologies for optimum utilisation and in-situ management of crop residue.
2. Create and promote appropriate crop machinery in farming practises, such as grain recovery machine modifications (harvesters with twin cutters to cut straw). Discounts and incentives are available for the purchase of mechanised sowing machinery such as the happy seeder, turbo seeder, shredder, and baling machines.
3. Collaborate with the National Remote Sensing Agency (NRSA) and the Central Pollution Control Board (CPCB) to monitor crop residue management using satellite-based remote sensing technologies.
4. Provide financial support for innovative ideas and project proposals in various ministries through a multidisciplinary approach and fund mobilisation.

Conclusion:

Farm mechanisation, increased arable land for farming with new irrigation schemes and the use of agrochemicals have all contributed to an exponential increase in agricultural production as well as agricultural waste in many countries. Sustainable agricultural waste management has become a major challenge, particularly for developing countries such as India, which has a growing population, production rates and economic growth. Crop residues are one type of agricultural waste that has presented unique challenges due to their large volume and lack of management capacity. Given that rice and wheat are the major staples of India, large-scale cultivation of these crops to feed the country's ever-increasing population has obviously resulted in the generation of large quantities of crop residue, which the country is unable to cope with.

References:

1. Hiloidhari, M., Das, D., &Baruah, D. C. (2014). Bioenergy potential from crop residue biomass in India. *Renewable and sustainable energy reviews*, *32*, 504-512.
2. Devi, S., Gupta, C., Jat, S. L., &Parmar, M. S. (2017). Crop residue recycling for economic and environmental sustainability: The case of India. *Open Agriculture*, *2*(1), 486-494.
3. Sahu, S. K., Mangaraj, P., Beig, G., Samal, A., Pradhan, C., Dash, S., &Tyagi, B. (2021). Quantifying the high resolution seasonal emission of air pollutants from crop residue burning in India. *Environmental Pollution*, *286*, 117165.

4. Singh, R., Yadav, D. B., Ravisankar, N., Yadav, A., & Singh, H. (2020). Crop residue management in rice–wheat cropping system for resource conservation and environmental protection in north-western India. *Environment, Development and Sustainability*, *22*, 3871-3896.
5. Singh, B., Shan, Y. H., Johnson-Beebout, S. E., &Buresh, R. J. (2008). Crop residue management for lowland rice-based cropping systems in Asia. *Advances in agronomy*, *98*, 117-199.
6. Sidhu, B. S., &Beri, V. (2008). Rice residue management: farmer's perspective. *Indian Journal of Air Pollution Control*, *8*(1), 61-67.
7. Tayade, A. S., Geetha, P., Dhanapal, R., &Hari, K. (2016). Effect of in situ trash management on sugarcane under wide row planting system. *Journal of Sugarcane Research*, *6*(1), 35-41.
8. Zhang, K., Wang, X., Li, Y., Zhao, J., Yang, Y., Zang, H., &Zeng, Z. (2022). Peanut residue incorporation benefits crop yield, nitrogen yield, and water use efficiency of summer peanut–winter wheat systems. *Field Crops Research*, *279*, 108463.
9. Aynehband, A., Gorooei, A., &Moezzi, A. A. (2017). Vermicompost: An eco-friendly technology for crop residue management in organic agriculture. *Energy Procedia*, *141*, 667-671.
10. Singh, Y., &Sidhu, H. S. (2014). Management of cereal crop residues for sustainable rice-wheat production system in the Indo-Gangetic plains of India. *Proceedings of the Indian National Science Academy*, *80*(1), 95-114.
11. Turmel, M. S., Speratti, A., Baudron, F., Verhulst, N., &Govaerts, B. (2015). Crop residue management and soil health: A systems analysis. *Agricultural Systems, 134*, 6-16.
12. Bhuvaneshwari, S., Hettiarachchi, H., &Meegoda, J. N. (2019). Crop residue burning in India: policy challenges and potential solutions. *International journal of environmental research and public health*, *16*(5), 832.

ARTIFICIAL INTELLIGENCE AND FUZZY SETS

Trupti Mohite

Department of Mathematics,

KMC College, Khopoli, Dist. Raigad, Tal. Khalapur, 410203

Corresponding author E-mail: shindetrupti813@gmail.com

As far as the proposition of mathematics refers to reality, they are not certain; and as far as they are certain, they do not refer to reality.

Albert Einstein

A machine may perform the labor of three to four humans, making the task of men easier. A machine's capacity to use its own intellect to solve complex issues is known as artificial intelligence [1]. John McCarthy is regarded as the "father of artificial intelligence." Education makes one wiser; the human brain is a tremendously potent tool for science and technology. Artificial intelligence is used in every industry, from banking to healthcare. Robots, washing machines, and mobile phones are all examples of artificial intelligence in use. Robots with artificial intelligence are crucial in unsafe scenarios since their primary function is to create machines that are intelligent. A crucial component of artificial intelligence is fuzzy sets. Even while some things we encounter lack accuracy, they are nonetheless significant. In daily life, we cannot avoid or reject imprecise things. Mathematics exists to investigate sets, and fuzzy sets are a particular kind of set where uncertainty exists. One person remarks, "That boy is very smart." What does it mean and what criteria do we use to distinguish between intelligent and extremely intelligent people? There was no way for analyzing qualitative data before fuzzy mathematics. There is traditional mathematics probability theory, although it serves various functions. It is employed to research the likelihood that occurrences will occur. While the study of objects without boundaries is known as a fuzzy set.

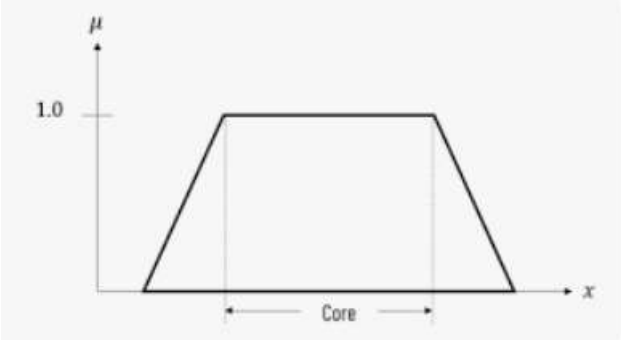
Development of traditional set theory, fuzzy set theory was created by Prof. Zadeh [2] in 1965. It has since become a well-known area of study. In fuzzy set theory, several concepts from classical set theory are expanded. The membership function for the fuzzy set is $B: R \rightarrow [0,1]$, where B(x) where B(x) denotes the grade of membership of B at x. Pair (x, B(x)) is used to represent it. The membership grade of a set's elements is either 0 or 1 according to classical set theory. Consequently, a crisp set is a subset of a fuzzy set. Fuzzy sets can be thought of as the fundamental units that make up the uncertainty of all kinds. The fuzzy set theory is utilized when

knowledge about any entity is lacking or incorrect. The fuzzy set theory is utilized when there is insufficient or incorrect information about any entity. Following are some key fuzzy set concepts.

Support of fuzzy set: A fuzzy set B:$R \rightarrow [0,1]$ then the support of fuzzy set B is denoted by supp(B) and is defined by supp(B) =$\{x \in R/\ B(x) \geq 0\}$.

Core of B: A fuzzy set B:$R \rightarrow [0,1]$ then core of B is defined as

Core(B)= $\{x \in R\ /\ B(x) = 1\}$.

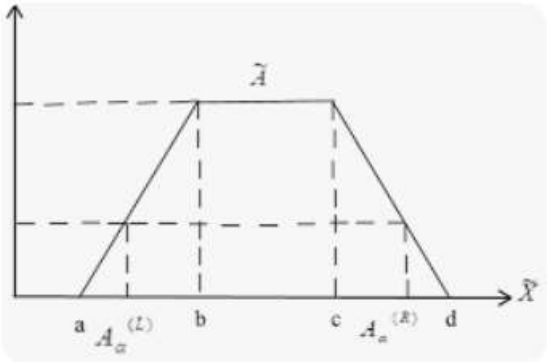


Boundary of B: It is Supp(B) – Core(B).

Height of fuzzy set: It is maximum membership grade present in fuzzy set B.

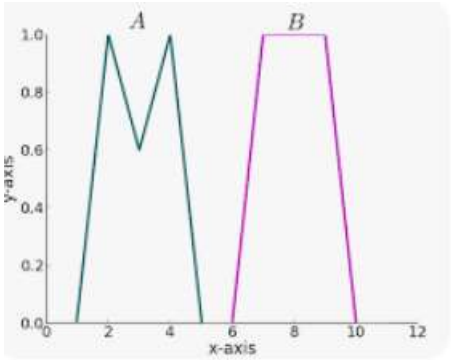
$\boldsymbol{\alpha - cut}$: A fuzzy set B:$R \rightarrow [0,1]$ then $\alpha - cut$ of fuzzy set B is defined as

$\alpha - cut = \{x \in R\ /\ B(x) \geq \alpha\};\ \alpha \in [0,1]$.



There are different types of fuzzy sets as below:

1.**Convex fuzzy set:** A fuzzy set B:$R \rightarrow [0,1]$ then B is said to be convex fuzzy set if and only if B $(\mu x + (1-\mu)y) \geq \min[B(x), B(y)]\ , \forall x, y \in R\ and\ \mu \in [0,1]$.

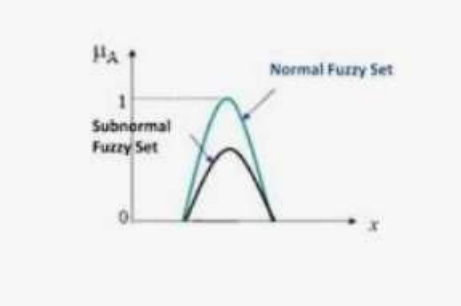


2.Strongly convex fuzzy set: A fuzzy set B:$R \rightarrow [0,1]$ then B is said to strongly convex fuzzy set if B $(\mu x + (1-\mu)y) > \min[B(x), B(y)], \forall x \neq y \in R \; and \; \mu \in (0,1)$.

3.Strictly convex fuzzy set: A fuzzy set B:$R \rightarrow [0,1]$ then B is said to strictly convex fuzzy set if B $(\mu x + (1-\mu)y) > \min[B(x), B(y)], \forall B(x) \neq B(y), x, y \in R \; and \; \mu \in [0,1]$.

4.Concave fuzzy set: A fuzzy set B:$R \rightarrow [0,1]$ then B is said to be concave fuzzy set if and only if B $(\mu x + (1-\mu)y) \leq \max[B(x), B(y)], \forall \; x, y \in R \; and \; \mu \in [0,1]$.

5.Normal Fuzzy set: A fuzzy set B:$R \rightarrow [0,1]$ then B is said to be Normal fuzzy set if $\exists \; x \in R$ such that $B(x) = 1$.



6.Subnormal fuzzy set: A fuzzy set B:$R \rightarrow [0,1]$ then B is said to be subnormal fuzzy set if there does not exist any $x \in R \; such \; that \; B(x) = 1$.

7.Equal fuzzy set: Two fuzzy sets B:$R \rightarrow [0,1]$ and $C: R \rightarrow [0,1]$ then B is said to be equal if $B(x) = C(x); \; \forall x \in R$.

8.Subset of fuzzy set: A fuzzy set B is said to be subset of fuzzy set C if $B(x) \leq C(x); \; \forall x \in R$.

9.Non convex fuzzy set: A fuzzy set B:$R \rightarrow [0,1]$ then B is said to be non-convex fuzzy set if $\exists x, y \in R \; and \; \mu \in [0,1] \; such \; that \; B(\mu x + (1-\mu)y) < \min[B(x), B(y)]$.

10.Connected fuzzy set: A fuzzy set B:$R \rightarrow [0,1]$ then B is said to be connected fuzzy set if and only if all its $\alpha - cuts$ are connected; $\alpha \in [0,1]$.

11.Disjoint fuzzy sets: Two fuzzy sets B:$R \rightarrow [0,1]$ and $C: R \rightarrow [0,1]$ then B is said to be disjoint if $\forall x \in R: \min[B(x), C(x)] = 0$.

The use of fuzzy sets is widespread in many scientific disciplines. Artificial intelligence's fuzzy logic offers useful flexibility for thinking [3]. Many industries, including aerospace, altitude control, speed and traffic, automatic systems, decision-support systems, the chemical industry, natural language processing, model control systems, neural networks, uncertainty in engineering, commercial and practical applications, and control machines, use fuzzy sets. Using the membership function, we may generate several results for Fan and student assessment, as shown below:

- If hot then fast.
- If warm them medium.
- If cold then slow.

Similarly, we can say that

- If marks below 40 is fail.
- If marks above 40 and below 50 is C grade.
- If marks above 50 and below 60 is B grade.
- If marks above 60 and below 75 is A grade.
- If marks above 75 is O grade.

We can see that fuzzy sets have real-world uses. To further generalise the usage of fuzzy sets, fuzzy relations, fuzzy soft set theory, fuzzy linear algebra, fuzzy topology, and fuzzy analysis are all included.

Application of fuzzy sets

Soil science [4]:

To comprehend the classification and assessment of land. With the aid of a fuzzy processor, modelling and simulation of soil physical processes and systems are examined.

Student Evaluation [5]:

Using a computer-based fuzzy methodology and vector valued marking, a new technique of evaluating the responses provided by pupils is mandated and is known as fem.

Climatic classification [6]:

Fuzzy c-mean analysis is used in a study of climate changes that takes into account China and Australia. The fuzzy technique is a more effective strategy than traditional approaches for examining data on climate changes since it is realistic and adaptable.

Safety and reliability [7]:

Due to the lack of direct observation and the ensuing dearth of statistical information on failure components, it is not always possible in practice to fully acquire data. Fuzzy set theory

has been effectively applied in innovative probabilistic risk assessment methodologies for safety and reliability evaluation under uncertain conditions to manage such circumstances.

For safety and reliability engineering, several approaches of fuzzy set theory are employed, such as fault tree analysis, failure mode and effects analysis, and event tree analysis.

Tranquility and anxiety [8]:

Use of tranquility in decision making and measure of tranquility is studied with the help of fuzzy sets. When one has more than one alternative to choose result into anxiety by choosing the best decision and by choosing the less valued decision and so to overcome this situation one can use fuzzy set to study this.

Psychology [9]:

People's behavioral patterns change over time, and fuzzy sets make it easier to examine them. Fuzzy sets are more relevant, helpful, and maybe required to explain some psychological results during cognitive learning.

Mathematical programing [10]:

In classic linear and nonlinear programming, in integer and fractional programming, fuzzy models of programming offer flexibility in constraints and fuzziness in the objective function.

These models give vector maximum problem solutions that are computationally effective.

Conclusion:

Fuzzy set theory is flexible and takes a realistic approach; as a result, it has many applications in a variety of domains. The examples from many articles above illustrate the range of fuzzy set theory. Examining the value of fuzzy set theory, one may increase numerous conventional set theory concepts to fuzzy set theory and research. Due to fuzzy set theory's application-focused approach, it will be advantageous.

References:

1. Singh Anant Manish, Wasif Bilal Haju (2022). Artificial intelligence, International Journal for Research in Applied Science and Engineering Technology. Volume 10, Issue VII: 1210-1220.
2. Zadeh Lotfi, (1965). Fuzzy sets, Information and control.
3. Sayantini (2023). What is fuzzy logic in AI and what are its applications? https://www.edureka.co/blog/fuzzy-logic-ai/
4. McBratney Alex. B. and Inakwu O.A.Odeh,'Application of fuzzy sets in soil science, Geoderma, Volume 77, Issues 2–4: 85-113.

5. Biswas Ranjit (1995). An application of fuzzy sets in student evaluation, Fuzzy sets and systems 74: 187-194.
6. McBratney A. B. and A. W. Moore (1985). Application of fuzzy sets to climatic classification, Agricultural and Forest Metereology, Volume 35, Issues 1–4, Pages 165-185.
7. Kabir S., Y. Papadopoulos (2018). A review of applications of fuzzy sets to safety and reliability engeeniring, International journal of Approximate Reasoning, Vol. 100: 29-55.
8. Yagar Ronald (1982). Measuring tranquility and anxiety in decision making: An application of fuzzy sets, International journal of general system, volume 8.
9. Kochen Manfred (2014). Application of fuzzy sets in psychology, Mental Health Research Institute University of Machigan
10. Zimmerman H. J. (1993). Application of fuzzy set theory to mathematical programing, Readings in fuzzy sets for intelligent systems, 795-809.

HERBAL IMMUNOBOOSTER AGENTS

Swarnima Pandey and Geeta Biswas*

Apex college of Pharmacy,

Bilaspur, Rampur, Uttar Pradesh, India

*Corresponding author E-mail: biswasgeet000@gmail.com

Abstract:

In this chapter we study about the herbal drugs, its active constituents, its different characteristics it is obtained from plants due to this reason more patients prefer naturally drugs for the treatment of diseases and its prevention. The main reason of utilization of herbal drugs due to its less side effects or free from harmful chemicals all herbal drug has their own special properties and these properties helps to kill bacterial infection.

