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Devendra Fadnavis
Chief Minister
Maharashtra

सत्यमेव जयते

Mantralaya
Mumbai-400 032

Date: 16th December, 2024

MESSAGE

It gives me immense pleasure that K.M.E. Society's G.M. Momin Women's College Bhiwandi is organizing the National Conference on "Biochemical Approach towards Sustainable Development".

I congratulate the efforts of G.M. Momin Women's College for organizing the conference to create a platform for young and promising students of Chemistry, Biotechnology and Interdisciplinary Studies to discuss their problems with their peers.

I hope that this conference will provide a springboard to the upcoming experts and give a chance to know about the latest developments in the field of research and knowledge.

I extend my best wishes to all those involved in the effort.

(Devendra Fadnavis)

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प्रा. रविंद्र द. कुलकर्णी
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कुलगुरू

Prof. Ravindra D. Kulkarni
M.Tech., Ph.D.
Vice Chancellor

NAAC : A++ Grade
(CGPA 3.65)

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Category-I University Status awarded by UGC, 2023

MESSAGE

I am extremely happy to know that K.M.E. Society's G.M. Momin Women's College Bhiwandi is organizing the National Conference on "Biochemical Approach Towards The Sustainable Development" on January 11th, 2025.

The Conference has interdisciplinary approach amongst all branches of Science covering almost all fields with sustainable development and commercial applications. Conference will definitely have tremendous economic impact on society in general.

I am sure that researchers from various fields of Science from all over the country will participate in this National Conference and will contribute their best in the latest trends in the research of various fields igniting the minds of young scientist and students.

I compliment all the organizers of the above conference for their best efforts to make the event successful.

I wish all the participants a pleasant learning opportunity with motivating deliberations.

I wish the conference a great success.

(Prof. Ravindra Kulkarni)
Vice Chancellor
University of Mumbai

University of Mumbai

NAAC CYCLE III Accredited A++
(CGPA 3.65)

Prin. Dr. Ajay Murlidhar Bhamare
M.Com., Ph.D
Pro-Vice Chancellor

MESSAGE

I am pleased to learn that K.M.E. Society's G.M. Momin Women's College Bhiwandi is organizing the National Conference on "Biochemical Approach towards Sustainable Development" on January 11th, 2025.

In the constantly evolving world of technology, it is essential to upgrade with the changes and advances in the field. I hope that the experts will uphold their potential of excellence and introduce new developments of science keeping in view the needs of the present age, adding to the emerging pool of research and to the mutually beneficial experience for both the experts and the students in the conference. This initiative illustrates the foresight and efforts of the organizers towards enhancing our academic structure.

I extend my best wishes to the organizers and the participants of the event and wish them success in their future endeavours.

(Prin.Dr. Ajay Bhamare)

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Principal and Editors Desk

Arranging a national conference each year is a unique feature of G. M. Momin Women's college. I am delighted that this year our college has arranged a topic that is both timely and crucial: the biochemical approach towards sustainable development.

We are aware that the world is facing unprecedented challenges, from climate change to environmental degradation and from social inequality to economic instability. But l strongly feels that there is hope, and that hope lies in the power of biochemical innovation.

The biochemical approach to sustainable development is a rapidly growing field that seeks to harness the power of biochemistry and biotechnology to create innovative solutions to the world's most pressing problem. From the development of sustainable biofuels to the creation of novel bio products, this field has the potential to transform the way we live, work and interact with our environment.

This conference with such accomplished and highly experienced speakers will promote a new way of thinking, being and interacting with the natural world.

Let us all come together and embrace this new approach and work together to create a brighter, more sustainable future for all.

I sincerely thank our management for promoting this culture of bringing the best in holding such seminars ,the concerned departments namely Chemistry, Biotechnology and Interdisciplinary Studies, Dr. Jayashree Thakre, Dr. Mukesh Pimpliskar and Mrs. Ruby Patel respectively along with their teaching and non-teaching colleagues who have been working for the success of this conference enthusiastically.

May the almighty bless this institution for a meaningful academic development.

Principal
KMES G M Momin Women's College
Bhiwandi

From the Desk of the Convener….

Wish you all a happy New Year 2025.

It gives me great pleasure and happiness to conduct the National Conference on "Biochemical Approach Towards Sustainable Development" (BATSD 2025) being held at KMES G M Momin Womens College, Bhiwandi on 11th January 2025 organised by the Department of Chemistry, Department of Biotechnology and Department of Interdisciplinary Studies. I thank the Association of Chemistry Teachers and University of Mumbai for extending their support and collaboration in this endeavour.

The conference is a source of powerful impact as it draws upon the expertise from various disciplines and is also able to bring together leading authorities from Academy Institution and sustainable management society for focusing on new approaches in the field of Chemistry and Biotechnology in order to achieve the Universal goal of Sustainable Development.

Participants will be motivated by the drive towards innovation and progress contributing to positive change. This conference seeks to energize participants in encouraging research, collaboration and actionable solutions to tackle both environmental and healthcare challenges through the lens of biochemical science.

This platform will provide a grand opportunity to meet and interact with leading scientist researchers, industrialists and participants coming from all over the nation. I thank the Management of KME Society and Principal G M Momin Womens College for their motivation, guidance and inspiration and also for giving me the opportunity to organise this National Conference in our college.

By working together, we can make a significant difference in preserving our environment and protecting the atmosphere.

The committee invited original submissions from researchers, faculties, scientists and students that illustrate analytical research results, review works projects, survey works and industrial experiences describing significant advantages in the areas related to the relevant themes and tracks of the conference. The entire process which includes the submission review and acceptance process was done electronically.

I take the opportunity to thank our advisory committee members.

I wish the young researchers, especially students, would definitely generate interest and will develop green processes which will save our environment.

The conference aims to promote environmental preservation and green processes.

I am grateful to my Co- conveners, organizing secretary, treasurer, all members of the organizing committee and student's volunteers for working tirelessly.

I am thankful to all teaching, non teaching, administrative staff and all my dear students for extending their helping hands in this venture.

Dr. Jayashree Thakare
Head Department of Chemistry
KMES G M Momin Womens College Bhiwandi.

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Nanotechnology in Modern Agriculture: Efficiency, Sustainability, and Future Prospects

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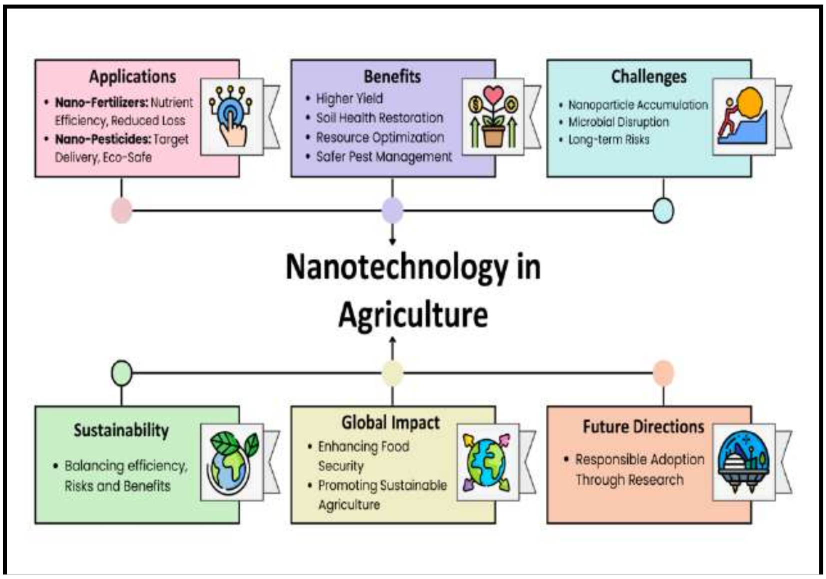
Abstract

Nanotechnology is revolutionizing modern agriculture by offering innovative solutions to critical challenges such as pest infestations, soil deterioration, environmental pollution, and inefficient resource use.This review explores the applications of nanotechnology in agriculture focusing specifically on nano-fertilizers and nano-pesticides as sustainable alternatives to conventional practices.Nano-fertilizers, designed with nanoscale particles, optimize nutrient delivery through controlled release mechanisms, ensuring higher nutrient use efficiency (NUE) while reducing nutrient losses and environmental contamination.These fertilizers address issues such as soil nutrient depletion, leaching, and excessive chemical use, thereby contributing to the restoration of soil health.Similarly, nano-pesticides, including nano-imidacloprid and nano-silica formulations, revolutionize pest management by providing enhanced bioactivity, slow-release functionality, and target-specific delivery.This approach reduces pesticide residues in the environment and minimizes harm to non-target organisms, offering a safer alternative to traditional chemical pesticides.

In developing nations like India, where agriculture forms the backbone of rural livelihoods, nanotechnology can play a pivotal role in addressing food security challenges by improving crop yields, mitigating pest resistance, and enhancing soil fertility.However, the persistence of nanoparticles in the environment raises significant concerns, particularly regarding their potential to accumulate in soil, disrupt microbial communities, and introduce long-term ecological and health risks.This review highlights the dual-edged nature of nanotechnology in agriculture, where its benefits in improving efficiency and sustainability must be carefully balanced against its potential risks.While nanotechnology holds immense promise in driving sustainable agricultural practices and enhancing global food security, responsible implementation supported by comprehensive research into its environmental impacts is imperative to unlock its full potential.

Keywords: Nanofertilizers; Nanopesticides; Sustainable agriculture

Graphical Abstract:



Introduction

Agriculture is the backbone of many developing economies, including India, where it serves as the primary source of livelihood for a significant portion of the population, particularly in rural areas(Mathur et al., 2006).Although contribution of the sector to the Indian economy has declined over the years from approximately 51.8% in 1950-1951 to around 15.8% in 2018-19, agriculture still plays a vital role. It continues to employ over 50% of the workforce, especially in rural areas (Foster and Rosenzweig, 2004). In India, agriculture is a critical sector to the economy, contributing approximately 17% of the total GDP and offering employment opportunities to over 60% of the population (GOI, 2011). Despite its critical importance, the sector faces mounting challenges from climate change, population growth, and land degradation, which threaten national food security in a country with over 1.4 billion people, now the world's most populous nation. Traditional farming practices, such as cereal-cereal crop rotations, have exacerbated soil degradation, nutrient imbalances, and pest infestations, necessitating innovative approaches to sustainable agriculture (Bhattacharyya et al., 2015).

While chemical fertilizers and pesticides have played a significant role in improving yields, their excessive and unbalanced use has resulted in nutrient loss, environmental pollution, and reduced soil fertility .Unbalanced nitrogen application has been linked to reduced nitrogen use efficiency (NUE) and significant greenhouse gas emissions, making precise nutrient management critical for sustainable agriculture.Pesticide use, while essential for managing pests, weeds, and diseases, has yielded mixed outcomes in agriculture.Alarmingly, only about 0.1% of applied pesticides reach their intended targets, with the remainder contributing to environmental contamination through leaching, runoff, and volatilization (Arias-Estévez et al., 2008).This inefficiency not only reduces pesticide efficacy but also poses environmental contamination risks (Larramendy and Soloneski, 2014).

Studies have highlighted that sustainable nutrient management, including balanced fertilizer application and organic amendments, is vital for reversing soil degradation and achieving long-term agricultural productivity This is underscored by the United Nations Environment Programme through its Sustainable Development Goals (UNEP and the Sustainable Development Goals) which emphasize the need of producing food in a way that safeguard environment and resources for future generations. Achieving this vision requires the adoption of sustainable food production systems and adaptive agricultural practices. Such methods must mitigate the adverse impacts of climate change, including extreme weather events, droughts, and flooding, while simultaneously enhancing soil and land quality. The challenge lies in producing an ample supply of grains, meat, plants, and other agricultural products to meet the needs of society, while also being mindful of the impact on our planet(Tilman et al., 2002).

Sustainable agriculture aims to provide high-quality food, fiber, and ecosystem services while promoting environmental stewardship. This goal requires enhancing crop yields, improving the efficiency of water, nitrogen, and phosphorus use, preserving soil nutrients, promoting ecologically sound management practices, minimizing air pollution, and judiciously using fertilizers and pesticides (Cassman, 1999). Nanotechnology, recognized by the European Commission as a key enabling technology, offers significant potential for sustainable agriculture. Integrating nanotechnology in an environmentally friendly manner can foster agricultural growth, reduce poverty, ensure food security, enhance environmental services, promote public welfare, manage natural resources, and achieve desirable social outcomes(Mittal et al., 2020). However, it is crucial to evaluate the potential risks to human health and the environment with this technology(Parisi et al., 2015).

Application of Nanotechnology in Agriculture

Nanotechnology is emerging as a transformative field in modern agriculture, offering innovative and sustainable solutions to address critical challenges such as inefficient resource utilization, soil degradation, pest infestations, and environmental concerns(Nair et al., 2010). By harnessing the unique properties of nanomaterials at the molecular level, nanotechnology is enhancing productivity, precision, and sustainability in agriculture, as illustrated in the Figure 1.A key application of nanotechnology includes increase in crop growth, where nanomaterials improve seed germination, promote faster plant development, and significantly increase crop yields. These advancements address global food demands while ensuring resource efficiency. Additionally, nanotechnology strengthens disease management by providing advanced protection against pathogens through nano-coatings. These protective coatings create an effective barrier, reducing crop losses caused by bacterial and fungal infections and ensure better harvest outcomes(Noman et al., 2023).

Soil degradation is another critical concern that nanotechnology addresses through soil enhancement. By improving water and nutrient retention, nano-additives optimize soil health, making agricultural practices more sustainable (Rajput et al., 2023). Enhanced soil fertility ensures that crops receive adequate nutrients for robust growth while reducing the overuse of traditional fertilizers, which often contribute to environmental pollution. Furthermore, nanotechnology improves stress tolerance in crops by increasing their resilience to adverse environmental conditions such as drought, salinity, and temperature extremes(Sekhon, 2014). This capability is particularly crucial in mitigating the impacts of climate change and ensuring stable food production under unpredictable conditions.

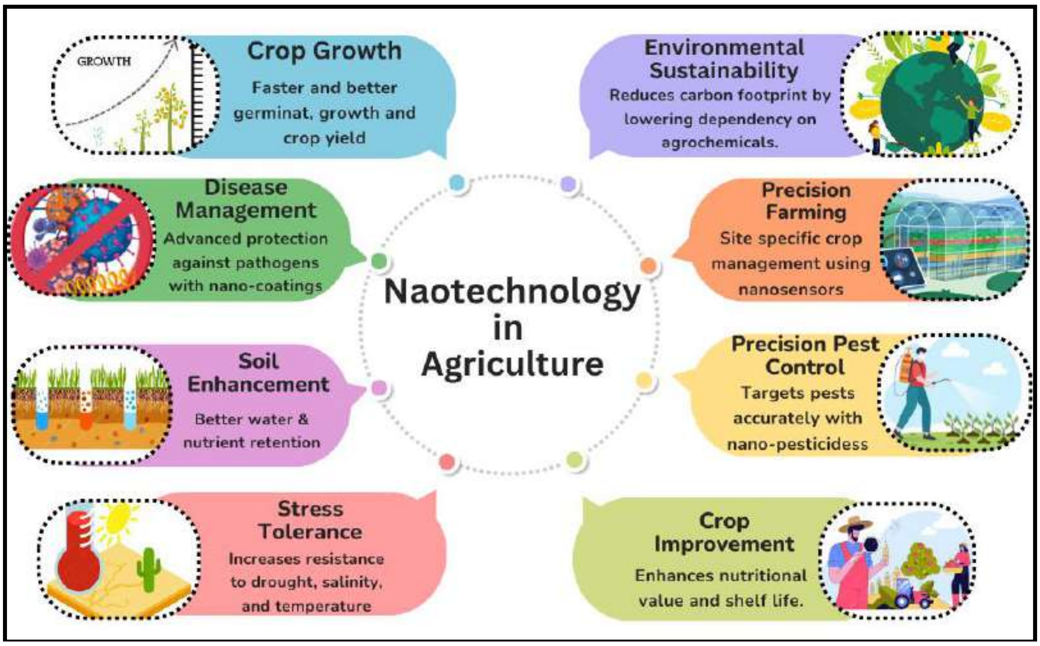


Figure 1 Applications of nanotechnology in agriculture

Nanotechnology also plays a pivotal role in promoting environmental sustainability. By reducing the reliance on agrochemicals such as conventional fertilizers and pesticides, nanotechnology helps lower the agricultural sectors carbon footprint. Nano-fertilizers and nano-pesticides prove a more targeted and efficient delivery of nutrients and pest control solutions, minimizing harmful runoff into ecosystems andensuring eco-friendly agricultural practices. The introduction of precision farming through nano-sensors marks a major advancement in site-specific crop management. Nano-sensors can monitor soil health, water levels, and crop conditions in real time, enabling farmers to make data-driven decisions that optimize resource allocation. This precision reduces waste, enhances productivity, and supports sustainable farming. Similarly, in precision pest control, nano-pesticides accurately target pests with minimal collateral damage to beneficial organisms and the environment. This targeted approach improves pest management while reducing the ecological impact of excessive pesticide use(Kumar et al., 2024).

Finally, nanotechnology contributes to crop improvement by enhancing the nutritional quality, shelf life, and safety of agricultural produce. Nano-based technologies in food packaging and preservation help prevent spoilage, ensuring that food remains fresh for longer periods while meeting global food security demands(Kumar, 2024). This innovation bridges the gap between production and distribution, reducing food loss across supply chains. In summary, the integration of nanotechnology in agriculture through tools like nano-fertilizers, nano-pesticides, and nano-sensorsoffer immense potential to revolutionize farming practices. By addressing challenges such as environmental stress, resource inefficiency, and food security, nanotechnology provides a pathway for sustainable agricultural growth. As research and development continue to advance, the adoption of nanotechnology promises to shape the future of global agriculture, ensuring both increased productivity and environmental stewardship.

Nano Fertilizers

The rapid increase in global population especially in the developing country such as India has put an increased pressure on the agricultural output to meet the needs. This has promoted the use of chemical fertilizers to boost agricultural productivity and yield. Many studies have supported the negative impacts of fertilizer use, showing that these chemicals not only pollute the soil but also make it unfit for future agricultural output. Chemical fertilizer use has also been associated with soil and water pollution and greenhouse gas emissions (Chandiniet al., 2019). Additionally, chemical fertilizers introduce heavy metals such as cadmium (Cd), arsenic (As), mercury (Hg), nickel (Ni), lead (Pb), and copper (Cu) into the soil, further exacerbating soil pollution and posing risks to both ecosystems and human health (Nsengimana et al., 2023). The evident drawbacks of chemical fertilizers make it imperative to transition towards sustainable agricultural practices that integrate innovative and eco-friendly solutions. One promising approach is the use of nanotechnology to develop advanced fertilizers that improve crop productivity while preserving soil and environmental health.

Nano fertilizers (NFs) are advanced formulations of conventional fertilizers, developed using chemical, physical, mechanical, or biological techniques to enhance their properties. These fertilizers consist of nanoscale particles, typically smaller than 100 nanometres, designed to optimize nutrient delivery and uptake by plants.Nano fertilizers (NFs) are synthetic or enhanced forms of conventional fertilizers, fertilizer bulk materials, or extracts from various vegetative or reproductive portions of the plants using various chemical, physical, mechanical, or biological methods. They are also referred to as smart fertilizers, which have drawn growing interest recently due to their potential to boost crop yields and minimize environmental impacts.

3.1 Types of Nano fertilizers

Nanofertilizers can be broadly classified based on the type of nanomaterials used and their nutrient content. The primary categories include carbon-based nano fertilizers, metal and metal oxide nano fertilizers, and polymeric nano fertilizers. Carbon based nano fertilizers include carbon nanotubes, graphene, and fullerenes. Carbon-based nanomaterials are renowned for their high surface area and unique chemical properties, which facilitate efficient nutrient adsorption and release. For instance, carbon nanotubes can enhance the uptake of water and nutrients by plants, leading to improved growth and yield. The high surface area of these materials allows for a greater interaction with plant roots, thereby improving nutrient availability and uptake(Khodakovskaya et al., 2012).

Metal and metal oxide nanofertilizers contains nanoparticles of essential metals such as zinc, iron, and copper, or their oxides. These nanoparticles provide micronutrients that are crucial for plant growth and development. For example, zinc oxide nanoparticles can improve the zinc content in plants, which is vital for enzyme function and protein synthesis. Their small size and high surface-area-to-volume ratio allownanofertilizersto penetrate plant tissues more effectively through stomatal openings and nanoscale channels known as plasmodesmata which are nanosized (50- 60 nm) passageways between cells, enhancing nutrient absorption and nutrient use efficiency (NUE)(Yadav et al., 2023).

Polymeric nanofertilizers involve the use of biodegradable polymers to encapsulate nutrients, ensuring a slow and controlled release. Polymeric nanofertilizers can be designed to release nutrients in response to specific environmental triggers, such as changes in soil pH or moisture levels. This targeted delivery system minimizes nutrient loss and enhances plant uptake. The polymers used in these fertilizers are often derived from natural sources, making them environmentally friendly and sustainable(Dasgupta et al., 2015).

3.2 Mechanism of Action of Nano fertilizers

The mechanism of action of nanofertilizers involves a series of advanced processes that significantly enhance nutrient delivery and uptake in plants as shown in Figure 2. One of the primary mechanisms through which nanofertilizer's function is their ability to provide a gradual and controlled release of nutrients. The high surface area of nanoparticles enables them to adsorb and release nutrients slowly over an extended period(Kopittke et al., 2019). This controlled release ensures a steady supply of essential elements to plants, which supports sustained growth and development. Unlike conventional fertilizers, which often result in rapid nutrient loss due to leaching or volatilization, nanofertilizers reduce these losses significantly by maintaining nutrients in the root zone for longer durations.

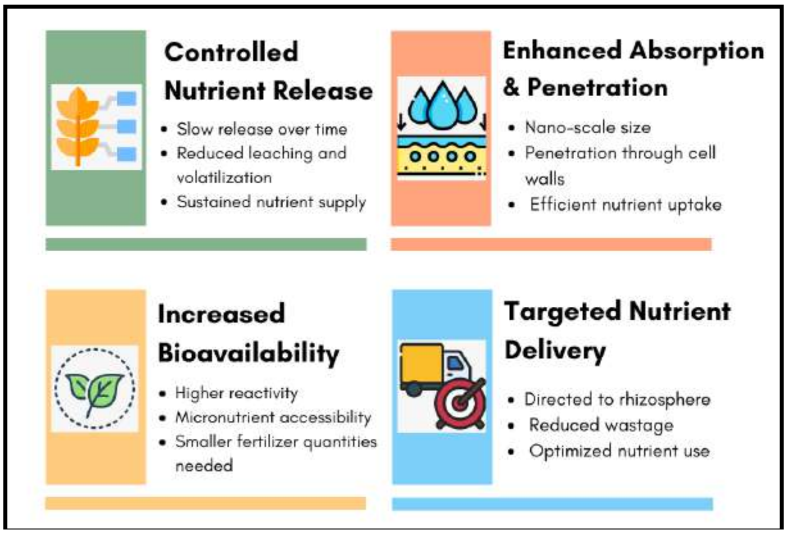


Figure2. Mechanism of Action of Nano fertilizers

This attribute not only improvesnutrient use efficiency(NUE), but also reduces the frequency of fertilizer application, making agricultural practices more cost-effective and sustainable (Dimkpa and Bindraban, 2018).

The nanoscale size of nanofertilizers plays a critical role in their enhanced absorption by plants. Due to their small dimensions, nanoparticles can penetrate plant tissues more efficiently than conventional fertilizers. They are capable of traversing plant cell walls, which are composed of rigid cellulose microfibrils, and can enter cells through nanosized channels such as plasmodesmata(Kah et al., 2018). Additionally, nanoparticles can pass through stomatal openings on leaf surfaces, facilitating foliar nutrient uptake. Once inside plant cells, these nanoparticles release nutrients in a highly bioavailable form, ensuring that plants can utilize them effectively for various metabolic and physiological processes(DeRosa et al., 2010).

Nanofertilizers can be engineered for targeted delivery, ensuring that nutrients are concentrated in specific regions such as the plant rhizosphere, where they are most needed(Verma et al., 2023). This targeted delivery mechanism minimizes nutrient wastage and optimizes plant growth by supplying nutrients directly to active root zones. For instance, polymeric nanofertilizers often employ biodegradable polymer coatings to encapsulate nutrients, which are released in response to environmental triggers such as soil pH or moisture changes(Dasgupta et al., 2015). This precision delivery system not only improves NUE but also reduces the environmental impact of fertilizer application by limiting runoff and eutrophication of water bodies.Nanofertilizers enhance the bioavailability of nutrients by presenting them in nanoscale forms that are more reactive and easily assimilated by plants(Servin and White, 2016). For example, nanoparticles of essential metals such as zinc and iron are absorbed more efficiently by plant roots compared to bulk fertilizers. This enhanced uptake allows plants to meet their micronutrient requirements with smaller quantities of fertilizers, contributing to resource efficiency and environmental sustainability(Dimkpa and Bindraban, 2018).

3.2 Application of Nano fertilizers

Nanotechnology plays a pivotal role in the development of novel fertilizers due to the unique properties of nanoparticles, including their high surface-to-volume ratio, controlled nutrient release kinetics, and superior sorption capacity (Beig et al., 2022). Nano fertilizers hold significant economic value as they reduce both application and transportation costs (Jakhar et al., 2022). A relatively lower concentration use of nano fertilizersprevents the accumulation of salts in the soil, a common issue associated with the overapplication of traditional fertilizers over time. Moreover, nano fertilizers can be tailored to meet the specific nutritional requirements of various crops, offering another key advantage (Khatri and Bhateria, 2023).Slow or controlled release mechanisms in nano fertilizersensure sustained nutrient availability over an extended period, promoting steady plant growth and development, which is advantageous for enhancing agricultural productivity. The increased solubility of NFs in water further aids in distributing nutrients uniformly in the soil, improving nutrient accessibility to plants(Wang et al., 2020). Furthermore, nano fertilizers can be taken up by plant roots or absorbed through the leaves, making the method of application an important factor in their effectiveness (Nongbet et al., 2022).

The application of nano fertilizers has been shown to yield substantial improvements in plant growth and physiological function. Research has demonstrated that NFs positively influence plant development, contributing to faster germination rates compared to conventional fertilizers. Specific benefits reported include increased seedling length, higher plant height, and greater chlorophyll content in crops such as rice and barley. In wheat, the use of nano fertilizers has been linked to increased yield, while in sorghum, enhanced growth parameters like plant height, dry matter production, and a greater number of leaves per plant have been observed(Pudhuvai et al., 2024). Additionally, the use of nano fertilizers has been associated with longer shoots and an expanded root system (Buates and Imai, 2021).Improved root growth, superior nutrient uptake and NUE, and enhancements in photosynthetic activity and nitrogen metabolism have all contributed to increaseplant dry weight, more flowers and panicles, higher grain production, and elevated chlorophyll content in cereals(Jyothi and Hebsur, 2017). Various types of commercial nano fertilizers and their usage are given in Table 1.

To address global food insecurity and improve agricultural output, specific nanoscale materials have demonstrated promising potential. Zinc oxide nanoparticles, for instance, exhibit enhanced physicochemical properties and have been utilized as nano fertilizers in soil-grown soybean, significantly improving seed yield, nutrient content, and oil and protein quality(Yusefi-Tanha et al., 2020). Similarly, iron oxide nanoparticles can be employed for a variety of nano-biotechnological applications, including the iron fortification of green gram and other food crops and improved iron fertilizer efficiency (Revathy et al., 2023). Nano titanium-oxide treatment has been linked to increased dry weight, photosynthetic rates, and chlorophyll-a production, indicating its role in improving seed germination and overall plant growth (Chaudhary and Singh, 2020). Copper based nano fertilizers have shown significant increase in the leaf area, chlorophyll content, the number of spikes per pot, the number of grains per spike, and grain production (Mahmood, 2015). Furthermore, silicon-based nano fertilizers have been shown to enhance plant resilience to abiotic stressors, such as heavy metal toxicity, heat, water deficit, and salinity(Okeke et al., 2023). Nitrogen-based nano fertilizers, for example, significantly enhance crop productivity by increasing chlorophyll content and accelerating plant growth (Verma et al., 2023). The use of nano-formulated agrochemicals and slow-release fertilizers has been associated with improved nutrient absorption while minimizing environmental impacts, thereby supporting sustainable farming practices (Saurabh et al., 2024). Additionally, nano-priming techniques have been shown to enhance seed germination and drought resilience, further contributing to improved crop performance (Nile et al., 2022). Recent advancements underscore the role of nano fertilizers in promoting agricultural sustainability. These advancements collectively position nano fertilizers as a critical component in addressing the dual challenges of food security and sustainable agriculture.

Nano pesticide

Pest infestations have been a persistent challenge to food production and agriculture for centuries. Insects, rodents, birds, and plant pathogens can cause significant damage to crops, leading to yield losses and decreased quality of food products.The impact of pests on food production can be devastating, resulting in economic losses, food insecurity, and environmental damage. Pest infestations can cause significant reductions in annual food production, with an average decrease of 45%. These losses can be caused by a wide range of pests, including insects, rodents, birds, and plant pathogens (Abhilash and Singh, 2009).

Table 1: Application of Nano Fertilizers in Various Commercial settings

S. No.	Type of Nano Particle	Usage	Reference
01	Nano-Cu	Enhances the activity of key enzymes, specifically superoxide dismutase (SOD) and ascorbate peroxidase (APX) in Maize, protecting plants from oxidative stress and improving overall plant health.	(Mahawar et al., 2024)
02	CuO-NPs	Applied to onion (Allium cepa) roots, leads to an increase in reactive oxygen species (ROS) levels, which can act as signaling molecules for stress responses. Also, enhances the activity of key enzymes, boosting the plant's ability to cope with oxidative stress and improving overall root health.	(Bhattacharjee et al., 2022)
03	Si-NP	Protects wheat seedlings (Triticum aestivum) from UV-B radiationthrough nitric oxide (NO)-induced activation of the plant's antioxidant defense system, enhancing the plant's ability to combat oxidative damage caused by UV-B exposure.	(Tripathi et al., 2017)
04	ZnO-NPs	Applied to both soil and foliar surfaces of sorghum (Sorghum bicolor L.) enhanced crop productivity and improved grain nutritional quality. The treatment also helped modulate the accumulation of essential nutrients, including nitrogen (N), phosphorus (P), and potassium (K), contributing to better plant growth and nutritional content.	(Dimkpa et al., 2017)
05	TiO_2-NPs	Improved growth of tomato (Solanum lycopersicum) by increasing chlorophyll content, thereby enhancing photosynthesis. This treatment also induced the expression of the Photosystem I (PSI) gene, further boosting the plant's photosynthetic efficiency and overall productivity.	(Tiwari et al., 2017)
06	Fe_2O_3 NPs	Applied foliarly to squash plants (Cucurbita), which enhanced the nutritional content of the fruits. This treatment resulted in higher levels of organic matter, protein, lipids, and total energy (K cal/g), improving the overall quality and nutritional value of the squash fruits.	(Shebl et al., 2019)

According to a study, pathogens, and pests are causing global wheat losses ranging from 10% to 28%, rice losses ranging from 25% to 41%, maize losses ranging from 20% to 41%, potato losses ranging from 8% to 21%, and soybean losses ranging from 11% to 32% (Nayak & Solanki, 2021).The impact of pests and pathogens on food production and agriculture is significant, and the need for sustainable pest management strategies is critical. The Green Revolution, a significant period in human history characterized by the extensive use of chemical fertilizers and pesticides to amplify crop production and address the growing food demands of ever-expandingglobal population, resulted in a range of environmental issues. These issues included the acceleration of soil fertility loss, soil acidification, nitrate leaching, increased weed species resistance, and loss of biodiversity(Verma et al., 2013).