Immunity:

Immunity is derived from Latin word *"immunis"* it means free from weight. In this case weight refers to disease caused by toxic product of microorganisms or microorganisms.

Immunity is referred as the state of susceptibility or resistance in to disease caused by or their toxic products of particular microorganisms.

Immunity is a type power it provides energy to the human body and protects our body from harmful viruses and foreign materials. It protects the body against infectious disease which is caused by virus or fungus, some virus and fungus are useful for our health, it acts like enzymes. It helps in digestion, provides energy to protect you from diseases.

Immunity is the capability of an organism to prevent disease, some antibodies are produced in the form of immunity and act like immunity it activates the specialized activities in blood streams and cells or antibodies produced by them like natural response like some antibodies are produced from a mother to her baby, immunity also artificial or natural.

The capability of body is explained itself to against foreign materials, bacteria, viruses, and toxins. The immune system consists of cells and tissues that carry out immune response.

Every single person has special discovery or immunity to fight with toxins and microorganism which effectual our immunity system, its environment and our body organs. It result, the immunity and immune system of every single person is special or unique even through their cells tissues and organs have the same immune technology challenges for their responds.

The study of immune system or immunity is called as immunology it includes many biological processes such as blood sample tests, urine sample tests, how to works our immune system we also know with the help of immunology. It also helps in diagnose of many diseases our immune system consists various cells and antibodies which helps to improve your immune system it plays very important role in our life. A strong immune system prevents the growth of microbes in our body. The immune system is made up of a complex network of organs, cells and proteins that fight infection (microbes)[1].

Ways to boost your immunity and our immune system:

These are commonly ways for healthy -health guidelines good health and good food is always a best choice to fit fine which we take takes naturally and free from artificial components its keeping you to helps in health immunity or immune system and it works properly and it should be protects from polluted environment due to polluted environment is also harmful for our immune system. These guidelines are as follows:

- Minimization of stress
- Appropriate weight maintains
- Take a healthy diet
- Avoid smoke
- Appropriate sleep
- Healthy diet and fruits included in diet
- Meditation
- Regular exercise and walk
- Take vitamins
- Take minerals and nutrients

According to increasing age day by day is also important factor for weak immunity. If your age is above 40 years your immunity capability is reduced naturally and your body is infused with many infections and infectious disease like corona virus, AIDs, malarial infections.

Always every mother has said to her baby wear jacket or woolen clothes otherwise you are suffering from fever or common cough or cold behind these there are two reasons winter is flu season and cold season in this season the people more time spend inside and comes closer to another people who can pass their germs. The mainly parts of immune system are as follows:

- Antibodies
- White blood cells
- Bone marrow
- Thymus

- Lymphatic system
- Spleen

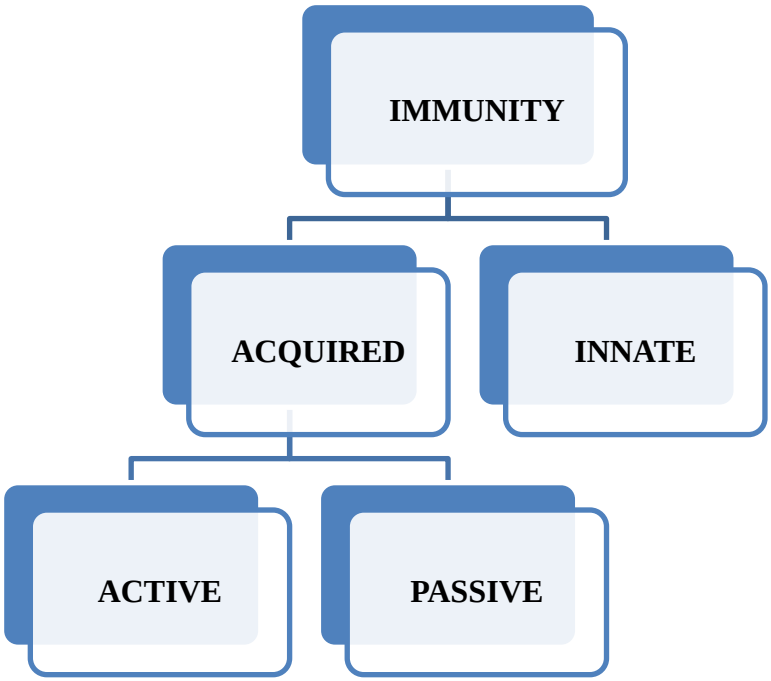
Common disorders of immune system:

Foreign materials sometimes may be very dangerous for our health because it becomes serious disease. Sometimes these disorders are natural and sometimes it is caused by any foreign materials or bacteria which are harmful for our body or immune system these are as follows:

1. Allergic diseases- Dermatitis and asthma
2. Auto-immune diseases- Rheumatoid arthritis and autoimmune thyroid diseases
3. Immunedeficiency- covid [2]

   It includes sometimes fever also in some infections

Types of immunity



1. Acquired immunity:

- Acquired immunity kills a specific type of pathogen.
- When the pathogen enters in the body produce a response called primary response.[3]

a. Active acquired immunity:

- In this type of immunity body produce the various Anti-bodies to give the energy to kill bacteria or diseases.
- The immunogens are injected in the body in controlled quantity to stimulate the production of immunoglobins, Killed and attenuated strain of bacteria and viruses are now used widely for immunization against many diseases.[4]

b. Passively acquired immunity:

- Several drug manufacturing companies are involved in the large production of antibodies in horses and cause by active immunization. [5]

2. Innate immunity:

- It is present at the time of the birth.
- It is non-specific type defense like skin [6]

Herbal Immuno boosting agents:

In this country herbs play an important role to defeat diseases and viral infection, various herbal plants have their own medicinal properties to cure diseases or syndrome the main reason of using herbal drugs is it is free from harmful chemicals because they are obtained from plants naturally. Some of natural drugs are as follows with their biological source, chemical constituents, morphology and uses.

1.	Amla	6.	Tulsi	11.	Aloevera	16.	Clove
2.	Turmeric	7.	Neem	12.	Fennel	17.	Rose
3.	Ginger	8.	Ashwagandha	13.	Orange	18.	Hibiscus
4.	Honey	9.	Lemon	14.	Cardamom	19.	Daisy
5.	Green chiretta	10.	Cinnamon	15.	Cumin	20.	Brahmi

These are the name of some natural traditional or ayurvedic medicines used to cure diseases these all have their own special properties and special characteristics to kill the infections, bacteria, viruses and treated the diseases.

Figure 1: Some herbal immune boosting agents

1. Amla (amalki):

Biological source -Amla is the richest source of vitamin c and used to cure hair fall, it consists of fresh fruits of the plant *Emblica officinalis* it belongs to family Euphorbiaceae.

Colour-Yellowish- green

Odour- Strong

Taste- Sour and slightly bitter

Amla plays an important role in hair growth due to his medicinal properties it helps in stronger, shiny and thinner hair, with these properties amla is used in the manufacturing of shampoos, hair oils and conditioner also. It is mainly found in the forests of India, Malya, China and Sri Lanka.

Chemical constituents- Amla contains large amount of vitamin c, tanins and minerals.

Uses- It is used as immunity booster.

Used in the treatment of skin diseases.

It increased blood circulation in our body.

It is also used in adequate digestion.

Reduce hair fall and improve hair growth, hair makes more beautiful and shinier. Amla juice is used for weight balance.

2. Turmeric (haridra):

Biological source- Turmeric is most commonly drugs and best drug for minor infection and immunity booster, it is a dried rhizome of *Curcuma longa* linn and it belonging to the family Zingiberaceae.

Colour- Orange to yellow

Odour- Piquant

Taste- Earthy and pleasantly bitter

Turmeric is mostly found in India. And used in powder form also

Chemical constituents- Tumeron, curcuminoids, cymene, curcumin

Uses- used as immunity booster.

Used in skin treatments.

Used as colouring agents and improve the taste of foods.

Curcuma is used to treat infections and wounds also.

3. Ginger (Adrak):

Biological source: It is well-known for herbaceous plant and widely used for herbal medicine and flavoring agent for centuries. The utilization of ginger treats common health problems, common cold, cough, nausea, including pain and vomiting [7] more than 70 compounds are activated from ginger. It contains dried rhizomes of *Zingiber officinale* and it belongs to the

family Zingiberaceae. So many effects of zingiber were included in a variety of health conditions and diseases.

Colour- Pale (light) yellow colour

Odour-Piquant

Taste- Pleasant

Moreover, respiratory symptoms and cardiovascular symptoms were observed in a zingiber-treated patient group who underwent laparoscopic surgery.

Ginger has so many significance it is used in traditionally rituals provide protection from spirits and mainly found in India, China and Nigeria. The leaves and roots of ginger are used to produce floavoured in food products mainly in India. Ginger provides relief from common cold and cough and it is most powerful immunity booster and antioxidant.

Chemical constituents- Alkaloid, gingerols, shogaols and paradols

Uses – It is used as antioxidants, spices, flavouring agents, immunity booster and mats.

4. Honey (Madhu):

Biological source- Honey is a natural product obtained from nectar of flowers by honeybees *Apis mellifera* and it is belonging to the family Apidae.

Honey is produced in Australia, Africa, New Zealand, India and California.

Colour- Colorless to dark brown

Odour- Pleasant

Taste- Faintly acid and sweet

Chemical constituents- Maltose, fructose, niacin, Glucose and water present in honey.

Uses- Honey is a most commonly source of sweetening agents and used in the preparation of drugs to make sweet.

Honey is also used in cosmetic preparations and helps in remove skin marks, dark circles, skin tightening (make skin beauty).

Honey is traditionally use in the treatment of hiccups, dizziness, throat infections, fatigue, eye diseases, asthma, tuberculosis, infections, piles, constipation, ulcers, nutritious supplements and wounds.

Honey is also immunity booster.

Table 1: Summary of herbal immunity boosting agents

S. No.	Drug	Biological Source	Chemical	Uses
1.	Amla	Amla fresh fruits of the plant Emblica 0fficinalis it belongs to family Euphorbiaceae.	Vitamin C, Tannins, and minerals.	Amla juice is used for weight balance.
2.	Turmeric	It is a dried rhizomes Curcuma longa linn and it belongs to the family Zingiberaceae.	Tumeron, curcuminoids, cymene and curcumin	Used in skin treatments.
3.	Ginger	It contains dried rhizomes of Zingiber officinale and it belongs to the family Zingiberaceae.	Alkaloid, gingerols, shogaols and paradols	It is used as spices, flavouring agents, and making mats.
4.	Honey	It is a natural product obtained from nectar of flowers by honeybees Apis mellifera and it is belonging to the family Apidae	Maltose, fructose, niacin, Glucose and water present in honey.	Honey is a most commonly source of sweetening agents.
5.	Green chiretta	Kalmegh is also commonly known as herbaceous plant belonging to the family Acanthaceae and the other name of green chiretta is Andrographis Paniculata.	Andrographine and Andrographolide present in Kalmegh	Kalmegh may also have building properties of immunity.
6.	Tulsi	Tulsi consists of fresh and dried leaves of *Ocimum sanctum* Linn, belonging to family Labiatae.	Citric and alkaloids	Used in ayurvedic and naturopathic.
7.	Neem	Neem belongs to the family Meliaceae.	Salanin present in neem.	Used to treat fungal infection
8.	Ashwagandha	It consists of dried roots and stem basis of Withania Somnifera and it belonging to the family Solanaceae	It contains large amount of terpenoids.	Ashwagandha is also the mainly source of immunity booster.

5. Green chiretta (Kalmegh):

Biological source - Kalmegh is also commonly known as herbaceous plant belonging to the family Acanthaceae and the other name of green chiretta is *Andrographis paniculata*.

Kalmegh is distributed in Sri Lanka and south India. The plant is cultivated in many countries as well Java Malaysia and Thailand.

Color- Green

Odour- Odorless

Taste - Bitter

Chemical constituents- Andrographine and Andrographolide present in Kalmegh

Uses- Kalmegh contains a property of laxatives and helps to improve digestion.

Kalmegh reduced supply of blood and availability of oxygen to heart muscles may cause the heart muscles damage. [8]

Kalmegh may have antimalarial properties.

Kalmegh may also have building properties of immunity.

Kalmegh may also have antibiotic properties.

It also may act as pain killer.

6. Tulsi (Pavani):

Biological source- The queen of all herbs is Tulsi and it is mainly used in the manufacturing of holistic medicine, and traditional drug which helps to cure many diseases or infectious disease and it consists of fresh and dried leaves of *Ocimum sanctum Linn***,** belonging to family Labiatae.

Tulsi is herbaceous plant mainly found in India and used all parts of Tulsi is used in medicines and it is grown in parks and grow near holy place like temple to the worship of gods.

Color-Green

Odor- Astringent

Taste- Slightly peppery note.

Chemical constituents – Tulsi contains saponin, tannins, an appreciable amount of vitamin C traces of maleic, glycosides, and tartaric acid. Citric and alkaloids

Uses- Tulsi used in the treatment of skin disease.

Tulsi is used as flavouring agent in tea.

Increase the capacity of immunity.

7. Neem (Margosa):

Biological source – Neem contains many active constituents which help to cure disease and it is also known as margosa, Indian Lilac and Azadirachta, belonging to the family Meliaceae.

All parts of this plant used to making drugs. It is cultivated in India also.

Color- Green

Odor- Garlic like smell

Taste- Bitter

Chemical uses- Salanin present in neem.

Uses – used to treat fungal infection.

Used in the treatment of fever.

Also treat cough.

Also effective in common cold

Neem contains antimalarial properties.

8. Ashwagandha (Asandha):

Biological source- "Ashwagandha" describes the smell of its root, meaning "like a horse." Ashwa means horse it is an important herb in traditional medicines. Asandha helps you maintain both mentally and physically. It consists of dried roots and stem basis of *Withania somnifera* and it belonging to the family Solanaceae.

Colour- Whitish cream

Odour- Smell of horse

Taste- Bitter

Chemical constituents- It contains large amount of terpenoids and phenolic acids. And it is found in India and its different states like Rajasthan and Madhya Pradesh

Uses- Stress is treated by ashwagandha.

Anxiety is also treated by ashwagandha.

Ashwagandha is also the mainly source of immunity booster.

Skin condition is also cure by ashwagandha.

Arthritis is also treated by ashwagandha.

Epilepsy is also reduced by ashwagandha.

Conclusion:

We know that Herbal drugs are playing most significant role in the management, prevention and treatment of various viral diseases as well as boosting our immunity. So in this perspective authors have tried to promote the interest of readers in herbal drugs.

Acknowledgement:

Authors would like to thank Dr. Mandeep Singh (MD, Apex College of Pharmacy) for providing the necessary facilities for writing the work.

References:

1. Australasian Society of Clinical Immunology and Allergy (ASCIA).
2. National Institute of Allergy and Infectious Diseases, USA.
3. The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General.
4. Mrityunjaya, M., Pavithra, V., Neelam, R., Janhavi, P., Halami, P.M. and Ravindra, P.V., 2020. Immune-boosting, antioxidant and anti-inflammatory food supplements targeting pathogenesis of COVID-19. Frontiers in Immunology, p.2337.
5. Mishra, S. and Patel, M., 2020. Role of nutrition on immune system during COVID-19 pandemic. Journal of Food Nutrition and Health, 3(2).
6. Institute of Medicine. Dietary reference intakes for thiamin, riboflavin, niacin, vitamin B6, folate, vitamin B12, pantothenic acid, biotin, and choline. Washington, DC: National Academy Press, 1999.
7. Li H., Liu Y., Luo D., Ma Y., Zhang J., Li M., Yao L., Shi X., Liu X., Yang K. Ginger for health care: An overview of systematic reviews. *Complement. Ther. Med.* 2019; 45:114–123. doi: 10.1016/j.ctim.2019.06.002.
8. Siddhartha KM, Neelam SS, Rajendran SS. Plant Review Andrographis paniculata (Kalmegh): A Review. *Pharmacogn Rev*. 2007;1(2):283-298

EXTRACTION AND PRELIMINARY PHYTOCHEMICAL INVESTIGATION OF BARK OF *TINOSPORA CORDIFOLIA*

C. Y. Patil, Y. K. Patil, D. K. Sambare and T. A. Rajput*

Arts, Commerce and Science College, Onde,

Tal. Vikramgad Dist. Palghar (India)

*Corresponding author E-mail : tejenrajput@gmail.com

Abstract:

This work report presents a comprehensive study on the extraction and preliminary phytochemical investigation of *Tinospora cordifolia*, a medicinal plant known for its numerous therapeutic properties. The objective of this research work was to explore the phytochemical composition of bark of This project report presents a comprehensive study on the extraction and preliminary phytochemical investigation of *Tinospora cordifolia*, a medicinal plant known for its numerous therapeutic properties. The objective of this research work was to explore the phytochemical composition of bark of *Tinospora cordifolia* medicinal plant and evaluate its potential pharmacological activities. The extraction process involved the use of two solvents including ethanol and water, to obtain the plant's crude extracts. Subsequently, these extracts were subjected to preliminary phytochemical screening to identify the presence of different classes of secondary metabolites, such as terpenoids, steroids, alkaloids, flavonoids, tannins, saponins, glycosides, and phenolic compounds.

Keywords: *Tinospora cordifolia*, cold maceration, ethanol extracts, water extracts.

Introduction:

Trust in traditional medicine: According to the World Health Organization (WHO), more than 80% of the global population relies on traditional medicine, particularly plant-based remedies, for their primary healthcare needs. This highlights the widespread belief and trust in the medicinal properties of traditional remedies derived from plants[1].

Empirical knowledge in India: In India, local communities have developed empirical knowledge about the medicinal properties of plants, which forms the basis for their use as home remedies. Traditional medicine in India, such as Ayurveda, relies on this empirical knowledge to identify and utilize plant products for various therapeutic purposes[2].

Historical use of plants for therapy: A research chapter published in the journal 'Science' in 1973 titled "A Neanderthal flower burial in northern Iraq" provided evidence of plant use for

therapeutic purposes in the Middle Paleolithic age approximately 60,000 years ago. Fossil studies confirmed that plants were utilized as a form of therapy during that time, indicating the long-standing history of using plants for medicinal purposes[3].

***Tinospora cordifolia* (Guduchi):** One significant herb in the Ayurvedic system of medicine is *Tinospora cordifolia*, commonly known as Guduchi. This plant belongs to the Menispermaceae family and holds great importance in Ayurveda. It has been used in various medicinal preparations to address somatic, psychosomatic, and lifestyle disorders in humans for centuries.

Overall, the points highlighted in the introduction emphasize the global trust in traditional medicine, the empirical knowledge of medicinal plants in India, the historical use of plants for therapy, and the significance of *Tinospora cordifolia* (Guduchi) in Ayurveda[4].

Material and Methods

Plant material collection and authentication

The bark of plant Tinospora cordifoli. were collected from village Onde of Vikramgad tehasil in Palghar district (MS). The specimens of plants were authenticated by Dr. L. K. Kshirsagar, Department of Botany, S.S.V.P.S's L. K. Dr. Ghogrey Science College, Dhule (MS). The dried uniform barks powder was used for the extraction of constituents of the plant, and phytochemical investigation[5].

Drying and pulverization

Barks of *Tinospora cordifolia* were shade dried and pulverized and stored in an air tight container for future use.

Extraction of powdered leaves[6]

The extraction of *Tinospora cordifolia* bark were carried out using known standard procedures. The powdered leaves were successively extracted by cold maceration process using organic solvents like ethanol and water. All the extracts were evaporated to dryness and stored for future use.

Preliminary phytochemical screening

The extracts were subjected to preliminary Phytochemical screening for the presence of different chemical groups of compounds. Air dried powdered plant material were screened for the presence of saponins, tannins, flavonoids, steroids, triterpenoids, proteins, glycosides, carbohydrates as described in literatures[6,7].

Result and Discussion:

Physical appearance, color and odor of different extracts were recorded in (Table 1).

Table 1: Shows characteristics of *Tinospora cordifolia* extracts.

Sr. No.	Extract	Physical Appearance	Color	Odor
1	Ethanol	Semi-Solid mass	Dark Green	Pungent Aromatic
2	Water	Semi-Solid mass	Greenish Brown	Pungent Aromatic

The physical constants evaluation of drugs is an important parameter in detecting adulteration or improper handling of drugs. The loss on drying is important in evaluation of purity of drugs i.e. presence or absence of foreign inorganic matter. Moisture content of barks were determined, and results are shown in (Table – 2)

Table 2: Shows physicochemical parameters of *Tinospora cordifolia* leaves.

Sr. No.	Parameters	Values (%) w/w
1	Loss on drying	6.00%

Phytochemical tests for the presence of secondary phytoconstituents showed following results (Table -3)

Table 3: Show preliminary Phytochemical screening of *Tinospora cordifolia* bark powder.

Sr. No.	Phytoconstituents	Ethanol	Water
1	Alkaloids	_	+
2	Carbohydrates	+	+
3	Glycosides	+	+
4	Flavonoids	+	_
5	Phenol& Tannins	+	+
6	Steroids	_	_
7	Terpenoids	+	+
8	Saponins	_	+
9	Proteins	+	+
10	Amino Acids	+	+

(#EE- Ethanol extract, AE- Aqueous extract)

Conclusion:

The introduction not only highlights the specific project on *Tinospora cordifolia* but also emphasizes broader themes such as the global reliance on traditional medicine, the empirical knowledge of medicinal plants in India, the historical use of plants for therapy, and the significance of *Tinospora cordifolia* (Guduchi) in Ayurveda. These points provide a broader context for understanding the importance of studying and exploring medicinal plants for their potential therapeutic applications.

Acknowledgment:

Authors are thankful to The Principal, Arts, Commerce and Science college, Onde, Tal. Vikramgad Dist. Palghar for providing all necessary facilities.

References:

1. Bannerman R, Burton J, Wen-Chieh C. The role of traditional medicine in primary health care, in traditional medicine and health care coverage- Areader for health administrators and practitioners. The WHO, 1983, Geneva, Switzerland.
2. Sharma A, Gupta A, Batra S.S.A. *Tinospora cordifolia* (Wild.) Hook. F. & Thomson - A plant with immense economic potential. Journal of Chemical & Pharmaceutical Research 2010, 2 (5): 327-33.
3. Bury K.L, Rao Y, Kumar K.B. Efficacy of *Tinospora cordifolia* on learning and memory in healthy volunteers. Iranian Journal of Pharmacology & Therapeutics 2004,3: 57-60.
4. Sinha, K, Mishra N.P, Singh J, Khanuja S.P.S. A Review: *Tinospora cordifolia* (Guduchi), a reservoir plant for therapeutic application. Indian Journal of Traditional Knowledge 2004, 3 (3): 257-270.
5. Sivakumar V, Dhanarajan M.S, Riyazullah M.S. Preliminary phytochemical screening and evaluation of free radical scavenging activity of *Tinospora cordifolia*. International Journal of Pharmacy and Pharmaceutical Sciences 2011, 2:186-88.
6. Nayanmpalli S.S, Desai N.K, Ainapure S.S. Anti allergic properties of *Tinospora cordifolia* in animal models. Indian Journal of Pharmacology 1986,18:250-252.
7. Suk KT, Kim DJ. Drug-induced liver injury: present and future. Clin Mol Hepatol 2012; 18(3):249-257.
8. Sandhu N, Navarro V. Drug-Induced Liver Injury in GI Practice. Hepatol Commun 2020; 4(5):631-645.
9. Larrey D, Ursic-Bedoya J, & Meunier J. Chapter 27. Drug-induced Hepatotoxicity. In: Schiff's Diseases of the Liver. 2018: West Sussex, PO19 8SQ, UK.
10. Rathi C, Pipaliya N, Patel R, Ingle M, Phadke A, Sawant P. Drug-Induced Liver Injury at a Tertiary Hospital in India: Etiology, Clinical Features and Predictors of Mortality. Ann Hepatol 2017;16(3):442-450.

DRUG CHEMISTRY

Shilpi Shrivastava*, Sarvaree Bano, Preeti Pandey,
Priyanka Gupta and Anushree Shaha
Department of Chemistry,
Kalinga University, Naya Raipur (C.G.) India 492101
*Corresponding author E-mail: shilpi.vikas2905@gmail.com,
shilpi.srivastava@kalingauniversity.ac.in

Abstract:

Drug chemistry is a branch of medicinal chemistry that focuses on the design, synthesis, characterization, and optimization of chemical compounds with therapeutic potential. The field of drug chemistry plays a crucial role in the development of new drugs, understanding their molecular mechanisms of action, and optimizing their effectiveness and safety profiles. This abstract provides an overview of the fundamental concepts and processes involved in drug Chemistry, highlighting its significance in modern pharmaceutical research. The primary objective of drug chemistry is to discover and design chemical compounds that can interact selectively with target molecules in the human body, such as enzymes, receptors, or DNA, to modulate their biological functions. This targeted interaction allows drugs to treat diseases by altering specific biochemical pathways or physiological processes.

Keywords: Illicit drugs, Prescription drugs, LSD (Lysergic acid diethylamide), Overdose, Drug trafficking, Opioids, Narcotics, Drug interdiction, Designer drugs

Introduction:

The process of drug discovery and development begins with identifying a suitable target for intervention, often a disease-related protein or nucleic acid. Researchers employ various computational and experimental techniques to design and synthesize small organic molecules or biologics that can interact with the target in a desired manner. These molecules undergo rigorous testing for efficacy, specificity, and safety using in vitro assays, animal models, and clinical trials.

Drug chemistry also involves the study of drug metabolism, pharmacokinetics, and pharmacodynamics. These areas explore how drugs are absorbed, distributed, metabolized, and eliminated within the body, as well as their mechanisms of action at the molecular and cellular

levels. Understanding these factors is essential for optimizing dosage regimens and predicting potential drug-drug interactions or adverse effects.

The advent of modern analytical techniques, such as X-ray crystallography, nuclear magnetic resonance (NMR) spectroscopy, and mass spectrometry, has revolutionized drug chemistry by enabling researchers to determine the three-dimensional structures of drug molecules and their interactions with target biomolecules. This structural knowledge is vital for rational drug design, as it facilitates the identification of critical binding sites and the optimization of molecular interactions.

Drug chemistry is a branch of chemistry that deals with the study of the chemical composition, properties, and interactions of drugs or pharmaceutical substances. It involves understanding the structure and function of drugs at a molecular level, as well as their synthesis, formulation, and analysis.

Here are some key aspects of drug chemistry:

Drug design: Drug chemists work on designing new drugs or modifying existing ones to improve their effectiveness, reduce side effects, and enhance their therapeutic properties. This process involves studying the target disease or condition, identifying potential drug targets, and designing molecules that can interact with these targets.

Medicinal chemistry: Medicinal chemistry focuses on the optimization of drug candidates through the modification of their chemical structure. Medicinal chemists use their knowledge of organic chemistry and biochemistry to synthesize and evaluate a wide range of compounds for their biological activity, pharmacokinetics (absorption, distribution, metabolism, and excretion), and pharmacodynamics (mechanism of action).

Drug synthesis: Drug synthesis involves the preparation of drugs through organic chemical reactions. It includes designing synthetic routes, selecting appropriate starting materials, and carrying out reactions to produce the desired drug molecule. Drug synthesis can be complex and requires expertise in organic chemistry techniques and methodologies.

Drug formulation: Drug formulation is the process of converting a drug substance into a dosage form suitable for administration, such as tablets, capsules, injections, or topical creams. Drug chemists work on developing formulations that ensure optimal drug delivery, stability, and bioavailability.

Drug analysis: Drug analysis involves the development and application of analytical techniques to determine the identity, purity, and quality of drugs. Analytical methods such as spectroscopy,

chromatography, and mass spectrometry are employed to assess the chemical composition and concentration of drug substances and formulations.

Pharmacokinetics and pharmacodynamics:

Drug chemistry also encompasses the study of how drugs are absorbed, distributed, metabolized, and excreted by the body (pharmacokinetics) and how they interact with their target receptors or biomolecules to produce a therapeutic effect (pharmacodynamics).

Overall, drug chemistry plays a crucial role in the discovery, development, and production of safe and effective medications. It combines principles from various disciplines, including organic Chemistry, biochemistry, pharmacology, and analytical Chemistry, to advance our understanding of drugs and improve healthcare outcomes.

References:

1. Shrivastava, S. (2009). Anti-microbial Activity of Crude Extract from Agaeratum Conyzoides L. (Asteraceae).
2. Dixit, A. & Shrivastava, S. (2011).Molar volume and Viscosities of hydrochloride in Methanol water(50:50 v/v) at 303.15K . Asian journal of chemistry
3. Shrivastava, S. Dixit A. Tiwari, PN, Kataryia, HC.(2014). Synthesis and its study of Antihyperglycemic activity of newly synthesized from fresh water algae. Asian journal of research in Chemistry, 7(2),144-147.
4. Dixit, A., & Shrivastava, S. (2013). Assessment of Parameters of Water Quality Analysis of Hanumantal and Robertson Lake at Jabalpur (MP). Asian Journal of Research in Chemistry, 6(8), 752-754.
5. Shrivastava, S. (2016). Water Quality analysis of Devtal and Gangasagar Lake at Jabalpur(M.P.). 5(9),220-221
6. Shrivastava, S. H. I. L. P. I., & Verma, A. L. O. K. E. (2023). Nano Chemistry and Their Application. Recent Trends of Innovations in Chemical and Biological, 5, 67.
7. Sinha, I., Verma, A., & Shrivastava, S. (2023). Synthesis of Polymer Nanocomposites Based on Nano Alumina: Recent Development. European Chemical Bulletin, 12, 7905-7913.
8. Verma, A. L. O. K. E., Shrivastava, S. H. I. L. P. I., & Diwakar, A. K. (2022). The Synthesis of Zinc Sulfide for Use in Solar Cells by Sol-Gel Nanomaterials. Recent Trends of Innovations in Chemical and Biological, 4, 69.
9. Yadaw, P., & Shrivastava, S. (2019). Properties and uses of some medicinal plants found in Jashpur district of Chhattisgarh. IOSR journal of applied chemistry, 12(8), 51-54.
10. Shrivastava, S. (2023). Biogenesis of silver nanoparticles using the bacteria and its antibacterial study. BioGeeko, 12, 864-870.

11. Netam, V., & Shrivastava, S. (2023). Review of heavy metal ion removal from wastewater. Ann. For. Res, 66(1), 3371-3384.
12. Shrivastava, S., & Sharma, S. (2020). A brief review to study of rice mill water pollution on Mahanadi River at Chhattisgarh. Int Res J Multidiscip Scope, 1, 18-20.
13. Yadaw, P., & Shrivastava, S. (2020). A study of the use of some medicinal plants by tribes living in Jashpur district of Chhattisgarh state. International Research Journal of Multidisciplinary Scope (IRJMS), 1(4), 45-51.
14. Shrivastava, S. (2018). Synthesis of MgO nanoparticle by Neem leaves obtained from local area of Kotni village, Chhattisgarh through green method. Eur J Biomed Pharm Sci, 5, 746-747.
15. Shrivastava, S., & Dixit, A. (2011). Molar Volume and Viscosities of Hydroxylamine Hydrochloride in Methanol-Water (50: 50 v/v) at 303.15 K. Asian Journal of Chemistry, 23(12), 5528.
16. UpAdHYAY, R., & BANO, S. (2023). A Review on Terpenoid Synthesized Nanoparticle and It's Antimicrobial Activity.
17. Banoa, S., Agrawal, M., & Palc, D. (2020). A review on green synthesis of silver nanoparticle through plant extract and its medicinal applications. J. Indian Chem. Soc, 97, 983-988.
18. Naga, S., & Banob, S. Chemical Sensors for Soil Analysis: Emerging Technologies.
19. Rakesh, S. B. A COMPREHENSIVE STUDY OF BIOCHEMICAL SENSOR.
20. Lakra, A., & Bano, S. Biofuels as an opportunity to sustainable energy. world, 1, 5.
21. Shrivastava, S. & Verma, A. (2023). Nano Chemistry and Their Application. Recent Trends of Innovations in Chemical and Biological Sciences (Volume-V). Bhumi Publishing, India. ISBN: 978-93-88901-38-3.

COMPARE THE ISOTHERMAL BULK MODULUS AND ITS FIRST PRESSURE DERIVATIVE BY USING EQUATIONS OF STATE

Sanjay Singh

Department of Physics,

Chintamani College of Arts and Science, Gondpipri (MS)

Corresponding author E-mail: sanjaynaac19@gmail.com

Introduction:

Extraction of exact values for the isothermal bulk modulus and its pressure derivative was the goal of the study, an extension of a recent one. Here, two EOSs created by Born-Mie and Bardeen, respectively, are taken into consideration. We applied all the EOS models to the accurate and model-independent isotherms of three solids, with no limits on the parameters. The degree of agreement between the fit parameters and the compression and pressure ranges, as well as how many wiggles there are in the data deviation curves relative to the fit parameters, have all been used to determine the applicability. To scale the relative applicability of the EOSs in relation to the test parameters, a systematic technique is also created. The current inquiry has produced some impressive findings. Unexpectedly, the popular Born-Mie and Bardeen EOSs—older EOSs—are also still in use.

Born- Mie equation of state

The first pressure derivative bulk modulus K_0' and isothermal bulk modulus K_0 express the relationship between pressure and volume analytically in the phenomenological equation, both of which are at zero pressure. Using a particular potential function for kind range potential energy, the Born-Mie equation of state is derived from interionic potentials. Eliminating these characteristics from a basic relationship with K_0 and K_0' is challenging.