Pesticides encompass a broad array of inorganic and organic compounds such as herbicides, insecticides, nematicides, fungicides, and soil fumigants. These substances are employed in agriculture to boost crop productivity and quality, and to increase economic profits by averting pest damage. However, pesticides are bioactive and toxic agents that can exert direct or indirect impacts on soil fertility, soil health, and the overall quality of the agroecosystem (Hassaan and El Nemr, 2020). The use of pesticides can have significant repercussions on the composition and diversity of soil microbial communities, as well as their metabolic activities, reproduction, and growth. Farmers may not always be aware of the critical loads of pesticides that can be safely applied to agricultural crops and soils. As a result, they may use these chemicals to control pests without understanding the potential negative consequences for soil health and the broader ecosystem.

These chemicals can exert direct toxic effects on soil organisms or indirectly influence the microbial communities by altering the physical and chemical properties of the soil (Odukkathil and Vasudevan, 2013). Numerous studies have been conducted to investigate the impact of pesticides on soil organisms, with particular attention paid to bacterial populations which play an essential role in the soil ecosystem, participating in nutrient cycling, organic matter decomposition, and disease suppression (Beaumelle et al., 2023). The intensive and frequent use of these pesticides in agriculture has resulted in the persistence of these chemicals in soil. This persistence can be attributed to the slow degradation of some pesticides, as well as their repeated application to agricultural fields (Odukkathil and Vasudevan, 2013). Pesticides also pose a significant risk to human health through multiple routes of exposure, including inhalation, ingestion, and dermal contact. Exposure to pesticides has been linked to a range of adverse health effects, such as cancer, mutagenicity, and circulatory problems. Moreover, chronic pesticide exposure has been associated with suppression of the immune system, male and female sterility, and behavioural disorders, particularly in children (Colosio et al., 2009; Jokanovic & Prostran, 2009; Rekha et al., 2006).

Nanopesticides are a novel and more effective pesticide products that primarily refer to the two pesticides defined as follows. The first category of nanopesticides are pesticides with nano-sized active ingredients. Powder pesticides and nano dispersant/(micro) emulsion pesticides are examples of this type of pesticide. The second class of nanopesticides are pesticides that are either loaded with nanomaterials, doped with nanomaterials, or physically coated with nanomaterials to create a "nano-coat" on their surface. Nano-components in these pesticides typically improve the performance of efficient components of original pesticides, target transportation, protect pesticides, and regulate pesticide release(Atta et al., 2015; Chaudhry et al., 2018; Lim et al., 2012).

Advantages of Nano-Pesticides over Conventional Pesticides

Nanopesticides offer several advantages over traditional pesticides, including high efficiency and low-volume usage. In contrast, traditional pesticides often suffer from several drawbacks, such as coarse drug carrier particles, low dispersibility, poor stability, and limited biological activity. Furthermore, the utilization rate of traditional pesticides for targeted crops is typically less than 30% (Tong et al., 2018). Nanopesticides have emerged as a promising alternative to traditional pesticides due to their targeted delivery and controlled release, which can improve pesticide utilization while reducing residue and pollution. Specifically, nano-microcapsule formulations have shown significant potential for slow release and protection, utilizing light-sensitive, thermo-sensitive, humidity-sensitive, enzyme-sensitive, and soil pH-sensitive high polymer materials to deliver pesticides. These formulations also offer improved adhesion on plant surfaces, reducing drift losses and enhancing the dispersion and bioactivity of the active ingredient. Consequently, nanopesticides exhibit superior efficacy compared to conventional formulations such as D-Dust, G-Granule, P-Pellet, EC-Emulsifiable Concentrate, WP-Wettable Powder, WDG-Water Dispersible Granule, among others. Their small size, improved droplet ductility, wettability, and target adsorption make them highly efficient and environmentally friendly. As such, nanopesticides offer an extraordinary means of establishing an eco-friendly and sustainable agriculture system by reducing overall chemical usage, decreasing toxic residues, and enhancing crop protection (Huang et al., 2018; Solanki et al., 2020; Zhao et al., 2023).

Applications of Nano Pesticides

Nano-imidacloprid is a term used to describe imidacloprid pesticides that have been coated with a nano-sized material (Guan et al., 2010). Imidacloprid is a widely used pesticide that specifically targets the micro-energy neural pathway of pests to achieve effective insecticidal results (Stara et al., 2019). However, the biological activity of imidacloprid is often compromised by external factors, which can hinder its effectiveness. By utilizing a nano-coating, the active components of imidacloprid can be protected and controlled for more targeted delivery, leading to improved biological activity, and enhanced insecticidal effects. The use of nano-coated imidacloprid represents a promising strategy for increasing the efficacy of this pesticide while minimizing its negative environmental impact. This approach has the potential to significantly contribute to the development of sustainable and eco-friendly pest control solutions (Graily Moradi et al., 2019; Guan et al., 2010).

Nano-silica is an ultrafine inorganic material characterized by its small particle size ranging from 1 to 100 nm, which imparts unique properties due to size effects, surface effects, and macroscopic quantum tunnelling effects. As a result of these properties, nano-silica has found widespread applications in diverse fields such as catalysis, light absorption, and medicine. Additionally, the toxic effect of nano-silica on insects and microorganisms has led to the expansion of its use in the field of pesticides. Experimental evidence indicates that nano-silica can significantly reduce the population of Spodoptera littoralis, which is commonly known as the cotton leafworm, thereby demonstrating its efficacy as a pesticide. The utilization of nano-silica in pest control represents a promising strategy for improving the efficacy and sustainability of agricultural practices while minimizing the negative environmental impact of traditional pesticides(Biswas et al., 2019; Du and Qiao, 2015).

Environmental Impacts and Human Health Risks

Nanotechnology has demonstrated significant potential in agriculture, particularly in increasing crop yields and improving crop management. However, concerns regarding its toxicity and long-term effects are still under investigation. Nanomaterials are increasingly preferred over conventional additives due to their unique properties, such as a high surface area-to-volume ratio and enhanced surface reactivity. However, excessive use of nanoparticles can lead to their accumulation in crops and soil and further pose the risk to human health and the environment as shown in Figure 3. Due to their small size (1–100 nm), nanoparticles persist in soil for extended periods, inhibiting nutrient leaching and potentially increasing soil toxicity levels(Das et al., 2022).Their presence in the soil affects multiple plant components, with roots being particularly susceptible to damage.Additionally, oxidative stress is a frequently observed phenomenon in plants exposed to high nanoparticle concentrations (Bhattacharyya et al., 2015; Rasheed et al., 2022). Beyond their effects on plants, nanoparticle interactions also pose risks to human health. Studies have indicated that these interactions can lead to neuronal damage, severe DNA damage, and increased risks of mutagenesis, carcinogenesis, and aging-related diseases (Fu et al., 2014).

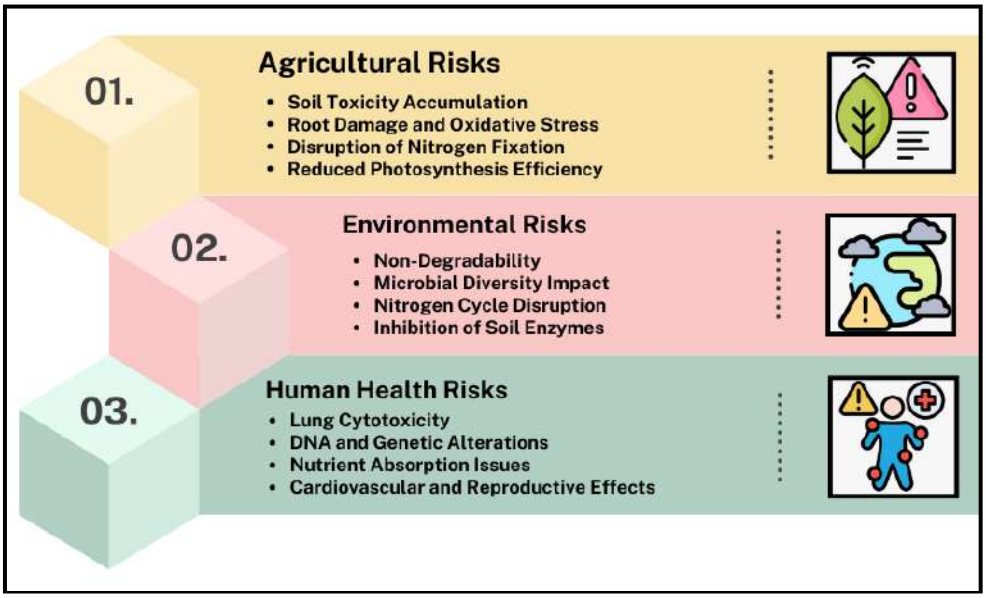


Figure 2 Risk of nanotechnology in agriculture

Nanoparticles harm plants significantly when overused. Their small size facilitates entry into plant cells through mechanisms such as binding to carrier proteins, utilizing aquaporins and ion channels, or through endocytosis, creating new pores in the process (Sembada and Lenggoro, 2024). Upon entering the plant, nanoparticles are translocated to the shoots, where they accumulate in various tissues. This accumulation reduces shoot macronutrients and chlorophyll concentrations, which can impair photosynthetic efficiency, especially under excessive nanoparticle use (Rizwan et al., 2021). Specific types of nanoparticles, such as cerium dioxide, have been shown to disrupt nitrogen fixation in leguminous plants by killing nitrogen-fixing bacteria in their roots. While the impact of nanoparticles on seed germination is dependent on concentration, studies have found no definitive size-related effects, and germination is typically not completely inhibited (Ma et al., 2022).

The widespread application of nano fertilizers and nano pesticides through soil exposes soil systems to substantial risks of nanoparticle accumulation. The soil acts as a reservoir and a transport medium for nanoparticles to reach plants and crops. Nanoparticles, particularly metal and metal oxide-based variants, are largely non-degradable, enabling them to persist in the soil for extended periods and potentially affecting deeper soil layers. This persistence can adversely impact the microbial community within the soil, including its functional and genetic diversity (Ahmed et al., 2023). For instance, certain nanoparticles have been found to interfere with the functioning of denitrification-associated genes, thereby disrupting the nitrogen cycle in soil systems (Zhao et al., 2020). Additionally, nanoparticles like silver (Ag) nanoparticles can inhibit the activity of specific soil enzymes, further impairing microbial functionality (Asadishad et al., 2018).

In addition to their environmental and agricultural effects, nanoparticles pose significant risks to human health. Humans may be exposed to nanoparticles through inhalation, oral ingestion, or dermal contact. Studies have highlighted the cytotoxic effects of nanoparticles on the lungs, which occur through direct pore penetration (Xuan et al., 2023).Nanoparticles have also been linked to genetic alterations, cell death, tissue dysfunction, cancer development, and reproductive harm (Ajdary et al., 2021). Exposure to nanoparticles induces intracellular production of reactive oxygen species (ROS), leading to primary DNA damage (Dayem et al., 2017). In the digestive system, nanoparticles can reduce the surface area of intestinal villi, impair nutrient absorption, and cause malnutrition and weight loss (Baranowska-Wójcik et al., 2022). Furthermore, interactions between nanoparticles and specific proteins may reduce the functionality of these proteins (Saptarshi et al., 2013)). Cardiovascular health may also be impacted by nanoparticles, with studies indicating their ability to affect cardiovascular function through neurogenic mechanisms (Kan et al., 2019).In summary, while nanotechnology offers significant benefits for agricultural productivity, its widespread use raises environmental and health concerns. The persistence and accumulationof nanoparticles in soil, plants, and human systems necessitate a balanced approach and further research to mitigate potential risks while maximizing their agricultural advantages.

Conclusion

Sustainable agriculture has become a pressing necessity to address the challenges of modern food production. Nanotechnology holds significant potential to transform agriculture, offering solutions to pressing challenges such as declining soil fertility, pest resistance, and environmental degradation. By enhancing nutrient and pesticide efficiency, nanofertilizers and nanopesticides pave the way for sustainable and eco-friendly farming practices. However, the risks associated with nanoparticle accumulation in soil and plants, as well as their impacts on microbial diversity and human health, highlight the need for responsible usage and comprehensive risk assessments. Future research should focus on developing biodegradable nanoparticles, optimizing application techniques, and conducting long-term impact studies to ensure safe integration into agricultural systems.

Future Scope

The future of nanotechnology in agriculture lies in advancing its applications while mitigating the associated environmental and health risks. Developing biodegradable nanoparticles that can degrade naturally in soil without leaving harmful residues will be a critical area of focus. This advancement would address concerns about the persistence of nanoparticles in soil and their potential toxicity to microbial communities and plants. Additionally, integrating nanotechnology with precision agriculture technologies, such as nano-sensors and intelligent systems, could revolutionize farming by enabling real-time monitoring of soil and crop conditions. This data-driven approach will enhance resource efficiency, optimize input usage, and improve decision-making. Long-term field studies are essential to evaluate the cumulative impacts of nanoparticles on ecosystems, soil health, and food chains. Such research will provide evidence-based guidelines for the safe and sustainable use of nanotechnology in agriculture. Regulatory frameworks tailored to nano-agrochemicals should also be established to ensure responsible implementation, balancing innovation with ecological preservation. Expanding nanotechnology's role in combating abiotic stresses such as drought, salinity, and extreme temperatures could further enhance its contribution to global food security.

In developing countries like India, wherefarmers are the backbone of agricultural productivity, integrating nanotechnology with government-supported initiatives can foster widespread adoption and economic upliftment. By addressing knowledge gaps and promoting education on nanotechnology's safe use, policymakers and researchers can create pathways for its equitable and sustainable deployment. With responsible innovation and adaptive strategies, nanotechnology can pave the way for a resilient, efficient, and environmentally sustainable agricultural future.

Authorship contribution

Arhama T.A. Ansari: Conceptualization, Investigation, Visualization, Data curation, Resources, Writing – original draft, Writing – review & editing.

Sameer Shafi Ganaie: Investigation, Data curation, Resources, Writing – review & editing.

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Effects of Climate Change on Women's Health

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Abstract

(This article is critically trying to review the **Effects of Climate Change on Women's Health**).

Climate change represents one of the most significant global challenges of the 21st century, with profound implications for human health. However, its impact is neither uniform nor equitable, disproportionately affecting women due to a combination of social, economic, and physiological vulnerabilities. Women, particularly those in low-income and marginalized communities, face a unique set of challenges stemming from climate-sensitive health risks. These include malnutrition, increased susceptibility to vector-borne diseases, and heightened mental health challenges during and after climate-related disasters.

Physiologically, women's reproductive and maternal health can be severely compromised by environmental changes, such as extreme heat, water scarcity, and food insecurity. Socially and economically, traditional caregiving roles, restricted access to resources, and limited representation in decision-making processes further exacerbate their vulnerability. Women in developing nations, who often depend on natural resources for livelihood and sustenance, are disproportionately burdened by climate-induced disruptions such as droughts, floods, and deforestation. Additionally, climate change magnifies existing inequities, as marginalized women face intersecting disadvantages due to poverty, ethnicity, and geographic location.

This paper explores the multifaceted relationship between climate change and women's health, providing an in-depth analysis of the vulnerabilities and health impacts faced by women across various regions. It delves into socio-cultural barriers, such as patriarchal norms, that limit women's access to healthcare, education, and adaptive technologies. Furthermore, it highlights the cascading effects of climate events on women's mental health, emphasizing the psychological toll of displacement, loss of livelihood, and exposure to violence during climate-induced crises.

Recognizing these disparities, this paper underscores the critical need for gender-sensitive policies and global interventions aimed at mitigating climate-related health risks. Strengthening community resilience, investing in women's education and empowerment, and integrating gender considerations into climate action frameworks are essential steps toward achieving health equity. By addressing the intersection of gender and climate change, this paper advocates for a more inclusive approach to climate adaptation and mitigation, ensuring that women are not only protected but empowered to be agents of change in building a sustainable and equitable future.

Keywords: vulnerabilities, susceptibility, disproportionately, cascading, mitigatin

Introduction

The ongoing climate crisis represents one of the greatest existential threats to humanity, impacting ecosystems, economies, and societies on an unprecedented scale. While the repercussions of climate change are global, they are not experienced equally by all populations. Certain groups, particularly women in developing and marginalized communities, bear a disproportionate burden due to a combination of social, economic, and physiological factors.

Women, who often play critical roles in caregiving, agriculture, and community well-being, face unique challenges as climate change exacerbates health disparities. These challenges are further amplified by structural inequalities such as limited access to healthcare, education, and decision-making platforms. For instance, during extreme weather events, pregnant women are particularly vulnerable due to their heightened physiological needs, and menstruating women often face hygiene challenges when water and sanitation resources are compromised.

This paper delves into the multifaceted relationship between climate change and women's health, focusing on how the evolving climate disproportionately affects women. It examines the underlying vulnerabilities, the range of health impacts experienced by women, and the socio-cultural barriers they face in coping with these challenges. Finally, it proposes gender-sensitive strategies for mitigation and adaptation to ensure equitable and sustainable health outcomes for women worldwide.

Climate Change and It's Global Impact

Climate change refers to long-term and significant shifts in the Earth's climatic systems, driven primarily by human activities such as deforestation, industrialization, and the burning of fossil fuels. These changes manifest through a variety of environmental disruptions, each with profound and far-reaching consequences for the planet and its inhabitants. Below is an in-depth examination of key effects and their cascading impacts:

1 Rising Temperatures Leading to Heatwaves and Droughts

Global temperatures have been rising steadily due to the accumulation of greenhouse gases such as carbon dioxide and methane in the atmosphere. The result is an increase in the frequency, duration, and intensity of heatwaves, which have direct and indirect effects on human health and livelihoods:

Heatwaves: These disproportionately affect women, particularly those in physically demanding roles like farming or labor. Pregnant women are at higher risk of heat stress, dehydration, and complications such as preterm labor.

Droughts: Prolonged droughts compromise water availability, forcing women in rural areas to travel longer distances to fetch water. This increased workload can lead to physical exhaustion, musculoskeletal disorders, and reduced time for childcare or income-generating activities.

The lack of adequate water and food during droughts also exacerbates malnutrition, with women often eating last and least in resource-constrained households

2 Extreme Weather Events: Hurricanes, Floods, and Cyclones

The increasing frequency and severity of extreme weather events such as hurricanes, floods, and cyclones are some of the most visible consequences of climate change. These events have devastating impacts on communities, particularly women:

Displacement and Health Risks: Floods and cyclones displace millions, pushing families into temporary shelters where women face heightened risks of sexual violence and limited access to reproductive healthcare.

Loss of Livelihood: Many women in developing countries depend on agriculture for their livelihoods. Extreme weather events destroy crops and livestock, plunging families into poverty and exacerbating food insecurity.

Mental Health Impacts: The trauma of losing loved ones, homes, and livelihoods contributes to anxiety, depression, and post-traumatic stress disorder (PTSD) among women.

3 Shifts in Ecosystems: Agriculture and Biodiversity

Climate change disrupts ecosystems, leading to a domino effect on agriculture, food security, and biodiversity:

Agricultural Disruption: Erratic rainfall patterns, prolonged dry spells, and floods significantly reduce crop yields. Women, who are often responsible for subsistence farming, struggle to secure food for their families, leading to increased malnutrition and food scarcity.

Loss of Biodiversity: Climate change threatens vital ecosystems such as forests and coral reefs, which are sources of food, medicine, and income for women in indigenous and rural communities. The depletion of these resources further restricts their survival options.

4 Rising Sea Levels: Coastal Displacement

Rising sea levels, a result of melting glaciers and thermal expansion of oceans, threaten coastal communities worldwide:

Displacement of Populations: Coastal flooding forces families to relocate, often to overcrowded and unsanitary conditions. Women in such environments face challenges in accessing clean water, maintaining hygiene, and caring for children.

Salination of Water Resources: As seawater infiltrates freshwater sources, access to clean drinking water diminishes. This increases the prevalence of waterborne diseases like diarrhea and cholera, which disproportionately affect pregnant women and children.

Loss of Cultural and Economic Ties: Women in coastal communities often depend on fishing and related activities for income. Rising sea levels disrupt these traditional livelihoods, leading to economic insecurity.

5 Cascading Impacts on Public Health, Food Security, and Economic Stability

The effects of climate change extend beyond immediate environmental disruptions, triggering cascading impacts on vital systems:

Public Health: Rising temperatures and changing weather patterns increase the prevalence of diseases such as malaria, dengue, and respiratory illnesses. Women, particularly those in poverty, often lack access to preventive measures like vaccines or treatment facilities.

Food Security: Reduced agricultural productivity due to droughts and extreme weather events worsens food scarcity. Women and children, who are most vulnerable to malnutrition, bear the brunt of these impacts.

Economic Stability: Climate disruptions disproportionately affect industries where women are overrepresented, such as agriculture and small-scale trading. This deepens gendered economic disparities and limits women's ability to recover from climate-induced losses

By understanding these global impacts and their disproportionate effects on women, it becomes clear that climate change is not just an environmental issue but a gendered health crisis. Addressing it requires integrating gender-specific needs into climate action plans to ensure that women are adequately protected and empowered to adapt to changing conditions.

Vulnerabilities of Women to Climate Change

Climate change exacerbates existing vulnerabilities among women, particularly those in low-income and marginalized communities. These vulnerabilities are rooted in physiological, socio-economic, and intersectional factors, each of which uniquely impacts women's ability to adapt to and recover from the consequences of a changing climate.

1 Physiological Vulnerabilities

Reproductive Health: Women's reproductive health is particularly sensitive to environmental stressors induced by climate change. For instance:

Heat Stress: Pregnant women are more vulnerable to extreme heat due to increased metabolic demands. Heat stress can lead to dehydration, preterm labor, and complications during childbirth.

Malnutrition: Climate-induced food shortages result in poor nutrition, which has severe consequences for maternal and fetal health. Malnourished pregnant women face higher risks of anemia, pre-eclampsia, and low birth weight babies.

Vector-Borne Diseases: Pregnant women are more susceptible to diseases like malaria and Zika virus, which can result in maternal mortality, miscarriages, and birth defects such as microcephaly.

Menstrual Health: During climate crises, access to clean water, hygiene products, and private spaces for menstrual hygiene management is often compromised:

In floods and droughts, water scarcity worsens menstrual hygiene, increasing the risk of infections like bacterial vaginosis and urinary tract infections (UTIs).

The stigma surrounding menstruation further exacerbates these issues, as women and girls may refrain from seeking help or medical care.

2 Socio-Economic Vulnerability

Caregiver Roles: In many societies, women bear primary responsibility for caregiving. During climate-induced crises, they prioritize the needs of their children, elderly, and other family members over their own health. For example:

Women may delay seeking medical treatment for themselves, leading to worsening of preventable illnesses.

Increased caregiving responsibilities during disasters result in higher physical and emotional stress, which can lead to burnout.

Economic Dependence: Women's limited access to financial resources restricts their ability to recover from climate shocks:

Many women work in informal sectors like agriculture and small-scale trade, which are highly susceptible to climate-related disruptions.

Lack of ownership of land and property further hinders their ability to secure loans or rebuild after disasters.

Education Gaps:

Women and girls in regions with low literacy rates are less likely to be aware of climate-resilient practices or participate in decision-making processes:

They may lack knowledge about health risks and preventive measures during climate events.

Limited education reduces their capacity to advocate for policies that address their specific needs.

3 Intersectionality and Marginalization

Intersectionality highlights how overlapping identities, such as gender, ethnicity, caste, and socio-economic status, amplify the health challenges faced by women in a changing climate. For instance:

Poverty: Poor women are often the first to lose access to healthcare, clean water, and food during climate disasters.

Ethnicity and Geography: Indigenous women and those living in remote areas face additional barriers in accessing climate adaptation resources and healthcare.

Discrimination: Social norms and patriarchal structures limit women's ability to participate in climate adaptation and mitigation strategies

Health Impacts of Climate Change on Women

1 Heat-Related Illnesses

Rising global temperatures lead to heatwaves that disproportionately impact women:

Women engaged in outdoor labor, such as farming or construction, face a higher risk of heat exhaustion, dehydration, and heatstroke.

Pregnant women are especially vulnerable, as heat exposure can increase the likelihood of preterm births, stillbirths, and low birth weights.

2 Malnutrition and Food Security

Climate change affects agricultural productivity, leading to food shortages and higher prices:

Women, often the last to eat in patriarchal households, are more likely to suffer from malnutrition and its consequences, such as anemia, weakened immunity, and complications during pregnancy.

Malnourished mothers are more likely to give birth to underweight or stunted children, perpetuating cycles of poor health and poverty.

3 Water Scarcity and Sanitation

Water shortages and poor sanitation disproportionately affect women and girls:

Women spend more time fetching water, exposing them to musculoskeletal injuries and reducing their time for education or income-generating activities.

Limited access to sanitation facilities increases risks of infections, particularly for menstruating and pregnant women.

Inadequate sanitation in refugee or disaster relief camps can lead to outbreaks of diseases like cholera and diarrhea.

4 Vector-Borne Diseases

Climate change extends the habitats of disease-carrying vectors, increasing the incidence of illnesses such as malaria, dengue, and Zika virus:

Pregnant women are at higher risk, as these diseases can cause severe complications for both mother and child, including miscarriages and birth defects.

Women in rural areas with limited access to healthcare are disproportionately affected by delayed diagnoses and inadequate treatment.

5 Mental Health Challenges

Climate-induced disasters such as floods, droughts, and cyclones take a heavy toll on women's mental health:

Displacement and loss of livelihood result in anxiety, depression, and post-traumatic stress disorder (PTSD).

Women who face gender-based violence during climate crises experience additional mental health burdens.

The stress of caring for children and family members during and after disasters further exacerbates psychological strain.

Case Studies

1 Cyclone Amphan (2020)

Cyclone Amphan displaced millions in India and Bangladesh, with women bearing a disproportionate share of the burden:

Relief camps lacked adequate facilities for menstrual hygiene and maternal healthcare, leading to infections and complications.

Reports of gender-based violence increased, as women were more vulnerable in overcrowded shelters.

2 Droughts in Sub-Saharan Africa

Prolonged droughts in Sub-Saharan Africa have worsened food and water scarcity:

Women, responsible for household sustenance, must travel longer distances for water, risking physical exhaustion and violence.

Malnutrition among women has surged, particularly affecting pregnant and lactating mothers.

Strategies for Mitigation and Adaptation

1 Gender-Sensitive Health Policies

Develop healthcare systems that prioritize maternal and reproductive health during climate crises.

Ensure equitable access to nutrition and clean water for women in disaster-affected regions.

2 Empowering Women

Promote education programs to raise awareness about climate change and adaptive practices.

Strengthen women's leadership roles in climate policy and decision-making.

3 Community-Based Interventions

Train community health workers to address gender-specific health needs.

Implement water, sanitation, and hygiene (WASH) programs that address women's requirements.

4 Research and Data Collection

Collect and analyze gender-disaggregated data to understand vulnerabilities and inform targeted interventions.

Support research on the intersection of climate change, gender, and health.

5 International Collaboration

Integrate gender considerations into global climate agreements like the Paris Agreement.

Mobilize funding for women-centric climate adaptation programs through international organizations.

Conclusion

The intersection of climate change and women's health represents a critical yet underexplored domain that demands urgent attention. Women's disproportionate vulnerability to climate change arises from a combination of physiological, socio-economic, and structural factors, compounded by existing gender inequalities. Addressing these challenges requires a multifaceted approach that combines gender-sensitive policies, community resilience, and global cooperation.

Empowering women to be agents of change in climate resilience can transform them into key contributors to sustainable solutions. By ensuring that women's voices are heard and their needs are prioritized, the global community can move closer to achieving health equity and building a more inclusive and resilient future.

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Strategies Employed in the Indian Ancient Era for Sustainable Development - A Review

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Abstract:

Sustainable development is generally thought to be a modern concept. However, this approach and thought process were regularly practiced in the ancient Indian era. The principles of environmental balance and conservation of resources were part and parcel of daily life. Practices ensuring ecological sustainability have been developed and implemented in India since ancient times. A harmonious co-existence with nature, addressing the needs of the present without depleting resources for future generations was sought and achieved. Sustainable development in agriculture, conservation of forests, water management, and urban planning was achieved using traditional knowledge systems.

Principles of organic farming, crop rotation, and using natural fertilizers were practiced to ensure the maintenance of soil fertility without affecting food security. Construction of tanks, wells, and canals comprised of the water management techniques. The Indus Valley Civilization exhibited meticulous urban planning inclusive of waste management and sanitation systems ensuring minimal environmental degradation. Forest conservation and biodiversity protection were attained through concepts of sacred groves and allied religious practices. Ancient scriptures like the Vedas and Ayurveda underlined the role of humans as trustees of natural wealth and the concept of environmental stewardship. This article reviews these sustainable practices, highlighting their relevance in today’s world, where climate change and resource depletion demand a return to environmentally conscious development.

Key Words: Sustainable development, Ancient civilizations, Environmental balance, Ecological sustainability, Water management, Urban planning, Indus Valley Civilization, Waste management, Forest conservation, Biodiversity protection, Climate change, Environmental stewardship

Introduction

Brundtland (1985) defined sustainable development as the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” Though this concept got established in the 20th century, ancient Indian civilizations had already been practicing this concept in India for ages. A deep understanding of the concept of trusteeship about the environment, environmental stewardship and resource management is described in detail in many Indian scriptures and texts, such as the *Rigveda*, *Atharvaveda*, and *Arthashastra*, to name a few. Agricultural practices like mixed cropping, crop rotation, and the use of organic fertilizers (manure and compost) were implemented to maintain soil fertility in ancient India (Patel et al., 2020). Step-wells, tanks, and canals were designed and used to ensure efficient use of water resources, especially in arid regions (Jain et al., 2022).

The Harappan civilizationhad advanced urban planning and waste management systemswhich indicated society’s awareness and plans to maintain environmental balance. Forest conservation practices in the form of sacred groves gave a religious sacred touch to the concept of protecting the environment, natural resources and biodiversity (Singh, et al., 2017). Ayurvedic and Vedic literature emphasised on promotion of harmony between mankind and nature. This article explores the ways in which those ancient principles of sustainability can be applied to contemporary practices to seek solutions for the modern environmental challenges.

Literature Review

1 Agricultural Systems

Indian agriculture in the ancient era practiced sustainability. Attention was given to preserving the soil's quality and optimizing the water use. Cow dung and plant-based compost were used as fertilizers. This helped to maintain soil fertility and also boosted agricultural productivity. Employing crop rotation and mixed croppinghelped in prevention of soil depletion and promotion of biodiversity in farming landscapes (Patel et al., 2020).

Ther are many important quotes in Vedic texts such as the *Rigveda* and *Atharvaveda*about sustainable agricultural practices. The *Rigveda* (Book 10) underlines the importance of ploughing fields after due considerations about monsoon rains, thereby promoting optimal moisture retention for crops. The *Atharvaveda* (Book 3) discusses the significance of water conservation, and recommends bunding and terracing to minimise water loss, especially in arid regions (Singh, et al., 2020). Rainwater harvesting was regularly practiced by ancient Indian farmers through the construction of tanks and step-wells. These techniques are still in vogue in rural India today. These traditional agricultural systems reflected an intricate understanding of the natural environment, aimed at ensuring sustainability for both present and future generations (Patel et al., 2020).

2 Water Management

Water is an essential, important, and vital resource for the survival of agriculture in particular and of entire mankind in general.Systems of water harvesting and management were developed in ancient India to conserve and efficiently utilize water. The construction of tanks, step-wells, and canals was carried out at various places in ancient India to collect and store rainwater, ensuring its year-round availability (Jain et al., 2022). Apart from taking care of irrigation needs for agriculture, these methods also provided for the daily water needs of communities, particularly in arid and semi-arid regions.

The *Kund* water utilization system, prevalent in Rajasthan is one such example. Herein, stepwells were constructed to harvest rainwater and to preserve itfor dry periods (Venkateswarlu, 2009). Similarly, the *Baolis* and *Johads* of northern India played an important role in water storage and recharging groundwater levels (Murthy, 2022). The *Arthashastra*, an all-encompassing bookby Kautilya (Chanakya), describes water management methodology in detail. The importance of water reservoirs and canals for irrigation is discussed in detail in this book. Chanakya discusses regular monitoring of these water systems and strongly recommends intervention by the king, should it be required to maintain these systems to ensure agricultural productivity (Jain et al., 2022).