We start the basic thermodynamics relationship

$$P = -\frac{dW}{dV} \qquad \text{------} \qquad (1)$$

The inverse of isothermal compressibility, the isothermal bulk modulus K_T is defined as

$$K_T = -V\left(\frac{dP}{dV}\right)_T = V\frac{d^2W}{dV^2} \qquad \text{-------} \qquad (2)$$

Here K_T is the isothermal bulk modulus. The volume derivative is taken at constant temperature. Here W is the crystal lattice potential energy which can be expressed as a function of unit cell volume V as follows

$$W = -\frac{\alpha_m Z^2 e^2}{V^{1/3}} + \phi(V) \qquad \text{-------} \qquad (3)$$

Where the first term on denotes the long-distance electronic Potential energy modeling, and $\phi(V)$ is the sort range overlap repulsive potential energy. The following are the short range constants:

$$A = \frac{1}{3}\left[\frac{d^2\phi}{dr^2} + \frac{2}{r}\frac{d\phi}{dr}\right] \qquad \text{-------} \qquad (4)$$

The derivative of ϕ with respect to nearest interionic separation r can be transformed to the corresponding derivative with respect to V using the relationship

$$V = ar^3 \qquad \text{-------} \qquad (5)$$

Where a is the geometrical factor depending on type of structure of solid. Thus we can write

$$\frac{dW}{dV} = \frac{dW}{dr} \times \frac{dr}{dV} \qquad \text{------} \qquad (6)$$

$$\frac{dW}{dV} = \frac{1}{3ar^2} \times \frac{dW}{dr}$$

And

$$V\frac{d^2W}{dV^2} = \frac{1}{9ar}\left[\frac{d^2W}{dr^2} - \frac{2}{r}\frac{dW}{dr}\right] \qquad \text{------} \qquad (7)$$

Equation (7) can be rearranged in the following term

$$V\frac{d^2W}{dV^2} = \frac{1}{9ar}\left[\frac{d^2W}{dr^2} + \frac{2}{r}\frac{dW}{dr}\right] + \frac{4}{3}P \qquad \text{------} \qquad (8)$$

The last term in equation (8) appears as a result of using equations (1) and (6). The purpose of writing equation (8) in its present form is to introduce the force constants A in term of Laplacian operator

$$A = \frac{1}{3}\left[\frac{d^2\phi}{dr^2} + \frac{2}{r}\frac{d\phi}{dr}\right] \qquad \text{------} \qquad (9)$$

It is found that A can be expressed as function of volume and the derivatives of A have been used in the studies on pressure dependence of dielectric properties of solids. Equation (8) with the help of equation (2), (5) and (9) can be written as following term.

$$K_T = \frac{A}{3a^{2/3}V^{1/3}} + \frac{4}{3}P \qquad \text{------} \qquad (10)$$

The pressure derivative of K_T represented by $K' = \frac{dK_T}{dP}$ obtained from equation (10) is given blow

$$K' = \frac{dK_T}{dP} = \left(\frac{4}{3}\frac{P}{K_T} - 1\right)\left(\frac{V}{A}\frac{dA}{dV} - \frac{5}{3}\right) + \frac{16}{9}\frac{P}{K_T} \qquad \text{------} \qquad (11)$$

An expression for second order pressure derivative of bulk modulus can be obtained by differentiating twice first part of equation (11) thus

$$\frac{d^2K_T}{dP^2} = -\frac{1}{K_T}\left(\frac{dK_T}{dP}\right) - \frac{1}{K_T}\left(\frac{dK_T}{dP}\right)^2 + \frac{V^2}{{K_T}^2}\left(\frac{d^2K_T}{dV^2}\right) \quad \text{------} \quad (12)$$

The last term in equation (12) can be taking second order value derivative of equation (12) which yield

$$V^2\left(\frac{d^2K_T}{dV^2}\right) = -\left(K_T - \frac{4}{3}P\right) \times \left(\frac{V^2}{A}\frac{d^2A}{dV^2} - 2\frac{V}{A}\frac{dA}{dV} + 4\right) + \frac{112}{27}P \text{ ------} \quad (13)$$

There is a direct correlation between the short range force constants and volume, as shown by the values of A and its volume derivative that Shanker et al. calculated from data on higher order elastic constants and the pressure derivative of the dielectric constants for ionic crystals. The following expression can be used to analyses the state-volume dependency of A,

$$A = A_0 f\left(\frac{V}{V_0}\right) \quad \text{------} \quad (14)$$

Where $f\left(\frac{V}{V_0}\right)$ is a function of $\left(\frac{V}{V_0}\right)$. We consider an inverse power from as well as exponential form the function f appearing in equation (14) thus

$$f\left(\frac{V}{V_0}\right) = \left(\frac{V}{V_0}\right)^{-m} \quad \text{------} \quad (15)$$

Where A_0, m and K are constants independent of volume and pressure. Inverse power from equation (14) and (15) then

$$\frac{V}{A}\frac{dA}{dV} = -m \quad \text{------} \quad (16)$$

And

$$\frac{V^2}{A}\frac{d^2A}{dV^2} = m(m+1) \quad \text{------} \quad (17)$$

Substituting equation (16) in equation (11) and applying the boundary conditions at P=0, $K = K_0'$ and V=V_0, then we get found the value of m is equal to $(K_0' - 5/3)$. The constants A_0 is determined by substituting equation (14) for A in equation (10) and taking $K_T = K_0$ at P = 0 and V=V_0, values of A_0 , m and K thus determined. We finally obtained the following expression with the help of equation (10)-(13) using the relations (16) and (17) based on the inverse power form

$$K = K_0\left(\frac{V}{V_0}\right)^{-m-1/3} + \frac{4}{3}P \quad \text{------} \quad (18)$$

$$\frac{dK}{dP} = \left(1 - \frac{4}{3}\frac{P}{K}\right)K_0' + \frac{16}{9}\frac{P}{K} \quad \text{------} \quad (19)$$

$$\frac{d^2K}{dP^2} = -\frac{1}{K}\frac{dK}{P} - \frac{1}{K}\left(\frac{dK}{dP}\right)^2 + \left(\frac{1}{K} - \frac{4}{3}\frac{P}{K^2}\right)(m^2 + 3m + 4) + \frac{112}{27}\frac{P}{K^2} \text{ ----} \quad (20)$$

Analytical forms of EOS representing the relationship between pressure and volume ratio V/V_0 can be obtained using the volume dependence of A given by equation (14) and (15). Equation (10) with the help of equation (14) can be written as

$$K = \frac{A_0 V^{-1/3}}{3a^{2/3}} f\left(\frac{V}{V_0}\right) + \frac{4}{3}P \qquad \text{------} \qquad (21)$$

At P = 0 and $K = K_0$ and therefore we have

$$\frac{A_0}{3a^{2/3}} = \frac{K_0 {V_0}^{-1/3}}{f_0} \qquad \text{------} \qquad (22)$$

Substituting equation (22) in equation (21) and relationship for isothermal bulk modulus given equation (2) we get

$$-V\left(\frac{dP}{dV}\right)_T = \frac{K_0}{f_0}\left(\frac{V}{V_0}\right)^{-1/3} f + \frac{4}{3}P \qquad \text{------} \qquad (23)$$

Here $f\left(\frac{V}{V_0}\right)$ is denoted by f and f_0 is the value of at $V=V_0$when P = 0.Equation (23) can be rearranged as follows

$$\eta^{2/3}\left(\frac{dP}{d\eta}\right) + \frac{4}{3}P\eta^{1/3} = -\frac{K_0}{f_0} f \qquad \text{------} \qquad (24)$$

Where $\eta = \left(\frac{V}{V_0}\right)$ on integrating equation (24) we find

$$P\left(\frac{V}{V_0}\right)^{4/3} = -\frac{K_0}{f_0 V_0}\int f dV + C \qquad \text{------} \qquad (25)$$

Where is the C constant of integration. Analytical forms of EOS are obtained from equation (25) using equation (15) for f. Value of C is determined in each case by applying condition that $V=V_0$ at P = 0. The inverse power form when used in (25) yields the following expression

$$P = \frac{3K_0}{(3K_0{}' - 8)}\left[\left(\frac{V}{V_0}\right)^{4/3 - K_0{}'} - \left(\frac{V}{V_0}\right)^{-4/3}\right] \qquad \text{-----} \qquad (26)$$

Equation (26) represent the relationship P and V/V_0 in term of K_0 and K_0' only. Equation (26) is known as the Born-Mie equation of state.

Bardeen Equation of state

A potential function of general form is required which obtained by adding another terms

$$E(r) = A\left(\frac{a}{r}\right)^l + B\left(\frac{a}{r}\right)^m + C\left(\frac{a}{r}\right)^n \qquad \text{------} \qquad (27)$$

In order to maintain the equations' symmetry, we avoided adding a negative sign but required one or two of A and B to be negative. Differentiating of equation (27) with respect to r then we get

$$\frac{dE}{dr} = -\frac{Al}{a}\left(\frac{a}{r}\right)^{l+1} - \frac{Bm}{a}\left(\frac{a}{r}\right)^{m+1} - \frac{Cn}{a}\left(\frac{a}{r}\right)^{n+1} \qquad \text{------} \qquad (28)$$

Again differentiating of equation (28) with respect to r then we get

$$\frac{d^2E}{dr^2} = \frac{Al(l+1)}{a^2}\left(\frac{a}{r}\right)^{l+2} + \frac{Bm(m+1)}{a^2}\left(\frac{a}{r}\right)^{m+2} + \frac{Cn(n+1)}{a^2}\left(\frac{a}{r}\right)^{n+2} \qquad \text{------} \qquad (29)$$

Again differentiating of equation (29) with respect to r then we

$$\frac{d^3E}{dr^3} = -\frac{Al(l+1)(l+2)}{a^3}\left(\frac{a}{r}\right)^{l+3} - \frac{Bm(m+1)(m+2)}{a^3}\left(\frac{a}{r}\right)^{m+3} - \frac{Cn(n+1)(n+2)}{a^3}\left(\frac{a}{r}\right)^{n+3} \quad \text{---} \quad (30)$$

Using the thermodynamic definition of pressure, the equation of state and the relationship between pressure and volumetric strain are discovered.

$$P = -\left(\frac{d\varepsilon}{dV}\right) \quad \text{-------} \quad (31)$$

$$= -\frac{dr}{dV}\frac{d\varepsilon}{dr}$$

Where ε is total atomic interaction energy where ε =3 $Nf_1E(r)$ and V is the volume in which the separation of the pair of neighbors is r then $V = Nf_2r^3$

$$V = Nf_2r^3 \quad \text{-------} \quad (32)$$

Differentiating of equation (32) this with respect to r then we get

$$\frac{dV}{dr} = 3Nf_2r^2 \quad \text{-------} \quad (33)$$

So therefore equation (31) can be written as

$$P = -\left(\frac{d\varepsilon}{dV}\right) = -\frac{d}{dV}[3\ Nf_1E(r)]$$

$$P = -\frac{3Nf_1dE/dr}{dV/dr} = -\frac{3Nf_1dE/dr}{3Nf_2r^2}$$

$$P = -\frac{1}{r^2}\frac{f_1}{f_2}\frac{dE}{dr} \quad \text{-------} \quad (34)$$

Differentiating of equation (34) this with respect to r then we get

$$\frac{dP}{dr} = -\frac{1}{r}\frac{f_1}{f_2}\left(\frac{1}{r}\frac{d^2E}{dr^2} - \frac{2}{r^2}\frac{dE}{dr}\right) \quad \text{-------} \quad (35)$$

The inverse of isothermal compressibility, the isothermal bulk modulus K, is defined as

$$K = -V\left(\frac{dP}{dV}\right)_T \quad \text{-------} \quad (36)$$

$$= -V\frac{dP/dr}{dV/dr}$$

$$= -\frac{V\left[-\frac{1}{r}\frac{f_1}{f_2}\left(\frac{1}{r}\frac{d^2E}{dr^2} - \frac{2}{r^2}\frac{dE}{dr}\right)\right]}{3Nf_2r^2}$$

$$K = -\frac{f_1}{3f_2}\left(\frac{1}{r}\frac{d^2E}{dr^2} - \frac{2}{r^2}\frac{dE}{dr}\right) \quad \text{--------} \quad (37)$$

Differentiating of equation (37) this with respect to r then we get

$$\frac{dK}{dr} = \frac{f_1}{3f_2}\left(\frac{d^3E}{dr^3} - \frac{3}{r}\frac{d^2E}{dr^2} + \frac{4}{r^2}\frac{dE}{dr}\right) \quad \text{-------} \quad (38)$$

The first pressure derivative of isothermal bulk modulus K'

$$K' = \left(\frac{dK}{dP}\right)$$

$$= \left(\frac{dK}{dr} \times \frac{dr}{dP}\right)$$

$$K' = \frac{dK/dr}{dP/dr} \qquad \text{-------} \qquad (39)$$

Putting the values of $\frac{dK}{dr}$ and $\frac{dP}{dr}$ from equation (38) and (35) in equation (39) then we get the first pressure derivative of isothermal bulk modulus K'

$$K' = \frac{\frac{1}{r}\frac{f_1}{3f_2}\left(\frac{d^2E}{dr^3} - \frac{3}{r}\frac{d^2E}{dr^2} + \frac{4}{r^2}\frac{dE}{dr}\right)}{-\frac{1}{r}\frac{f_1}{f_2}\left(\frac{1}{r}\frac{d^2E}{dr^2} - \frac{2}{r^2}\frac{dE}{dr}\right)}$$

$$K' = \frac{\frac{d^2E}{dr^3} - \frac{3}{r}\frac{d^2E}{dr^2} + \frac{4}{r^2}\frac{dE}{dr}}{\frac{6}{r^2}\frac{dE}{dr} - \frac{1}{r}\frac{d^2E}{dr^2}} \qquad \text{------} \qquad (40)$$

Putting the values of $\frac{dE}{dr}$ from equation (28) in equation (34) then we get the pressure P

$$P = \frac{1}{ar^2}\frac{f_1}{f_2}\left[Al\left(\frac{a}{r}\right)^{l+1} + Bm\left(\frac{a}{r}\right)^{m+1} + Cn\left(\frac{a}{r}\right)^{n+1}\right] \qquad \text{------} \qquad (41)$$

Putting the values of $\frac{dE}{dr}$ and $\frac{d^2E}{dr^2}$ from equation (28) and equation (29) in equation (37) then we get the isothermal bulk modulus K

$$K = -\frac{f_1}{3f_2}\left(\frac{1}{r}\left\{\frac{Al(l+1)}{a^2}\left(\frac{a}{r}\right)^{l+2} + \frac{Bm(m+1)}{a^2}\left(\frac{a}{r}\right)^{m+2} + \frac{Cn(n+1)}{a^2}\left(\frac{a}{r}\right)^{n+2}\right\} - \frac{2}{r^2}\left\{\frac{Al}{a}\left(\frac{a}{r}\right)^{l+1} - \frac{Bm}{a}\left(\frac{a}{r}\right)^{m+1} - \frac{Cn}{a}\left(\frac{a}{r}\right)^{n+1}\right\}\right) \qquad \text{-------} \qquad (42)$$

$$K = \frac{f_1}{3f_2}\frac{1}{ar^2}\left[Al(l+2)\left(\frac{a}{r}\right)^{l+1} + Bm(m+2)\left(\frac{a}{r}\right)^{m+1} + Cn(n+2)\left(\frac{a}{r}\right)^{n+1}\right] \quad \text{---} \quad (43)$$

Putting the values of $\frac{dE}{dr}$, $\frac{d^2E}{dr^2}$ and $\frac{d^3E}{dr^3}$ from equation (28) (29) and (30) in equation (40) then we get the first pressure derivative of isothermal bulk modulus K'

$$K' = \frac{\left\{-\frac{Al(l+1)(l+2)}{a^3}\left(\frac{a}{r}\right)^{l+3} - \frac{Bm(m+1)(m+2)}{a^3}\left(\frac{a}{r}\right)^{m+3} - \frac{Cn(n+1)(n+2)}{a^3}\left(\frac{a}{r}\right)^{n+3}\right\} - \frac{3}{r}\left\{\frac{Al(l+1)}{a^2}\left(\frac{a}{r}\right)^{l+2} + \frac{B\,m(m+1)}{a^2}\left(\frac{a}{r}\right)^{m+2} + \frac{C\,n(n+1)}{a^2}\left(\frac{a}{r}\right)^{n+2}\right\} + \frac{4}{r^2}\left\{-\frac{Al}{a}\left(\frac{a}{r}\right)^{l+1} - \frac{Bm}{a}\left(\frac{a}{r}\right)^{m+1} - \frac{Cn}{a}\left(\frac{a}{r}\right)^{n+1}\right\}}{\frac{6}{r^2}\left\{-\frac{Al}{a}\left(\frac{a}{r}\right)^{l+1} - \frac{Bm}{a}\left(\frac{a}{r}\right)^{m+1} - \frac{Cn}{a}\left(\frac{a}{r}\right)^{n+1}\right\} - \frac{1}{r}\left\{\frac{Al(l+1)}{a^2}\left(\frac{a}{r}\right)^{l+2} + \frac{Bm(m+1)}{a^2}\left(\frac{a}{r}\right)^{m+2} + \frac{Cn(n+1)}{a^2}\left(\frac{a}{r}\right)^{n+2}\right\}}$$

$$K' = \frac{Al(l+3)^2\left(\frac{a}{r}\right)^{l+1} + Bm(m+3)^2\left(\frac{a}{r}\right)^{m+1} + Cn(n+3)^2\left(\frac{a}{r}\right)^{n+1}}{3\left[Al\,(l+3)\left(\frac{a}{r}\right)^{l+1} + Bm\,(m+3)\left(\frac{a}{r}\right)^{m+1} + Cn\,(n+3)\left(\frac{a}{r}\right)^{n+1}\right]} \text{----------} \qquad (44)$$

Now applying the boundary conditions P=0, K = K0, r=a in equation (16) and relative the boundary conditions P=0, K' = K'$_0$, r=a in equation (16) and leaving K'$_0$ as an arbitrary parameter in eliminating A, B and then pressure equation using (14) then we get

$$P = 3K_0\left[\frac{(3K_0'-n-m-6)}{(n-l)(m-l)}\left(\frac{a}{r}\right)^{l+3} + \frac{(3K_0'-n-l-6)}{(n-m)(m-l)}\left(\frac{a}{r}\right)^{m+3} + \frac{(3K_0'-m-l-6)}{(n-l)(n-m)}\left(\frac{a}{r}\right)^{n+3}\right] \text{\_\_\_(45)}$$

Now using the relation $\frac{\rho}{\rho_0} = \left(\frac{a}{r}\right)^3$ or $\frac{a}{r} = \left(\frac{\rho}{\rho_0}\right)^{1/3}$ we write in equation (18) then we get

$$P = 3K_0\left[\frac{(3K_0'-n-m-6)}{(n-l)(m-l)}\left(\frac{\rho}{\rho_0}\right)^{(l+3)/3} + \frac{(3K_0'-n-l-6)}{(n-m)(m-l)}\left(\frac{\rho}{\rho_0}\right)^{(m+3)/3} + \frac{(3K_0'-m-l-6)}{(n-l)(n-m)}\left(\frac{\rho}{\rho_0}\right)^{(n+3)/3}\right] \text{--------} \quad (46)$$

$$P = 3K_0\left[\frac{(3K_0'-n-m-6)}{(n-l)(m-l)}\left(\frac{\rho}{\rho_0}\right)^{(l/3+1)} + \frac{(3K_0'-n-l-6)}{(n-m)(m-l)}\left(\frac{\rho}{\rho_0}\right)^{(m/3+1)} + \frac{(3K_0'-m-l-6)}{(n-l)(n-m)}\left(\frac{\rho}{\rho_0}\right)^{(n/3+1)}\right] \text{----------} \quad (47)$$

The pressure P (ρ) is relation from Bardeen conditions (l=1, m=2 and n=3) can be putting in equation (20) we get

$$P = 3K_0\left[\frac{(3K_0'-11)}{2}\left(\frac{\rho}{\rho_0}\right)^{4/3} - \frac{(3K_0'-10)}{2}\left(\frac{\rho}{\rho_0}\right)^{5/3} - \frac{(3K_0'-9)}{2}\left(\frac{\rho}{\rho_0}\right)^{2}\right] \text{--------} \quad (48)$$

$$P = 3K_0\left[\frac{(3K_0'-11)}{2}\left(\frac{V}{V_0}\right)^{-4/3} - (3K_0'-10)\left(\frac{V}{V_0}\right)^{-5/3} - \frac{(3K_0'-9)}{2}\left(\frac{V}{V_0}\right)^{-2}\right] \text{------} \quad (49)$$

Equation (49) can be written as

$$P = 3K_0\left[\left(\frac{V}{V_0}\right)^{-5/3} - \left(\frac{V}{V_0}\right)^{-4/3}\right]\left\{1 + \frac{3}{2}(K_0'-3)\left[\left(\frac{V}{V_0}\right)^{-1/3} - 1\right]\right\} \text{--------} \quad (50)$$

The isothermal bulk modulus K which is the inverse of the isothermal compressibility is defined as

$$K = -V\left(\frac{dP}{dV}\right)_T \text{------- (51)}$$

Differentiating of equation (49) with respect to V then we get

$$\frac{dP}{dV} = 3K_0\left[\frac{(3K_0'-11)}{2} \times -\frac{4}{3}\left(\frac{V}{V_0}\right)^{-7/3}.\left(\frac{1}{V_0}\right) - (3K_0'-10) \times -\frac{5}{3}\left(\frac{V}{V_0}\right)^{-8/3}.\left(\frac{1}{V_0}\right) - \frac{(3K_0'-9)}{2} \times -2\left(\frac{V}{V_0}\right)^{-3}.\left(\frac{1}{V_0}\right)\right] \text{------} \quad (52)$$

$$\frac{dP}{dV} = -\frac{K_0}{V_0}\left[2(3K_0'-11)\left(\frac{V}{V_0}\right)^{-7/3} - 5(3K_0'-10)\left(\frac{V}{V_0}\right)^{-8/3} + 3(3K_0'-9)\left(\frac{V}{V_0}\right)^{-3}\right] \text{-------} \quad (53)$$

Putting the values of $\frac{dP}{dV}$ from equation (53) in equation (51) and obtained the isothermal bulk modulus K

$$K = K_0\left(\frac{V}{V_0}\right)\left[2(3K_0'-11)\left(\frac{V}{V_0}\right)^{-7/3} - 5(3K_0'-10)\left(\frac{V}{V_0}\right)^{-8/3} + 3(3K_0'-9)\left(\frac{V}{V_0}\right)^{-3}\right] \text{---------- --------} \quad (54)$$

$$K = K_0\left[2(3K_0' - 11)\left(\frac{V}{V_0}\right)^{-4/3} - 5(3K_0' - 10)\left(\frac{V}{V_0}\right)^{-5/3} + 3(3K_0' - 9)\left(\frac{V}{V_0}\right)^{-2}\right]$$

---------- (55)

The first pressure derivative of isothermal bulk modulus K'

$$K' = \left(\frac{dK}{dP}\right) = \left(\frac{dK}{dx}\right) / \left(\frac{dP}{dx}\right)$$

$$= -\frac{V}{K}\frac{dK}{dV} \qquad \text{------- (56)}$$

Now differentiating of equation (55) with respect to V then we get

$$\frac{dK}{dV} = K_0\left[2(3K_0' - 11) \times -\frac{4}{3}\left(\frac{V}{V_0}\right)^{-7/3}.\left(\frac{1}{V_0}\right) - 5(3K_0' - 10) \times -\frac{5}{3}\left(\frac{V}{V_0}\right)^{-8/3}.\left(\frac{1}{V_0}\right) + 3(3K_0' - 9) \times -2\left(\frac{V}{V_0}\right)^{-3}.\left(\frac{1}{V_0}\right)\right]$$

$$\frac{dK}{dV} = -\frac{K_0}{V_0}\left[\frac{8}{3}(3K_0' - 11)\left(\frac{V}{V_0}\right)^{-7/3} - \frac{25}{3}(3K_0' - 10)\left(\frac{V}{V_0}\right)^{-8/3} + 6(3K_0' - 9)\left(\frac{V}{V_0}\right)^{-3}\right] \qquad \text{------} \qquad (57)$$

Putting the values of $\frac{dP}{dV}$ and $\frac{dK}{dV}$ from equation (53) and (57) in equation (56). Relation for the first pressure derivative of isothermal bulk modulus K' can be written as

$$K' = \frac{-\frac{K_0}{V_0}\left[\frac{8}{3}(3K_0'-11)\left(\frac{V}{V_0}\right)^{-7/3} - \frac{25}{3}(3K_0'-10)\left(\frac{V}{V_0}\right)^{-8/3} + 6(3K_0'-9)\left(\frac{V}{V_0}\right)^{-3}\right]}{-\frac{K_0}{V_0}\left[2(3K_0'-11)\left(\frac{V}{V_0}\right)^{-7/3} - 5(3K_0'-10)\left(\frac{V}{V_0}\right)^{-8/3} + 3(3K_0'-9)\left(\frac{V}{V_0}\right)^{-3}\right]}$$

$$K' = \frac{\left(8K_0' - \frac{88}{3}\right)\left(\frac{V}{V_0}\right)^{-7/3} - \left(25K_0' - \frac{250}{3}\right)\left(\frac{V}{V_0}\right)^{-8/3} + (18K_0' - 54)\left(\frac{V}{V_0}\right)^{-3}}{(6K_0' - 22)\left(\frac{V}{V_0}\right)^{-7/3} - (15K_0' - 50)\left(\frac{V}{V_0}\right)^{-8/3} + (9K_0' - 27)\left(\frac{V}{V_0}\right)^{-3}}$$

Multiplication by $\left(\frac{V}{V_0}\right)^{7/3}$ in numerator and denominator in this equation then we get

$$K' = \frac{\left(8K_0' - \frac{88}{3}\right) - \left(25K_0' - \frac{250}{3}\right)\left(\frac{V}{V_0}\right)^{-1/3} + (18K_0' - 54)\left(\frac{V}{V_0}\right)^{-2/3}}{(6K_0' - 22) - (15K_0' - 50)\left(\frac{V}{V_0}\right)^{-1/3} + (9K_0' - 27)\left(\frac{V}{V_0}\right)^{-2/3}} \qquad \text{----------(58)}$$

Discussion:

According to the discussion of Born-Mie equation of state from equation (11), (18) and eqn. (26) and According to Bardeen Equation of state (43), (44) and (55), (58) explain the Compare the isothermal bulk modulus and its first pressure derivative by using equations of state.

Table 1: Calculated by- (a) Born- Mie equation of state (b) Bardeen Equation of state

Values of isothermal bulk modulus K for MgO at different Compression			**Values of isothermal bulk modulus K for CaO at different Compression**			**Values of isothermal bulk modulus K for $CaSiO_3$ at different Compression**		
V/V_0	(a)	(b)	V/V_0	(a)	(b)	V/V_0	(a)	(b)
1.00	0	0	1.00	0	0	1.00	0	0
0.95	9.24	9.24	0.95	6.49	6.49	0.95	13.5	13.5
0.90	21.2	21.2	0.90	14.9	14.9	0.90	31.5	31.4
0.85	36.9	36.8	0.85	25.8	25.7	0.85	56.0	55.4
0.80	57.6	57.1	0.80	40.1	39.9	0.80	89.3	87.5
0.75	85.0	84.0	0.75	59.1	58.5	0.75	135	132
0.70	122	119	0.70	84.6	83.3	0.70	200	190
0.65	173	168	0.65	119	117	0.65	291	270
0.60	243	234	0.60	167	162	0.60	424	383
0.55	344	327	0.55	235	225	0.55	623	543

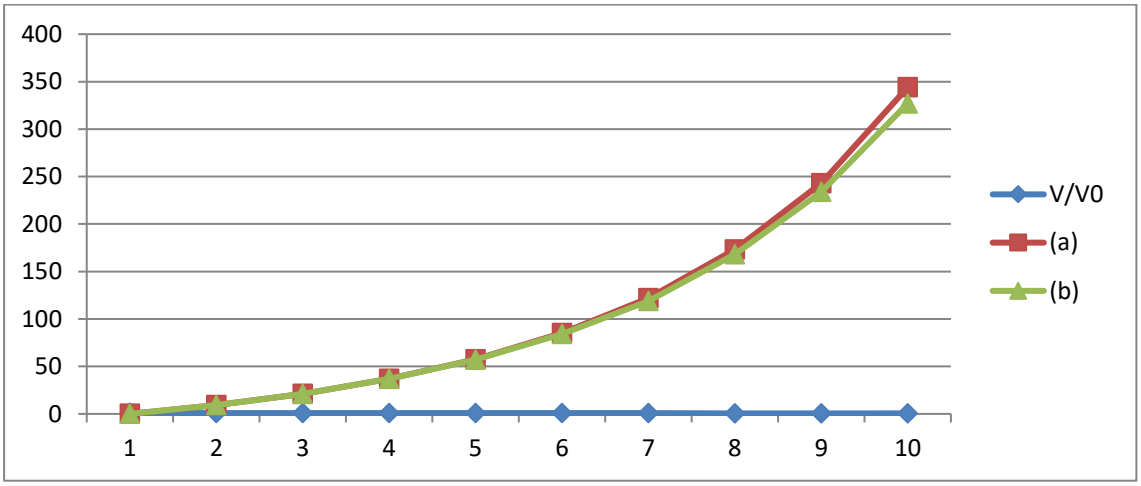
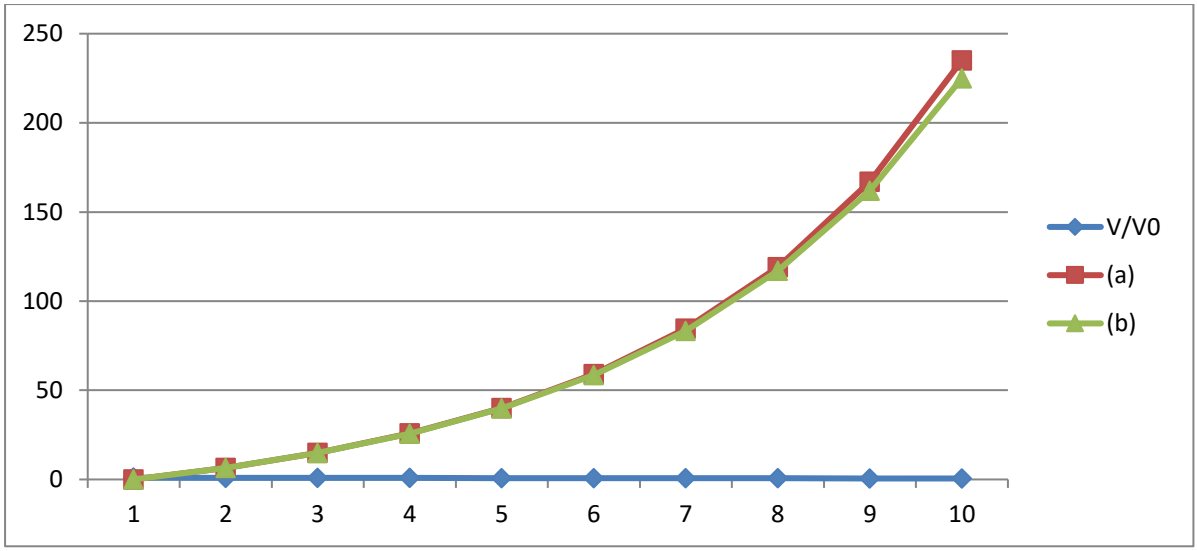


Figure 1: Values of isothermal bulk modulus K for MgO at different Compression



Figur 2: Values of isothermal bulk modulus K for CaO at different Compression

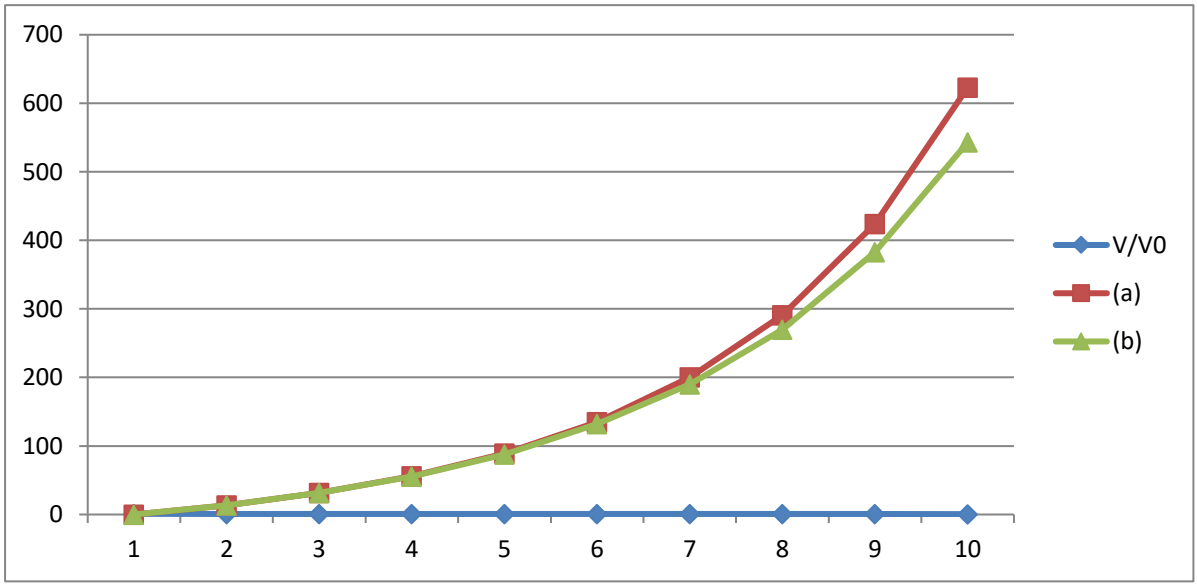


Figure 3: Values of isothermal bulk modulus K for $CaSiO_3$ at different Compression

Conclusion:

It can be concluded that the current formulation was developed for the Born-Mie and Bardeen equation of state. Equations of state and fundamental thermodynamic relations are used to theoretically study the isothermal bulk modulus and its first pressure derivative. Born-Mie and Bardeen EOSs offer EOSs that meet the fundamental requirements of an EOS and deliver positive outcomes at higher compressions of an EOS. The new formulation may therefore be very useful for studying the high pressure elastic behaviour of materials.