Ancient Southern India predominantly used the tank irrigation system. Sundaram and Bhaskaran (2021) mention that the *Kaveri* Delta system of large reservoirs is one of the earliest examples of man-made irrigation in ancient India.They also give an in-depth account of the tank irrigation method in Southern ancient India. All these examples as observed across the length and breadth of ancient India indicate that Indians were thoroughly aware of the importance and significance of water, were aware of the necessity to use this resource carefully, and had carefully designed and executed strategies to conserve water – long before the present day scenario where water scarcity has become an increasing global concern.

3 Urban Planning

The Indus Valley Civilization is one of the earliest and most advanced examples of urban planning. With its elaborate design and infrastructure management, it exhibits a detailed understanding of urban organization, hygiene, and environmental sustainability, especially in the cities of Mohenjo-daro and Harappa (around 2500 BCE). Meticulously laid-outcities with well-planned streets, residential and public buildings, and advanced drainage systems were discovered in the archaeological excavations. A highly methodological and organized civic life is evident through the grid pattern of these urban maps. Main roads are found to be intersecting at right angles, residential areas are found to be systematically planned, and ease of movement and functional zoning is seen in the remains of these cities (Bisht et al., 1984).

The waste management and drainage system of these Indus Valley cities consisted of underground drainage channels made of baked bricks. These underground channels running along the roads were connected to the household drainsand ensured efficient drainage and removal of wastewater and rainwater. As a result of this, the risk of waterborne diseases was considerably reduced, thereby confirminga clean and healthy living environment. Awareness of public health, hygiene, and the importance given to cleanliness and sanitation is evident in structures like the Great Public Bath of Mohenjo-daro(Bisht, 1999).

There existed highly efficient, elaborate and sophisticated water management systems in these cities. Strategic placement of wells throughout the cities ensured provision of fresh water to households. Large reservoirs and tanks, by their storage and conservation of water ensured availability of water during the dry seasons. Later civilisations in rest of ancient India – in Rajasthan and Gujrat, practised water management techniques such as *kunds*, *baolis*, and step-wells and similar structures were observed in Harappa and Mohenjo-Daro also (Rao, 1985).

Careful attention given in designing and executing the waste management, sanitation and water conservation in the Indus Valley urban planning speaks volumes about the thorough understanding of sustainable development at that era and times. The thought process and attention to detail in waste management, water conservation and in ensuring sanitation by the people of Mohenjo-Daro and Harappa echo the modern ideas of sustainability. Those ancient civilisations had understood the essence of the importance of balance between human activity and the environment (Possehl, 2002). These practices underline the relevance of traditional knowledge in present day urban planning and environmental conservation efforts.

4 Forest Conservation

Forests were not merely looked upon as a wealth of natural resources, but were also looked upon as a sacred entity that had to be protected. Forests occupied an important position in ancient Indian culture. Their religious, ecological and spiritual importance is chronicled in ancient Indian literature – in the *Vedas.* The *Aranyakas*(Forest Works) are a part of the *Vedic* texts, and they focus on the religious, contemplative, logical, metaphysical, philosophical and meditative practices, many times carried out in solitude in forests. The *Aranyakas* discuss the inter-relationship between the mankind and nature, and advocate a harmonious lifestyle with the environment. The *Vedas* also advocated least interference with nature, natural resources and ecosystems thereby achieving and maintaining ecological balance (Singh, 2017). Mankind in ancient era worshipped nature.

The concept of the sacred groves emerged from this logical thought process. People revered the deities in these patches of forest land – the Sacred Groves (*devrai* or *dev-van*). Cutting down trees or harming wildlife within the boundaries of the sacred grove was strictly a taboo. Without the disturbance and interference from humans, the trees flourished in these land patches, sheltering wildlife and promoting biodiversity. The ecosystem thrives and remains stable inside the sacred groves and in the surrounding areas. Sacred groves were particularly prominent in states like Kerala, Karnataka, Maharashtra, and Rajasthan, and they still exist in some parts of India today, protecting rare plant species and wildlife (Gadgil & Vartak, 1975).

Apart from the *vedas*, other ancient texts like the *Mahabharata* and *Ramayana* alsochronicle and record the practices of conserving forests for religious reasons. These texts cited and narrated the ecological richness in the forests and depicted forests as spiritual havens. Ancient India did not look upon forest conservation merely from religious, cultural and traditional angle alone, it had its practical aspects also in consideration. They knew that forests were important sources of medicinal plants, timber, and other resources, and their maintenance, conservation, protection and promotion ensured a sustainable recurring supply of these resources (Patra, 2016).

These traditional approaches and practices of forest conservation in India provide vital insights into sustainable resource management. Cultural and religious beliefs were intricately linked to ecological stewardship, long before the emergence of the modern environmental movements. The legacy of these ancient practices continues to inspire contemporary efforts to preserve forests and biodiversity in India.

5 Traditional Knowledge Systems

An in-depth comprehension and awareness about ecology, biodiversity and interactions thereof is portrayed in Indian traditional knowledge systems. By incorporating the principles of ecology and biodiversity into the cultural and spiritual fabric of society, a competitive edge is provided to their conservation and promotion. The *Vedas*, *Charaka Samhita*, and *Sushruta Samhita* deeply respect nature and sustainable practices. These ancient Indian texts provide an outline about the use of plants, herbs, and natural resources in everyday life, especially in medicine, agriculture, and religious rituals, and describe the inherent connection between health and well-being of the mankind and nature. The *Charaka Samhita* and *Sushruta Samhita*, describes the Ayurvedic way of medical treatment. The Ayurved finds use of over 2000 plants for their medical applications and equivocally endorses their sustainable use(Mukherjee and Wahile, 2006). This promoted the conservation of plant biodiversity and also fostered a balanced approach to health and environmental care.

Religious and traditional rituals were employed to conserve the biodiversity. Ancient Indian pundits were aware that if something is decreed by the sacred books, a commoner shall not go against it and thus, the desired goal shall be achieved. This is amply reflected in the preservation of sacred groves (*Devrais*). These groves were protected by religious customs, ensuring that certain areas of forest remained untouched by human activity, thus acting as repositories of biodiversity (Singh, et al., 2017). Rituals and festivals in India often worshipped rivers, mountains, and trees – important aspects of nature. This resulted in entrenchment of environmental consciousness in cultural practices. For example, the *Tulsi* plant, considered sacred in Hindu households, was traditionally worshipped and protected, reflecting the role of cultural rituals in biodiversity preservation (Sharma and Kumar, 2021).

Traditional knowledge of seasonal variations over the year, water requirement by the crops and diversity of crops were amalgamated by the Indian agricultural systems. Techniques such as rainwater harvesting, described in ancient texts like the *Arthashastra*, demonstrate how environmental balance was achieved through sustainable resource use (Jain et al., 2022). These examples of India's traditional knowledge systems emphasize the ancient link between ecological preservation and human health, offering valuable insights into modern sustainable practices.

Methodology

This review article is founded on an in-depth examination of secondary sources, including ancient Indian scriptures, archaeological studies, and scholarly articles. A systematic review approach was employed, whereby data on sustainability practices from various periods and regions within India were collected, analyzed, and synthesized to form coherent conclusions. The study focusses on the relevant findings in the *Vedas, Arthashastra,* and *Upanishads* as well as in comparatively modern interpretations from archaeological findings from sites like Mohenjo-daro and Harappa. The *Rigveda* and Atharvaveda discuss about early agricultural and water conservation methods.

The Arthashastra elaborates on ancient strategies for resource management and environmental governance (Jain et al., 2022). The evaluation of sacred groves and forest conservation practices from Vedic periods expounded the importance and significance of biodiversity in the said time span (Singh, et al., 2017). Evidences of sustainable urban planning and waste management are unearthed from the excavations in the areas of the Indus Valley Civilization (Bisht, 2016). An attempt is made to ensure that this research review captures both historical knowledge and modern academic interpretations of ancient Indian practices, offering a detailed perspective on how ancient sustainability strategies can inform contemporary approaches.

Data Analysis: Ancient Indian Strategies for Sustainable Development

1 Sustainable Agricultural Practices

In ancient times, Indian agriculture had a thorough scientific understanding of the concepts of sustainability and ecological balance. The *Rigveda* (c. 1500 BCE) and *Atharvaveda* (c. 1200 BCE) provide documentary evidence that ancient Indian farmers were mindful of the importance of soil health. To maintain and increase soil fertility, they used organic fertilizers like cow dung and compost(Patel et al., 2020). These practices prevented soil degradation and maintained long-term productivity. Traditional ploughing methods avoided deep tilling. They prevented land erosion and preserved the soil structure.Polycropping and mixed farming were regularly practiced, which acted as biological/natural pest control and also resulted in an increase in biodiversity.

The *Arthashastra* (c. 300 BCE), a treatise written by Chanakya (Kautilya) has an in-depth discussion about irrigation techniques minimizing wastage of water.The book informs about how canals were used to divert river water to provide irrigation to agricultural fields. It also talks about the use of tanks to store water for later use providing water to crops even in periods of drought. Cultivation of crops well suited to local conditions of soil and climate was advocated, reducing the need for excessive water use and thereby maintaining a balance with the environment (Jain et al., 2022). This approach tosustainable agricultural practices resulted not only in long-term food security but also enriched the perspective of environmental conservation.

2 Water Management Systems

Water management systems in ancient India were a wonderful combination of engineering technology and cooperation within the society. The inventivenessand resourcefulness of water harvesting techniques aremagnificently elaborated in the construction of step-wells (locally known as *vavs* in Gujarat and *baolis* in Rajasthan) (Murthy, 2022). These wells are decorated with beautiful delicate designs in stone displaying not only the cultural and practical importance of water but also artistry in ancient India. even in drought-prone semi-arid localities, these step-wells ensured a year-round supply of water(Jain et al., 2022). These step-wells acted as collection points of the monsoon water and the same is stored underground. This underground storage of water resulted in a decrease in evaporation and allowed its use later on during the dry seasons, other systems such as tanks (*kuls* and *bandhas*) and canals played a key role in sustaining agriculture, as well as in maintaining public water supplies. Water management was a task jointly executed by the king and the subjects at large. One of the **key examples** of a state-sponsored effort of water management was the construction of the Sudarshan Lake in Gujarat during the reign of Chandragupta Maurya (c. 300 BCE) (James and James, 2013). Kings constructed large irrigation systems like these and the local communities looked after their management and maintenance. These early forms of decentralized environmental managementensured that water resources were conserved for both immediate and future use.

3 Urban Sustainability

The concept of sustainable urban development was aptly depicted in the urban plannings of the Indus Valley Civilization cities like Mohenjo-daro and Harappa (c. 2500 BCE). Well-planned streets were laid out in grid patterns, and advanced drainage systems for waste disposal away from residential areas, preventing contamination of water sources and maintaining public health were carried out in these cities (Bisht, 2016). Understanding of the concepts of hygiene and spatial planning was evident from the presence of public baths and separate residential and commercial zones in these cities.

Archaeological evidence supports that natural resources were sustainably managed by the population of the Indus Valley. They were able to bake durable and long-lasting bricks which reduced the need for frequent reconstructions. This avoided the depletion of resources. Building city centres near riversfacilitated easy access to water and transportation, and also maintained a balance with natural ecosystems.

4 Forest and Biodiversity Conservation

The conservation of forests, along with the flora and fauna within it and thus the biodiversity within the forests, was deeply rooted in the ancient Indian culture and religion. The *Aranyakas* and *Upanishads* – ancient Indian texts– accentuate living in harmony with nature. The practice of creating and maintaining sacred groves (*devrai*) : areas of the forests that were protected for religious and cultural reasons, was common throughout ancient India. These groves were thought to be sacred. They were considered to be the dwelling places of deities. Humans were not allowed to hunt nor were allowed to cut trees within these sacred groves. The flora and fauna within the sacred groves were thus preserved from human exploitation, ensuring biodiversity conservation (Sharma and Kumar, 2021).These sacred groves acted as natural reserves. They were natural habitats for various species of flora and fauna and maintained the natural ecological balance. Sacred groves also served as seed banks and promoted the regeneration of forests. This, in turn, ensured that the natural resources stayed available for future generations also. Conservation and sustainability through religious veneration highlights the integrated approach of ecological sustainability with spiritual and cultural beliefs.

5 Knowledge Systems for Environmental Protection

Sustainability was tremendously supported and promoted by traditional knowledge systems in the fields of medicine and environmental management. The importance of biodiversity, especially that of medicinal plants was highlighted by the Charaka Samhita (c. 100 BCE) - an ancient Indian text on Ayurveda. Ayurveda employs the services of plants and plant products as medicine. There existed a thorough awareness and knowledge of medicine-providing plants, their ecosystems, and the sustainability thereof (Mukherjee and Wahile, 2006). Ayurveda firmly believes in the preservation of biodiversity and minimization of environmental degradation to maintain its repository of renewable resources.

In every avenue of life, in every profession, in ancient times, the thrust was on the use of local materials and sustainable technologies. The incorporation of this traditional knowledge into various aspects of daily life ensured the minimization of transportation costs, minimization of overall costs, fulfillmentof one’s duties towards the environment, and continued availability of natural resources for future generations.

Discussion and Implications

Concep of sustainability, water management, soil management, and protection of the environment were entwined and inherently ingrained in the very thought process of the societies existing in the ancient Indian era. Wise people realized that the common persons of those times were religious and they abided by religious dictates. They, therefore, introduced the sustainability principles as religious concepts, resulting in wholehearted adherence to those principles. The concept that mankind is a mere trustee of the natural wealth and not an owner, was, thus, engraved on the mindset of the people ensuring that ecological stewardship became a natural part of human behavior. Forests were considered sacred; rivers and seas were either called goddesses and gods or gods were considered to be living in them. These natural resources, therefore, became religious symbols for the common people, none of them dared to defile them, rather everyone worshipped them and saw to it how they could remain in pristine condition and how the flora and fauna within them flourish. And these practices were followed by generation after generation.

Associating with humbleness, people thought of themselves as a mere custodian of the natural wealth. They knew that they were never supposed to greedily exploit nature but were rather supposed to add to it for the benefit of the next generations. Various water management techniques employed in the ancient era in the forms of rainwater harvest systems, constructions of step-wells, tanks and canals become especially relevant today when many parts in the world face extreme water scarcity. Meticulous and meaningful revival of such techniques in areas with irregular and inadequate rainfall shall mitigate ill effects of water shortages, especially in drought-prone areas.

Modern-day farming heavily relies on chemicals. Weedicides, insecticides, pesticides, chemical fertilizers – all these are chemicals and have both acute and chronic ill effects. These not only affect the health of mankind adversely but also result in the deterioration of the quality of the natural resources of soil and water. Agriculture in the ancient period dealt with organic farming, the use of natural fertilizers – composts and farm yard manures, and biological control measures against pests and diseases. This enriched the soil health and promoted agricultural sustainability. There exists a trend in contemporary agriculture towards the shift to organic farming and this should be encouraged, supported, and promoted.

Be it agriculture or the management of natural wealth, resource management in the ancient era was always a joint community effort. Honouring the commitment to protecting rivers, soils, and sacred groves remained the responsibility of the entire society. This is applicable even in the present scenario. For modern sustainability movements to be effective and successful, the involvement of the entire community is vital. Teachings, experiments, and experiences of the past shall remain a guiding light for this movement. Community efforts and shared responsibility shall strengthen society's relationship and help in successfully achieving the goal.

Conclusion

People in ancient era had an in-depth understanding of the concepts of environment, need of its protection, ecology, ecological balance and sustainability. They were also aware that people shall follow the right path if the instructions are entrained and attuned in religious beliefs. This resulted in contribution by everyone and achievement of sustainability. By introducing the *dharmic* angle – the religious doctrine-based angle, it was seen that various sustainability and water management practices were not merely meticulously and conscientiously followed but were celebrated as well. Use of farm yard manure, compost, crop rotation and mixed farming-maintained fertility levels of soil over generations. Sacred groves, through their divine angle, nourished and nurtured the flora and fauna within them and thus protected the biodiversity.

These methods are rich in age-old wisdom and are, by no means, orthodox or obsolete. They are applicable even today to tackle the present-day environmental challenges of global warming, climate change, water management and deforestation. Going back to basics and back to these methods can still be effective in finding solutions to the modern-day environmental problems. Involving and encouraging community to take conservation methods and integrating modern technology with traditional methods combining renewable energy sources like wind mills / solar energy with water management shall prove immensely useful in environment management.

Government and policymakers should take the initiative and apply wisdom of ancient era to find solution to environmental problems. Making the impressionable minds of students aware about the traditional knowledge and its suitability and applicability to achieve environmental balance and sustainability is the first step in this direction.

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Chemistry in Conservation of Environment- A Review

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Abstract:

Chemistry plays an important role in environmental conservation offering various tools and techniques to mitigate ecological challenges. This review explores various effects of pollution on environment and various key contributions of chemical science in sustainable development, pollution mitigation and ecosystem restoration. It includes environmental protection through green chemistry which emphasizes non-toxic processes which focuses on waste minimization and energy conservation and many more aspects which are used for reducing pollution, eliminating greenhouse gases, and many more conservative approaches.

There are various emerging topics like artificial photosynthesis, biodegradable materials, nanomaterials, etc. a point of the future of chemistry in environmental conservation. This review emphasizes the nature of environmental chemistry which attains global sustainability goals.

Keywords: Green Chemistry, Artificial Photosynthesis, Environmental Conservation, Global Sustainability Goals

Introduction:

Chemistry being a fundamental science, plays an important role in conservation of environment, being a part of sustainable practices, it plays a vital role in addressing the environmental challenges by providing innovative solutions for sustainable development and environmental conservation. Green chemistry is one of the best sustainable practice that has been beneficial for reversing the impact of environmental degradation, it is a non-scientific method of creating chemical processes and goods that minimises or completely doesaway with the usage and manufacturing of potentially harmful, toxic, and bio accumulative chemicals by humans. It comprises developing chemicals' raw materials that will be utilised later and are healthier for the environment and people's health[1].

This article concentrates on the multifaceted contributions of Chemistry in conserving the environment, with a focus on sustainable practices, pollution mitigation, and remediation efforts. By focusing on areas such as Green Chemistry, air and Water Chemistry, Soil Conservation, and Advanced Waste Management, it can highlight the transformative potential of Chemical Science in tackling pressing environmental challenges. Along with this it also shows the interdisciplinary nature of environmental chemistry, which promotes scientific innovation like artificial photosynthesis, artificial rain, carbon capture, etc.

A] Green Chemistry And Sustainable Chemical Practices

a. Principles of Green chemistry*:* The Twelve Principles of Green Chemistry provide a comprehensive framework for designing chemical processes and products that are environmentally sustainable and socially responsible[2,3]. Let's delve into each principle:

Prevent Waste*:* Imagine factories that operate in a closed-loop system, where waste from one process becomes the feedstock for another. Green Chemistry research is actively developing these innovative techniques, reducing reliance on landfills and minimizing environmental strain.

Atom Economy*:* By maximizing the incorporation of starting materials, chemists can not only reduce waste but also improve reaction efficiency. This translates to lower production costs, making green chemistry not just environmentally friendly but also economically attractive.

Less Hazardous Syntheses: Safer synthetic methods lead to safer workplaces for chemists and reduced risks during transportation and storage. Additionally, it minimizes the potential for environmental contamination if spills or accidents occur.

Safer Chemicals: Products designed with inherent safety in mind can revolutionize various industries. Imagine non-toxic cleaning products that are just as effective, or fire retardants that don't pose health risks. Green chemistry paves the way for a safer future.

Safer Solvents: The development of bio-derived solvents or even water-based alternatives can significantly reduce the environmental impact of chemical processes. These advancements not only minimize health risks but also open doors for more sustainable manufacturing practices.

Energy Efficiency: Green chemistry pushes the boundaries of reaction engineering, enabling the development of processes that operate at room temperature and pressure. This not only reduces energy consumption and greenhouse gas emissions but also simplifies reaction setups, potentially leading to more portable and decentralized chemical production.

Renewable Stocks: Transitioning from fossil fuels to renewable resources like plant-based materials or captured carbon dioxide represents a significant step towards a sustainable future. Green chemistry is at the forefront of this transition, developing methods to utilize these renewable resources for chemical production.

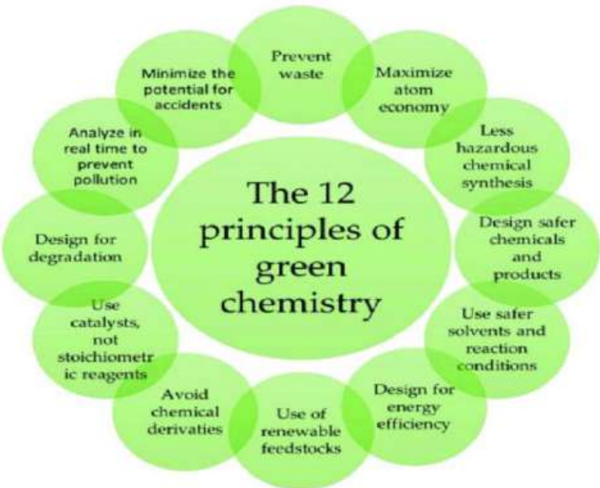
Avoid Derivatives: Minimizing unnecessary steps in a synthesis not only reduces waste but also streamlines the process, potentially leading to faster production times and lower costs. Green chemistry is constantly seeking elegant Green Chemistry and Sustainable Practices solutions that achieve the desired outcome with minimal manipulation.

Catalysis: Catalysts are the workhorses of green chemistry. By using them strategically, chemists can achieve high reaction efficiency with minimal waste. Research in this area is ongoing, with scientists developing ever more powerful and selective catalysts for specific reactions.

Design for Degradation: Imagine a world where disposable products decompose into harmless components after use. This principle paves the way for the development of bioplastics and other biodegradable materials, significantly reducing plastic pollution and its negative impact on ecosystems.

Real-Time Analysis: Advanced monitoring systems can detect potential problems in real-time, allowing for immediate adjustments to prevent pollution formation. This not only safeguards the environment but also ensures consistent product quality and minimizes production downtime.

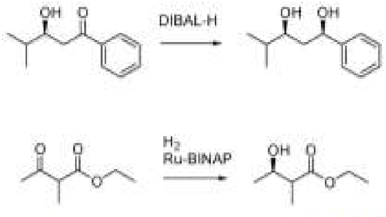
Accident Prevention*:* Inherently safer chemicals reduce the risk of accidents throughout the chemical lifecycle. This translates to safer workplaces, lower insurance costs, and ultimately, a more sustainable chemical industry[4].



Designing Safer Chemicals: It is quite known that the majority of the manufacturing products are derived from petroleum feedstock or natural gas, leading to their depletion from natural environment.

Turning towards renewable feedstocks both for material and fuel has now become more urgent. The major renewable feedstock on the planet both for material and energy is bio-mass,[5] the material available from living organisms. This includes wood, crops, agricultural residues, food, etc.[6]. Examples of renewable material include cellulose, lignin, suberin and other wood compounds, polyhydroxyalkanoates, lactic acid, chitin, starch, glycerol and oil.[7] Lignin, for instance, is a major waste of the pulp and paper industry. It has been burned on the production site to provide energy for many years. In recent years it has found new applications as, for example, dispersants, additives, and raw materials for the production of chemicals such as vanilin, DMSO or humic acid[7].

In many cases, the formation of waste is linked to the traditional use of a stoichiometric amount of reagents[8].Catalysis can improve the efficiency of a reaction by lowering the energy input required, by avoiding the use of stoichiometric amount of reagents, and by greater product selectivity. This implies less energy, less feedstock and less waste[10]. Moreover, it often opens the door to innovative chemical reactions and bring unconventional solutions to traditional chemical challenges. Oxidation and reduction reactions illustrate this concept. Reduction employing DIBAL-H as the hydride donor is a well-established procedure used by organic chemists[11]. It generates a significant amount of waste since a stoichiometric amount of reducing agent is needed to complete the reaction. Switching to catalytic hydrogenation like the Noyori hydrogenation[12] eliminates the need for stoichiometric reagents and in consequence decreases the amount of feedstock needed and the amount of waste generated.



Comparison between stoichiometric and catalytic reduction.

Solvents contributes a larger part in green chemistry. They represent an important challenge for Green Chemistry because they often account for the vast majority of mass wasted in syntheses and processes[13]. Moreover, many conventional solvents are toxic, flammable, and/or corrosive. Their volatility and solubility have contributed to air, water and land pollution, have increased the risk of workers' exposure, and have led to serious accidents.Recovery and reuse, when possible, is often associated with energy-intensive distillation and sometimes cross contamination. In an effort to address all those shortcomings, chemists started a search for safer solutions. Solventless systems, water, supercritical fluids (SCF) and more recently ionic liquids are some examples of those new ''green'' answers[14].

B] Air, Water And Soil Conservation:

Chemistry of Air Pollution Control:

Suspended PM can be categorized according to total suspended particles: the finer fraction, PM_{10}, which can reach the alveoli, and the most hazardous, $PM_{2.5}$ (median aerodynamic diameters of less than 10.0 microns and 2.5 microns, respectively). Much of the secondary pollutants $PM_{2.5}$ consists of created by the condensation of gaseous pollutants—for example, sulfur dioxide (SO_2) and nitrogen dioxide (NO_2). Types of suspended PM include diesel exhaust particles; coal fly ash; wood smoke; mineral dusts, such as coal, asbestos, limestone, and cement; metal dusts and fumes; acid mists (for example, sulfuric acid); and pesticide mists[15].

A catalytic converter is a simple device mostly used in American cars to reduce the emission of harmful gases in the air by using basic redox reaction principle. It converts 98% of the harmful emitted fuels into less harmful gases before it is released. A three-way catalytic converter has three simultaneous functions:

1. Reduction of nitrogen oxides into elemental nitrogen and oxygen:
   $NOx \rightarrow Nx + Ox$
2. Oxidation of carbon monoxide to carbon dioxide:
   $CO+O_2 \rightarrow CO_2$
3. Oxidation of hydrocarbons into carbon dioxide and water:
   $CxH_4\ x + 2\ xO_2 \rightarrow xCO_2 + 2\ xH_2O$

There are two types of "systems" running in a catalytic converter, "lean" and "rich." When the system is running "lean," there is more oxygen than required, and the reactions therefore favor the oxidation of carbon monoxide and hydrocarbons (at the expense of the reduction of nitrogen oxides). On the contrary, when the system is running "rich," there is more fuel than needed, and the reactions favour the reduction of nitrogen oxides into elemental nitrogen and oxygen (at the expense of the two oxidation reactions). With a constant imbalance of the reactions, the system never achieves 100% efficiency[16,17].

Chemistry of Water Pollution Control: Water pollutants are substances that alter the physical and chemical characteristics of water thus deteriorating their quality. Release of industrial effluents into fresh water systems decreases the availability of clean water. Major water pollutants are categorized into pathogens, organic and inorganic chemicals which include heavy metals, dyes, volatile organic solvents, etc[18].

Nanomaterials have unique size-dependent properties related to their high specific surface area (fast dissolution, high reactivity, strong sorption) and discontinuous properties (such as super paramagnetism, localized surface plasmon resonance, and quantum confinement effect). These specific nanobased characteristics allow the development of novel high-tech materials for more efficient water and wastewater treatment processes, namely membranes, adsorption materials, nanocatalysts, functionalized surfaces, coatings, and reagents. Adsorption is the capability of all solid substances to attract to their surface's molecules of gases or solutions with which they are in close contact. Solids that are used to adsorb gases or dissolved substances are called adsorbents, and the adsorbed molecules are usually referred to collectively as the adsorbate[19]. Due to their high specific surface area, nanoadsorbents show a considerably higher rate of adsorption for organic compounds compared with granular or powdered activated carbon.

Current research activities mainly focus on the following types of nano-adsorbents:
carbon-based nano-adsorbents i.e., carbon nanotubes (CNTs) metal-based, nano-adsorbents, polymeric nano-adsorbents.

Photocatalysis is an advanced oxidation process that is employed in the field of water and wastewater treatment, in particular for oxidative elimination of micropollutants and microbial pathogens. As reported in the literature, most organic pollutants can be degraded by heterogeneous photocatalysis. Due to its high availability, low toxicity, cost efficiency, and well-known material properties, TiO_2 is widely utilized as a photocatalyst. When TiO_2 is irradiated by ultraviolet light with an appropriate wavelength in the range of 200–400 nm, electrons will be photoexcited and move into the conduction band. As a result of photonic excitation, electron-hole pairs are created, leading to a complex chain of oxidative-reductive reactions. Hence, the biodegradability of heavily decomposable substances can be increased in a pretreatment step[20].

Chemistry of Soil Pollution Control: Soil is one of the important and valuable resources of the nature. Life and living on the earth would be impossible without healthy soil. 95% of human food is derived from the earth. Making plan for having healthy and productive soil is essential to human survival. Entrance of materials, biological organisms or energy into the soil will cause changes in soil quality. This problem causes soil to remove from its natural state. The soil is composed of two parts. 1- Soil Living Part, 2- Soil Dead Part

The dead part of the soil includes weathered rocks and minerals which are obtained from the decay of plants and animals, which is called organic matter or humus, and water and air are categorized in this part. But the live soil is the soil which enjoys small animals like insects and worms and plants, fungi, bacteria and other microbes are grown in the live soil[21].

The hydrodynamic separation depends upon the velocity with which particles fall through the water flow or the applied various centrifugal force to the water flow. The centrifugal force is more powerful than the gravity force and easily separates fine soil particles from large sand particles[22]. Further, this process also reduced the separation operating time. Khulbe and Matsuura 2017 used the hydrodynamic separation method for the removal of heavy metal ions from the metal-polluted sites[23].

The soil washing process is an ex-situ remediation process that removes the metal contaminants from the soil by washing with extractant solution viz. water, surfactants, chelators, organic and inorganic acids respectively. The reactants react with these solutions and produce sulfides, carbonates, phosphates, and metal hydroxides. At the end of the process solid particles can be separated via filtration and sedimentation process. Further, the clean soil may be reused as a backfill at the site[25].

C] Waste Management and Recycling:

Chemical treatment of waste is defined as the process of using specific chemicals like acids, bases, oxidizers, and reducers to reduce the hazardous nature of waste. It also involves recovering valuable byproducts from hazardous wastes, thereby lowering the overall costs of waste disposal.

Hazardous waste can be treated by chemical, thermal, biological, and physical methods. Chemical methods include ion exchange, precipitation, oxidation and reduction, and neutralization. Among thermal methods is high-temperature incineration, which not only can detoxify certain organic wastes but also can destroy them. Special types of thermal equipment are used for burning waste in either solid, liquid, or sludge form. These include the fluidized-bed incinerator, multiple-hearth furnace, rotary kiln, and liquid-injection incinerator. One problem posed by hazardous-waste incineration is the potential for air pollution[25].

The electrochemical process is one of the most efficient methods for the removal of hazardous soluble metal ions from industrial wastewater. Electrolysis gases provide aeration to enhance the reaction kinetics of the process. In this method, electricity was passed through an aqueous solution containing metal ions, a cathode plate, and an insoluble anode. This is based on the mechanism of applying an electric current to con-jugate electrodes[26]. Heavy metals precipitate as hydroxide in weakly acidic or neutralized electrolytes. Thus, the choice of electrode provides a specific application and also plays a crucial role in enhancing the process proficiency for contaminants[27].

Substantial quantities of discarded plastic have resulted in detrimental effects on the environment and ecosystems, calling for effective recycling of plastic wastes. Chemical methods for managing plastic wastes have been extensively studied, and selective recycling of products has grown in popularity. Pyrolysis, photocatalysis, and supercritical fluids were the main chemical methods reported for processing plastics[28].

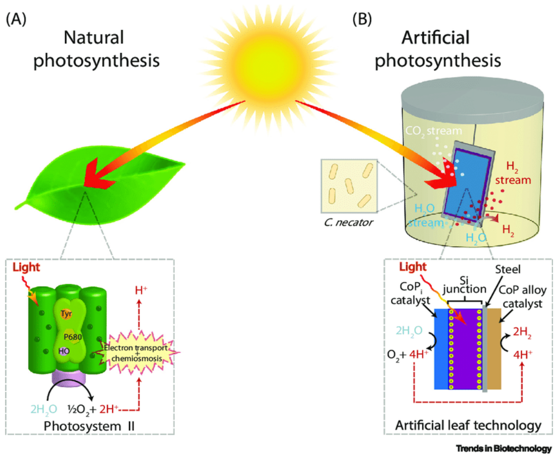
Gasification involves heating plastic waste at high temperatures (700-1500^{o}C) in a controlled environment with limited oxygen or steam. This process converts plastic into syngas (a mixture of hydrogen, carbon monoxide and methane). Depolymerization is another technique that reverses the polymerization process by breaking down plastics into their original monomers or oligomers.