References:

1. O.L Anderson, (1995). Equations of State of Solids for Geophysical and Ceramic Science (New York: Oxford University Press)

2. J. Bardeen (1938). J. Chem. Phys. 6: 372.
3. O.L Anderson, (1968). Phys. Earth Planer. Int.,1: 169.
4. O.L Anderson, (1967). Geophysics. J., R. Astron. Soc.13: 9.
5. O.L. Anderson, S. Yamamoto, (1987). Terra Scientific, Tokyo
6. P. K. Singh, (2012). Analysis of high derivative thermo elastic properties of MgO, Indian Journal of Physics, vol. 86, no. 4, pp. 259–265.
7. J. Shanker and S. S. Kushwah, (2001). High-pressure isothermal equation of state for materials with pressure derivative of the isothermal bulk modulus less than four, *High Temperatures High Pressures*, vol. 33, no. 2, pp. 207–21.
8. K. Kholiya, (2013). High pressure isothermal equation of state for nanomaterial's, Indian Journal of Physics, vol. 87, no. 4, pp. 339–343.
9. W Liu and B Li, (2006). Phys. Earth Planet. Inter., 157, 188

IMPACTS OF POPULATION GROWTH: A COMPREHENSIVE MATHEMATICAL ANALYSIS ON FOOD SECURITY, VECTOR-BORNE DISEASES, AND COASTAL EROSION

Megha Abhiman Bhamare

Department of Mathematics,

K. V. N. Naik Arts, Commerce and Science College, Nashik, Maharashtra

Corresponding author E-mail: drbhamaremegha@gmail.com

Abstract:

This chapter is a comprehensive mathematical analysis of the impacts of population growth on crucial aspects of human existence and the environment. By applying rigorous statistical methods, we unveil the complex relationships between population growth and food security, vector-borne diseases, and coastal erosion. The analysis reveals the exponential implications of a burgeoning global population on food security, accentuating demand pressures and challenges in equitable food resource distribution. Through polynomial modeling, we demonstrate how population growth exacerbates food shortages and leads to the quadratic degradation of arable land. Moreover, employing correlation analysis and differential equations, we unveil the exponential connections between population growth, urbanization, and the transmission dynamics of vector-borne diseases like malaria and dengue fever. We highlight the quadratic expansion of disease prevalence with increasing urban population density. Utilizing advanced numerical techniques, we evaluate the impact of population growth on coastal erosion rates, showcasing the exponential coastal habitat loss and its quadratic implications for vulnerable communities. In conclusion, this research underscores the urgency for integrated and sustainable solutions, guided by rigorous mathematical analysis, to address the intricate challenges posed by population growth and pave the way for a resilient and equitable future for humanity and the planet.

Keywords: Population growth, Food security, Vector-borne diseases, Coastal erosion, Sustainability, Mathematical analysis

Introduction:

The phenomenon of climate change has emerged as a critical global challenge, with far-reaching consequences for human populations across the world (Pan *et al.*, 2022). Its multifaceted impacts encompass diverse aspects of daily life, ranging from the well-being of

individuals and communities to the stability of entire ecosystems (Bogoni *et al.,* 2020). To gain a comprehensive understanding of the complex interplay between climate change and human populations (Cattaneo *et al.,* 2019), this chapter employs a rigorous mathematical approach, harnessing the power of statistical techniques and mathematical models (Waters *et al.,* 2021). By assimilating relevant climate-related data and demographic indicators, this study seeks to unveil underlying trends and patterns, while also projecting potential future scenarios (Tramblay *et al.,* 2020).

The integration of mathematical analysis enables a systematic examination of climate change's implications on various dimensions of human existence (Zeug *et al.,* 2023). By quantifying and exploring the relationships between climatic variables and demographic trends, this research seeks to illuminate the vulnerabilities and opportunities arising from climate-induced changes (Sang *et al.,* 2022). Moreover, the mathematical models utilized in this study facilitate predictive capabilities, offering valuable insights for policymakers and stakeholders to develop effective strategies for climate adaptation and resilience (Muhammad *et al.,* 2023).

Through this research, we aim to contribute evidence-based insights to the ongoing discourse on climate change, advocating for the formulation of informed policies and measures to safeguard human populations from the adverse effects of a changing climate. As climate change continues to shape the landscape of the world we inhabit (Sage, 2020), the findings of this study endeavor to empower societies in building a sustainable and resilient future for all.

Methodology:

Population growth is a defining challenge of our time, influencing various aspects of human existence and the natural environment (Thacker *et al.,* 2019). As the global population continues to increase, it has far-reaching impacts on critical areas, including food security, the spread of vector-borne diseases, and coastal erosion (Wijeskara,2023). These interconnected impacts present complex challenges that require integrated and sustainable solutions to ensure the well-being of both human populations and the planet.

Population impact on food security

As the global population continues to grow, the demand for food increases (Rohr *et al.,* 2019). The increasing population places pressure on agricultural systems to produce more food, leading to challenges in ensuring food security for all (Hatab *et al.,* 2019). Meeting the food needs of a growing population requires sustainable agricultural practices, increased productivity, and improved distribution systems (Antar *et al.,* 2019). However, rapid population growth can strain natural resources, lead to land degradation, and exacerbate food scarcity in regions already facing challenges in food production and distribution.

Consider a hypothetical dataset of temperature records and crop yields from a region over the past two decades:

Year: 2000, 2005, 2010, 2015, 2020

Temperature: 15.2, 15.5, 16.1, 16.8, 17.3

Crop Yield (tons/ha): 4.2, 4.0, 3.8, 3.6, 3.4

Suppose the linear regression model for the temperature and crop yield dataset is given by

Crop Yield = -0.25 * Temperature + 8.25

In this example, the coefficient -0.25 indicates that for every 1-degree Celsius increase in temperature, crop yield decreases by 0.25 tons per hectare. The intercept 8.25 represents the crop yield when the temperature is zero, which is not practically relevant in this context.

Based on the model, we can project potential future scenarios. For instance, if the temperature increases by 2 degrees Celsius by 2030, we can calculate the estimated crop yield as follows

Crop Yield (2030) = -0.25 * 19.3 + 8.25 ≈ 3.8 tons/ha

This projection suggests that a 2-degree Celsius temperature increase by 2030 may lead to a decline in crop yield to approximately 3.8 tons per hectare. Such insights can help policymakers and agricultural stakeholders develop adaptive measures to address food security challenges posed by climate change.

This demonstrates how rigorous mathematical analysis can be employed to analyze the effects of climate change on human populations. By integrating climate-related data and demographic indicators with appropriate statistical techniques and mathematical models, researchers can gain valuable insights into the challenges and opportunities for climate adaptation and resilience. The application of evidence-based findings can support policymakers in formulating effective strategies to mitigate the impacts of climate change on human societies and promote sustainable development.

Population impact on vector-borne diseases

Population growth and urbanization can contribute to the spread of vector-borne diseases (Wilke *et al.,* 2019). As more people inhabit urban areas, there is increased human exposure to disease vectors such as mosquitoes and ticks. Urbanization and changes in land use can create suitable habitats for disease vectors, allowing diseases like malaria, dengue fever, and Zika virus to spread more easily (Ortiz *et al.,* 2021). Population density and movement also play a role in disease transmission, making it crucial to implement effective public health measures and surveillance systems to control vector-borne diseases (Duval *et al.,* 2022).

Consider a hypothetical dataset representing the incidence of a vector-borne disease (e.g., malaria) and climate data (temperature and precipitation) over the past decade in a specific region:

Year: 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021

Disease Incidence: 200, 210, 180, 250, 220, 240 260, 280, 300, 320

Temperature (°C): 22.5, 23.0, 22.8, 23.5, 23.7, 24.0, 24.2, 24.5, 24.8, 25.0

Precipitation (mm): 120, 130, 140, 110, 100, 150, 160, 130, 120, 140

Suppose the multiple regression model for disease incidence, temperature, and precipitation dataset is given by:

Disease Incidence = 10 * Temperature + 2.5 * Precipitation + 100

In this example, the coefficient 10 indicates that for every 1-degree Celsius increase in temperature, disease incidence increases by 10 cases. Similarly, the coefficient 2.5 suggests that for every 1 mm increase in precipitation, disease incidence rises by 2.5 cases. The intercept 100 represents the baseline disease incidence when both temperature and precipitation are zero, which is not practically relevant in this context.

Based on the model, we can project potential future scenarios. For example, if the temperature increases by 1.5 degrees Celsius and precipitation increases by 20 mm by 2030, we can calculate the estimated disease incidence as follows:

Disease Incidence (2030) = 10 * 27.5 + 2.5 * 160 + 100 ≈ 482

This projection indicates that with the specified climate changes, disease incidence may rise to approximately 482 cases. Such insights can help public health authorities and policymakers develop targeted interventions to mitigate the impact of climate change on vector-borne disease transmission.

This demonstrates how rigorous mathematical analysis can be applied to analyze the impacts of climate change on vector-borne diseases. By integrating disease incidence data with climate variables and employing multiple regression analysis, researchers can gain valuable insights into the complex relationships between climate factors and disease transmission. The application of mathematical models can support evidence-based decision-making and assist in developing effective strategies to protect public health and foster climate resilience in vulnerable regions.

Population impact on coastal erosion

Coastal areas are highly vulnerable to the impacts of population growth and urbanization. Increasing population density along coastlines leads to greater infrastructural development, such as buildings and roads, which alters natural coastal processes (Al-Mutairi *et al.,* 2021). Urban

development can exacerbate coastal erosion and loss of coastal habitats like mangroves and wetlands, reducing the natural protection against storm surges and sea level rise (Al-Attabi *et al.*, 2023). As populations continue to concentrate along coasts, it becomes imperative to adopt sustainable coastal management practices and protect valuable coastal ecosystems to mitigate the risks of erosion and safeguard coastal communities (Guleria, 2020).

Consider a hypothetical dataset representing coastal erosion rates and sea level rise over the past 20 years for a specific coastal region:

Year: 2000, 2005, 2010, 2015, 2020

Erosion Rate (m/year): 0.5, 0.8, 1.2, 1.5, 2.0

Sea Level Rise (mm/year): 2.5, 3.0, 3.5, 4.0, 4.5

Suppose the linear regression model for the erosion rate and sea level rise dataset is given by**:**

Erosion Rate = 0.4 * Sea Level Rise + 0.5

In this example, the coefficient 0.4 indicates that for every 1 mm/year increase in sea level rise, the erosion rate increases by 0.4 meters per year. The intercept 0.5 represents the baseline erosion rate when sea level rise is zero, which may be attributed to other factors such as coastal processes and human interventions.

Based on the model, we can project potential future scenarios. For instance, if the sea level rises by 5 mm/year by 2030, we can calculate the estimated erosion rate as follows:

Erosion Rate (2030) = 0.4 * 5 + 0.5 = 2.5 meters/year

This projection suggests that with the specified sea level rise, the erosion rate may increase to approximately 2.5 meters per year. Such insights can help coastal planners and policymakers develop adaptive strategies to address coastal erosion and protect vulnerable areas from the impacts of rising sea levels.

This demonstrates how rigorous mathematical analysis can be applied to analyze the impacts of climate change on coastal erosion. By integrating erosion rate data with sea level rise and employing linear regression analysis, researchers can gain valuable insights into the linkages between these variables. The application of mathematical models can support evidence-based decision-making and assist in developing effective strategies to mitigate coastal erosion and enhance resilience in coastal communities.

Hence, population growth is a defining challenge of our time, influencing various aspects of human existence and the natural environment. As the global population continues to increase, it has far-reaching impacts on critical areas, including food security, the spread of vector-borne diseases, and coastal erosion. The analysis reveals that the increasing global population has significant implications for food security, with heightened demand posing challenges in ensuring

adequate and equitable access to food for all. While technological advancements and improved agricultural practices have increased food production in some regions, rapid population growth can lead to land degradation, water scarcity, and food shortages in vulnerable areas. Addressing food security in the context of a growing population necessitates sustainable agricultural practices, efficient distribution systems, and targeted support. Furthermore, population growth influences the transmission dynamics of vector-borne diseases, with urbanization and land use changes creating favorable conditions for disease vectors to thrive, leading to the geographical expansion of diseases like malaria and dengue fever. Effective control and prevention strategies are crucial to managing outbreaks and curbing disease transmission. Additionally, coastal erosion rates are influenced by population growth and urbanization, accelerating erosion and the loss of critical coastal habitats. Sustainable coastal management practices play vital roles in mitigating erosion and safeguarding coastal populations. By recognizing the significance of population dynamics, integrated and sustainable strategies can address these challenges and strive towards a more resilient and equitable future.

It is summarized that, the impacts of population growth on food security, vector-borne diseases, and coastal erosion are complex and interrelated. The analysis underscores the urgent need for integrated and sustainable solutions to address these challenges in the face of a growing global population. Ensuring food security requires a comprehensive approach that combines technological advancements with responsible land use and resource management. Controlling vector-borne diseases demands effective public health measures, community engagement, and surveillance systems to protect human populations. Similarly, mitigating coastal erosion requires balancing development with conservation efforts and implementing resilient coastal management practices. By recognizing the significance of population dynamics in shaping these challenges, policymakers, stakeholders, and communities can collaboratively work towards a more resilient and equitable future, safeguarding the well-being of current and future generations while preserving the health of the planet.

References:

1. Pan, S. L., Carter, L., Tim, Y., & Sandeep, M. S. (2022). Digital sustainability, climate change, and information systems solutions: Opportunities for future research. International journal of information management, 63, 102444.
2. Bogoni, J. A., Peres, C. A., & Ferraz, K. M. (2020). Effects of mammal defaunation on natural ecosystem services and human well being throughout the entire Neotropical realm. Ecosystem Services, 45, 101173.

3. Cattaneo, C., Beine, M., Fröhlich, C. J., Kniveton, D., Martinez-Zarzoso, I., Mastrorillo, M., ... & Schraven, B. (2019). Human migration in the era of climate change. Review of Environmental Economics and Policy.
4. Waters, S. L., Schumacher, L. J., & El Haj, A. J. (2021). Regenerative medicine meets mathematical modelling: developing symbiotic relationships. npj Regenerative Medicine, 6(1), 24.
5. Tramblay, Y., Koutroulis, A., Samaniego, L., Vicente-Serrano, S. M., Volaire, F., Boone, A., ... & Polcher, J. (2020). Challenges for drought assessment in the Mediterranean region under future climate scenarios. Earth-Science Reviews, 210, 103348.
6. Zeug, W., Bezama, A., & Thrän, D. (2023). Life cycle sustainability assessment for sustainable bioeconomy, societal-ecological transformation and beyond. In Progress in Life Cycle Assessment 2021 (pp. 131-159). Cham: Springer International Publishing.
7. Sang, Y., Long, Z., Dan, X., Feng, J., Shi, T., Jia, C., ... & Wang, J. (2022). Genomic insights into local adaptation and future climate-induced vulnerability of a keystone forest tree in East Asia. Nature Communications, 13(1), 6541.
8. Muhammad, A., Idris, M. B., Ishaq, A. A., & Abdullah, A. K. (2023). The Butterfly Effect and its Implications for Resilience in Complex Socio-Ecological Systems. Journal of Environmental Science and Economics, 2(2), 38-49.
9. Sage, R. F. (2020). Global change biology: a primer. Global Change Biology, 26(1), 3-30.
10. Thacker, S., Adshead, D., Fay, M., Hallegatte, S., Harvey, M., Meller, H., ... & Hall, J. W. (2019). Infrastructure for sustainable development. Nature Sustainability, 2(4), 324-331.
11. Wijeskara, N. (2023). The Need for One Health Approach at the Recent Anthropocene. One Health: Human, Animal, and Environment Triad, 1-18.
12. Rohr, J. R., Barrett, C. B., Civitello, D. J., Craft, M. E., Delius, B., DeLeo, G. A., ... & Tilman, D. (2019). Emerging human infectious diseases and the links to global food production. Nature sustainability, 2(6), 445-456.
13. Hatab, A. A., Cavinato, M. E. R., Lindemer, A., & Lagerkvist, C. J. (2019). Urban sprawl, food security and agricultural systems in developing countries: A systematic review of the literature. Cities, 94, 129-142.
14. Antar, M., Lyu, D., Nazari, M., Shah, A., Zhou, X., & Smith, D. L. (2021). Biomass for a sustainable bioeconomy: An overview of world biomass production and utilization. Renewable and Sustainable Energy Reviews, 139, 110691.