It is achieved through chemical reactions such as hydrolysis, glycolysis, etc. depending on plastic type.

D] Future Enhancement in Environmental Chemistry:

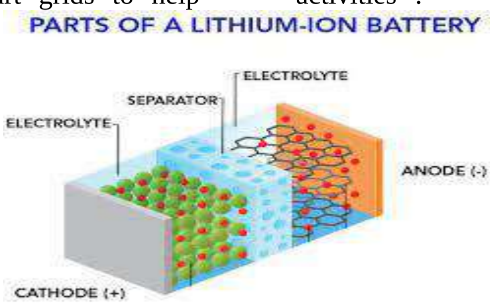
Environmental Chemistry is continuously evolving and developing to address the environmental challenges, focusing on sustainable practices, pollution mitigation and resource conservation.

Artificial Photosynthesis: Artificial photosynthesis system (APS) uses biomimetic systems to duplicate the process of natural photosynthesis that utilizes copious resources of water, carbon dioxide and sunlight to produce oxygen and energy-rich compounds and has potential to be an alternative source of renewable energy. APS like natural photosynthesis includes the splitting of water into oxygen and hydrogen, and the reduction of carbon dioxide into various hydrocarbons such as formic acid (HCOOH), methane (CH4) and carbon monoxide (CO), or even pure hydrogen fuel. These processes are accomplished by a handful of device designs, including photoelectrochemical cells or photovoltaic-coupled electrolysers which are driven by energy extracted from sunlight photons as well as suitable catalysts[29].



Next Generation Batteries*:* The rapid advancement of technology and the growing need for energy storage solutions have led to unprecedented research in the field of metal-ion batteries. This perspective article provides a detailed exploration of the latest developments and future directions in energy storage, particularly focusing on the promising alternatives to traditional lithium-ion batteries. With solid-state batteries, lithium-sulfur systems and other metal-ion (sodium, potassium, magnesium and calcium) batteries together with innovative chemistries, it is important to investigate these alternatives as we approach a new era in battery technology[30].

Lithium-ion batteries (LIBs) have the potential to improve frequency and voltage regulation in grid applications and provide backup power during outages. LIBs can be used in renewable energy plants or smart grids to help stabilize the power system and meet the changing demand for electricity. In addition, batteries can be employed to take advantage of price differences in the energy market, known as energy arbitrage. Specifically, energy is stored during periods when the cost is low and then released when the price is higher, thus providing economic benefits. They can also be used in off-grid settings such as telecom base stations or for household use.Research efforts for batteries are focused on the materials for the electrodes and electrolytes, the configuration and composition of the electrodes, the arrangement of the cells (in pouch, cylindrical, and prismatic shapes), the material and thickness of the separator, the design of other components such as the pack cover, electronics boards, sensors, and relays, and the cooling system. Eco-friendly design and ways to recycle are also major parts of the research activities[31].



Flow Chemistry: Organic synthesis has traditionally been performed in batch which means in round-bottomed flasks, test tubes, or closed vessels; recently, continuous flow methodologies have gained much attention from synthetic organic chemists. Until a few years ago, continuous flow processes were a prerogative of petrochemical and bulk chemicals industries, where dedicated continuous plants exist and proved as most economical; recently, application of these systems for the preparation of fine chemicals, such as natural products or Active Pharmaceutical Ingredients (APIs) has become very popular, especially in academia. Although pharma industry still relies on multipurpose batch or semi batch reactors, it is evident that interest is arising toward continuous flow manufacturing of APIs[32].

Conclusion:

Chemistry plays a vital role in environmental conservation, offering innovative sustainable solutions to mitigate the global environmental challenges. From green chemistry, advanced methods of pollution control, waste management and future innovations of chemistry, chemical science aims towards a cleaner and a sustainable pollution free world. The enhancement in nanotechnology, catalytic processes, chemical recycling techniques highlights the potential and impact of chemistry in minimizing the degradable environmental impact.

With future innovations like artificial photosynthesis and flow chemistry, chemical science will achieve the interdisciplinary approach, combining chemistry with biology and engineering to develop holistic solutions. This will help the society to achieve sustainable goal and preserve the environment for future generations.

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Synthesis of CNMs from Maize Stem

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Abstract

Two different types of Carbon Nanomaterials were synthesized by pyrolyzing Maize stem using the CVD method at 600^0C, 800^0C and 1000^0C, in presence of Ni, Fe, or Co as the catalyst. The morphology of CNM varied according to the catalyst used. HRSEM images showed that in presence of Fe as catalyst initiated formation of needle like CNFs whereas Co failed to generate any specific structure. CNB synthesized from stem using Ni catalystthey show a plate having spherical holes and beads arising out of their holes. The size of the holes and beads matches as they both are approximately 50nm, thus suggesting that beads originated from the plates.The XRD pattern and the Raman spectrum confirmed the graphitic nature of the carbon.

Keywords: Maize stem, carbon nanofibers, carbon nanobeads, chemical vapor deposition (CVD)

Introduction

Carbon nano materials are at the verge of becoming an important material for various industrial applications. The main hurdle in the production of CNM is the cost of raw material

There are two components in producing the CNMs, the precursors and the technique of the synthesis. It is almost certain that CVD Technique would be the most suitable for the production of large quantity of CNM. As a result CVD Technique is being explored by many research groups for synthesis of CNMs.

Cost of the precursor is another factor. Precursors obtained from fossil fuel and petroleum products mostly used for this purpose. But petroleum products are destined to get depleted one day. Hence synthesis of CNMs based on such precursors will also get depleted and the technology based on CNMs will come to halt. Considering these two factors, efforts are being made to search for precursors which are plant derived and could give the desired type of products at economical rate.

Advantages of using plant derived precursor are that they can be cultivated in required quantity as and when needed, there is no fear of their being depleted, moreover, plant materials possess different types of morphology which may have useful properties. There are few reports on the synthesis of MWCNTs and vertically aligned CNTs from camphor and turpentine oil (Sharon 2006). Eucalyptus oil has been found to be another promising precursor for pure SWCNTs synthesis (Afre et al 2007). Sharon's group have been trying to synthesize various carbon nano materials from precursors derived from plant materials such as camphor (Gaddam et al 2015) turpentine oil, oil seeds (like soybeans, mustard, etc.), and plant fibers (like sugar cane bagasse, coconut fibers etc.) to synthesize carbon nano materials (Sharon et al 2007). As an extension of this work, mature dried stem of maize plant was tried to synthesize carbon materials by pyrolyzing them at high temperature

Different three nano metal catalysts (Ni, Fe and Co) and different temperatures (600, 800 & 1000^0C) in inert atmosphere gives different types of Carbon Nano Materials (CNM). The Chemical Vapour Deposition (CVD) technique was used for synthesis of carbon nano materials. The morphology of CNMs was examined by high resolution scanning electron-microscopy (HRSEM), Raman spectroscopy and XRD

Materials and Methods

Precursor -for the present stem of mature maize plant was taken after harvest and were used as precursor for synthesizing carbon nano materials (CNM) by pyrolyzing them. Maize is the most widely grown grain crop in the America. It is staple food of many South American countries. Therefore, maize stem is available in plenty.

Maize stems resemble bamboo canes and the internodes can commonly be 7 inches. Maize stems are erect and 2–3 meters in height, with many nodes.

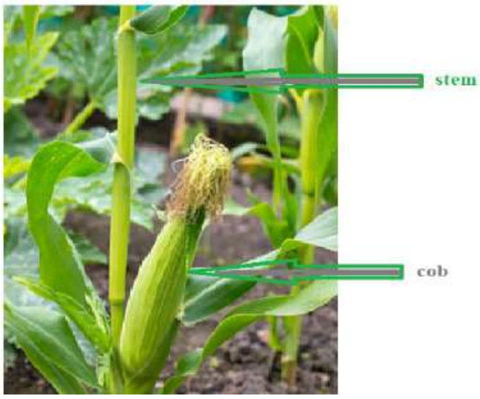

Figure 1: Maize Plant

Parameters considered – were catalysts, temperature and carrier gas.

Catalysts - Transition metal catalysts are found to be the best catalyst for the preparation of carbon nano materials from plant derived sources (Sharon et al 2006).A catalytic substance is capable of forming an unstable intermediate compound which readily decomposes yielding the product and regenerating the catalyst.

A + B + Catalyst → A. B. catalyst → C + Catalyst
(Reactants) (Intermediate) (Product)

The transition elements, on account of their variable valency, are able to form unstable intermediate compounds very readily. These elements can also provide a large surface area for the reactants to be adsorbed and thus come closer to one another for the reaction to occur readily on the surface of the catalyst itself. Transition metals like nickel, cobalt and iron are selected as catalyst and they were converted into nano forms by standard Urea Decomposition of the corresponding metal salts.

Carrier gases -It was observed from the literature survey that preparation of CNM from plant derived precursors in presence of the gases like hydrogen, nitrogen and argon gives good result. Hence these three gases are used in the present work for preparation of CNM.

Temperatures -used for the pyrolysis of maize stem are 600^0C, 800^0C and 1000^0C, for duration of two hrs.

Morphological Analysis of Maize Stem

HRSEM of stem both prior to and after pyrolysis was recorded; to see whether inherent anatomy of stem has any impact on carbon synthesized from them or not (Sharon and Sharon 2012). Moreover, impact of different transition metal catalysts on the morphology of CNM produced was also observed byHRSEM

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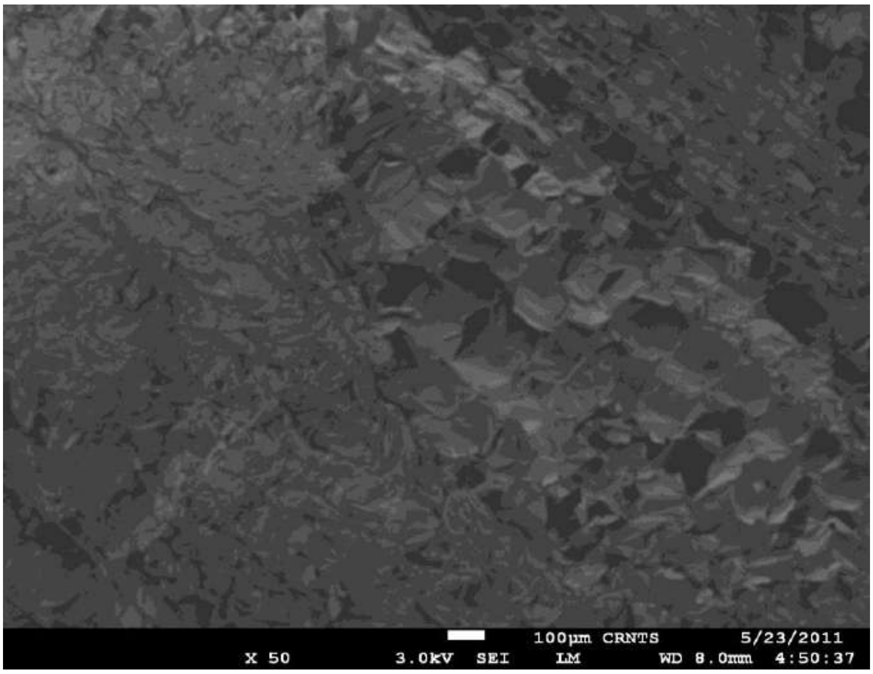
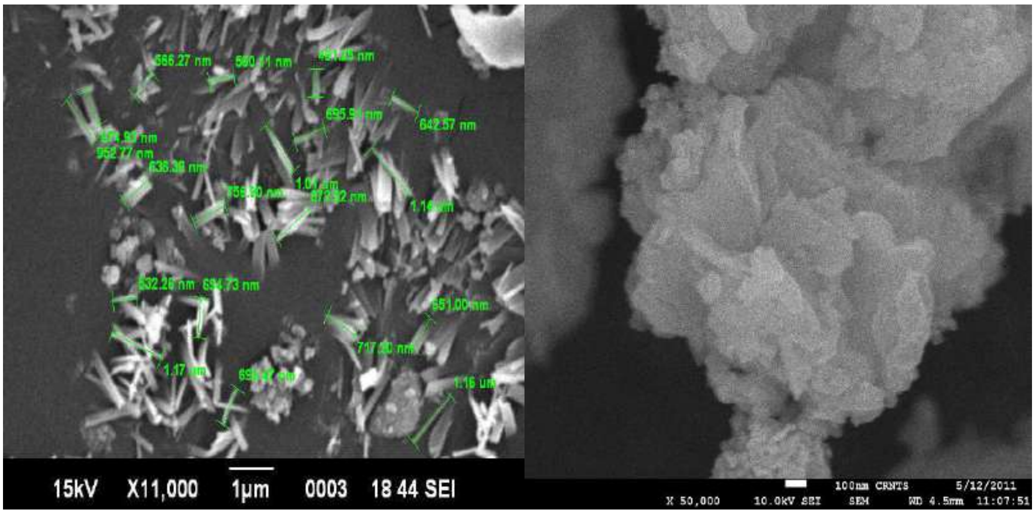
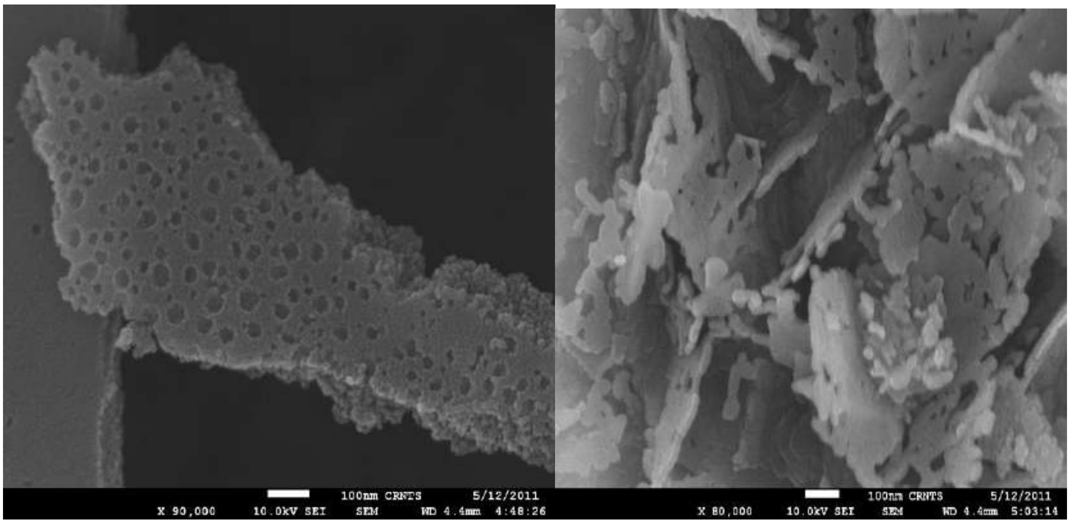


Figure- 2HRSEM of maize stem prior to pyrolysis



(a) (b)

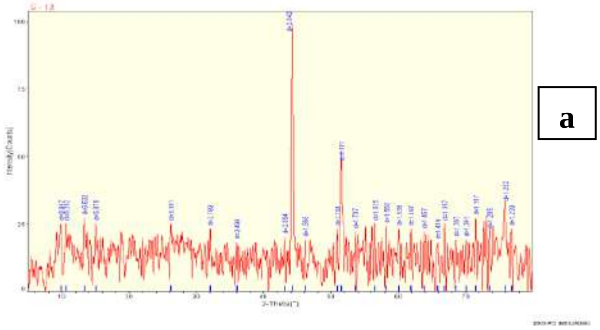


(c) (d)

Figure- 3: HRSEM of Maize Stem after pyrolysis at (a) 1000^{0}C in presence of Fe as catalyst and Ar as carrier gas (b) 800^{0}C in presence of Co as catalyst and H_2 as carrier gas and (c) & (d) 1000^{0}C in presence of Ni as catalyst and H_2 as carrier gas

It can be seen from the figure (3 a) Fe as catalyst initiated formation of needle like CNFs whereas though Co showed carbonization, it failed to generate any specific structure (Fig. 3b). Figure- 3 c and d show formation of CNB synthesized from stem using Ni catalyst. Figure- 3 c shows a plate having spherical holes whereas figure- 3 d shows beads arising out of their holes. The size of the holes and beads matches as they both are approximately 50nm, thus suggesting that beads originated from the plates.

4.0xrd Analysis of Cnm Synthesized From Maize Stem



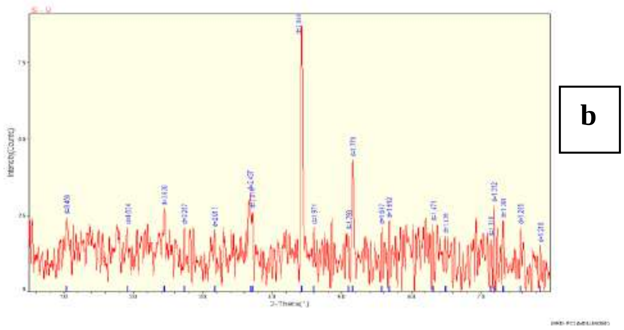


Figure- 4: XRD pattern of (a) carbon nano fibers and (b) carbon nano beads; synthesized from Maize Stemusing Fe and Ni respectively

XRD of needle like CNFs synthesized using Fe as catalyst (fig.-4 a) and CNBs synthesized in presence of Ni catalyst (fig. – 4 b) were recorded. The sharp peaks are observed at 44^0 and at 53^0 that correspond to planes {100} and {200} respectively. Many other peaks are also observed in both the patterns which may be due to the presence of amorphous carbon and plant residue in the sample.

5.0 Raman Spectrum of Cnm Synthesized From Maize Stem

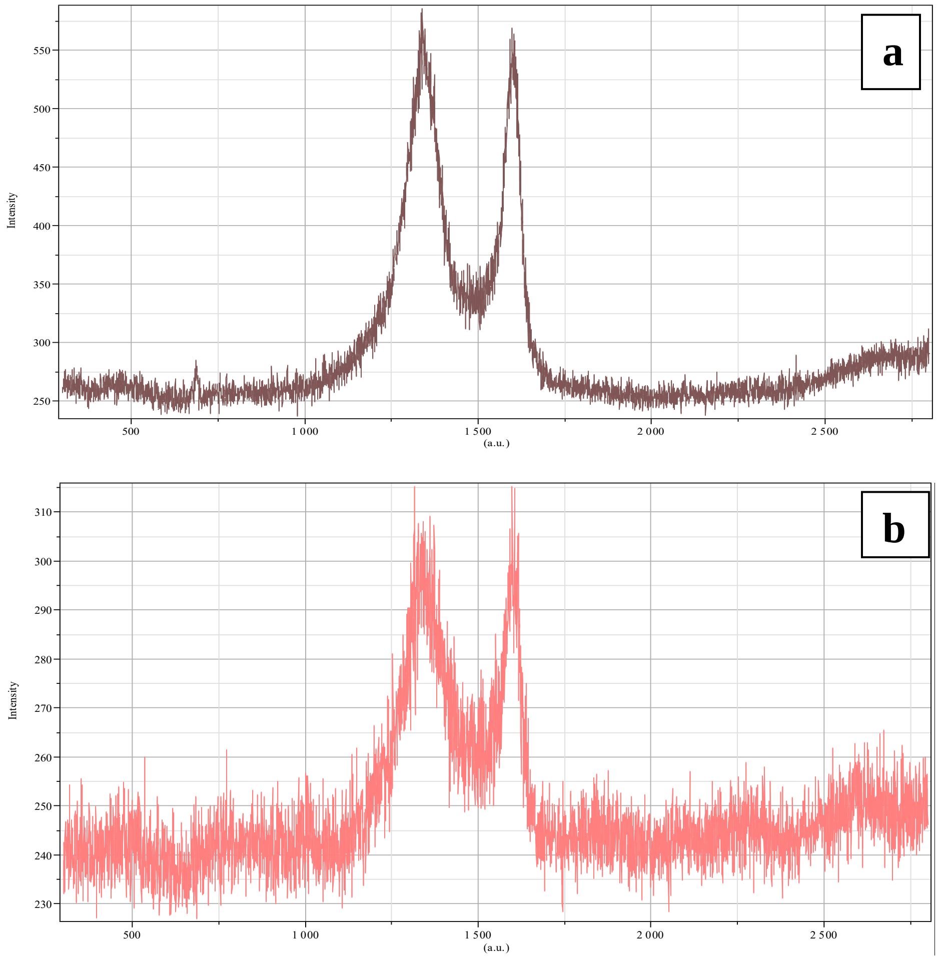


Figure- 5: Raman spectrum of (a)carbon nano fibers and (b) carbon nano beads; synthesized from Maize Stemusing Fe and Ni respectively

Raman spectrums of carbon nano fibers and carbon nano beads synthesized from Maize Stem using Fe and Ni show presence of peaks in the region between 1345 cm^{-1} to 1354 cm^{-1} which corresponds to the presence of CNFs and CNBs.

Conclusion

It must be mentioned here that the surface structure of maize inherent stem did not have any particular impact on the carbon material generated from them. At higher temperature in presence of Fe and Ni, formation of CNFs and CNBs is taking place whereas lower temperatures do not show its effect on CNM formation. XRD pattern and Raman spectrum confirms the formation of CNFs and CNBs.

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Synthesis, Characterization and Biological Evaluation of 2, 4, 5-Triphenylimidazole Compounds

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Abstract:

Imidazole is very popular heterocyclic compound which is five membered ring having two Nitrogen atoms. There are many moieties containing this Imidazole ring, of which 2,4,5-Triphenylimidazole (TPI) is a compound with significant biological activities, and its synthesis using different methods is having great importance.

The easier method of preparation of above said moiety (2,4,5-Triphenylimidazole) is by condensation reaction between benzil, benzaldehyde and ammonium acetate in presence of acidic catalyst.

Hippuric acid showing some good result as a catalyst for the above said reaction.

TPI is also synthesized by using Fe_3O_4 Nanoparticles and $CoFe_2O_4$ Nanoparticles dissolved in ethanol is used as a catalyst to promote the reaction. The yield of product increased.

Another method for the synthesis of 2,4,5-Triphenylimidazole is using a microwave-assisted condensation reaction. In this approach, microwave radiation is used as an energy source to drive the reaction, which leads to the production of 2,4,5-Triphenylimidazole in a shorter reaction time with higher product yield.

The synthesis of 2,4,5-Triphenylimidazole derivatives were achieved through condensation reactions with different carbonyl compounds resulting in substituted Triphenylimidazole derivatives with distinct biological activities. All the synthesized compounds were tested for their antimicrobial activity using agar diffusion technique against Gram positive (*Staphylococcus aureus*), Gram negative (*Escherichia coli*) bacteria. Structures were confirmed by using FT-IR.

Keywords: Triphenylimidazole, TPI, Fe_3O_4 and $CoFe_2O_4$ NP, Microbial activity, Hippuric acid

Introduction

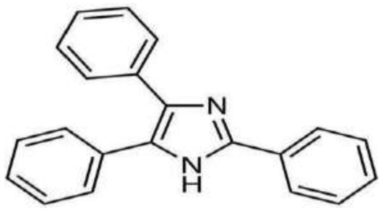
Triphenyl imidazole (TPI) is an organic compound which contains imidazole ring at a center and three phenyl ring substituted at 2nd , 4th and 5th position of Imidazole. The imidazole ring is planar and the phenyl groups are oriented in a perpendicular direction, leading to the molecule's twisted geometry.

The nitrogen atoms in the imidazole ring have lone pair electrons, which make the molecule a Lewis base, and hence, it can form coordination complexes with Lewis acids. The π-electrons in the phenyl groups contribute to the compound's aromaticity, making it a good electron donor and acceptor.

Multicomponent reactions are powerful and significant tools for the synthesis of heterocyclic compounds in the drug-discovery process because these offer expedient synthesis of library of drug-like compounds in a single operation.

Experimental Work:

Step 1: Preparation of 2, 4, 5-triphenyl-1H-imidazole without using catalyst

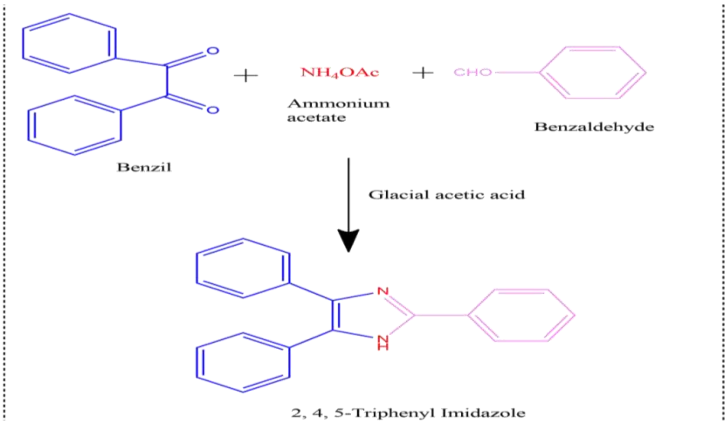


Benzil (1gm), Benzaldehyde (2ml), Ammonium acetate (1gm), Glacial acetic acid (4ml) were taken in a round bottom flask and reflux for 3 hours. Completion of reaction indicates dark orange color of reaction mixture and also confirmed by TLC. The reaction mixture was allowed to stand to attain room temperature. To that add 150 ml of water and then add 10 ml of the ammonium hydroxide to neutralize the solution. Check with Litmus paper. Solid thus obtained was filtered. The solid was recrystallized from ethanol.

Scheme 1.1: With the help of catalyst, Preparation of Catalyst: Fe_3O_4 and $CoFe_2O_4$ NPs

Solution combustion synthesis of Fe_3O_4 Nanoparticles

4g of Fe (NO_3) $39H_2O$ metal salt in a beaker and weighed 2g of fuel in another beaker and add 10 ml Distilled water stirred it to dissolve the fuel. Transfer the metal salt into fuel solution slowly with stirring, after 5 minutes transfer it into Furnace crucible set the temperature of furnace and place the crucible into the furnace for half an hour, after that cool the furnace crucible at room temperature and then mixed the FNPs till it appears as fine powder. Red Colour powder of FNPs is collected and stored carefully for further analysis and application.



Solution combustion synthesis of $CoFe_2O_4$ Nanoparticles

2g of Co $(NO_3)2.6H_2O$ and 1g of Fe $(NO_3)3.9H_2O$ in breaker. Weighed 3g of citric acid in another beaker add 10 ml Distilled water stirred it to dissolve the fuel. Transfer the metal salt mixture into fuel solution slowly with stirring, after 5 minutes transfer it into Furnace crucible set the temperature of furnace and place the crucible into the furnace for half an hour, after that cool the furnace crucible at room temperature then mixed the cobalt FNPs till it appears as fine powder. Cobalt FNPs is collected and stored carefully for further analysis and application.

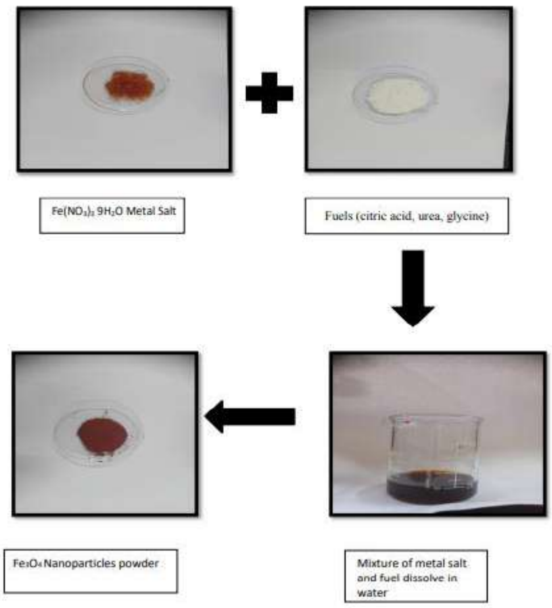


Fig. 2

The absorption spectrum of nanoparticles shows a prominent peak at 338 nm in Fig throughout the study the formation of Fe^3O^4 nanoparticles was confirmed by this method. The absorption maximum was noted in the range 300-400 nm for nanoparticles.

Fig 3 UV- Vis spectra of Fe_3O_4 nanoparticles

Investigated by X-Ray Diffractometry (XRD).
X-Ray Diffraction (XRD) Analysis

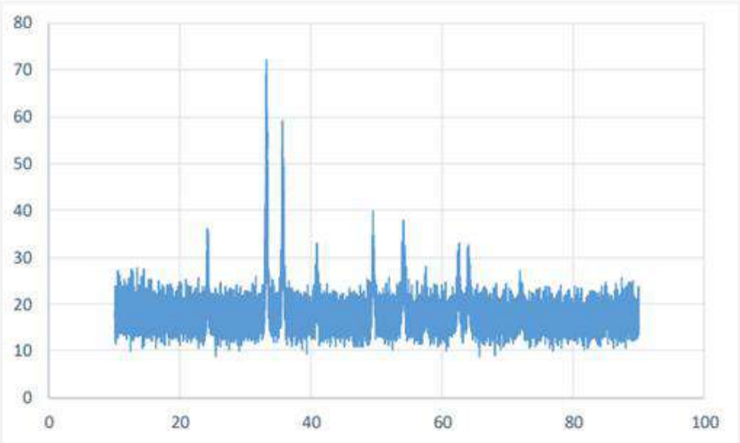


Fig 4 X-ray diffraction Fe_3O_4 Nanoparticles

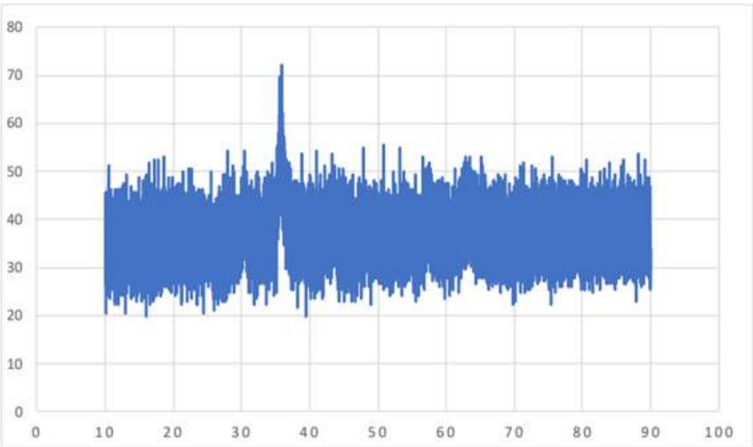
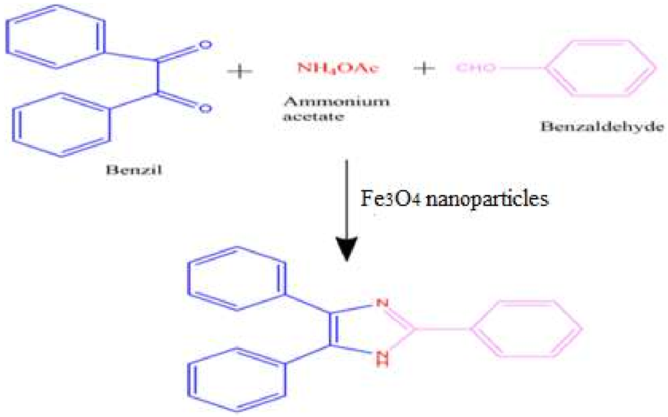


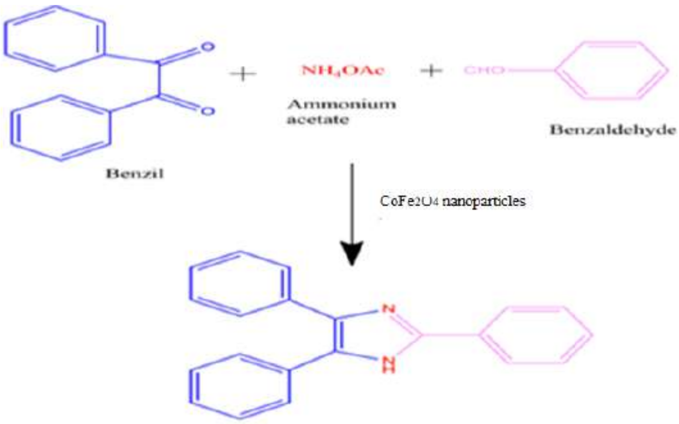
Fig 5 X-ray diffraction of $CoFe_2O_4$ Nanoparticles

Scheme 1.2:



2, 4, 5-Triphenyl Imidazole

Scheme 1.3:

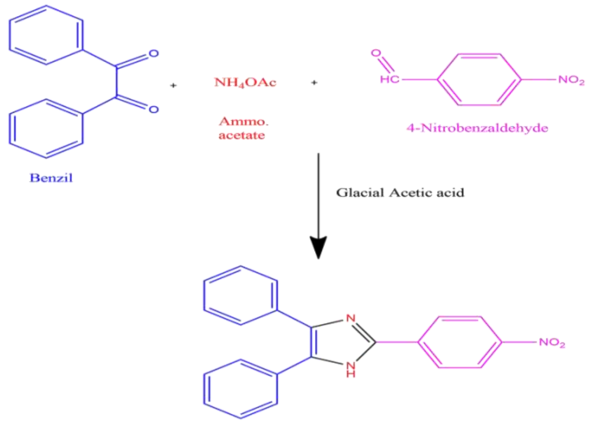


2, 4, 5-Triphenyl Imidazole

Preparation of 2-(4-Nitrophenyl)-4, 5-diphenyl-1H-imidazole.

Benzil (1gm), Ammonium acetate (1gm), p-Nitrobenzaldehyde (1gm), Glacial acetic acid(3ml) were taken in a round bottom flask and reflux for 3 hours. The reaction mixture was allowed to stand to attain room temperature. To that add 150 ml of water and then add 10 ml of the Ammonium hydroxide to neutralize the solution. Solid thus obtained was filtered. The solid was recrystallized from ethanol.

Scheme 1.4:



2-(4-Nitrophenyl)-4,5-diphenyl-1H-imidazole

Antimicrobial activity of the synthesized compounds was tested against

Gram positive bacteria Staphylococcus aureus

Gram negative bacteria Escherichia coli

Microbial inhibition testing method.

Procedure:

Take 1.9 gm of Muller-Hinton agar then add 1.4gm of nutrient agar in 50 ml of distilled water in the flask.

Stir or shake the solution vigorously for atleast one minute. The intent of stirring is to suspend the organisms in the solution.Allow it to stand for some minutes. Decant the liquid into two test tubes 25 ml each.

For sterilization, autoclave should be used, top should be covered by Aluminum foil to prevent contamination.Line sterile petri-plates along the edges of clean table or bench.

The sterile molten agar (25ml) was allowed to cool to 40 ˚C.

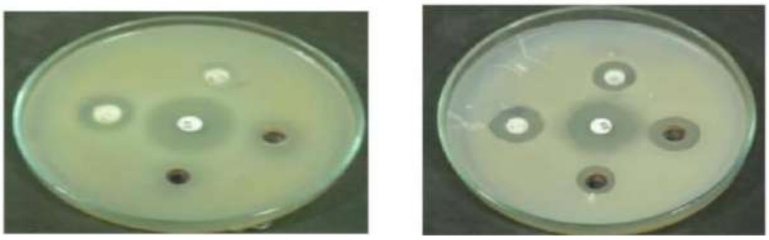
Inoculum (1 ml) was added to the sterile molten agar, mixed well, poured into the sterile petri plates and allowed to solidify.A sterile cork borer was used to bore wells of 10 mm diameter in the petri plates

The solution of compounds (1 ml) was poured into the wells along with culture (chloroform) and the plates were incubated at 37 ˚C for 24 hours for the bacterial culture.

After 24 hours of incubation the diameter of zone of inhibition was measured and reading observed in milli-meter.

Results and Discussion

Staphylococcus aureus Escherichia coli



Zone of Inibition of Synthesized Compounds against Bacteria

Table No: 1

Compound	E. Coli (mm)	Culture (chloroform)(mm)	S. aureus (mm)	Culture (chloroform)(mm)
2,4,5-triphenyl- 1H-imidazole	20	18	19	17
2-(4- nitrophenyl)-4,5-diphenyl-1H-imidazole	22	18	20	17

Table No: 2

Name of Compound	Appearance	% Yield	Melting Point	Solubility
2,4,5-triphenyl-1H- imidazole	Off-white	85	274°C	Chloroform
nyl)-4,5- diphenyl-1H-imidazole	Orange	88	241°C	Acetone

Thin Layer Chromatography

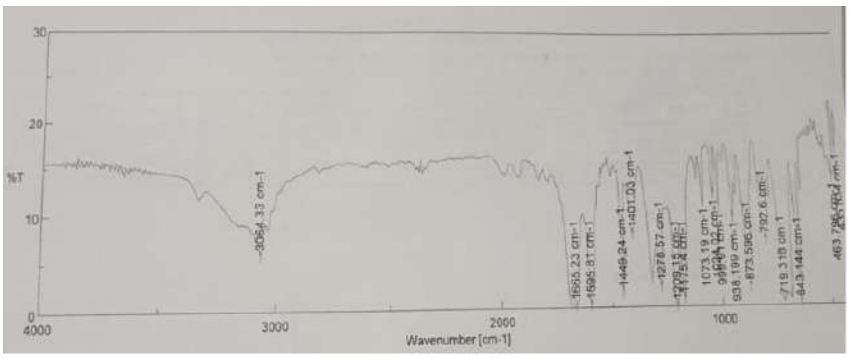
The thin layer chromatography was used to determine the purity of the compounds. Solvent system used:- Acetone : chloroform

Table No: 3

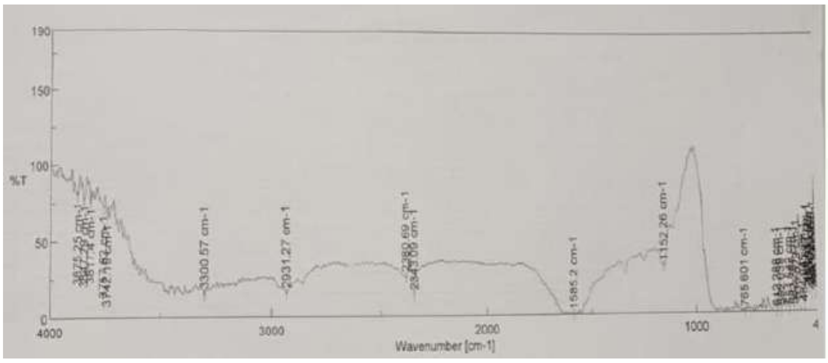
Sr. No	COMPOUND NAME	Rf Value
1	2,4,5-triphenyl-1H-imidazole	0.86
2	2-(4-nitrophenyl)-4, 5-diphenyl-1H-imidazole	0.72

Ftir Spectroscopy

For 2, 4, 5-triphenyl imidazole



For 2-(4-nitrophenyl)-4, 5-diphenyl-1H-imidazole



Conclusion

The synthesized compounds were found to be purified by TLC.
All synthesized compounds were identified and characterized by the IR.
The spectral data were coinciding with the structure of synthesized compounds.
All the relevant peaks were identified in all the spectra.
The synthesized compounds were screened for antimicrobial Activity.

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Extraction of natural dyes from vegetable waste and its application: An eco-friendly approach

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Abstract

Natural dyes help in the reduction of pollution level in textile dyeing, in realization of eco-friendly agriculture productions, and pollution. The main objective of extracting dye from natural sources is to avoid environmental pollution and search for an alternative source to synthetic dye**.** In this study, dyes are derived from vegetable waste including peels of onion, beetroot and banana using aqueous extraction procedures. The extracts were qualitatively analyzed for the major phytochemical components such as phenol, tannin, terpenoids, flavonoids, saponins, glycosides, steroids, quinine, cellulose. The extracted dyes were applied on cotton fabric by direct dyeing method. The dyes obtained from the vegetable may also be alternative sources to synthetic dyes for the dyeing of natural cotton fibric. It examines the potential applications of plant-based dyes in the textile, food and cosmetics sectors, emphasizing their eco-friendly and biodegradable approach for the environment. To reduce reliance on synthetic dyes and slow down environmental damage, the study concludes by discussing the significance of supporting sustainable practices in dye extraction and consumption.

Keywords: Extracting dyes, eco-friendly, vegetable waste, aqueous extraction, phytochemicals, textile, food, cosmetics sectors.

Introduction:

Dyes are substances that add color to textiles, and it may be natural or synthetic. The concept of 'ecofriendly dyes' is gaining momentum in the present era of ecological concern. With increasing awareness of the environmental preservation, control of pollution and health hazards associated with synthesis, processing and use of some synthetic dyes based on carcinogenic or allergic amines there is a worldwide interest in dyeing textiles with colorants extracted from renewable natural resources. [1] The development of eco-friendly and natural dyeing techniques is driven by the need to reduce the environmental impact of textile production, as well as to meet the growing demand for sustainable and ethical fashion. Consumers are becoming more aware of the impact of their purchases on the environment and are seeking products that are made with eco-friendly natural materials. The textile industry is one of the largest industries in the world, and it is also one of the most polluting. The process of dyeing textiles has been identified as a major contributor to environmental pollution due to the use of toxic chemicals and the large amount of water required. [2] Therefore, there has been an increased focus on developing eco-friendly and natural dyeing techniques in recent years. Natural dyes comprise those colorants that are obtained from plants, vegetables and flowers are generally considered safe and ecofriendly. [3] By using non-toxic, biodegradable, and renewable materials, we can reduce the amount of waste and pollution produced by textile production. The use of eco-friendly and natural materials also meets the growing demand for sustainable and ethical fashion and helps to protect our planet for future generations.Natural dyes are important since they are better than synthetic dyes in many ways. [4,5] They are more advantageous as they are biodegradable and renewable also non-toxic, non-allergic and non-carcinogenic as these are obtained from vegetable matters without any chemical processing.The colors produced by natural dyes are usually soft, lustrous and soothing to the eyes. Undeniably, the natural dyes are healthier products, purely because they do not comprise chemicals damaging to fitness.

Materials and Methods:

Peel of Onion: Utilizing onion peels for dyeing promotes recycling and reduces food waste, contributing to more sustainable and environmentally friendly practices. The antioxidants in onion peels, like quercetin, can help protect and rejuvenate the skin when used in cosmetic applications. Onion peels are typically discarded as waste, making them a cost- effective source of natural dye, particularly for small-scale projects.[6]

Fig 1: Peel of Onion

Peel of Beetroot: Beetroot provides a deep red or pink hue, which can be used for various applications such as food coloring, cosmetics, and fabric dyeing. The antioxidants in beetroot, particularly betalains, have anti-inflammatory and detoxifying effects. These properties can benefit skin health when used in cosmetics. The vitamins and minerals in beetroot can nourish and rejuvenate the skin, making it a valuable ingredient in skincare products.[7]

Fig 2: Peel of Beetroot

Peel of Banana: Depending on the processing method and type of banana, the dye can produce a range of colors from pale yellows to rich browns, offering versatility for different dyeing projects. Unlike many synthetic dyes, banana peel dye is biodegradable and does not contribute to environmental pollution. Due to its antioxidant properties, banana peel dye can also be used in skincare products, potentially providing benefits such as reducing inflammation and promoting healthy skin. [8,9]

Fig 3: Peel of Banana

Method for preparation of dyes:

Aqueous extraction method: All the vegetable waste (peel of banana, onion and beetroot) was washed with water to remove dirt and then cut into small pieces. The chopped pieces were ground in an electric mixer using 200 ml of distilled water to make a smooth paste. Take 10g of each in separate beaker and add 100ml of distilled water and heat it for 20min at 60^oC by using aqueous extraction. As the extract reduce to 50ml stop heating and cool down at room temperature. Filter the extract using Whatman filter paper no. 40 to remove the non-coloring matter from the dye liquor. Then the extracted dye is dried at 50^0 C and weighed.[10]

B. Chemical Analysis: Phytochemical analysis helps identify the chemical components of a plant, and whether any of them have bioactive properties. [11] The following are the compounds mostly present in the plant material:

• Phenol – Naturally occurring, complex organic compounds, that possess nitrogen containing rings which have physiological effects on animals, including humans. They are bitter to taste, colorless, and are generally crystalline.

• Tannins – Polyphenols, including Tannic acid, that are produced to a greater or lesser degree by all plants. They draw the tissues closer together and improve their resistance to infection. They have an astringent taste.

• Terpenoids –Terpenoids can be found in all classes of living things and are the largest group of natural products. They are lipid soluble, and color-less.

• Flavonoids – A group of water-soluble plant pigments that are beneficial to health. They are water soluble, phenolic in nature, antioxidant properties, anti-inflammatory and anti-viral properties

• Glycosides – Usually mixed acetals, in which the hydroxyl group on the anomeric carbon atom is replaced by a moiety possessing a nucleophilic atom. They are considered as sugar ethers, crystalline, colorless, bitter, and soluble in alcohol.

• Saponins-Any group of amorphous glycosides of terpenes and steroids occurring in many plants, characterized by the ability to form emulsion and foam in aqueous solutions. They can be used as detergents.

• Steroids – Unique compound found throughout the plant kingdom, which exert critical physiological effects including plant growth, development and reproduction.

• Quinine – It shows three spots for the free drug and two metabolites when exposed to ultraviolet light, and each spot gives off a bright fluorescent color.

• Cellulose – It is an unbranched glucose residue polymer together via beta -1,4 connections which enables the molecule to form long straight chains.

The following test was performed with the extracted dyes to know about their presence in the extract.

Test	Procedure	Observation
Phenols	0.5ml of extract +1 ml alcohol +few drops of FeCl3.	Greenish yellow color Phenol are present.
Tannins	0.5ml of extract +distilled water+ few drops of FeCl3.	Blue or green colour. Tannins are present.
Terpenoids	0.5ml of extract + 2ml chloroform +3ml conc H2SO4.	Reddish brown colour at the intermediate. Terpenoids are present.
Flavonoids	0.5ml of extract + few drops of 1N NaOH solution.	Crimson or pink colour. Flavonoids are present.
Glycosides	0.5ml extract + 2ml glacial acetic acid + 1 drop of FeCl3 + 1ml conc H2SO4.	Brown ring at the intermediate. Glycosides are present.
Saponins	0.5ml of extract + 5ml of Distilled water. Shake vigorously and observe for a persistent froth.	Formation of froth. Saponins are present.
Steriods	0.5ml of extract +2ml of chloroform +few drop of acetic acid+ heat+ 1ml of conc.H2S04	Orange color Steriods are present.
Quinine	0.5ml of extract +conc. HCL	Green color formed Quinine are present.
Cellulose	0.5ml of extract +I2 crystal +conc.H2SO4	Brown color seen Cellulose are present.

Table 1: Procedure and Observation for Phytochemical test

Determination of shelf life of the dye:

Thermal study

Packed dye was stored at two different temperatures and it's physical and other parameters were tested to determine storage condition and shelf life of the dye.The extracted dye was stored for 2 months, and its shelf life was observed.

Result And Discussion:

Determination of natural dye obtained from vegetable waste material:

Table 2: Percentage of dye obtained from vegetable waste

Name of sample	W	W1	W2	Amount of dye obtained	%age of dye obtained
Peel of onion	10g	100ml	60ml	0.145 gm	1.45%
Peel of beetroot	10g	100ml	40ml	0.309 gm	3.09%
Peel of banana	10g	100ml	50ml	0.363 gm	3.63%

Thedried dye was obtained by following the aqueous extraction method and the percentage yield was calculated.

The yield of light silky shade and subtle earthy toned dye from the banana is highest i.e. 3.63% whereas light pink shade and light orange shade obtained from the peel of onion and peel of beetroot shows 1.45% and 3.09% simultaneously.

Determination of Phytochemical test:

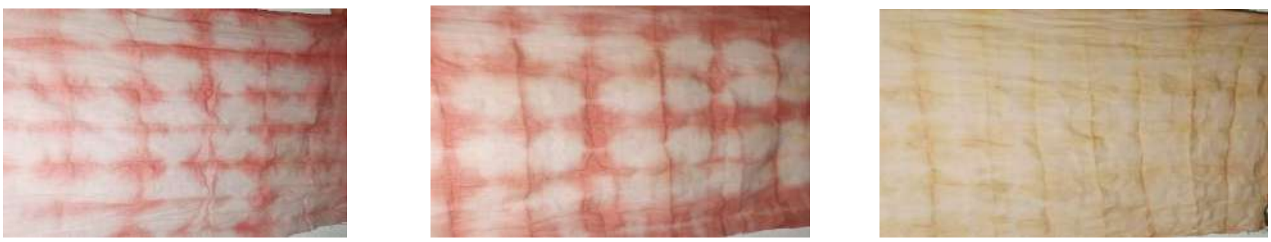
The following test was performed with the extract obtained from onion, beetroot and banana:

Table 3: Result of phytochemical tests

Test	Onion peel extract	Beetroot peel extract	Banana peel extract
Phenols	Absent	**Present**	**Present**
Tannins	**Present**	Absent	**Present**
Terpenoids	Absent	Absent	**Present**
Flavonoids	**Present**	**Present**	**Present**
Saponins	Absent	Absent	Absent
Glucosides	**Present**	**Present**	Absent
Steriods	Absent	Absent	**Present**
Quinine	Absent	Absent	Absent
Cellulose	**Present**	**Present**	**Present**

The phytochemicals test gives the appropriate analysis of the extract content. From table-3, it is observed as flavonoids and cellulose are present in all three dyes prepared peel of onion, beetroot and banana. The presence of flavonoids indicates the antioxidant, anti-inflammatory and anti-viral properties whereas presence of cellulose enables the molecule to form long straight chains. The peel of onion and banana extract shows the presence of tannin, indicating their resistance towards infections. To study the shelf-life of all three extracted dyes, they have stored at two temperatures i.e. at cold temperature around 2^0C and at room temperature about 40^0C. In cold conditions the extracted dye is in good condition whereas at room temperature after 1 month 15 days a slight change in color, smell and in appearance is observed.

Application of extracted dye: All the dyes extracted from vegetable waste such as peel of onion, banana, beetroot are used for dyeing cotton fabric by using direct dyeing method. [12,13,14] Pure bleached cotton with plain weave structure fabric has been used for the dyeing process. First, the fabric is soaked in cardamom water for 45 mins, so the fabric catches the dye color consistency and prevents skin problems. Natural mordant Alum (app 10% alum according to the weight of fabric) and water are boiled together for 45 min at 100 ^{0} C for better absorption. After drying the fabric under sunlight, it is used for actual dyeing with natural dyeing material.Dyeing of cotton fabric was done with natural extracted dye with a liquid ratio of 1:30 at 100 ^{0} C for 1hr. The dyeing process was performed in a stainless-steel vessel. After dyeing cloths were dipped in cardamom for 10-20 min. Cardamom water helps to suppress any odor due to dye material like onion etc. and cardamom has antibacterial and anti-inflammatory, anti-septic properties as a natural moisturizing agent. These qualities help to prevent allergies and heal acne, purifying skin clean. The dye extract was found to be suitable for cottonfabrics andit was observed that, the dye uptake was found to be good as shown in Figure 4



A B C

Fig. 4: Samples of natural dye fabrics from the dye extracted from: A) Peel of onion b) Peel of beetroot C) Peel of banana

Conclusion:

Natural dyes made from onion, beetroot, and banana peels have several benefits. The primary benefit is that waste material is used to extract the dye. Therefore, it leverages waste materials to produce enough dye. Hence, they are a more environmentally friendly and cost-effective alternative to synthetic dyes. These dyes provide a variety of natural colors, including shades of yellow to brown from onion peels, vivid reds and pinks from beetroot peels, and subtle earthy tones from banana peels. Utilizing food waste, such as peels, not only eliminates waste, but also lessens the environmental impact of dye production, so encouraging the circular economy. The extraction method is simple and normally uses nontoxic chemicals, making it safer for the environment and human health.

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Interdisciplinary Approaches: Interdisciplinary Perspectives on Health, Technology and Society

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Abstract

Sustainable development has emerged as one of the most crucial global goals, involving the integration of environmental, social and economic dimensions. The interdisciplinary intersection between health, technology and society plays a vital role in fostering sustainability. This paper explores the intersection of biochemical approaches, sustainable development and information technology (IT) to provide new perspectives on achieving long-term health and environmental goals. The biochemical approach offers insight into biological processes that can be harnessed to mitigate environmental impacts, improve health outcomes and promote resource efficiency. Meanwhile, IT enhances these efforts by providing tools for data analysis, innovation and global connectivity. Through a review of literature and case studies, this paper examines the ways in which health technologies, biochemical innovations and societal dynamics contribute to sustainability. It explores the challenges and implications of integrating IT and biochemistry in sustainable development, aiming to provide recommendations for future policies and practices. The paper concludes by emphasizing the need for continued collaboration between disciplines to achieve global health and environmental sustainability goals.

Keywords: Sustainable development, biochemical approaches, information technology, health technology, interdisciplinary perspectives.

Introduction

Sustainable development, as defined by the Brundtland Commission, involves meeting the needs of the present without compromising the ability of future generations to meet their own needs. Achieving sustainable development requires a holistic approach that addresses environmental, social and economic challenges simultaneously. In recent years, interdisciplinary perspectives have gained recognition for their potential to drive innovative solutions to these challenges. Among these, the intersection of health, technology and society has proven particularly crucial, as technological advances in fields such as biochemistry and information technology (IT) have the potential to transform public health systems, promote environmental sustainability and improve quality of life globally.

Biochemical approaches provide insights into the biological processes that underlie many sustainable practices, from environmental remediation to sustainable agriculture. When combined with IT, these approaches enable more efficient monitoring, data collection and resource management, essential for driving progress toward sustainable development goals (SDGs). This paper explores these interdisciplinary connections, focusing on how the integration of biochemistry and IT contributes to health, technology and sustainability.

Literature Review

Biochemical Approaches to Sustainable Development

Biochemistry plays an essential role in advancing sustainable development, especially in the context of health and environmental sustainability. Biochemical processes such as photosynthesis, fermentation and enzyme reactions can be harnessed to develop more sustainable agricultural practices, reduce waste and generate renewable energy. For instance, biochemistry has contributed to the development of biofuels derived from algae or waste materials, providing a cleaner energy source compared to traditional fossil fuels (Smith et al., 2020).

In the health sector, biochemistry also contributes to sustainable development by enabling the creation of eco-friendly medicines, treatments and diagnostic tools. By optimizing pharmaceutical production and improving the efficiency of medical treatments, biochemistry helps reduce the environmental footprint of healthcare practices. Furthermore, biochemistry's role in understanding human metabolism and disease mechanisms can lead to the development of personalized medicine, improving health outcomes and reducing unnecessary medical waste (Kumar & Gupta, 2021).

Role of Information Technology in Sustainable Development

Information technology has revolutionized every field it touches, including sustainable development. IT is indispensable in managing and analyzing large datasets, optimizing resource use and supporting decision-making processes. Technologies such as the Internet of Things (IoT), Big Data analytics and Artificial Intelligence (AI) are enabling more sustainable practices in various sectors. In agriculture, IT tools help optimize irrigation, monitor soil health and track crop yields, reducing resource waste and improving productivity. Additionally, AI-driven systems are used to predict and mitigate environmental risks, such as climate change and biodiversity loss (Patel et al., 2022).

Moreover, IT plays a significant role in health and medicine. It facilitates the management of health data, supports telemedicine and drives innovations in medical diagnostics and treatment. IT solutions like electronic health records (EHRs), mobile health apps and telehealth platforms have made healthcare more accessible and efficient. They also allow for the integration of health-related data with environmental data, enabling more comprehensive public health initiatives that account for the impacts of environmental factors on health.

Interdisciplinary Approaches to Health, Technology and Society

The integration of biochemistry and IT fosters a more interconnected approach to addressing global challenges. The interdisciplinary collaboration between biochemists, IT professionals, healthcare providers and environmental experts allows for the development of innovative solutions to improve public health, protect the environment and promote social equity.

For example, the use of AI in healthcare, coupled with biochemical research, enables more accurate diagnoses, personalized treatments and resource-efficient medical practices. Similarly, in environmental sustainability, the convergence of biochemistry and IT allows for the development of bio-based solutions to environmental problems, such as using genetically modified organisms (GMOs) to clean up pollution or developing sensors for environmental monitoring (Smith et al., 2020). These interdisciplinary collaborations are crucial for achieving the SDGs, particularly those related to health, clean energy and climate action.

Methodology

This research adopts a qualitative approach, incorporating literature review and case studies to explore the role of biochemistry and information technology in sustainable development. The methodology includes the following steps:

Literature Review:

A systematic review of academic journals, books and reports from recognized sources in the fields of biochemistry, information technology and sustainability. The review focuses on identifying key trends, innovations and challenges in the integration of these disciplines.

Case Studies: Case studies of organizations and initiatives that have successfully integrated biochemistry and IT to promote health, sustainability and technological advancements. These case studies provide concrete examples of how interdisciplinary approaches have been applied in real-world settings.

Research Design: The study employs a qualitative research design to investigate how technological advancements influence societal perceptions of health and well-being. This design is well-suited for examining the nuanced and context-dependent nature of these interactions. A mixed-methods approach complements the primary qualitative methods, incorporating quantitative data where appropriate to enhance the study's breadth and depth.

Data Analysis

The data gathered from the literature review, case studies and expert interviews revealed several key findings:

Synergy between Biochemistry and IT: The integration of biochemistry and IT has led to significant innovations in sustainable practices. For example, biotechnology companies use AI to optimize enzyme production, which reduces the environmental impact of industrial processes. In healthcare, IT tools help implement personalized medicine based on biochemical data, improving health outcomes while reducing costs.

Role of IT in Health and Sustainability: IT plays a crucial role in managing health data and optimizing resources for sustainability. Big Data analytics enable better management of healthcare systems, improving efficiency and reducing waste. IT tools also facilitate the monitoring of environmental health, providing real-time data that can be used to prevent and mitigate health risks related to pollution and climate change.

Challenges in Interdisciplinary Integration: Despite the potential benefits, several challenges hinder the full integration of biochemistry and IT. These include high costs of technology implementation, regulatory hurdles and a lack of collaboration between industries. Furthermore, the lack of infrastructure in developing regions prevents the widespread adoption of these technologies.

Discussion and Implications

The integration of biochemistry and information technology holds immense potential for promoting sustainable development. The synergy between these fields has already led to numerous innovations in healthcare, environmental management and agriculture. However, several challenges must be addressed to fully realize their potential. The high costs of technology, lack of standardization and insufficient regulatory frameworks pose significant barriers to the widespread adoption of these interdisciplinary solutions.

Policy implications include the need for governments to invest in research and development of biochemistry and IT solutions for sustainability. Collaboration between public and private sectors is essential to overcoming technological barriers and ensuring equitable access to sustainable innovations. Furthermore, international cooperation is needed to establish regulatory frameworks that facilitate the global adoption of these technologies.

Following are some interdisciplinary implications of on Health, Technology and Society:

Telemedicine and Remote Healthcare:

Health: Enables access to medical consultation for patients in remote or underserved areas.

Technology: Video conferencing tools, electronic medical records, and wearable devices that transmit real-time health data.

Society: Reduces barriers to healthcare, improves equity, but raises concerns about digital literacy and privacy.

Smart Cities and Public Health

Health: Use of IoT sensors to monitor air quality, water safety, and disease spread in urban environments.

Technology: Integration of connected devices, data analytics, and real-time reporting systems.

Society: Supports proactive health interventions but can highlight inequalities in access to technology-driven solutions.

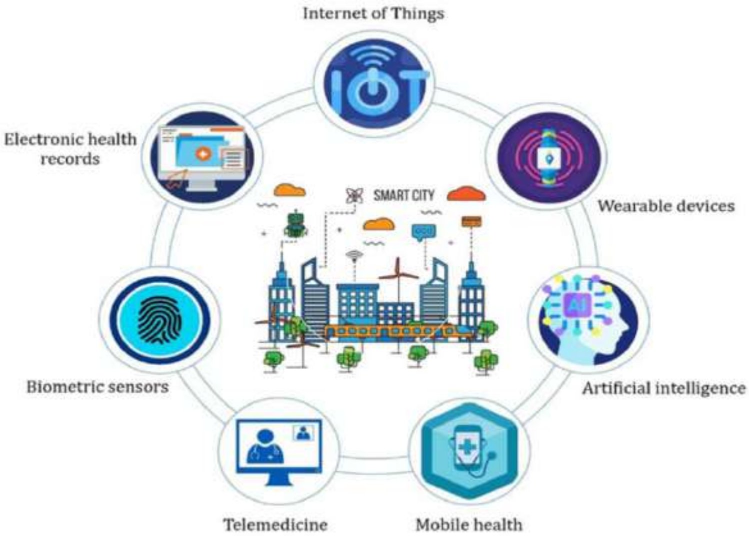

Figure 1: fundamental technologies for a smart city in providing health services

3. Biochemical Sensors in IT for Environmental Monitoring

Health: Using biochemical sensors, combined with IT systems, can help monitor environmental factors like air and water quality in real time.

Technology: These sensors can detect pollutants and send data to centralized IT systems, which analyze the data and provide actionable insights for mitigating environmental impact.

Society: IT-driven biochemical sensors can enhance environmental sustainability by enabling more effective management of natural resources, reducing pollution, and ensuring healthier ecosystems.

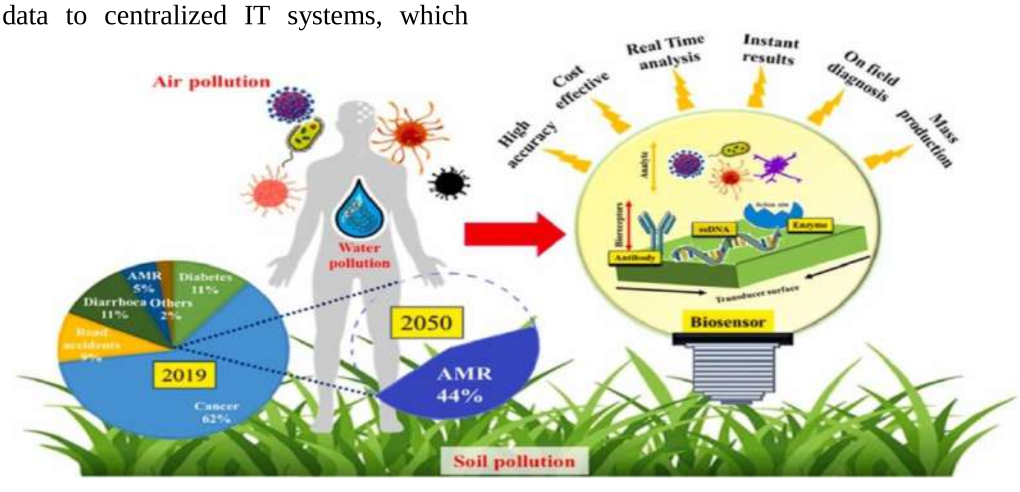

Figure 2: Biochemical Sensors in IT for Environmental Monitoring

Biofuels for Powering IT Infrastructure

Health: IT infrastructure, such as data centers, can be powered by biofuels (e.g., algae-based biofuels), which are renewable and have a lower environmental impact compared to fossil fuels.

Technology: The biochemical process of converting organic matter into fuel can support sustainable IT operations.

Society: Using biofuels to power IT systems can reduce the carbon footprint of data centers and other tech infrastructure, contributing to a more sustainable development of the IT sector.

Conclusion

In conclusion, interdisciplinary approaches that combine biochemistry and information technology offer a promising pathway toward achieving sustainable development. These approaches have the potential to address critical global challenges, including environmental degradation, public health issues and resource inefficiencies. By integrating these fields, society can develop more effective, efficient and equitable solutions for sustainability. However, continued research, investment and collaboration across disciplines are necessary to overcome existing barriers and unlock the full potential of these interdisciplinary approaches.