15. Wilke, A. B., Beier, J. C., & Benelli, G. (2019). Complexity of the relationship between global warming and urbanization–an obscure future for predicting increases in vector-borne infectious diseases. Current opinion in insect science, 35, 1-9.
16. Ortiz, D. I., Piche-Ovares, M., Romero-Vega, L. M., Wagman, J., & Troyo, A. (2021). The impact of deforestation, urbanization, and changing land use patterns on the ecology of mosquito and tick-borne diseases in Central America. Insects, 13(1), 20.
17. Duval, L. (2022). Climate Change, Vector-Borne Diseases, and Migration. In Handbook of Labor, Human Resources and Population Economics (pp. 1-15). Cham: Springer International Publishing.
18. Al-Mutairi, N., Alsahli, M., El-Gammal, M., Ibrahim, M., & Abou Samra, R. (2021). Environmental and economic impacts of rising sea levels: A case study in Kuwait's coastal zone. Ocean & Coastal Management, 205, 105572.
19. Al-Attabi, Z., Xu, Y., Tso, G., & Narayan, S. (2023). The impacts of tidal wetland loss and coastal development on storm surge damages to people and property: a Hurricane Ike case-study. Scientific Reports, 13(1), 4620.
20. Guleria, S. (2020). Sustainable development goals (SDGs) and risks to coastal communities. Development in Coastal Zones and Disaster Management, 171-184.

AN OVERVIEW OF PETROLEUM INDUSTRY

Raviraj S. Kamble*[1], Rajkumar S. Pandav[2], Santosh R. Sonwane[3] and Tanaji S. Patil[4]

[1]Department of Chemistry,

[4]Department of Physics,

Bhogawati College, Kurukali, Kolhapur- 416001, MS

[2]Department of Chemistry, Y. C. Warana College, Warananagar, Kolhapur- 416113, MS

[3]Department of Chemistry, The New College, Kolhapur

([1,2,3,4]Affiliated to Shivaji University, Kolhapur)

*Corresponding author E-mail: ravikam11@gmail.com

Abstract:

The most dynamic industry of 20th century is the petroleum and petrochemicals industry. Since World War II, the petroleum industry plays a significant role in the global economy, providing the primary source of energy for transportation, heating, and electricity generation. The industry plays a significant role in global economic growth and geopolitical relations. The petroleum industry is one of the essential industries that encompasses the production of energy resources necessary for transportation, generation and manufacturing various commodities. This industry comprises a range of activities like exploration, extraction, refining, and transportation of crude oil and natural gas, The petroleum industry deals with refining of crude petroleum and processes of natural gas into a multitude of products. There are various processes like refining and refinery operations, gas-field operations, refining technologies, and gas plant processing operations. This industry plays a critical role in modern society by providing the energy required for transportation, electricity generation, and many other applications. This chapter deals with petroleum and its composition, refining operations, major refinery products, role of catalysis in refining operations and future of petroleum industry.

Keywords: Petroleum, refining operation, catalysis

Introduction:

Petroleum and Petrochemicals industry can be considered as the most dynamic industry of 20th century. Since World War II, petroleum has replaced coal as leading source of energy. Today, the petroleum industry is a multi-billion-dollar global enterprise that operates in virtually every country in the world. The petroleum industry's upstream sector involves exploration and production. This includes drilling for oil and natural gas, as well as the development and operation of oil and gas fields. The industry also employs advanced technologies such as

hydraulic fracturing and horizontal drilling to extract oil and gas from unconventional sources such as shale formations. The downstream sector covers refining, transportation, and marketing of petroleum products. Crude oil is refined into various products such as gasoline, diesel, and jet fuel. These products are then transported via pipelines, tankers, and trucks to retail outlets such as gas stations, airports, and industrial facilities [1].

Petroleum and petrochemicals industry has been flourished by taking fundamental knowledge of chemistry and chemical engineering and transformed itself from a simple processing industry for fuels and lubricants to an extremely complex chemical process industry such as synthetic rubber, plastic, fertilizers etc. [2]. Crude oil and natural gas have played a key role in the rapid economic development of the 20th century Undoubtedly, it is the foundation of the industrial civilization. Energy indeed plays a vital and very important role in industrial and economic development of any country. Petroleum or crude oil provides a relatively cheap and convenient source of energy as compared to other energy sources such as coal and electricity. The consumption is growing annually at 10-12 percent while the production of crude oil is stagnating. According to the latest data available from the U.S. Energy Information Administration (EIA), the world consumed about 93 million barrels of crude oil per day in 2021. If we assume that there are 365 days in a year, the world's annual consumption of crude oil would be approximately 33.9 billion barrels. In fiscal year 2021, the consumption volume of petroleum products in India was about 194 million metric tons [3].

Most of the world moves on the petroleum e.g., gasoline for cars, jet fuel for fuels, diesel fuel for trucks etc. Petroleum is used mostly, by volume for producing fuel oil and gasoline (petrol), both important primary energy sources. Most of the hydrocarbons present in the petroleum (84%) are converted into energy rich fuels (petroleum based fuels) including gasoline, diesel, jet, heating and other fuel oils and liquefied petroleum gas. Oil provides a larger share of world energy consumption than any other energy source, at 41 percent of the total in 2020. Petroleum is used heavily in the transportation sector and is also used to provide heat and power as well as industrial feed stocks [4]. The global demand of oil and gas market raised from $6,989.65 billion in 2022 to $7,330.80 billion in 2023 at a compound annual growth rate (CAGR) of 4.9% [5]. According to US Energy Information Administration Report, on the global level, liquid fuels consumption in future increases from an average of 99.4 million barrels per day (b/d) in 2022 to 100.9 million b/d in 2023, which is 0.4 million b/d higher than in last month’s outlook. World liquid fuels production averaged about 100 million b/d in 2022, and there is possibility that it will rise by an average of 1.6 million b/d in both 2023 and 2024 [6].

Petroleum consumption in the developing countries was just over one-half (56 percent) of the total consumption in the industrialized countries in 1997, but was projected to reach 90 percent of that in the industrialized countries by 2020. The US is the world's largest consumer of petroleum, oil, and gas, accounting for about 20% of the world's total consumption. The country's high demand is due to its vast transportation sector, which heavily relies on oil and gas. China is the second-largest consumer of petroleum, oil, and gas, accounting for about 13% of the world's total consumption. The country's rapid economic growth and industrialization have fueled its high demand for energy. India is the third-largest consumer of petroleum, oil, and gas, accounting for about 5% of the world's total consumption. The country's large population and fast-growing economy have led to increased demand for energy.

Petroleum and its composition

Petroleum (Petroleum derived from Greek (Petra) - rock + (oleum) – oil) or crude oil is a naturally occurring yellowish-black liquid found in the earth consisting of a complex mixture predominantly of hydrocarbons and/or of sulfur, a nitrogen and/or oxygen derivative of hydrocarbons. Petroleum also known as fossil fuel, is formed when huge quantities of deceased organisms, typically algae and zooplankton, are suppressed underneath sedimentary rock and subjected to both prolonged pressure and heat. Petroleum or crude oil is mainly recovered by oil drilling. Drilling can be carried out after studying structural geology, reservoir characterization, and sedimentary basin analysis. Recent developments in technologies have helped to find out other unconventional reserves like oil shale and oil sands. The composition of petroleum can vary depending on the source and location from where it is extracted. Extracted crude oil has to be refined and separated, commonly by distillation process, into various products for direct use or use in manufacturing. Crude oil is commonly accompanied by varying quantities of extraneous substances such as water, inorganic matter and gas which have to be removed. The crude oil is subjected to various processes for upgradation so that it can be utilized for various purposes. Hydrocarbons present in the crude oil can be classified as paraffins (alkanes), cycloparaffins (naphthenes), olefins, aromatics and acetylene. Paraffin range of petroleum varies in chain length from one carbon methane to over 30 carbon compounds. Other important hydrocarbon type constituent of crude oil is the aromatic hydrocarbons, which are usually present in relative lesser quantity than paraffins or cycloparaffins e.g. benzene, ethyl benzene, cumene etc. [7]. The physical properties and exact chemical composition of crude oil varies from one locality to another. Relatively simple crude oil assays are used to classify crude oils as paraffinic, naphthenic, aromatic, or mixed. One assay method (United States Bureau of Mines) is based on distillation, and another method (UOP "K" factor) is based on gravity and boiling

points [8]. More comprehensive crude assays determine the value of the crude (i.e. its yield and quality of useful products) and processing parameters. Crude oils are usually grouped according to yield structure. Crude oils are also defined in terms of API (American Petroleum Institute) gravity. The higher the API gravity, the lighter is the crude. For example, light crude oils have high API gravities and low specific gravities. Crude oils with low carbon, high hydrogen, and high API gravity are usually rich in paraffins and tend to yield greater proportions of gasoline and light petroleum products; those with high carbon, low hydrogen, and low API gravities are usually rich in aromatics [9,10]. Crude oils that contain appreciable quantities of hydrogen sulfide or other reactive sulfur compounds are called "sour." Those with less sulfur are called "sweet." Some exceptions to this rule are West Texas crudes, which are always considered "sour" regardless of their H_2S content, and Arabian high-sulfur crudes, which are not considered "sour" because their sulfur compounds are not highly reactive [11,12]. This crude oil must be transported to a refinery where it can be separated into different constituents such as gasoline, aviation fuel, fuel oil, etc. before it can be used by the consumer.

The hydrocarbon components are separated from each other by various refining processes. In a process called fractional distillation, petroleum is heated and sent into the tower. The separated fractions are then drawn from the collectors and further processed into various petroleum products. The atmospheric and vacuum distillation towers can be used to obtain a dozen or so petroleum cuts of volatilities similar to those of commercial products. One of the many products of crude oil is a light substance with little colour that is rich in the gasoline. Petroleum refining begins with the distillation, or fractionation, of crude oils into separate hydrocarbon groups. The resultant products are directly related to the characteristics of the crude processed. Most distillation products are further converted into more usable products by changing the size and structure of the hydrocarbon molecules through cracking, reforming, and other conversion processes. These converted products are then subjected to various treatment and separation processes such as extraction, hydrotreating, and sweetening to remove undesirable constituents and improve product quality. Integrated refineries incorporate fractionation, conversion, treatment, and blending operations and may also include petrochemical processing [13,14].

Refining operations

Petroleum refining is the process of converting crude oil into various useful products by separating and purifying the different hydrocarbons and other impurities in the crude oil. A basic refinery layout is shown in Fig. 1. Petroleum refining processes and operations can be separated into five basic areas:

1] Fractionation (Distillation) is the separation of crude oil in atmospheric and vacuum distillation towers into groups of hydrocarbon compounds of differing boiling-point ranges called "fractions" or "cuts." The lighter hydrocarbons, such as gasoline and propane, are distilled at the top of the tower, while heavier hydrocarbons, such as diesel and lubricating oils, are distilled at the bottom.

The crude oil is first heated in a distillation column, and the resulting vapours rise up through the column. As the vapours rise, they cool and condense at different heights in the column, depending on their boiling points. The components with higher boiling points condense at the lower temperatures near the bottom of the column, while those with lower boiling points condense at higher temperatures near the top of the column.

The column is designed with a series of trays or plates that allow the condensed liquid to flow down to the next tray, while the remaining vapor rises to the next tray. This process is repeated until the vapor reaches the top of the column and is condensed into various fractions.

The different fractions obtained from petroleum distillation include gases such as propane and butane, naphtha, kerosene, diesel fuel, lubricating oil, and residual fuel oil. These fractions are further refined and processed to obtain a wide range of products, including gasoline, jet fuel, diesel fuel, heating oil, and asphalt.

2] Conversion processes change the size and/or structure of hydrocarbon molecules. These processes include:

a) Cracking: In cracking, large hydrocarbon molecules are broken down into smaller ones by heat and pressure. This process produces more gasoline and other light products, which are in high demand, from the heavier components of crude oil. Two types of cracking processes are used: thermal cracking by using heat, and catalytic cracking by using a catalyst.

b) Reforming: Reforming is a process that rearranges the molecular structure of hydrocarbons to produce higher-octane gasoline. This process is typically used to increase the octane rating of naphtha, a component of crude oil.

c) Isomerization: Isomerization is a process in which rearrangement take place within a molecule to produce isomers. Isomerization is used to produce branched-chain hydrocarbons, which have higher octane ratings than straight-chain hydrocarbons.

d) Alkylation: Alkylation is a process that combines smaller molecules, such as olefins and isobutane, to produce larger, more complex molecules with high octane ratings. This process is used to produce high-octane gasoline components.

e) Hydrocracking: Hydrocracking is a process that combines cracking and hydrogenation. Hydrogen is used to break down large hydrocarbon molecules into smaller ones and remove

impurities, such as sulfur and nitrogen. This process is used to produce high-quality diesel fuel and other clean-burning fuels.

f) Hydrotreating: Hydrotreating is a process that uses hydrogen to remove impurities, such as sulfur and nitrogen, from petroleum products. This process is used to produce cleaner-burning fuels and to meet environmental regulations.

3] Treatment processes are intended to prepare hydrocarbon streams for additional processing and to prepare finished products. Treatment may include the removal or separation of aromatics and naphthenes as well as impurities and undesirable contaminants. Treatment may involve chemical or physical separation such as dissolving, absorption, or precipitation using a variety and combination of processes including desalting, drying, hydrodesulfurizing, solvent refining, sweetening, solvent extraction, and solvent dewaxing.

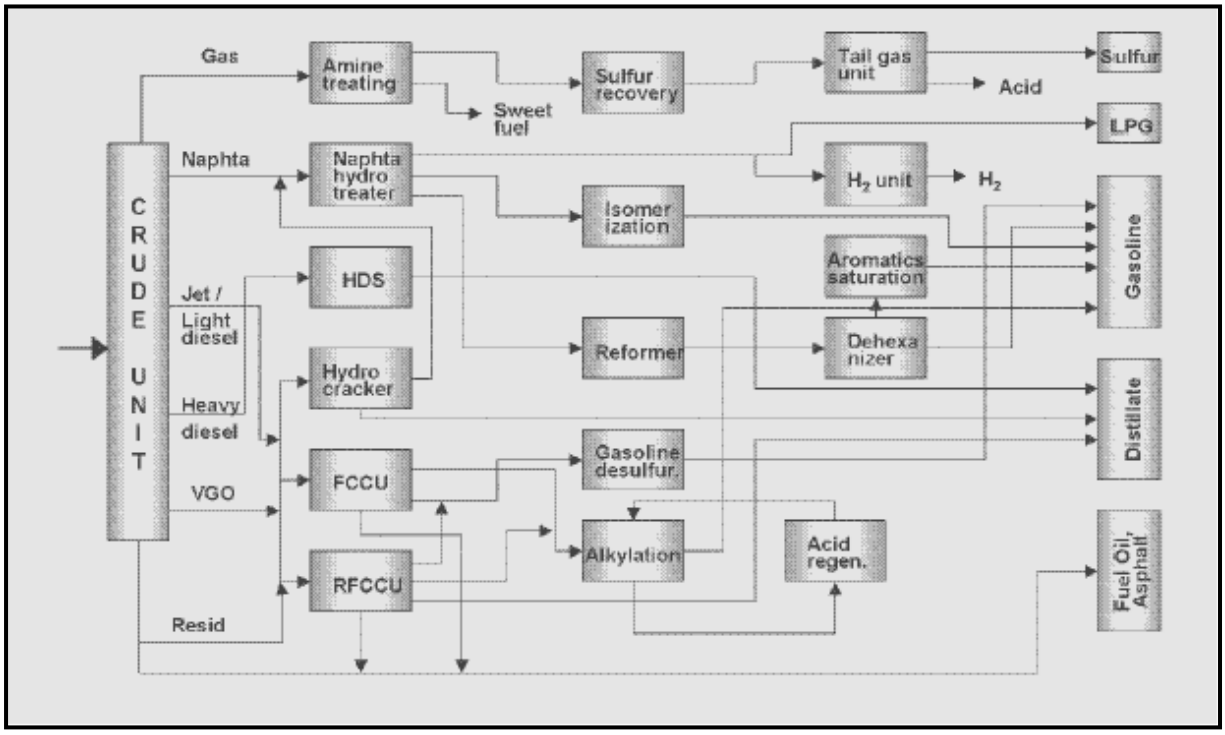


Figure 1: Basic refinery layout

4] Formulating and Blending is the process of mixing and combining hydrocarbon fractions, additives, and other components to produce finished products with specific performance properties. The process of blending involves mixing two or more different types of crude oil or refined products together in specific proportions to achieve the desired properties such as viscosity, density, octane rating, and sulfur content. The blending process can be done either in-line or in a dedicated blending unit.

In-line blending is a process where different components are mixed together in the pipeline while being transported from the refinery to the storage facility. In this process, the blending is done in real-time to meet the required specification of the customer.

Dedicated blending units are designed to mix components together in specific ratios to create blends with the desired properties. These units have tanks, pumps, and meters that measure and control the flow of each component. The blending process is automated and computer-controlled to ensure accurate and consistent mixing.