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Technological Innovations and Sustainability in Life Sciences and Chemistry: Data-Driven Insights in Chemistry and Biotechnology in the Digital Era

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Abstract

The convergence of technological innovations and sustainability in life sciences and chemistry has reshaped the approach to global environmental challenges. By leveraging data-driven insights, tools such as big data analytics, artificial intelligence (AI) and the Internet of Things (IoT) have enhanced green chemistry, bioprocess optimization and sustainable agriculture. These digital technologies enable precise resource management, reduce energy usage and support the development of eco-friendly products. This paper examines how IT-driven solutions are applied in biotechnology and chemistry to advance sustainable development. Examples include computational modeling in green chemistry, AI-optimized biofuel production and precision agriculture. The study highlights how these innovations promote resource efficiency, reduce waste and address ecological concerns. Through data-driven processes, industries can align economic growth with environmental responsibility, offering a pathway to a sustainable future.

Keywords: Technological innovations, Sustainability, Biotechnology, Data-driven insights, Green chemistry

Introduction

The rapid advancement of technology in the digital age has transformed industries and scientific research, including life sciences and chemistry. As the world grapples with pressing environmental challenges—ranging from resource depletion to rising pollution—innovative technologies offer new pathways to achieve sustainable development.

Sustainability in biochemistry focuses on improving processes while reducing environmental harm. Technological tools such as artificial intelligence (AI), machine learning and big data analytics are revolutionizing these fields by offering efficient, data-driven solutions. For example, computational simulations help identify sustainable chemical processes, while biotechnology optimizes biofuel production and enables the development of biodegradable materials. Additionally, information technology (IT) integrates IoT devices and analytical models, improving agricultural practices and industrial sustainability.

Data-driven insight refers to the actionable knowledge or understanding derived from analyzing data. It is the process of using data (often collected through various sources like customer interactions, sales, social media, sensors, etc.) to uncover patterns, trends, or correlations that provide valuable perspectives on a given situation or problem. These insights can help organizations make informed decisions, optimize operations, improve strategies, or innovate products and servicesThe key components of data-driven insights include:

Data Collection: Gathering relevant and accurate data from various sources.

Data Analysis: Using statistical methods, machine learning algorithms, or simple analytical techniques to explore the data and identify meaningful patterns or trends.

Insight Generation: Interpreting the results of data analysis to generate actionable conclusions or recommendations.

Action: Applying the insights in real-world scenarios to drive decisions, improve processes, or create new opportunities.

Examples of Data-Driven Insights:

Customer Behavior: Analyzing purchasing patterns to identify which products are more likely to be bought together or which demographic groups tend to favor certain products.

Operational Efficiency: Examining production data to uncover inefficiencies, predict equipment failures, or optimize supply chain logistics.

Market Trends: Using data from social media or sales trends to predict shifts in consumer preferences or emerging market opportunities.

In short, data-driven insights turn raw data into useful, strategic knowledge that helps guide decisions and improve performance.

This paper explores the role of data-driven insights in promoting sustainability within chemistry and biotechnology. It examines technological innovations, methodologies and applications that contribute to reducing resource consumption, lowering environmental impact and advancing global sustainability goals.

Literature Review

Technological Innovations in Chemistry

Green Chemistry emphasizes creating chemical processes and products that minimize the use of hazardous substances and reduce environmental impact. Traditionally, this field relied on experimental methods that were resource-intensive and time-consuming. However, recent developments in machine learning and computational chemistry have transformed the field.

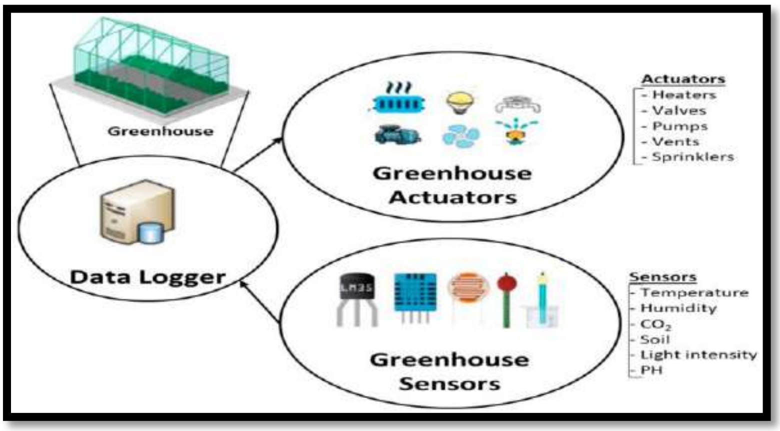

Figure 1: Smart greenhouse architecture

Computational tools, such as Density Functional Theory (DFT) and quantum simulations, predict molecular interactions and chemical behaviors accurately, minimizing trial-and-error experimentation. These models optimize reactions, identify renewable materials and develop eco-friendly catalysts. Pérez-Rodríguez et al. (2020) note that machine learning algorithms have significantly accelerated the discovery of efficient chemical processes that align with sustainability goals.

Biotechnology: A Sustainable Pathway

Biotechnology provides innovative solutions for achieving sustainability by leveraging biological systems for industrial and environmental applications. Bio-based production processes replace resource-intensive and polluting practices with eco-friendly alternatives. For example:

Biofuels: AI tools optimize fermentation processes to maximize biofuel yields while minimizing energy input.

Biodegradable Materials: Synthetic biology designs microorganisms capable of producing bio-based polymers, reducing reliance on petrochemicals.

Gupta et al. (2021) emphasize how integrating data analytics into bioprocess engineering enhances production efficiency, reduces costs and ensures minimal environmental impact.

Information Technology: Enabling Sustainability

Information technology bridges the gap between data and action by providing tools to process, analyze and interpret massive datasets. In precision agriculture, IoT devices and AI algorithms monitor soil health, weather conditions and crop development to optimize resource use. This data-driven approach enables sustainable farming practices, ensuring minimal water and fertilizer wastage.

Sharma et al. (2019) report that IoT-supported systems improve agricultural productivity and reduce environmental degradation by providing real-time insights into field conditions. Similarly, IT enhances research in genomics and bioinformatics, contributing to precision medicine and sustainable healthcare advancements

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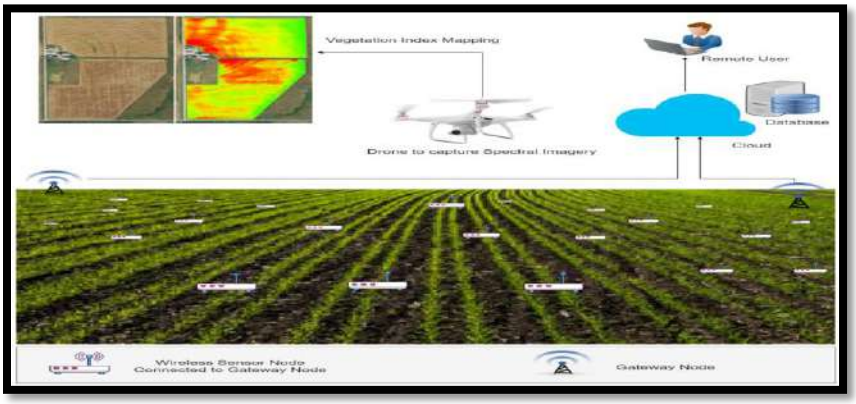

Figure 2: UAV-Based and IoT-Based Precision Agriculture

Methodology

Research Design

This study adopts a qualitative approach using secondary data sources to analyze the relationship between technological innovations and sustainability in life sciences and chemistry.

Data Collection: Data were gathered from the following sources:

Peer-reviewed journals, including ScienceDirect and IEEE Xplore.

Reports from international organizations, such as the United Nations and WHO.

Case studies highlighting practical applications of data-driven tools in biotechnology, agriculture and chemistry.

Analytical Framework: Thematic analysis was conducted to identify the following key focus areas:

Applications of Information Technology in Chemistry and Biotechnology.

Data-driven tools improving resource efficiency and sustainability.

Case studies demonstrating IT-driven innovations in Green Chemistry and precision agriculture.

Data Analysis Applications of IT in Green Chemistry

Technologies such as AI and big data analytics have made Green Chemistry more efficient. For instance:

Technology	Application	Impact
Computational Modeling	Predicting chemical reactions	Reduces trial-based experiments
Machine Learning	Optimizing catalyst design	Improves efficiency, minimizes waste
Quantum Simulations	Designing sustainable molecules	Facilitates eco-friendly innovations

These tools provide predictive insights that eliminate resource wastage and reduce environmental footprints while enabling sustainable production processes.

Role of Biotechnology in Sustainability

Biotechnology, supported by IT, drives sustainable solutions for industrial and environmental applications:

Biofuel Optimization: AI algorithms optimize fermentation parameters, leading to higher bioethanol production with lower energy costs.

Synthetic Biology: Data analytics facilitate the creation of microbial strains that produce biodegradable plastics and bio-based chemicals.

These innovations reduce industrial reliance on fossil fuels and contribute to the production of sustainable materials.

Precision Agriculture and Resource Efficiency

Precision agriculture integrates IoT, AI and data analytics to manage farming systems effectively. For example:

Soil Monitoring: Sensors collect data on nutrient levels, enabling targeted fertilizer application.

Water Management: AI-driven irrigation systems optimize water usage based on crop requirements.

By analyzing real-time data, farmers reduce resource wastage while improving crop productivity and environmental sustainability.

Discussion and Implications

Promoting Sustainable Practices

Technological advancements offer solutions to longstanding sustainability challenges by integrating digital tools into biochemical processes. In chemistry, computational models and AI-driven systems optimize chemical reactions, reducing the environmental impact of industrial processes.

Addressing Resource Scarcity

IT tools enhance resource management across industries by improving efficiency and minimizing waste. In biotechnology, big data analytics optimize biofuel production and bio-based material synthesis, reducing dependency on non-renewable resources. Similarly, precision agriculture conserves water and fertilizer while improving yields.

Economic and Environmental Benefits

IT-driven innovations not only reduce ecological footprints but also deliver significant economic benefits. Industries achieve cost savings through optimized processes and increased efficiency. Additionally, sustainable practices ensure compliance with environmental regulations and global sustainability goals.

Ethical and Social Considerations

While technological innovations offer immense potential, they raise concerns regarding data privacy, access inequality and ethical use of genetic tools. Responsible implementation of IT-driven solutions requires transparent policies, regulatory oversight and ethical frameworks.

Conclusion

Technological innovations have revolutionized the fields of life sciences and chemistry, offering new opportunities for achieving sustainable development. The integration of information technology, including AI, IoT and big data analytics, enhances biochemical processes, green chemistry and biotechnological advancements.

This paper highlights how data-driven tools promote resource efficiency, reduce energy consumption and address environmental challenges. Innovations in biofuel production, synthetic biology and precision agriculture demonstrate the transformative potential of IT-driven sustainability.

Future research should focus on addressing ethical concerns, scaling up these technologies for global implementation and fostering interdisciplinary collaborations to advance sustainability goals. By leveraging IT solutions, industries can achieve a balance between economic growth and ecological preservation, paving the way for a sustainable future.

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Isolation and Screening of Invertase Producing Fungi from Textile Sizing Site

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Abstract

Filamentous fungi are important due to their high enzyme production potential. Many enzymes produced by fungi have been related to biotechnological applications in several industrial sectors. This research explores the isolation and characterization of invertase-producing fungi from textile sizing sites, with a focus on their biotechnological potential. Invertase (β-fructofuranosidase) is an enzyme that catalyses the hydrolysis of sucrose into glucose and fructose, making it invaluable in various industrial applications, including the food and beverage sectors. Soil samples were systematically collected from multiple textile sizing locations, and fungal strains were isolated using selective media. Total ninety fungi were isolated and screened for invertase production potential on Czepak Dox medium. Invertase producing colonies were detected by the formation of orange to reddish precipitate around the growth of the fungi. Out of ninety fungal isolates thirty-seven fungal colonies were found to be positive for invertase production. The use of enzyme technology to meet various human needs is becoming more popular. This study not only enhances the understanding of microbial diversity in waste environments but also highlights the feasibility of utilizing these organisms for sustainable enzyme production, thereby contributing to advancements in bioprocessing and environmental bioremediation.

Key Words: Invertase, Textile Sizing Site, *Aspergillus sp.*

Introduction

Enzymes function as biological catalysts predominantly produced by plants, animals, and microorganisms to enable a diverse array of chemical reactions that are vital for life-sustaining processes. These biomolecules assume pivotal roles in essential cellular activities, encompassing DNA replication, transcription, protein synthesis, metabolism, and signal transduction. Their aptitude for catalysing specific chemical transformations has established their significance in various industrial applications (Li et al., 2012; Oumer and Abate, 2018). The natural world offers a heterogeneous selection of microorganisms with considerable potential to produce commercially viable enzymes. Microorganisms such as bacteria, fungi, and actinomycetes have been extensively employed for the biosynthesis of enzymes. Microbial enzymes are acknowledged as effective instruments for sustainable biotechnological processes, which are increasingly pertinent in modern society (Vuppu and Mishra, 2011; Oumer and Abate, 2018). Fungi, in particular, exhibit the capacity to generate a variety of extracellular enzymes that facilitate the hydrolysis of complex polysaccharides into simpler sugars, thereby promoting growth and reproduction. These enzymes find applications across environmental and industrial domains, including food processing, brewing, biofuel production, and bioremediation. The demand for innovative sources of functional fungal extracellular enzymes is progressively escalating (Reddy and Sreeramulu, 2012). Fungi, which are omnipresent in the environment, especially within soil ecosystems, are prolific producers of valuable enzymes and bioactive secondary metabolites (Reddy et al., 2014). Filamentous fungi release an array of extracellular enzymes, comprising amylases, cellulases, xylanases, invertases, pectinases, lipases, and proteases. Numerous fungi yield industrially relevant polysaccharide-degrading enzymes, resulting in enhanced interest in the assessment of soil biodiversity and its biological roles (Barrios, 2007). The industrial application of enzymes is proliferating due to advancements in various sectors, including food and beverage processing, leather treatment, textile manufacturing, pharmaceutical production, and the paper and pulp industries (Ogbonna et al., 2014). Microorganisms are favoured as sources of enzymes due to their rapid life cycles, elevated productivity rates, economic viability, and the lack of deleterious chemical byproducts (Bhim et al., 2015).

Invertase (β-fructofuranoside-fructohydrolase; fructofuranosidase; E.C.3.2.1.26) is an enzyme that hydrolyses sucrose by cleavage the glycoside bond (β1-2linkage) from disaccharide sucrose forming mixture of monosaccharide glucose and fructose. Invertase is no crystallizable and is ~1.5times sweeter than sucrose.

Fungi, bacteria, and yeast are capable for production invertase enzyme, which has a wide range of commercial applications in food industries and in pharmaceutical sectors (Hussain et al., 2009). Invertase is widely distributed in various microorganisms such as bacteria (Yoon et al., 2007 and Awad et al., 2013), fungi (Kurakake et al., 2010 and Giraldo et al., 2014), and yeasts (Plascencia-Espinosa et al., 2014 and Andjelković et al., 2015). Jorge and Guimarães, 2013, reported that there are few results on production of invertase from molds. Most fungi that produce invertase are filamentous fungi especially from *Aspergillus sp*. (Lucca et al., 2013 and Rustiguel et al., 2015), *Penicillium sp*. (Flores-Gallegos et al., 2012), *Rhizopus sp*. (Goulart et al., 2009), and *Fusarium sp*. (Wolska-Mitaszko et al., 2007). There is a great demand for production of invertase from filamentous fungi, which is probably owing to their biotechnological applications to produce invert sugar, food, and beverages (Nehad and Atalla, 2020).

Invertase is extensively used in confectionaries, food industries and in pharmaceuticals (Ashokkumar et al., 2001). Microbial invertase is used for the manufacture of calf food and food for honeybees. Many organisms produce invertase such as *Neurospora crassa, Candida utilis*, *Fusarium oxysporum*, *Phytophthora meganosperma*, *Aspergillus niger*, *Saccharomyces cerevisiae, Schizosaccharomyces pombe,* and *Schwanniomyces occidentalis* (Silveira et al., 2000). *Saccharomyces cerevisiae* is the organism of choice for invertase production because of its characteristic high sucrose fermentability.

This research sought to conduct a series of steps including sample gathering, isolation, microscopic examination, and evaluation of native fungal diversity capable of invertase hydrolysis from a textile sizing location. The objective was to comprehensively explore and assess the hydrolytic capabilities of fungi for potential widespread applications in the future, driven by the need for invertase in food and pharmaceutical sectors.

Materials and Methods

Selection of sample sites

Different textile sizing sites of Bhiwandi city were selected for the sample collection.

Collection of soil samples

The samples were collected from different spots in each site in zip lock polythene bags. Almost 5-10 soil samples were taken from each sizing industries. The soil sample was mixed well and processed next day.

Isolation of fungi

Fungal colonies were isolated from soil samples by serial dilution method where SDA (Sabouraud dextrose agar) media was prepared, autoclaved and poured in sterile petri plates. Soil samples (1 gm) diluted up to 10^{-5} dilution was spread on respective solidified SDA plates with the help of sterile spreader. The inoculated petri plates were incubated at 28°C for 48 h. About 120 different fungal isolates differentiated based on physical characteristics obtained after incubation were selected for the further processes. The isolates were further inoculated on SDA plates by point inoculation and incubated at 28°C for 48 h to obtain pure fungal cultures (Khan and Kumar, 2011).

Screening of Fungal Isolates for Invertase Production

The fungal isolates were tested for invertase production by sucrose hydrolysis method. From 120 fungal isolates about ninety fungal isolates were screened for invertase production efficiency in Czepak Dox medium comprising the following in gm/L- Sucrose 30.00, K_2HPO_4 1.0, $MgSO_4.7H_2O$ 0.50, KCl 0.50, NaNo3 2.00, $FeCl_3.6H_2O$ 0.01, Agar 15.00, pH-7.3. The entire ninety fungal discs were centrally inoculated on sterile solidified Czepak Dox plates with the help of cork borer. The diameter of disc was 1cm. Plates were incubated at 28°C for 72 H. Screening for invertase activity was done by using Fehling's reagent. All the plates were flooded with Fehling's reagent, formation of orange to reddish precipitate indicates a positive reaction for invertase production (Chelliappan and Madhanasundareswari, 2013), Figure 1.

Microscopy of Invertase producing isolates

Microscopy of all the positive isolates was done by lactophenol cotton blue staining method. In aseptic condition, a loop full of fungal cultures was placed on a clean glass slide, a drop of lactophenol cotton blue stain was mixed with the culture. A clean coverslip was placed over the culture and viewed under the microscope (10X and 45X). Morphological characteristics including colour of the colony and growth pattern studies, as well as their vegetative and reproductive structures were carefully observed under the microscope (Devi and Kumar, 2012), Figure 2.

Results and Discussion

The soil plays a predominant role as it serves as a habitat for numerous microorganisms. Potent isolates can be obtained from natural environments. Consequently, the selection of soil samples may influence the efficacy of the enzyme. Isolation of fungi was conducted using the serial dilution method. The pure cultures of fungal isolates were evaluated for their capacity to produce invertase. Ninety fungal isolates underwent a screening procedure on Czapek-Dox plates containing sucrose as a substrate for the invertase enzyme. The plates were incubated for 72 H. Upon completion of the incubation period, varying degrees of sucrose utilization were observed after flooding with Fehling's reagent. Out of 90 fungal isolates, 37 isolates exhibited orange-coloured precipitates and were determined to be positive for invertase production potential. Following microscopic examination, most of the isolates were identified as belonging to the genera *Aspergillus, Penicillium, Fusarium, Rhizopus,* and *Trichoderma.*

Microorganisms, flora, and certain animal tissues serve as natural biosynthetic entities for invertase production (Kumar and Kesavapillai, 2012). Documented microbial origins of invertase encompass yeasts, fungi, and bacteria (Rubio et al., 2002; Awad et al., 2013). The invertase derived from filamentous fungi is currently under extensive global investigation. A particularly noteworthy characteristic of filamentous fungi is their ease of cultivation, along with their vigorous production of extracellular enzymes, which holds significant potential for large-scale industrial applications (Guimarães et al., 2006; Lincoln and More, 2017).

The enzymatic function of invertases has predominantly been elucidated within the realm of plant biology (Alberto et al., 2004; Hussain et al., 2009). A variety of filamentous fungi, including those classified within the genus *Aspergillus* (Ashok Kumar et al., 2001; Nguyen et al., 2005; Guimaraes et al., 2009), along with various yeast species such as *Candida utilis* (Belcarz et al., 2002) and *Rhodotorula glutinis* (Rubio et al., 2002), as well as numerous other organisms including *Neurospora crassa, Fusarium oxysporum, Phytophthora megasperma, Aspergillus niger, Saccharomyces cerevisiae, Schizosaccharomyces pombe,* and *Schwanniomyces occidentalis,* are known to synthesize invertase (Silveira et al., 2000). (Chelliappan and Madhanasundareswari, 2013).

Invertase-producing fungus species have been identified by numerous investigations. One of the most researched fungi for producing invertase is *Aspergillus niger*, which is well-known for having high enzymatic activity and adapting well to a variety of substrates.

According to research, *A. niger* is a strong contender for industrial use because of its notable invertase activity. It has also been observed that other fungus, including *Aspergillus flavus* and *Penicillium aurantiogriseum*, produce invertase, however their protein concentration and enzyme activity differ (Matei et al., 2017).

Aspergillus sp. has been described to be a credible producer of different enzymes possessing properties which are preferred in biotechnological and many industrial functions. There are a few reports of *Aspergillus sp*. reported for production of invertase which demands a great deal of consideration (Lincoln and More, 2017).

In conclusion, Textile sizing sites are suitable habitat that harbours invertase producing microorganisms and can be explored the more on whether these isolates can proffer help in the area of bioremediation of sizing processing wastes environment. Future perspective of this study would be focus on pilot scale production and purification of invertase enzyme by using potential invertase hydrolysing isolates.

Figure 1: Screening of Fungal isolates producing Invertase

Figure 2: Microscopic Images

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Advances in Chemical Waste Management: A Review of Sustainable Practices and Technologies

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Abstract

Chemical waste, a byproduct of industrial, laboratory, and manufacturing processes, poses significant environmental and health risks if improperly managed. This study focuses on sustainable management and recycling strategies to mitigate these impacts while promoting resource recovery and conservation. It highlights advanced techniques such as chemical neutralization, solvent recovery, and distillation, alongside innovative methods for recovering valuable metals and transforming hazardous compounds into non-toxic materials. The role of regulatory frameworks, industry compliance, and public-private partnerships is emphasized as critical to ensuring safe and effective chemical waste management. The study underscores the importance of global collaboration, research, and education to advance technologies and practices, aiming to reduce environmental pollution, conserve raw materials, and enhance the sustainability of chemical-intensive industries.

Keywords: Chemical waste, waste management, recycling, sustainability.

Introduction:

Chemical waste management is a critical area of study, given its significant environmental and health implications. With the rapid growth of industrial, laboratory, and manufacturing activities, the generation of hazardous chemical waste has become a pressing global challenge. .In parallel, the management of biomedical waste (BMW) is an equally important concern. Biomedical waste, including materials like sharps, pharmaceuticals, and body fluids, poses significant risks to public health and the environment if not handled properly. Healthcare settings around the world are increasingly adopting eco-friendly methods like sterilization, autoclaving, and alternative disposal techniques to address these concerns This review explores advanced techniques such as chemical neutralization, solvent recovery, and innovative recycling methods, alongside the role of regulatory frameworks and global collaboration, in promoting sustainable management practices. Figure 1 explores advancements in biomedical waste treatment and disposal, emphasizing safer and eco-friendly practice. Bio medical waste management varies globally, methods like incineration, autoclaving, and land filling being common disposal. Segregation, safe handling, and treatment methods like disinfection, autoclaving, and incineration are crucial for compliance with the 1998 Bio-Medical Waste Management Rules[6].Biomedical waste (BMW) management is crucial to prevent disease transmission, environmental degradation, and public health hazards. Proper segregation, storage, treatment, and disposal are essential. Guidelines like India's Biomedical Waste Management Rules (1998) ensure safe management. Methods include incineration, chemical treatment, and plasma pyrolysis. Public awareness and adherence to safety protocols are vital to minimize risks and ensure a sustainable approach to health and environmental protection[7].The study examines the impact of illegal toxic waste dumping in Campania. The region faces significant environmental pollution from improper disposal and burning of waste, releasing hazardous substances like dioxins. These pollutants contaminate air, soil, water, animals, and humans, leading to health risks and including increased cancer. The research links higher cancer mortality rates to waste exposure despite controlling for socioeconomic factors. It work for waste management[8]The paper highlights improper biomedical waste management as a significant threat to human health and the environment. The objectives include analyzing its impact on livelihood, the legal framework in India, and the judiciary's role. The study emphasizes that biomedical waste categorized into human anatomical waste, sharps, and chemical waste contains infectious agents like HIV and hepatitis. According to Article 21 the recommendations include proper segregation, waste minimization, and education programs[9]. Biomedical waste, generated from healthcare facilities, poses severe risks to public health and the environment. It includes infectious materials like sharps, body fluids, pharmaceuticals, and radioactive substances. Poor management leads to disease spread, contamination of water bodies, and environmental pollution, particularly in developing countries. Incineration and non-incineration methods are commonly used for disposal, with challenges like emission of toxic pollutants and financial constraints. Proper segregation, education, and training of healthcare personnel, along with government enforcement of regulations, are critical for effective management. Addressing this issue requires technological solutions, public awareness, and a robust waste disposal framework[10].India's 2016 Biomedical Waste Management Rules outline procedures for healthcare waste management. Biomedical waste is categorized into color-coded bags with specific segregation, collection, storage, transportation, and treatment methods. The rules emphasize compliance with standards, monitoring, and staff training to ensure public health and environmental safety through proper waste management practices[11].A novel composite of photosynthetic bacteria integrates photo catalytic and bio degrative processes to effectively treat dye wastewater. By harnessing visible light, this innovative approach breaks down dyes into easily degradable compounds, achieving remarkable results: 94% dye removal and $4.7% reduction in chemical oxygen demand (COD)[12].India's biomedical waste management is criticized for environmental and health risks. The 2016 BMWM rules aim to improve waste handling and reduce pollution through stricter standards and enhanced facilities, but government support and innovative solutions are needed to overcome challenges[13].A ground breaking photosynthetic bacteria composite simultaneously leverages photo catalysis and biodegradation to remediate decontaminated wastewater, yielding impressive outcomes: 94% dye removal and 84.7% COD reduction. By merging visible-light-driven photo catalysts with microbial metabolism, this innovative method provides rapid decolourization and eco-friendly benefits for sustainable wastewater treatment[14].The document reviewed about the challenges and solutions for achieving complete recycling of medical textiles, which are vital for clinical and hygienic applications. Medical textile waste, often contaminated and classified as hazardous, presents significant environmental concerns. Current recycling approaches include chemical processes, incineration, and innovative methods like molecular tagging to maintain polymer integrity during recycling. Key challenges in the industry involve microbial resistance, liquid penetration, tensile strength, and lint production. Proposed solutions include the use of breathable barriers, conductive polymers, and advanced materials such as ε-Polylysine. The study underscores the importance of sustainability through life cycle analysis, the development of reusable medical textiles, and the adoption of ecofriendly innovations. With growing demand for personal protective equipment (PPE) during pandemics, the global medical textiles market is expected to expand. The paper calls for enhanced recycling technologies and collaborative efforts among stakeholders to transition toward a circular economy[15]. The document offers a comprehensive survey of biomedical waste (BMW) management in India, highlighting its vital role in protecting public health and the environment. Biomedical waste, produced by health facilities, consists of infectious and hazardous materials such as sharps, pathological waste, and chemical remains. The management can result to the public health hazards, environmental contamination, and outbreaks of diseases like hepatitis HIV[16].The document details guidelines for BMW handling emphasizing the "3Rs" (Reduce, Reuse, Recycle) alongside proper segregation, treatment, and Joposalpractions Key recommendations include the adoption of advanced technologies, thorough small training, and strict compultion with the Biomedical Waste Management Rules, 2016. Effective UMW management such as cleaner environments, lower infection rates, and enhanced public safety[17].The document tackles the critical issue of COVID-19 waste management in India, where the improper disposal of biomedical waste poses significant risks to public health and the environment. It emphasizes the alarming rise in waste generated from personal protective equipment (PPE), healthcare facilities, and households, advocating for the implementation of efficient waste management systems, increased public awareness, sustainable practices, and cutting-edge technologies to mitigate the dangers of contamination and a looming "waste disaster." [18].The reports stress the importance of adopting sustainable waste management practices, including circular economy approaches, to achieve the United Nations' Sustainable Development Goals (SDGs) They underscore the crucial role of recycling, green technologies, and policy reforms in mitigating environmental harm. Furthermore, post-pandemic innovations such as waste-to-energy conversion, bio-nanotechnology, and advanced waste segregation infrastructure can foster green job creation, economic revival, and climate action. [19].The article explores sustainable strategies for managing food waste, with a focus on anaerobic digestion to produce biogas and recycle nutrients, examining factors like pH, temperature, and C/N ratio, as wellas pre-treatment methods and microbial dynamics to optimize biogas production[20].The research paper addresses about the critical issue of biomedical waste, comprising infectious, toxic, and hazardous materials generated by healthcare activities. Mismanagement poses significant environmental, health. and economic risks, particularly in developing regions, emphasizing the need for effective segregation, treatment methods, and regulatory enforcement[21].The review discusses global medical waste (MW) management challenges, emphasizing safe disposal to avoid environmental and health risks. It explores alternatives to incineration, highlights varying country efficiencies, and recommends stricter regulations, improved segregation, and eco-friendly technologies to minimize MW and transition to a circular economy, mitigating pollution and health impacts[22].plastic waste during the COVID-19 pandemic due to PPE and medical equipment. It details plastic types, disposal methods like land filling and incineration, and innovative recycling techniques such as microbial degradation. Emphasis is placed on sustainable solutions, including life cycle assessments and circular economy strategies, to mitigate environmental impacts[23].A recent study explores the potential of recycling food and agricultural waste into eco-friendly silver nanoparticles (AgNPs) through green synthesis. Derived from fruit and vegetable waste, these AgNPs show promise in antimicrobial applications, water purification, and insect control, but face challenges in scale-up, environmental impact, and integration with nanotechnology[24].A recent study evaluated the knowledge, attitude, and practices of healthcare workers regarding Biomedical Waste Management Rules, revealing significant gaps in waste segregation awareness, particularly among housekeeping staff, and highlighting the need for regular training and evaluations to ensure compliance and proper waste management practices[25].The paper discusses about the biomedical waste and plastic management, particularly in the context of COVID-19. The surge in medical plastic waste, like PPE kits, masks, and syringes, poses challenges for waste management systems, especially in developing countries. It highlights the classification, disinfection methods (autoclaving, chemical treatment, UV radiation), and recycling techniques. The study emphasizes converting biomedical plastic waste into value-added products through mechanical recycling and other processes like pyrolysis. The paper advocates for sustainable waste reduction using the "Reduce, Reuse, Recycle" approach while addressing environmental concerns. Proper segregation, disinfection, and recycling can transform medical waste into resources[26].The uploaded document discusses sustainable metallurgy, highlighting the substantial environmental impact of metal production, which contributes to 40% of industrial greenhouse gas emissions and consumes 10% of global energy. It underscores the urgency of adopting sustainable practices across primary, secondary, and tertiary metal production. Major challenges include meeting rising demand despite limited recycling capabilities and reducing emissions from fossil fuel-dependent processes. Suggested solutions include advancements in recycling technologies, implementing circular economy principles, designing alloys for improved recyclability, and minimizing dependence on rare or critical metals. The study emphasizes the necessity of integrating scientific, economic, and social perspectives to promote sustainable practices on a global scale [27].The document provides an in-depth analysis of the plastic life cycle and its effects on human health, the environment, and the economy. It highlights the significant health risks posed by chemicals associated with plastics, made worse by inadequate recycling and disposal systems. The report underscores the social inequities of plastic pollution, which disproportionately harm marginalized communities. It calls for reducing plastic production, especially single-use plastics, and proposes the establishment of a Global Plastics Treaty. Additionally, it advocates for improved waste management, stricter chemical safety regulations, and enhanced global research to better understand and address these issues. This thorough examination aims to increase awareness and drive international efforts to tackle the plastic crisis effectively [28].The document explores the use of artificial intelligence (AI) in enhancing waste management systems within smart cities. AI technologies improve efficiency in waste collection, sorting, monitoring, and recycling. Innovations such as smart bins, robotic waste sorters, predictive models, and sensor-based systems help minimize environmental impacts and reduce operational expenses. AI facilitates precise waste identification (with accuracy ranging from 72.8% to 99.95%), optimizes logistics, and supports energy recovery methods like pyrolysis. Furthermore, machine learning contributes to carbon emission estimation, route optimization, and detecting illegal dumping. However, challenges such as high implementation costs and data quality concerns persist. The paper emphasizes AI's transformative potential in advancing circular economy practices and enhancing the sustainability of urban waste management [29].Two reports highlight challenges and innovations in recycling waste materials, exploring advancements in plastic recycling and biomedical waste management. They emphasize the need to address environmental concerns and adopt sustainable, eco-friendly solutions in waste management, promoting a circular economy and mitigating ecological impacts[30].The reports delve into the global plastic waste crisis, highlighting its devastating environmental consequences on terrestrial and marine ecosystems. They explore critical issues such as waste-to-energy technologies, recycling strategies, and micro plastics pollution, proposing comprehensive solutions that encompass sustainable waste management, stringent policies, upgraded infrastructure, and heightened public awareness to combat pollution and foster a circular economy[31].he document is a review to focused on the sustainable valorization and recycling of bio plastic waste, with an emphasis on biopolymers such as PLA, PBAT, and starch-based plastics. It examines various waste management strategies, including biodegradation, mechanical recycling, and thermal depolymerisation. The study highlights that while starch-based plastics biodegrade effectively in composting environments, PLA and PBAT require alternative treatments due to compatibility challenges. Thermal degradation shows potential for chemical recycling in line with circular economy principles, although further research is needed. The review concludes that while bio plastics present environmental advantages, improving recycling techniques is essential to overcome current waste management challenges[32][33]. This review examines the surge in biomedical plastic waste during the COVID-19 pandemic, associated challenges, and potential solutions. It delves into disinfection methods, innovative recycling technologies, and the up cycling of waste into valuable products. With a focus on sustainability, the review underscores the promise of mechanical recycling in converting hazardous medical waste into environmentally safe renewable sources , mitigating ecological threats[34].Recent breakthroughs in chemical recycling technologies, particularly pyrolysis and gasification, offer promising solutions for managing plastic waste. By transforming plastics into fuels and high-value chemicals, these processes contribute significantly to environmental sustainability. Despite challenges related to energy consumption, efficiency, and processing mixed plastics, ongoing innovations in catalyst development and biodegradable alternatives are enhancing recycling efficiency, driving the transition towards a circular economy. 35]Recent reports delve into the complexities of plastic waste management, showcasing chemical recycling innovations like pyrolysis and gasification. While these methods convert waste into fuels and valuable chemicals, significant challenges persist, including low recycling rates, energy consumption, environmental concerns, and the need for advanced catalysts and sorting technologies[35].Recent reports examine breakthroughs in recycling and waste management, highlighting chemical recycling methods such as pyrolysis for plastics and biomedical waste. By converting waste into fuels and chemicals, pyrolysis offers significant energy and environmental advantages, although challenges persist, including costs, contamination, and scalability, which can be addressed through innovations in thermal technologies and improved waste segregation systems[36].A recent review examines chemical recycling methods for plastic waste, including hydrolysis, pyrolysis, and gasification, which convert polymers into valuable products, supporting circular economies. The report addresses challenges like energy consumption, contamination, and scalability, while emphasizing sustainable waste management to combat global plastic pollution[37]. The document reviews biopolymer recycling as a sustainable alternative to synthetic plastics. It discusses mechanical, chemical, and biological recycling methods, their challenges (e.g., contamination, costs, regulatory issues), and the need for innovation like AI-powered sorting and enzymatic degradation. Emphasizing collaboration, it highlights case studies and suggests integrating recycling into circular economy models to enhance sustainability[38]. The paper reviews global challenges and strategies for managing biomedical and solid waste during COVID-19. It highlights increased waste from personal protective equipment, emphasizes proper segregation and environmentally sound disposal, and recommends sustainable waste-management practices, regulatory updates, public awareness, and innovative technologies to mitigate health and environmental risks[39][40].