Blending is essential to produce different grades of gasoline, diesel, and other fuels that meet regulatory specifications and customer demand. It also allows refiners to adjust the properties of their products to meet changing market conditions and supply chain constraints.

5] Other refining operations include light-ends recovery; sour-water stripping; solid waste and wastewater treatment; process-water treatment and cooling; storage and handling; product movement; hydrogen production; acid and tail-gas treatment; and sulfur recovery.

6] Auxiliary operations and facilities include steam and power generation; process and fire water systems; flares and relief systems; furnaces and heaters; pumps and valves; supply of steam, air, nitrogen, and other plant gases; alarms and sensors; noise and pollution controls; sampling, testing, and inspecting; and laboratory, control room, maintenance, and administrative facilities.

Major refinery products

The fractional distillation of petroleum gives various refinery products as given in Table 1. They can be summarized as follows

1] Gasoline: The most important refinery product is motor gasoline, a blend of hydrocarbons with boiling ranges from ambient temperatures to about 423 K. Gasoline is a complex mixture of different types of hydrocarbons. Most are saturated and contain 4 to 12 carbon atoms per molecule. The important qualities for gasoline are octane number (antiknock), volatility (starting and vapor lock), and vapor pressure (environmental control). Additives are often used to enhance performance and provide protection against oxidation and rust formation. The gasoline has been the most preferred automobile fuel because of its high energy of combustion and ability to mix instantly with air in a carburetor.

2] Kerosene: Kerosene is typically derived from the fractional distillation of crude oil, and it is a mixture of hydrocarbons with a boiling range between 423 K - 573 K. It is a relatively stable liquid that can be stored for long periods without deteriorating or losing its properties. Kerosene is a refined middle-distillate petroleum product that finds considerable use as a jet fuel and around the world in cooking and space heating. When used as a jet fuel, some of the critical

qualities are freeze point, flash point, and smoke point. Kerosene, with less-critical specifications, is used for lighting, heating, solvents, and blending into diesel fuel.

3] Liquefied Petroleum Gas (LPG): LPG, which consists principally of propane and butane, is produced for use as fuel and is an intermediate material in the manufacture of petrochemicals. The important specifications for proper performance include vapor pressure and control of contaminants. It is a colourless, odourless, and flammable gas that is commonly used as a fuel for heating and cooking, as well as in industrial applications such as refrigeration, heating, and metalworking.

LPG is derived from crude oil refining and natural gas processing. It is typically stored and transported as a liquid under pressure in steel cylinders, tanks, or in large-scale storage facilities.

4] Distillate fuels: Diesel fuels and domestic heating oils have boiling ranges of about 573 K to 623 K. The desirable qualities required for distillate fuels include controlled flash and pour points, clean burning, no deposit formation in storage tanks, and a proper diesel fuel cetane rating for good starting and combustion.

Table 1: Petroleum distillation fractions

Sr. No.	Name of Fraction	Boiling range	Approx. compositions of alkanes	Uses
1	Natural gas	Upto 303 K	C_1-C_4	Fuel gas
2	Crude naphtha 303 K-423 K	(i) Petroleum ether (303 K- 363 K)	C_5-C_7	Solvent
		(ii) Gasoline (363 K – 423K)	C_6-C_{10}	Motor fuel
3	Kerosene	423 K - 573 K	C_{10}-C_{16}	Illuminant, Domestic fuel
4	Gas oil (Diesel)	573 K – 623 K	C_{16}-C_{20}	Fuel for diesel engine
5	Lubricating oil	623 K – 673 K	C_{20}-C_{24}	Paint oil, lubricant.
6	Paraffin wax	Above 673 K	C_{24} upwards	Ointments, candles, paraffin wax

5] Residual fuels: Many marine vessels, power plants, commercial buildings and industrial facilities use residual fuels or combinations of residual and distillate fuels for heating and processing. The two most critical specifications of residual fuels are viscosity and low sulfur content for environmental control.

6] Coke and asphalt: Coke can refer to a solid carbonaceous material left after distillation of crude oil. Coke is almost pure carbon with a variety of uses from electrodes to charcoal briquets. Asphalt, on the other hand, is a sticky, black, and highly viscous liquid or semi-solid form of petroleum. Asphalt, used for roads and roofing materials, must be inert to most chemicals and weather conditions.

7] Solvents: A variety of products, whose boiling points and hydrocarbon composition are closely controlled, are produced for use as solvents. These include benzene, toluene, and xylene.

8] Petrochemicals: Many products derived from crude oil refining, such as ethylene, propylene, butylene, and isobutylene, are primarily intended for use as petrochemical feedstock in the production of plastics, synthetic fibers, synthetic rubbers, and other products.

9] Lubricants: Special refining processes produce lubricating oil base stocks. Additives such as demulsifiers, antioxidants, and viscosity improvers are blended into the base stocks to provide the characteristics required for motor oils, industrial greases, lubricants, and cutting oils. The most critical quality for lubricating-oil base stock is a high viscosity index, which provides for greater consistency under varying temperatures.

Common refinery chemicals

1] Leaded gasoline additives: Tetraethyl lead (TEL) and Tetramethyl lead (TML) are additives formerly used to improve gasoline octane ratings but are no longer in common use except in aviation gasoline.

2] Oxygenates: Ethyl tertiary butyl ether (ETBE), Methyl tertiary butyl ether (MTBE), Tertiary amyl methyl ether (TAME), and other oxygenates improve gasoline octane ratings and reduce carbon monoxide emissions.

3] Caustics: Caustics are added to desalting water to neutralize acids and reduce corrosion. They are also added to desalted crude in order to reduce the amount of corrosive chlorides in the tower overheads. They are used in some refinery treating processes to remove contaminants from hydrocarbon streams.

4] Sulfuric acid and Hydrofluoric acid: Sulfuric acid and hydrofluoric acid are used primarily as catalysts in alkylation processes. Sulfuric acid is also used in some treatment processes.

Role of catalysis in petroleum refining

Most of the refinery products are produced mainly through catalytic processes. The most important catalytic processes in a petroleum refinery as given in Table 2 are Fluid catalytic cracking (FCC), Hydrocracking, Catalytic reforming, Hydrodesulphurization (HDS), and Alkylation etc. [15,16]. These processes are briefly described below.

Table 2: The catalysts used in the major processes in petroleum refining

Sr. No.	Name of the process	Purpose	Typical catalyst
1	Fluid catalytic cracking (FCC)	Convert heavy fractions into light ones	REY/SiO_2-Al_2O_3; Additives/ZSM-5
2	Hydrotreating (HT) Hydrodesulfurization (HDS)	Remove olefins, S & N	Ni-Mo-Al_2O_3(sulfided) Co-Mo-Al_2O_3 (sulfided)
3	Hydrocracking (HCR)	Convert heavy fractions into light ones	Ni-W- SiO_2-Al_2O_3; Pt/Pd/Zeolites
4	Isomerization (ISOM)	Isomerize n-C_6 and n-C_7	Pt/SiO_2-Al_2O_3; Pt/ Zeolites
5	Catalytic reforming (REF)	Convert C_6- C_9, n-paraffins and naphthenes into aromatics	Pt (+ promoters)/Al_2O_3
6	Alkylation (ALK)	React iso-butane with butenes	HF; H_2SO_4 Solid catalysts under development.

1] Fluid catalytic cracking: Typically, crude petroleum contains more heavy fractions (B.P. > 650 K; > 30 wt.%) than actually required in the market. As a result, the transformation of these heavy oils into lighter products becomes necessary. An important process for obtaining lighter fractions from heavier oils is 'cracking' by which the large molecular weight hydrocarbons are broken down into lower boiling smaller (low molecular weight) hydrocarbon molecules. Fluid catalytic cracking (FCC) is the most important single process today in petroleum refining industry both in terms of volume processed and catalyst usage.

In the beginning, heavy petroleum oils were cracked thermally to produce lighter products such as kerosene and gasoline. This was followed by the use of $AlCl_3$ as cracking catalyst. Subsequently, it was found that acid washed clays of montmorillonite type made good catalysts. The clays were then replaced by amorphous silica-alumina and subsequently by zeolite based catalysts like Y, RE-Y (RE = Rare Earth ions), USY and ZSM-5 additive

2] Hydrocracking: It is another important refinery process used to transform heavy petroleum fractions into lighter materials. Unlike FCC, hydrocracking is carried out at high pressures (100 – 200 bar) and moderate temperatures (300 - 450 ^{o}C) in the presence of hydrogen over catalysts containing hydrogenation and acidic functions. Even highly refractory aromatic compounds which are not easily cracked in the FCC unit, are cracked into hydrocracker. Under the conditions of reaction, aromatic molecules are hydrogenated to alicyclics, which are easily cracked.

Many types of hydrocracking catalysts are used. The hydrogenation components are either Ni-W (sulfided) or a noble metal like Pt or Pd. The noble metals are more suited when the sulfur present in feed is low. The Ni-W system is used when S and other poisons are high. The noble metal catalysts are generally used in combination with a high active zeolite support and principally used when gasoline is desired product. On the other hand, Ni-W is usually used in combination with amorphous silica-alumina and is used when more middle distillates are desired.

3] Hydrotreating: Hydrotreating is a generic name given to processes utilizing hydrogen which include hydrodesulfurization (HDS), hydrodenitrogenation (HDN), hydrodemetallization (HDM). HDS is the most important of these processes. HDS and HDN take place simultaneously over most hydrotreatment (HT) operations though to different extents depending upon the feed, catalyst and process conditions.

Typical hydrotreating catalysts are Co-Mo or Ni-Mo sulfides supported on alumina. Co-Mo catalysts are preferred when HDS is predominantly desired reaction while Ni-Mo catalysts are used when HDN or hydrogenation is the desired reactions. These catalysts are prepared in the oxide form and are usually sulfided prior to the reaction.

4] Catalytic Naphtha Reforming: Originally, catalytic reforming was developed to produce high octane gasoline from straight run naphtha for automotive applications. Subsequently, applications have been extended to the production of aromatics, LPG, H_2 and to the upgrading of olefinic stocks. The major reactions that take place during naphtha reforming are:

i) Dehydrogenation of naphthenes to aromatics (e.g. methyl cyclopentane to toluene)

ii) Dehydrocyclization of alkanes to aromatics (e.g. n-heptane or iso-hexanes to toluenes)

iii) Hydroisomerization of n-alkanes (e.g. n-hexane and n-heptane to iso-hexanes)

The major breakthrough in catalytic reforming was the commercialization by UOP (Universal Oil Products, USA) of the platforming process developed based on Pt-alumina catalysts. The next improvement in reforming catalysts came with introduction of the bimetallic Pt-Re catalyst by Chevron, USA in 1969. Subsequently other bimetallic and multimetallic

catalyst containing promoters such as Ir, Sn, and Ge have come into practice. Recently Ga/ZSM-5 has been used as catalyst for reforming especially for the aromatization reaction [17].

5] Alkylation: The alkylation reaction consists of "grafting" a molecule of isobutane on a molecule of a light alkene with a maximum of five carbon atoms to produce a gasoline cut composed of iso-paraffins with five and about ten carbon atoms. Alkylates produced after alkylation process offer significant advantages as compared with gasoline produced using other processes; their high octane number largely compensates for the disappearance of lead from gasoline, their average toxicity is lower than that of the other sources of gasoline and their emissions are less polluting [18].

The first processes produced an alkylate rich in dimethyl butanes by reaction between isobutane and ethylene on $AlCl_3$. The main disadvantages of this process are high consumption of this Lewis acid catalyst, together with the associated corrosion problems. Further, the cheap liquid catalysts like HF and H_2SO_4 have been used for alkylation. Scientists are also striving to find out solid acid catalysts to replace these hazardous liquid acids catalysts where research is being done on zeolites like Beta, USY etc.

Future of petroleum industry

The future of the petroleum industry is a complex and multifaceted topic, as it is influenced by various economic, technological, and environmental factors. Here are some possible scenarios for the future of the petroleum industry:

a) **Continued dominance:** Despite the growing interest in renewable energy sources, petroleum will continue to be the dominant energy source for the foreseeable future. This is because petroleum is still the most cost-effective and widely available energy source, especially in developing countries.
b) **Decline:** As the cost of renewable energy sources continues to decline, the demand for petroleum may decline, especially in developed countries. This could lead to a gradual decline in the industry as companies shift their focus to cleaner energy sources.
c) **Diversification:** Petroleum companies may begin to diversify their offerings by investing in renewable energy sources and other energy-related technologies. This could help them stay competitive in a changing market and reduce their environmental impact.

Regulation: Increasing regulation and pressure from governments and consumers may force petroleum companies to transition to cleaner energy sources more quickly. This could lead to a rapid decline in the industry if companies are not able to adapt quickly enough

a) **Innovation:** New technologies, such as carbon capture and storage, may allow petroleum companies to continue producing oil and gas while minimizing their environmental impact. This could lead to a more sustainable future for the industry.

References:

1. Marcilly, C. (2006). Acido-basic catalysis: Application to refining and petrochemistry. Vol. 1, IFP Publ., Ch. 5.
2. Dalvi, S. (2015). Fundamentals of Oil and G.as Industry for Beginners, Notion Press Publ.
3. Inkpen, A. C. & Moffett, M. H. (2011). The Global Oil and Gas Industry, Pennwell Publ.
4. [4] Black, B. C. (2020), Crude Reality : Petroleum in World History, The Rowman and Littlefield Publishing Group.
5. https://www.eia.gov/outlooks/aeo/
6. https:// www.eia.gov./oil_gas/Petroleum/info_glance/petroleum.html.
7. Finar, I. L. (1973). Organic Chemistry Vol. 1: The Fundamental Principles, 6th Edition Longman Ltd., Ch. 3, p.88
8. http:// www.eia.gov./oil_gas/Petroleum/info_glance/petroleum.html.
9. https://uop.honeywell.com/en/objects
10. Anderson, R. O. (1984), Fundamentals of the Petroleum Industry, University of Oklahoma Press
11. www.freepatentsonline.com/4335598.html.
12. http://en.wikipedia.org/wiki/API_gravity.
13. www.encyclopedia.com/doc/10135-APIgravity.html.
14. www. freepatentsonline.com/3850745.html.
15. www.secinfo.com
16. Garry, J. H. & Handwerck, G. E. (2001). Petroleum Refining Technology and Economics, 2nd Edition, Marcel Dekker, Inc.
17. Speight, J. G. (1991). The Chemistry and Technology of Petroleum, Marcel Dekker.
18. Sivasankar, S. (2002). Catalysis : Principles and Applications, B. Vishwanathan, S. Sivasankar, A. V. Ramaswamy (Eds.), Narosa Publ. House, , p . 362.

Research Trends in Science and Technology Volume I (ISBN: 978-93-88901-64-2)

About Editors

Dr. Rohit Srivastava (M.Sc.NET., Ph.D Gold Medallist) is presently working as an Assistant Professor in the Department of Chemistry St. Andrew's College. Gorakhpur. U. P. He has published many papers and articles in national and international repute journals and has presented more than 10 paper's in different conferences and seminars. He owns a credit to contribute chapter's on varied topics in books having ISBN number. Dr. Rohit Srivastava has 4 patents on his name and authored 3 books of academic interest. His field of research is Nanomaterials and synthesis of thin chalcogenide films for solar cell applications.

Dr. Preeti Mahawar is presently working as Associate Professor (Biotechnology) Faculty of Agricultural sciences, Madhav University, Abu Road (Rajasthan). She has completed her Bachelor's and Master's degree in Biotechnology from University of Kota, Rajasthan. She has obtained her doctorate degree in Biotechnology (UGC-JRF) and supervised several Ph.D students. Dr. Mahawar is the recipient of the "Young women scientist" and "Best Biotechnologist" award. She has also published several research papers, articles and book chapters in various journals and publications of national and international repute.

Dr. Mainak Banerjee, Assistant Professor and Head, Department of Zoology, RKDF University, Ranchi. He completed his M.Sc and Ph.D in Zoology from The University of Burdwan. Apart from that, he also completed PG senior diploma in forensic sciences (PGFBDF) as well as in Education administration and supervision (PGDEAS) from Institute of Forensic Sciences, Pune, and Annamalai University, Chennai respectively. His research area mainly focused in fish biology, microbiology, plant-microbe interaction, pollution control and related fields. He has achieved life membership from Indian Science Congress Association. Dr. Banerjee's aptitude for research has resulted in several national and international publications including original research article, review papers as well as book chapters.

Dr. Samir M. Bagade M.Sc. Ph.D. working as an Assistant Professor in Physics at Arts & Science College Pulgaon, Wardha. (MS) He has teaching experience of 15 Years at UG & PG level. His area of research Acoustics and material science, recognized Ph.D. supervisor in Physics under science faculty of RTM Nagpur University and many research papers in National and International Journal and conferences in his credit.

Bhumi Publishing

ISBN 978-93-88901-64-2

9 789388 901642