Conclusion

Effective waste management, particularly of biomedical and plastic waste, is a critical component of ensuring environmental sustainability and public health. This comprehensive review highlights the importance of adopting innovative, eco-friendly waste treatment methods and regulatory compliance. Approaches such as chemical recycling, non-incineration treatment, advanced technologies, and the “3Rs” (Reduce, Reuse, Recycle) play pivotal roles in minimizing health risks and environmental degradation.The surge in waste during the COVID-19 pandemic underscores the urgent need for sustainable practices and technological advancements, such as AIenabled systems and nanotechnology, to optimize waste management processes. Policies like India’s Biomedical Waste Management Rules (2016) provide a framework, but their effective implementation requires collaboration among governments, industries, and the public.To mitigate the ecological impact of biomedical and plastic waste, transitioning to a circular economy is imperative. Innovative recycling methods, waste-to-energy technologies, and public awareness campaigns must be prioritized. Ultimately, the integration of sustainable practices, robust regulations, and cutting-edge technologies will not only protect ecosystems but also contribute to achieving global environmental and health goals.

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The Role of Women in Water Conservation: Empowering Change for Sustainable Water Governance

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Abstract

Water scarcity, driven by climate change, population growth, and unsustainable practices, poses a global challenge. Women play vital yet under recognized roles in water management, from household water collection to leading community projects and advocating for policy changes.[1] Case studies from India[1] and Jordan[2] highlight their leadership in bridging traditional knowledge with modern practices. Despite cultural and economic barriers, women drive progress in water conservation through education, innovation, and leadership.[3] Emphasizing gender-inclusive policies and empowering women can unlock transformative solutions for sustainable and equitable water management.[3]

Keywords: women, conservation, governance, sustainability, stewardship, empowerment, scarcity, sanitation.

Introduction

Water scarcity is one of the most pressing global challenges, with billions of people already facing limited access to clean and reliable water sources.[1] The situation is compounded by climate change, over-exploitation of resources, and rapid urbanization, leading to further stress on available water. [3] Despite being directly affected by water issues, women have historically been marginalized in water governance.[3] However, their essential role in managing and conserving water at the household, community, and national levels is increasingly recognized as critical to addressing water scarcity.

The Role of Women in Water Conservation: Case Studies And Contributions

Across the world, women have demonstrated remarkable leadership in addressing water-related challenges. Their involvement ranges from promoting sustainable practices in their households to leading large-scale community projects that enhance water security and improve livelihoods.[3]

India: Grassroots Women Leaders Driving Change

India, a country with significant regional variations in water availability and access, provides numerous examples of women leading water conservation initiatives.[3] Women in rural and urban areas alike have been instrumental in improving water management practices, often in the face of severe water scarcity.[3]

For instance, in Jharkhand, Akali Tudu mobilized her community to construct over 70 ponds, which significantly improved groundwater recharge and water availability for agriculture and domestic use. Similarly, Aruna Das in Assam led the establishment of Women Water User Groups (WWUGs), advocating for embankment projects that alleviated flooding risks and provided women with leadership roles in water governance.[3] These efforts not only tackled water-related challenges but also contributed to social empowerment and economic development in local communities.

In Maharashtra, Asha Komati addressed water scarcity and poor sanitation by organizing her village to develop soak pits, conduct water quality tests, and improve hygiene practices. Gayatri Sharma from Rajasthan focused on educating her community about water literacy and conservation technologies, leading to increased groundwater recharge and biodiversity restoration.[3] These women exemplify how women's leadership in water conservation is essential for sustainable development and climate resilience.

Jordan: Women as Pioneers In Water Sustainability

Jordan, one of the most water-scarce countries in the world, provides another compelling example of women's contributions to water conservation. Women in Jordan have been at the forefront of efforts to address water scarcity through knowledge sharing, community mobilization, and the adoption of sustainable water management practices.

A study conducted in Jordan highlighted the role of women in advocating for water-saving technologies such as drip irrigation and wastewater recycling. In addition, women have been instrumental in promoting the 3Rs—reducing, reusing, and recycling water—at the household level, which is essential for conserving precious water resources.[2] Women's involvement in water stewardship has also led to greater community engagement, with women often spearheading awareness campaigns on the importance of water conservation.[4]

The research further emphasizes the Importance of women's knowledge of water sustainability (KWS), which influences their attitudes toward water conservation and the adoption of sustainable water practices (SWPs).[6] Women with higher KWS are more likely to advocate for broader societal changes and to lead by example, adopting water-saving practices in their households and communities. This knowledge spans various dimensions, including sociocultural, religious, economic, and technological factors, all of which contribute to shaping women's attitudes and behaviors toward water conservation.

Global Efforts to Empower Women in Water Governance

At the global level, initiatives like the United Nations Development Programme (UNDP) and the Stockholm International Water Institute (SIWI) have recognized the importance of integrating women into water governance. [3] Programs like the National Water Mission's "Catch the Rain" campaign and the Jal Jeevan Mission in India aim to amplify women's voices in water management and acknowledge their critical role in achieving Sustainable Development Goals (SDGs).[3] Research has shown that women-led councils are more likely to prioritize water conservation projects, making them a key factor in effective water governance.

The Knowledge, Attitudes and Practices (KAP) Framework

The KAP framework is a valuable tool for understanding the role of women in water conservation. By examining women's knowledge of water sustainability (KWS), attitudes toward sustainable water practices, and the adoption of those practices, the KAP model helps to identify key areas where interventions can promote more sustainable water management.

The findings from the Jordan study revealed that women with higher KWS were more likely to adopt water-saving practices, advocate for water conservation policies, and educate others about the importance of sustainable water management.[2] The study also highlighted the critical role of water stewardship (WS) in moderating the relationship between attitudes and practices. Women involved in community-based water stewardship initiatives were more committed to sustainability, demonstrating the power of collective action in addressing water-related challenges.[2]

Barriers to Women's Participation in Water Governance

Despite their significant contributions, women face numerous barriers to full participation in water governance. These barriers include cultural norms, social expectations, economic constraints, and limited access to education and decision-making processes. In many societies, women are less likely to own land or water sources, which excludes them from water-related decision-making and governance roles.

The under representation of women in water management roles has been a significant challenge, with women comprising less than 17% of the workforce in the WASH (Water, Sanitation, and Hygiene) sector in developing countries.[12] Cultural barriers, such as restrictive gender roles and lack of access to education and leadership training further hinder women's ability to influence water policies and governance structures.[5]

Addressing these barriers is essential for creating more inclusive and effective water governance systems. Gender-inclusive policies that train women as water stewards include them in policy formulation, and remove restrictions on their participation can enhance the effectiveness of water management efforts. Involving both men and women in decision-making has been shown to improve project outcomes and sustainability.[8]

The Need for Gender-Inclusive Water Governance

Incorporating women into water governance is essential for achieving equitable and sustainable water management.[6] Gender-inclusive policies that recognize the unique needs and contributions of women can lead to more effective water governance. By empowering women to take leadership roles in water management, communities can benefit from a more holistic and comprehensive approach to water conservation.[5]

The Dublin Principles, established In 1992, recognized the importance of women in water governance and called for policies that promote women's participation at all levels of decision-making.[9] Despite global recognition, achieving gender equality in water governance remains a work in progress.[10] Empowering women through education, leadership training, and policy reforms is critical for creating a more sustainable and inclusive future.[3]

Conclusion

Women's role in water conservation is multifaceted and critical for achieving sustainable water management. From grassroots initiatives to national policies, women have demonstrated leadership in addressing water scarcity, promoting water conservation technologies, and advocating for equitable water governance. However, women continue to face significant barriers to full participation in water governance, including cultural norms, limited access to resources, and underrepresentation in decision-making roles.

By empowering women, society can unlock transformative solutions for water sustainability, fostering a culture of shared responsibility and resilience.[11] Gender-inclusive policies that promote women's participation in water governance are essential for achieving sustainable and equitable water management. As water scarcity continues to threaten communities worldwide, the role of women in water conservation becomes more vital than ever, offering hope for a more water-secure future.

Future research should explore cross-cultural studies to identify universal and context-specific drivers of water sustainability, as well as long-term studies that track behavioural changes over time. By amplifying women's voices in water governance and supporting their leadership, we can ensure that water resources are managed more sustainably and equitably, benefitting generations to come.

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Artificial Photosynthesis for Sustainable Energy

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Abstract:

The rapid increase in greenhouse gases due to burning of fossil fuel has highlighted the urgent need for sustainable energy solution. Artificial photosynthesis mix natural photosynthesis to produce renewable fuels reducing carbon dioxide from atmosphere. This Paper highlights the process of splitting of water and Carbon dioxide reduction, facilitated by Hydrogen Evolution Reaction (HER) and Oxygen Evolution Reaction (OER). Catalyst like Titanium dioxide, Platinum and Nanomaterials place a mighty role in enhancing the efficiency of the reaction. It also explores Solar -driven Reactor like Photo-thermal Oligomerization Reactor and Photo-electro Chemical Reactor which converts carbon dioxide into Hydrocarbons. This study present a transformative approach to achieve sustainable goal and carbon neutrality.

Keywords: Artificial photosynthesis, Carbon dioxide reduction, Hydrogen Evolution Reaction, Oxygen Evolution Reaction, Photothermal Oligomerization Reactor, Photo electrochemical Reactor.

Introduction:

In the current era, entire world uses about 16.3 TW of energy annually, out of which USA and EU consume 40% of it. As the world is moving towards Industrialisation, need of energy is annually also increasing and is expected to rise significantly. Reaching 20TW by 2030 doubling by 2050 and tripling by 2100 (1).

These energies comes from burning of fossil fuels. But burning of fossil fuels is harmful, releases CO_2, threatening climate stability. At the same time, it is necessary to explore new sustainable energy sources. As the sun provide an amount of energy such that one hour of energy meets global annual needs of energy. Over time, innovations like artificial photosynthesis could offer a sustainable long-term solution(1).

Large level of burning of fossil fuels and extreme level of water pollution are disturbing the level of CO_2 in atmosphere resulting in greenhouse gas emissions (2). It is the need to address the sudden climate change that is rapid increase in level of carbon dioxide causing Greenhouse gas emission(3). Solar energy reaches the earth's surface in the range of terawatt. If we convert few percent of solar energy and store it, our energy requirement will be fulfilled. Artificial photosynthesis is the mimic of natural photosynthesis to achieve the result of natural photosynthesis (2). Natural process of photosynthesis involves in conversion of solar energy into chemical energy. In order to carry out artificial synthesis catalysis is an essential aspects. In natural process of photosynthesis of plants, algae, etc. solar energy converted into glucose(4). This target is achieved by series of light induced multi electron transfer reaction (2).

Photosynthesis which occurred naturally is highly optimised as compared to artificial photosynthesis(4).The history of artificial photosynthesis started from early 1900's, when Giacomo Ciamicial proposed shifting from fossil fuels to Solar energy. Honda- Fujishima effect , where a Photo electrochemical cell which was made up of TiO_2 photo anode and Platinum cathode split water molecules into Oxygen and Hydrogen under light. Later it was demonstrated that, how semiconductor could reduce the level of CO_2 in the presence of light particles (5).

Artificial photosynthesis carries out 3 key chemical reactions such as Hydrogen evolution reaction, Oxygen evolution reaction, and reduction of carbon dioxide(3). Artificial photosynthesis could become a cornerstone of renewable energy offering reduction of carbon dioxide from atmosphere(4). It's goal is to create sustainable fuels like of hydrogen and reduce carbon dioxide. One of the important aspect of artificial photosynthesis is splitting water molecule into hydrogen gas and Oxygen gas (4).

Conversion of CO_2 into liquid solar fuels: Scientists uses liquid water molecule to convert it into hydrogen gas or carbon dioxide to convert into related products. It is carried out by Solar Driven process. It involves two reactors:

1. Photo-thermal Oligomerization Reactor
2. Photoelectric chemical reactor

In the first reactor sunlight is absorbed by a solar absorber and then it is converted into methane and propane. All these process are carried out by quartz viewpoint, vacuum insulated layer, and copper black in photo thermal oligomerization reactor. Photoelectric chemical reactor is for the use for carbon dioxide reaction. It uses sunlight and electrochemical process takes Place using Catholyte and Anolyte.

Both the reactors works together in the way that, Photothermal Oligomerization reactor convert carbon dioxide into hydrocarbons using solar energy. Photo electrochemical reactor uses sunlight to process further of hydrocarbon with the help of catholyte and anolytes.

Splitting of water molecule: It is the key process in artificial photosynthesis. It is carried out using sunlight. Following reaction is carried out throughout the process:

$2H_2O + \text{photons} \rightarrow 2H_2 + O_2$

Efficiency of energy storage in artificial photosynthesis is completely dependent upon the performance of water splitting catalyst. Catalyst have to work close to the theoretical energy level which is required to splitting water molecule into Hydrogen and Oxygen. However it is much complicated as it involves two reaction. It requires to remove four electron and four proton to create O-O bond. Role of catalyst is to manage the proton-coupled electron transfer process efficiently. It is the biggest challenge in Artificial Photosynthesis(6).

Both hydrogen evolution reaction and oxygen evolution reaction are catalyst based reaction. Titanium dioxide is used as a catalyst. In HER, protons and electrons are combined to form hydrogen gas where is in OER, water molecule is oxidised to produce Oxygen gas and protons(3). Hydrogen evolution reaction: It involves 3 Steps:

i. Volume Step
ii. Heyrovski Step
iii. Tafel Step

In volume step water molecule is reduced to form adsorbed hydrogen atom and hydroxide ion. In Heyrovski step, adsorbed hydrogen atom combines with water molecule and an electron to form molecular hydrogen. In Tafel step, two adsorbed hydrogen atom recombined to produce molecular hydrogen.

In order to design better HER catalyst, several factors like activity, selectivity, cost, stability, etc. must be considered. Platinum metal is mostly used as their exceptional activity, selectivity and stability, etc (4).

Hydrogen production involved in Biological system contains enzyme known as Hydrogenase. It have higher efficiency as it turns over rates of 1000 times per second for hydrogen production. On the other hand, it have limitations that hydrogenase enzymes are sensitive towards Oxygen(7).

Oxygen evolution reaction:

It is one of the most important step in water splitting process. In this process, water molecules are splitted to release Oxygen gas with protons and electrons. It is much complicated than hydrogen evolution reaction, as it involves transforming four protons and electron making it slower and require more energy.

Steps include in it are such that water molecule get stick to catalyst's surface, losing proton step by step forming intermediate compound. These intermediate combines to form Oxygen gas which is released. Catalyst is most important in the entire process. If it hold compounds tightly or loosely process will not work. Material such as manganese, cobalt, nickel etc. are widely used as they have a lot of active spots to make oxygen. Scientist also uses nanotechnology to create a catalyst with a large surface area having many active spots to speed up the reaction(4).

Difference between Natural Photosynthesis and Artificial Photosynthesis: In Natural Photosynthesis, plants converts sunlight into chemical energy. It involves two Stages: 1: Light dependent reaction (Light Reaction): In thylakoid membrane of chloroplast, chlorophyll pigment captures light energy in 2 systems; Photosystem 1 and Photosystem 2.

This energy excites electron which move through electron carrier forming NADPH and ATP. Water is splitted into Hydrogen, Oxygen and Electron. Oxygen is released as a by-product.

2: Light independent reaction (Dark reaction): It occurs in stroma of chloroplast. NADPH and ATP power the Calvin cycle which uses carbon dioxide to produce Glucose.

Net reaction: $6H_2O + 6CO_2 \rightarrow C_6H_{12}O_6 + 6O_2$

Artificial Photosynthesis mimics the Natural Photosynthesis and produces Hydrogen fuels and Methanol. 3 steps are involved:

i. Captures light and transport electron
ii. Split water molecule into Hydrogen and Oxygen
iii. Reduces Carbon dioxide into fuel.

Hydrogen which is produced can be used as a clean energy source which replaces fossil fuels(8).

Limitations of Artificial Photosynthesis: US department of Energy-funded project developed a high efficient solar energy up to 19.1%, one of the highest report. In 1981, an idea of using nature to capture solar energy began, but real progress only happened in last 30 years. It is known to scientists about how to split water, but reducing CO_2 is less understood. Although some catalyst are best for splitting of water, but it is too expensive.

Future research are needed to focus on improving how to convert sunlight into fuel, finding better ways to make useful products from CO_2 and to solve problem related to CO_2 (9).

Conclusion:

As we are facing challenging situations of greenhouse gas emissions, and increase in the level of Carbon dioxide, Artificial photosynthesis is mimicking the natural photosynthesis to offer a viable solution for converting solar energy into renewable fuels reducing greenhouse gas emissions. Through efficient water splitting in Carbon Dioxide reduction, it produces renewable fuels like Hydrogen and hydrocarbons using Solar-driven reactors and several advanced catalysts. Artificial photosynthesis offers sustainable pathway to meet sustainable goal while mitigating environmental impact.

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Effect of Nano Micronutrients on Priming and Morphological Growth of Maize Seeds

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Abstract

The seed priming involves the soaking of the seeds in different formulations and then germinating them under regulated environment. The Priming trial experiment was carried out at the Research and Development Laboratory of Rashtriya Chemicals and Fertilizers Ltd. in Mumbai.

Maize seeds were coated with nano micronutrient solutions, with decreasing concentrations ranging from 20 mg to 0.156 mg containing Copper, Zinc, Manganese, Iron and Boron. The objective of the study is to observe the impact of nano micronutrients by priming of maize seeds on the germination rate.

Germination rates and sprout lengths were monitored under controlled conditions. After one week the effect of nano micronutrient were recorded in which, the treatment T8 with 0.312 mg of nano micronutrients exhibited the longest sprout length. Morphological observations revealed that treatment T8 (0.312 mg nano micronutrient) also led to the highest plant height (6.81 cm), root length (17.07 cm), and leaf count (1.61). The greatest number of roots was observed in treatment T7, which used 0.625 mg of nano micronutrient.

Statistical analysis through ANOVA, with a 5% critical difference (CD), showed significant differences among the treatments. The findings suggest that the lower concentration of 0.312 mg of nano micronutrients enhances both the germination rate and plant morphology compared to the control, commercial micronutrients, and micronutrient salts.

Key words: Priming, nano micronutrients, maize, germination, statistical analysis.

Introduction

The most favourable concentration of micronutrients along with the priming of the nutrients results in increase in the growth parameters and yield. Seed priming with micronutrients like zinc, boron and molybdenum increased rate of germination and early germination in seeds. Priming with lower concentration of micronutrients gave higher results at longer priming time as compared to higher concentration. (Adornis D. Nciizah et.al 2020). Lower concentration of zinc nano particles gave better results in maize yield contributing parameters and growth of maize. Coating of zinc nano particles to the seed have been effective in zinc delivery to the plants. The environmental hazards can be minimised by applying low concentration of zinc nano particles than conventional micronutrients. (Manisha Tondey et. al 2021). Priming the seeds with the nano fertilizers increases germination and breaks the seeds dormancy. (Shivraj Hariram Nile et. al 2022). Application of the nano fertilizers increases the total biomass, phosphorus, crude protein and carbohydrates. Application of nano iron and zinc increases chlorophyll and plant height. (Rozhin Sharifi et al 2016).

The priming of the seeds with the copper nano particles do not show toxic effect on maize seeds as compared to the bulk copper oxide and copper chloride treatment. The biomass was also high in copper nano particles treatment. However, the copper chloride treatment showed toxic effects on roots and shoots of maize. (Desenvolvimento et. Al 2020). Application of nano urea with recommended dose of fertilizer gave higher results in protein, carotenoid chlorophyll along with economic returns like gross income, benefit to cost ratio and net income. (Upasna et. al 2023). Nano priming with magnesium nano particles increases the rate of germination and development of nano pores which helps in absorption of the water. There is change in seed metabolism and increase in aquaporin genes expressions. (Sananda Mandal et al. 2023).

Seed priming can bring effective change in the plant metabolism to grow the plant faster in different environments. The nano priming toxicology study is the need for the future to living beings and human health. (Nidhi Kandhol et al 2022). The nano priming on seeds can resist with saline tolerance and resistant to disease. It can have high germination rate, Vigor and increase in the rate of photosynthesis. However, there are very few studies to intake of nano materials and accumulation. (Jisun H. J. Lee et al 2024). Pakistan is a zinc deficient country in which the concentration of 4% with priming gave high growth parameters results and yield. The mineral content also increased with priming of the zinc. (Ali raza et al 2023). Priming of the seeds with the nano particles enhances the electron transport and surface reactions of plant cells and tissues. It also enhances seed germination. (Shivraj Hariram Nile et al 2022). The selection of the appropriate concentration of the nano fertilizers for priming of the maize seeds is important which can also cause the inhibition of the germination rate of the priming. The concentration of the 80 mg/ litre shows the high seed germination rate, root length and biomass. (Michel Esper Neto et al 2020). Agar technique is an alternate substrate to the paper where germination can be calculated with growing the seeds in the agar and the root length and shoot length is noticed. (Rao et al 2006).

In the view the laboratory experiment was performed to see the effect of the nano micronutrient priming on the maize seeds on the rate of the germination and the plant growth parameters were measured.

Materials and methods

The laboratory experiment of priming trial was carried in the Research and Development centre (nano technology Laboratory) at Rashtriya Chemicals and Fertilizers Ltd. Chembur in the state of Maharashtra in southern part of the Mumbai with latitude of 19.034434 and longitude of 72.890891 with the total of the eleven treatments in duplicates. The maize seeds were surface sterilized by 0.1% Mercuric chloride solution for 30 minutes and afterwards washed with the distilled water 2 to 3 times. Further the seeds were soaked for one hour in different formulations of nano micronutrients as a priming agent ranging from 20 mg to 0.156 mg with water as control. The nano micronutrients were synthesized in a laboratory by mechanical method and further characterized for particle size, zeta potential, XRD, IR and FE SEM. Then the seeds were transferred to the sterilized Petri plates within the towels of the filter paper. Each Petri plate contained 5 seeds. The seeds were watered every day in each Petri plates. The amount of the water added was 1 ml per Petri plate. The Petri plates were kept in the incubator to about 24 to 28degree Celsius. The sprout length was measured after one week and the no. of seeds germinated was recorded.

After a week the seeds were transferred to the water agar tubes containing 1.8% agar solution. The tubes along with the water agar were sterilized and allowed to cool. After cooling the germinated seeds were transferred into the agar tubes for the development of the roots and shoots from maize seeds. The physical morphological characteristics like plant height, root length, no. of roots and number of leaves were measured. The samples of maize plants were dried for estimation of nitrogen, phosphorus, potassium and multielement like copper, zinc, manganese, iron and boron. The treatments are as follows:

Table 1: Treatment details:

Sr. No.	Dose	Treatment
1	T1 ABC	Absolute Control
2	T2 ABC	20 mg mixed Nano micronutrient
3	T3 ABC	10 mg mixed Nano micronutrient
4	T4 ABC	5 mg mixed Nano micronutrient
5	T5 ABC	2.5 mg mixed Nano micronutrient
6	T6 ABC	1.25 mg mixed Nano micronutrient
7	T7 ABC	0.625mg mixed Nano micronutrient
8	T8 ABC	0.312mg mixed Nano micronutrient
9	T9 ABC	0.156 mg mixed Nano micronutrient
10	T10 ABC	Micronutrient gr II foliar
11	T11 ABC	Salts of micronutrients

The rate of the germination is calculated by following equations,

1. Germination Rate = $\text{No. of germinated seeds} / \text{Total no. of seeds} * 100$
2. Germination Index = $\sum Gt/Dt$
3. Germination Vigor = No.of seeds germinated during the peak period of germination / total no.of seeds*100
4. Inhibition rate = (Values of treatment-ck)/Value of treatment*100

Results and discussion

Table 2: Effect of nano micronutrient priming on growth parameters:

Treatment	Plant height (cm)	No. of leaves	No. of roots	Root length (cm)
T1	1.58	1	6.22	7.14
T2	1.1	1	1.83	1.76
T3	2.01	1	2.83	2.44
T4	1.79	1	9.44	5.14
T5	2.97	1	9.88	8.72

T6	2.76	1	8.11	7.1
T7	3.9	1.33	11.8	13.34
T8	6.81	1.61	8.72	17.07
T9	4.33	1.22	8.88	11.56
T10	4.26	1.11	7.11	11.64
T11	1.46	0.86	2.2	3.46
SE +-	0.47	0.098	0.44	0.95
CD 5%	1.38	0.28	1.29	2.8

The Table 2 shows the plant growth parameters in which the plant height, no. of leaves and root length was maximum in treatment T8 with 0.312 mg nano micronutrient while no. of roots was maximum in treatment T7 with 0.625 mg of nano micronutrient. Statistical analysis using ANOVA showed the significant difference between the treatment and control

Treatment	Plate 1 Germination (number)	Plate II Germination (number)	Average	Germination rate (%)	Germination index	Germination Vigor
T1	3	5	4	80	0.57	126.4
T2	3	4	3.5	70	0.5	77
T3	4	4	4	80	0.57	160.8
T4	4	5	4.5	90	0.64	161.1
T5	5	5	5	100	0.71	297
T6	5	3	4	80	0.57	220.8
T7	5	5	5	100	0.71	390
T8	5	5	5	100	0.71	681
T9	5	5	5	100	0.71	433
T10	5	4	4.5	90	0.64	383.4
T11	4	2	3.5	70	0.5	102.2

Table 3 Effect of nano micronutrients on rate of germination:

The Table 3 shows rate of germination and germination index was higher in treatment T5, T7, T8 and T9 containing 2.5, 0.625, 0.312 and 0.156 mg of nano micronutrients. The germination Vigor was higher in treatment T9 with 0.156 mg nano micronutrients.

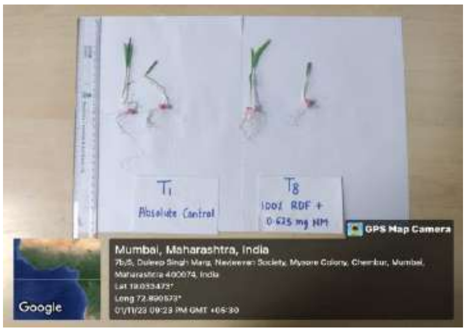

Fig. 1 Comparative image of control

Fig. 2 Comparative image of control and 0.156 mg and 0.312 mg NM

Fig. 3 Control rate of germination

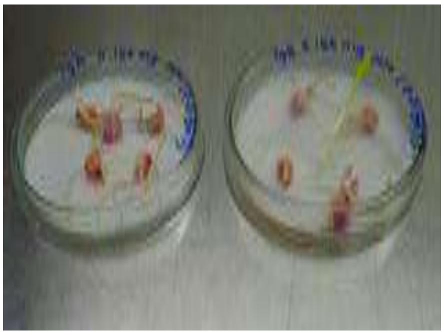

Fig. 4 0.312 mg NM rate of germination

Table 4 Effect of nano micronutrient on biomass weight:

Treatment	Biomass weight (gm)
T1	8.26
T2	9.5
T3	13.5
T4	14.2
T5	15.5
T6	14.6
T7	15.8
T8	17.5
T9	15.3
T10	14.9
T11	10.1

The biomass weight was higher in treatment T8 containing 0.312 mg nano micronutrient.

Table 5 Concentration of the nano micronutrients in dry matter of maize:

Treatment	Boron ppm	Copper ppm	Iron ppm	Manganese Ppm	Zinc ppm
T1	4.72	4.50	230.64	10.4	61.39
T2	8.42	10.14	250.33	20.14	75.04
T3	19.46	26.46	973.07	19.06	90.89
T4	17.9	58.00	1424.44	22.42	302.39
T5	24.24	11.65	277.59	29.36	115.94
T6	20.08	10.11	280.72	28.76	98.06
T7	11.70	9.53	672.34	59.06	78.5
T8	39.67	48.7	423.51	60.08	304.85
T9	14.93	8.13	656.34	18.87	76.1
T10	9.10	13.40	215.00	25.48	73.6
T11	5.464	6.04	271.67	36.13	140.81

The Table 5 represents the amount of the micronutrients present after development of roots and shoots in water agar. The Boron and Copper was high in treatment T8 with 0.312 mg of nano micronutrient. Iron was high in treatment T4 with 5 mg of nano micronutrient while Manganese and Zinc was higher in treatment T8 with 0.312 mg nano micronutrients.

The effect of the priming of nano micronutrients on maize seeds were higher in the treatment T8 with 0.312 mg of nano micronutrients in plant growth parameters like plant height, root length and number of leaves whereas the number of roots was higher in treatment T7 with 0.625 mg of nano micronutrients. The priming with the nano micronutrients improves the plant height and root length and biomass. (Rozhin Shrifi et al 2016). The rate of germination and germination index were higher in the concentrations like 2.5, 0.625, 0.312 and 0.156 mg of nano micronutrients. Abiyu Enyew Molla et al 2015). The germination Vigor was higher in 0.312 mg of nano micronutrient along with the weight of biomass. (M B Abadia et al 2024). The higher concentration of the nano micronutrients like copper, zinc, iron, manganese and born were found in 0.312 mg and other concentrations which are lower concentration of nano micronutrient. (T.D. Setiyono et al 2010). Seeds primed with the nano micronutrients shows higher rate of germination and growth of the seeds. (Prerna et al 2021).

Conclusions

The nano micronutrients applications as a priming increases the vegetative growth of the maize crop. The priming with the nano micronutrients proves to increase the availability of the nano micronutrients to the seeds thus increases the rate of germination. The lower concentration of nano micronutrients is beneficial to both crops and farmers, as it helps enhance the growth and health of the plants while ensuring a high nutritive value in the produce. Additionally, these micronutrients are cost-effective, making them an affordable option for farmers to improve crop yield and quality without significant financial investment. Due to less dosage of the nano micronutrients applied there will be less loss of the fertilizers and increases the soil fertility and maintained. The extensive use of conventional fertilizers is significantly reduced, leading to more efficient and sustainable farming practices. By applying lower concentrations of fertilizers, the nutrient uptake by crops becomes more effective, allowing plants to absorb the necessary nutrients in optimal amounts. This results in healthier crops and higher-quality produce, while also minimizing environmental impact and reducing the overall cost of farming.

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Comparative Antimicrobial Study of Probiotics *Lactobacillus casie* (CFS), Mint Extract and Common Detergent on Isolates from Currency Notes

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Abstract

The study finding indicates that Indian currency notes often harbor pathogenic microorganisms, thus possibly being vectors for infectious disease transmission. Samples of currency notes from different origins were analyzed and showed the presence of widespread contamination with pathogenic microorganisms. Interestingly, contamination was found to be less in bank notes compared with those acquired from other places. It further shows that lactobacilli and mint extract have higher antimicrobial efficiency than commercial detergents and sanitizers. Thus, these results indicate better hygiene practices in currency notes handling and also hint towards the capabilities of natural antimicrobial agents to reduce microbial contamination.

Key words: Currency notes, Infectious diseases, Contamination Lactobacilli, Antimicrobial agents.

Introduction

Micro-organisms are known to spread via air, water, food, etc. an important mechanism of the spread of pathogens by fomites. Paper currencies are widely exchanged for goods and services in countries worldwide and may carries various deadly pathogenic micro-organisms. Currency in the form of notes represents a universal medium for the transmission of microbes in the environment and among humans. In addition, currency notes have also been evaluated for their potential to transmit infectious pathogens and have been documented to cause infections in eye, skin, gastrointestinal tract, internal organs as well as respiratory tract in humans.

Although several studies on the hygiene status of some the world's currencies have been carried out elsewhere, data on the microbial contamination of currency in India is scanty Therefore there is an unmet need to find new antimicrobial agents from the natural sources such as Cell Free Supernatant from probiotic lactobacillus and mint extract instead of commercial detergents Lactic acid bacteria (LAB) are a group of gram-positive bacteria, non-spore forming, cocci or rods which produce a major end product during the fermentation of carbohydrates. The majority of microorganisms used as probiotics belongs to the LAB, within the group of LAB, *lactobacilli* species are the most commonly utilized group of microorganisms due to their potential beneficiary properties as probiotics and have antagonistic activities against large number of pathogens. *Mentha piperita L.*, a medicinally important plant belongs to the Family Lamiaceae and commonly known as peppermint. Peppermint and its oil have been used as an antispasmodic, aromatic, antiseptic and also in the treatment of cancers, indigestion and possesses antibacterial, antiviral and fungicidal activities activity in vitro. Different commercial preparations exhibit various activities Peppermint oil and menthol have moderate antibacterial effects against both Gram-positive and Gram-negative bacteria. Therefore, there is a need to focus on the following objectives:

- To study the bacterial contamination of the currency exposed to different areas in Bhiwandi, Thane.
- To determine and compare the antimicrobial effect of cell free supernatant (CFS) of Lactobacillus, mint extract and some detergents on these isolates from currency notes.

Review of Literature

Paper money is one of the important things in international trade as well as commerce, originally introduced from China during Five Dynasties period (1050-1450 AD), which developed to European countries in seventeen century (Ramsden, 2004). Paper notes are usually made from a linen-cotton mixture, able to serve for long circulation runs (Gadsby, 1998). But on the other hand, paper currency also represents a significant means for the entry of microbial contamination and so it raises questions about the contribution of this currency towards infectious disease transmission. The results depict that the currency notes contain frequently different pathogens like *Escherichia coli*, *Salmonella spp.*, and *Staphylococcus aureus*, which survive up to longer periods on the surface (Pope et al., 2002; El-Dars & Hassan, 2005). The bacteria on paper money can be transmitted by direct or indirect contact and the old and worn bills are able to provide more surface for the microbial growth (Podhajny, 2004).Research from various places like India, Egypt, and Turkey have shown the bacterial contamination of paper money, with some studies stating up to 96% of currency notes harboring pathogens (Basavarajappa et al., 2005; Goktas & Oktay, 1992). Another significant isolation was that of antibiotic-resistant bacteria, which calls to the fore the possibility that money can spread antimicrobial resistance (Pope et al., 2002). Factors like environment and the activities prior to the handling of currency impact the microbial load on paper money (Michael, 2002). Some of the bacteria isolated, including *E coli* and *Staphylococcus aureus* is present, but currency notes could still harbor other pathogens causing gut, respiratory, and other kinds of skin infections. Some possible remedies utilized natural antimicrobial agents would include *Lactobacillus* which were probiotic bacteria, besides an extract of the plant *Mentha piperita*, commonly an herb with antibacterial use to eliminate contamination on money. They may one day be a substitute for commercial disinfectants, which would more safely reduce microbial risks that come with paper money. Thus, there is a constant danger in using contaminated currency and a need for research that could develop effective means for the reduction of spread through paper notes.

Material and Methodology

Collection of Sample

Six Indian currency notes of ₹10 were collected from the hospital, dairy, vegetable vendor, butcher, stationary shop and bank. The notes were then transferred into sterile plastic bags under aseptic conditions.

Isolation and Identification of Organisms

1. Processing of Sample

- Sterile cotton swabs dipped in sterile saline were rubbed on both sides of the notes.
- The aseptic inoculation of swabs on to Nutrient Agar and Sabouraud Dextrose Agar plates and incubation at 37°C for 24 hours was done.

2. Identification

- Transfer to identification media.
- Gram staining, sugar fermentation, and biochemical tests were carried out as per Bergey's Manual for morphological characterization.
- Cultural properties such as margin, size, form, and texture (for example mucous, smooth, or rough) were observed.

3. Preparation of Cell-Free Supernatant of Lactobacilli:

1. To prepare an inoculum, probiotic lactobacilli powder was inoculated in sterile saline.
2. A loopful of inoculum was streaked onto MRS agar and incubated at 37°C for 24 hours.
3. Well-isolated colonies were transferred to 20 mL sterile MRS broth and incubated at 37°C for 48 hours.
4. Bacterial cells were removed via centrifugation (2000 rpm, 20 min, twice).
5. The pH of the supernatant was adjusted to 6.5–7.0 using 1N NaOH and then membrane-filtered.

4. Preparation of Test Solutions

1. Detergent Suspension:

- 3 g common detergent dissolved in 10 ml distilled water.

2. Dettol Suspension:

- 3 ml Dettol sanitizer diluted with 10 ml distilled water.

3. Mint Extract:

- 25 g powder mint leaves were mixed with 250 ml ethanol and shaken for 24 hours on rotary shaker.
- Solution was filtered using Whatman filter paper no. 1.

5. Comparative Antimicrobial Assay (Agar Well Diffusion Method)

1. Procedure:

- Isolated organisms were swabbed onto Mueller-Hinton Agar plates.
- 5 mm wells were punched using a sterile cork borer.
- CFS, mint extract, detergent suspension, and Dettol solution were added to the wells.
- Plates were kept at low temperature for 30 minutes and then incubated at 37°C for 24 hours.

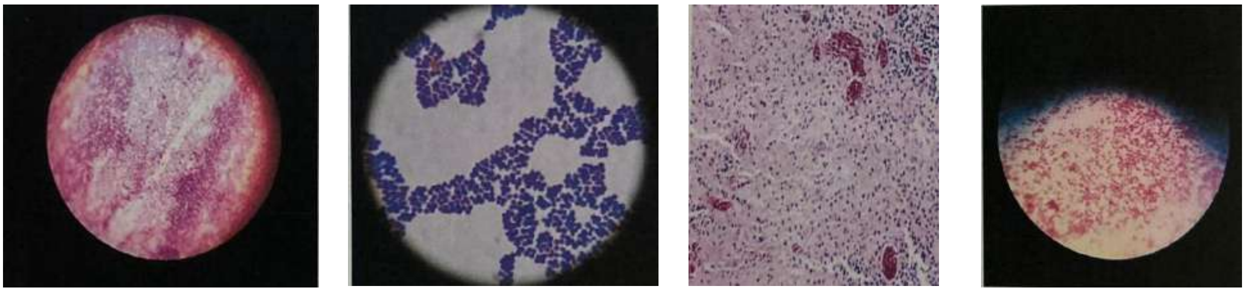
2. Observation: Antimicrobial activity was measured by the zone of inhibition (in mm) around each well.

Results

SAMPLES

Isolates from Currency Notes

Sr. no.	Organisms	Gram nature
1	*E.coli*	-ve
2	*S.aureus*	+ve
3	*Klebsiella pneumoniae*	-ve
4	*Salmonella typhi*	-ve



Microscopic Images of the Isolates

Isolates from the Samples:

Sr. No.	Source	Pathogens Identified
1	Hospital	***Salmonella typhi***
2	Dairy	***S.aureus E.coli, Klebsiella pneumoniae***
3	Vegetable vendor	***S.aureus E.coli, Klebsiella pneumoniae***
4	Butcher	***S.aureus E.coli,***
5	Stationary	***S.aureus E.coli, Klebsiella pneumoniae***
6	Bank notes	Least contaminated

Samples: Lactobacilli CFS, Detergent, Dettol, Mint Extract

Zone of Inhibition (mm):

Sr. No.	Isolates	Lactobacilli CFS	Detergent	Dettol	Mint
1	***E.coli***	22mm	18mm	-	12mm
2	***S.aureus***	13mm	12mm	-	-
3	***Klebsiella pneumoniae***	-	-	-	-
4	***Salmonella typhi***	-	16mm	-	-

Zone of inhibition: ***E.coli, S.aureus, Klebsiella pneumoniae, Salmonella typhi***

Discussion

In Bhiwandi, improper currency handling, such as squeezing and poor storage, significantly contributes to contamination and increases the risk of infection. Paper currency frequently carries pathogenic microorganisms, which can spread diseases like cholera, diarrhea, skin infections, respiratory illnesses, and gastrointestinal issues. Some of these pathogens may also show resistance to antibiotics.

An examination of currency notes revealed contamination by *E. coli, S. aureus, Klebsiella pneumoniae,* and *S. typhi.* Hospital notes were contaminated with *S. typhi,* while notes from dairies, vegetable vendors, butchers, and stationery shops carried *S. aureus, E. coli,* and *Klebsiella pneumoniae.* Banknotes had the least contamination. The presence of microorganisms is linked to moisture on the notes, which creates favorable conditions for microbial growth. These findings highlight the potential of currency to act as a carrier for pathogens in the community, given its frequent handling in daily life.

Antimicrobial testing showed that common detergent effectively eliminated all isolates. Probiotic lactobacilli CFS and mint extract were selectively effective against *E. coli* and *S. aureus,* while commercial disinfectants, including Dettol, had no significant effect. These results differ from previous studies, where lactobacilli CFS inhibited other pathogens, possibly due to variations in laboratory conditions or microbial resistance. This study emphasizes the need for better currency hygiene and highlights the potential use of natural antimicrobials like lactobacilli CFS and mint extract for safer disinfection methods.

Conclusion

This study concludes that Indian currency is generally contaminated with pathogenic microorganisms, which could play a significant role in the transmission of infectious diseases. The notes collected from the banks showed the least contamination, while those from the butchers, hospitals, vegetable vendors, dairies, and stationery shops showed higher levels of microbial presence. The study highlights that CFS of lactobacilli and mint extract have potential as a natural antimicrobial agent and demonstrates effectiveness against certain pathogens whereas commercial disinfectants, such as Dettol, failed to inhibit the isolates. The observations thus suggest that CFS and mint extract could be safer alternatives to chemical detergents and sanitizers for currency note decontamination. Currency notes should be used with care, especially around food, and personal hygiene practices when handling money and food should also be emphasized. Food salespersons, butchers and others should be educated as to how to prevent money from coming into contact with food, and public awareness campaigns should highlight the health risks that can be posed by contaminating the notes. Regular microbial testing of currency and a system for replacing contaminated notes are also required. The use of plastic currency notes, which are easier to clean, should be considered as an alternative to traditional paper notes.

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In vitro determination of drought tolerance capacity on cereals and pulses

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Abstract

Drought is one of the most important and naturally occurring disasters on the agricultural land. Many of the framer does not cultivate the crop because of drought condition leads to the improper growth and development of crops. To avoid drought, water is an essential environmental factor, for the growth of crop from seed germination to the various stages of the growth of crops. By our experiment, PEG use as to create a drought condition is acting a controlling water potential in seed germination. Drought stress inhibits the hypocotyl length, it affects the root, shoot length, significantly reduced the germination parameters and seedling related traits. Ion availability of the crop changes and decrease in the drought condition. It was concluded that the inhibition in germination at equivalent water potentials of PEG was mainly due to an osmotic effect.

Keywords: Drought stress; Polyethylene glycol (PEG); Root length; Germination percentage; Seedling growth; Drought tolerance index (DTI); Crops; Environmental factors; Water stress.

Introduction

Drought a meteorological event which involves the absence of raindrops for a period of time, long enough to cause moisture-depletion in soil and water-deficit with diminishing of water potential in plant tissues (*Mitra 2001*). Abiotic stresses like drought stress, heat, cold, temperature, salinity and water logging have antagonistic effects on crop productivity and causes severe agriculture losses predominantly in arid and semi arid tropic region like India. Water availability is valuable environmental factors influencing seed germination as it triggers the germination process and remains involved, directly or indirectly (*Kumar et al., 2011).* Seed germination and early seedling growth are considered as most critical phases for seed establishment, determining successful crop production.

Barley (Hordrum Vulgare), Chana (Cicer arietinum), Matki (Vigna aconitifolia), Moong (Vigna radiata), White pea (Lathyrus sativum), Green pea (Pisum sativum) is considered to the most important crop worldwide, largely due to its exceptional adaptations towards growing in a variety of different environmental conditions. Barley is particularly able to adapt to diverse conditions, such as drought and salt compared to other (Thabet et al., 2018). White pea (Lathyrus sativum), Green pea (Pisum sativum) is an annual plant in the family Fabaceae, grown virtually worldwide for its edible seeds. It is one of the major grain legumes of the crops of the tropics and subtropics (Karjol et al., 2011). Chana (Cicer arietinum), Methi (Trigonella foenum), Moong (Vigna radiata) and Matki (Vigna aconitifolia). Vigna aconitifolia is a drought resistant legume commonly grown in arid and semi-arid regions of India.

As seed germination and early seedling growth responses are critical phases to establish stress tolerance cultivars, there is need to study these responses to improve present yield (Kumara et al., 2011). PEG (polyethylene glycol) is commonly used to stimulate osmotic stress effect, to control water potential in seed germination studies. The non-toxic PEG solution is used because of high molecular weight and can't pass through plant cell walls (Kaydan et al., 2007). The aim of the present study, therefore, aims at studying the genetic variation of seed germination related-traits under artificially induced-drought stress conditions in order to identify the genetic factors controlling the variation in these traits.

Materials and Methods

The cereal samples like Barley (Hordrum Vulgare), Chana (Cicer arietinum), Matki (Vigna aconitifolia), Moong (Vigna radiata), White pea (Lathyrus sativum), Green pea (Pisum sativum) and Methi (Trigonella foenum) were collected from the local grocery store in Bhiwandi, Thane, and Maharashtra.

Germination test of seeds under drought condition

For the germination test, the all types of seeds per phenotype were randomly selected. The all types of 10 seeds are placed on wetted filter paper in 9cm diameter petri plates in order to evaluate the fleshing out and phenotypic variation in seedling related traits among genotypes. Abiotic stress was induced by adding PEG-3350 at a concentration of 1%, 5%, 10%, 15% and 20%. Without PEG distilled water used as a control (unstressed seeds). The petri plates were placed at 30°C in the darkness. The seeds were considered as germinated when the radical arrive at least 2-3mm in length. Germination was scored at 24 hour intervals for 10 consecutive days. In total germination and growth performance related traits were scored as.

Germination parameters were determined according to International Seed Testing Association rules (ISTA) as follows:

Germination percentage is expressed as (G %) = n / N × 100

Where, n is the number of germinated seeds at the end of the experiment and N is the total number of sown seeds.

Table 1: The name and abbreviation of measured traits and respective description of measurements.

Trait	Name	Measurement description
G%	Germination percentage	(G %) = n÷N×100, n is the number of germinated seeds at the end of experiment, N is the total number of seeds.
GP	Germination Pace	(GP) = N ÷ (n×g) ×100, N is the number of germinated seeds at the end of experiment, n is the number of newly germinated seed at certain day g, g = (1, 2, 3….)
DTI (G %)	Drought tolerance index(germination percentage)	DTI (G %) = G% under drought ÷ under control ×100
DTI (GP)	Drought tolerance index(germination pace)	DTI (GP) = GP under drought ÷ GP under control ×100
Reduction G %	Reduction Germination percentage	Reduction of G% =G% under control - G% under drought
Reduction GP	Reduction Germination percentage	Reduction of GP=GP under control -GP under drought
RL	Root Length	Root length was measured a scaled ruler(in cm)
Reduction RL	Reduction Root Length	Reduction of RL= RL under control -RL under drought
RL DTI	Root Length Drought tolerance index a	RL DTI= RL under drought÷ RL under control ×100

Results and Discussion

Collection of sample

The samples like Chana (Cicer arietinum), White pea (Lathyrus sativum), Green pea (Pisum sativum), Moong (Vigna radiata), Matki (Vigna aconitifolia), Methi (Trigonella foenum) and Barley (Hordeum vulgare) were collected from local grocery stores in Bhiwandi (Maharashtra.

Processing of sample

Phenotypically similar seeds of all the samples were randomly selected. Seeds were placed on wetted filter paper in petri plates to evaluate growth performance. PEG-3350 was added to induce drought stress at different concentration while distilled water was used as a control. The plates were at 30°C in the darkness. The seeds were considered as germinated when the radical reached at least 2-3mm in length. Germination was scored at 24 hours intervals for 9 consecutive days.

Germination test of seeds under drought condition

A large phenotypic variation for all traits was found under control condition as well as under induced drought. The germination responses of all seed accessions at different level of drought potential and various attributes resulting to germination and early seedling growth are presented in table 2, 3, 4, 5, 6 and 7.

Table 2: Observed phenotypic mean value under 20% PEG

Traits	*Cicer arietinum*	*Trigonella foenum*	*Lathyrus sativum*	*Pisum sativum*	*Vigna radiata*	*Vigna aconitifolia*
G %	50	80	80	90	90	90
GP	21.7	25	22.8	20.4	16.2	18.7
DTI (G %)	55.5	80	160	90	90	90
DTI(GP)	149.6	85	123.2	91.8	56.8	65.6
Reduction (G %)	40	20	30	10	10	10
Reduction (GP)	7.2	4.4	4.3	1.8	12.3	9.8
RL	2.9	3	3	2.7	11.5	3.8
DTI(RL)	82.8	75	75	81.8	383.3	63.3
Reduction (RL)	0.6	1	1	0.6	8.5	2.2

The similar result for G% was observed by Thabet et al., 2018 which showed 72% for Barley (Hordeum vulgare); Kumar et al., 2011 showed 50% for Pigeon pea (Cajanus Cajan [L.] mills); and Gamze et al., 2005 showed 65% for Pea (Pisum sativum). The germination parentage was similar to Thabet et al., 2018 which showed 0.63 for Barley (Hordeum vulgare). And the DTI-G%, Reduction G%, DTI-GP and Reduction GP is similar to Thabet et al., 2018 showed 84.50%, 15%, 71.82 and 0.24 for Barley (Hordrum vulgare). With respect to root length, Thabet et al., 2018 showed 9 for Barley (Hordrum vulgare); Bibi et al., 2012 showed 4.47 for Sorghum (sorghum bicolor) and Roy et al., 2009 which showed 9.30 for bold grained rice (Oryza sativa), which were approximately consistent with the results of present research. The DTI-RL was similar to Thabet et al., 2018 showed 58 for Barley (Hordrum vulgare). Similar reduction in root length was observed by Thabet et al., 2018 which showed 7.9 for Barley (Hordeum vulgare) and Bibi et al., 2012 which showed -1.03 for sorghum (sorghum bicolor) which stayed analogous to present research.

Table 3: Observed phenotypic mean value under 15% PEG

Traits	***Cicer arietinum***	***Trigonella foenum***	***Lathyrus sativum***	***Pisum sativum***	***Vigna radiata***	***Vigna aconitifolia***
G%	70%	70%	80%	90%	100%	90%
GP	20.5	21.2	22.2	23.6	22.2	19.5
DTI (G %)	77.7	70	160	90	100	90
DTI(GP)	141.3	72.1	120	106.3	77.8	68.4
Reduction (G %)	20	30	30	10	0	10
Reduction (GP)	6	8.2	3.7	1.4	6.3	9
RL	2.9	2.9	3	2.9	8	5
DTI(RL)	80	72.5	75	87.8	266.6	83.3
Reduction (RL)	0.7	1.1	1	0.4	5	1

The similar result for G% was observed by Kumar et al., 2011 showed 50% for Pigeon pea (Cajanus Cajan [L.] mills); and Gamze et al., 2005 showed 65% for Pea (Pisum sativum). With respect to root length, Bibi et al., 2012 showed 4.47 for Sorghum (sorghum bicolor) and Roy et al., 2009 which showed 9.30 for bold grained rice (Oryza sativa), which were approximately consistent with the results of present research. Similar reduction in root length was observed by Thabet et al., 2018 which showed 7.9 for Barley (Hordeum vulgare) and Bibi et al., 2012 which showed -1.03 for sorghum (sorghum bicolor) which stayed analogous to present research.

Table 4: Observed phenotypic mean value under 10% PEG

Traits	***Cicer arietinum***	***Trigonella foenum***	***Lathyrus sativum***	***Pisum sativum***	***Vigna radiata***	***Vigna aconitifolia***
G%	80	70	70	100	100	80
GP	25.8	24.1	21.8	20.4	22.7	23.5
DTI (G %)	88.8	70	140	100	100	80
DTI(GP)	177.9	74.4	117.8	91.8	79.6	82.4
Reduction (G %)	10	30	20	0	0	20
Reduction (GP)	11.3	5.3	3.3	1.8	5.8	5
RL	3cm	3.2cm	3	2.9	9.5	5.9
DTI(RL)	85.7	80	75	87.8	316.6	98.3
Reduction (RL)	0.5	0.8	1	0.4	-6.5	0.1

The similar result for G% was observed by Kumar et al., 2011 showed 50% for Pigeon pea (Cajanus Cajan [L.] mills); and Gamze et al., 2005 showed 65% for Pea (Pisum sativum). With respect to root length, Bibi et al., 2012 showed 4.47 for Sorghum (sorghum bicolor) and Roy et al., 2009 which showed 9.30 for bold grained rice (Oryza sativa), which were approximately consistent with the results of present research. Similar reduction in root length was observed by Thabet et al., 2018 which showed 7.9 for Barley (Hordeum vulgare) and Bibi et al., 2012 which showed -1.03 for sorghum (sorghum bicolor) which stayed analogous to present research.

Table 5: Observed phenotypic mean value under 5% PEG

Traits	***Cicer arietinum***	***Trigonella foenum***	***Lathyrus sativum***	***Pisum sativum***	***Vigna radiata***	***Vigna aconitifolia***
G%	80	90	60	100	100	80
GP	25.8	21.9	23	21.7	24.2	25.8

DTI (G %)	88.8	90	120	100	100	80
DTI(GP)	177.9	74.4	124.3	97.7	937.8	90.5
Reduction (G %)	10	10	10	0	0	20
Reduction (GP)	11.3	7.5	4.5	0.5	4.2	2.7
RL	3.2	3.5	3.1	2.9	10	6
DTI(RL)	91.4	87.5	77.5	87.8	33.3	100
Reduction (RL)	0.3	0.5	0.9	0.4	7	0

The similar result for G% was observed by Thabet et al., 2018 which showed 72% for Barley (Hordeum vulgare); Kumar et al., 2011 showed 50% for Pigeon pea (Cajanus Cajan [L.] mills); and Gamze et al., 2005 showed 65% for Pea (Pisum sativum). With respect to root length, Bibi et al., 2012 showed 4.47 for Sorghum (sorghum bicolor) and Roy et al., 2009 which showed 9.30 for bold grained rice (Oryza sativa), which were approximately consistent with the results of present research. Similar reduction in root length was observed by Thabet et al., 2018 which showed 7.9 for Barley (Hordeum vulgare) and Bibi et al., 2012 which showed -1.03 for sorghum (sorghum bicolor) which stayed analogous to present research.

Table 6: Observed phenotypic mean value under 1% PEG

Traits	*Cicer arietinum*	*Trigonella foenum*	*Lathyrus sativum*	*Pisum sativum*	*Vigna radiata*	*Vigna aconitifolia*
G%	80	90	60	100	100	90
GP	30.7	29	23	23.6	21.7	24.3
DTI (G %)	88.8	90	120	100	100	80
DTI(GP)	211.7	98.6	124.3	106.3	76.1	85.2
Reduction (G %)	10	10	10	0	0	10
Reduction (GP)	16.2	0.4	4.5	1.4	6.8	4.2
RL	3.5	3.8	3.2	3	12	7.2
DTI(RL)	100	95	80	90.9	933.3	120
Reduction (RL)	0	0.2	0.8	0.3	-10	-1.2

The similar result for G% was observed by Thabet et al., 2018 which showed 72% for Barley (Hordeum vulgare); Kumar et al., 2011 showed 50% for Pigeon pea (Cajanus Cajan [L.] mills); and Gamze et al., 2005 showed 65% for Pea (Pisum sativum). With respect to root length, Bibi et al., 2012 showed 4.47 for Sorghum (sorghum bicolor) and Roy et al., 2009 which showed 9.30 for bold grained rice (Oryza sativa), which were approximately consistent with the results of present research. Similar reduction in root length was observed by Thabet et al., 2018 which showed 7.9 for Barley (Hordeum vulgare) and Bibi et al., 2012 which showed -1.03 for sorghum (sorghum bicolor) which stayed analogous to present research.

Table 7: Observed phenotypic mean value in control

Traits	*Cicer arietinum*	*Trigonella foenum*	*Lathyrus sativum*	*Pisum sativum*	*Vigna radiata*	*Vigna aconitifolia*
G%	90	100	50	100	100	100
GP	14.5	29.4	18.5	22.2	28.5	28.5
RL	3.5	4	4	3.3	3	6

The similar result for G% was observed by Thabet et al., 2018 which showed 87% for Barley (Hordeum vulgare); Kumar et al., 2011 showed 50% for Pigeon pea (Cajanus Cajan [L.] mills); and Gamze et al., 2005 showed 76.6% for Pea (Pisum sativum). With respect to root length, Bibi et al., 2012 showed 4.47 for Sorghum (sorghum bicolor); Roy et al., 2009 which showed 9.30 for bold grained rice (Oryza sativa) and Thabet et al., 2018 showed the 16.8 for Barley (Hordrum vulgare), which were approximately consistent with the results of present research.

Drought stress suppressed shoot growth more than root growth and in certain cases root growth, increased Okcuet al., 2005. Reduction in seedling growth is the result of restricted cell division and enlargement, as drought stress directly reduces growth by decreasing cell division and elongation Kramer et al., 1983. Roots are the place where newly growing plants firstly affected by water stress, it is likely that the roots may be able to sense and respond to the stress condition Xiong et al., 2006

Reduction in shoot and root length and diminishing of plant growth, perhaps due to less water absorption and decrease in external osmotic potential created by PEG (poly ethylene glycol) but the higher root shoot length than the susceptible lines, which may have been responsible for their higher leaf water potential in the stressed environments. Yammer and Kaydan et al., 2008. Drought has drastically affected fresh shoot and root weight in some cultivars of Chana, Methi, White pea, Green pea, Moong, Matki and barley.

The germination responses of all types of seeds at different level of osmotic potential and various attributes resulting to germination and early seedling growth. Various parameters were recorded under drought stress condition such as germination percentage, Germination Pace, DTI (G %), DTI (GP), Reduction G %, Reduction GP, RL, DTI-RL, Reduction RL and FW.

PEG induced drought stress or significantly affected the final germination in all traits. Maximum seed germination was experiencing under control condition and germination in untreated seeds was rapid. Approximately 80-85% seeds were germinated within some day. It was seen that a decrease in osmotic potential of the medium resulted in a gradual decrease in germination percentage Ranjan and Naik et al.., 2011.

Conclusion

The present research work was conducted to evaluate the genetic potential of Chana (Cicer arietinum), White pea (Lathyrus sativum), Green pea (Pisum sativum), Moong (Vigna radiata), Matki (Vigna aconitifolia), Methi (Trigonella foenum) and Barley (Hordeum vulgare) through artificially created water deficit conditions by PEG of molecular weight 3350 in vitro. Root length is a vital trait against drought stress in plant cultivars. Water deficit condition had a significant effect on G%, DTI (G %), Reduction (G %), GP, DTI (G %) and Reduction (GP) in vitro. It had effect on ion availability which showed a decrease in the value along with the inhibited hypocotyl length. The size of seed and quality contributed vital role to cope with drought stress. The present study could be used as basis for open field irrigation system in cereals and pulses.

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A Survey On Save the Environment

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Abstract

In this study, an environmental survey was conducted regarding the "Awareness on save the earth" which was conducted through circulating google form consisting of 24 questionnaires. This survey explores public awareness regarding environmental conservation through a survey distributed via Google Forms, with 97 participants aged 15 and above. The questionnaire assessed participants' knowledge of environmental issues, actions they take to mitigate environmental degradation, and their willingness to adapt eco-friendly behaviors. Key findings indicate that 99% of respondents agree on the need to save the environment, though varying levels of interest and knowledge were observed. The majority demonstrated an understanding of sustainable practices such as recycling, composting, and using cloth bags while shopping. Despite this, misconceptions persist in areas such as the principles of environmental accountability.

Keywords: Environmental survey, awareness, conservation, environmental degradation

Introduction

Recent advances in various walks of human life has led to the Environmental degradation which has become one of the most pressing challenges of the 21st century, affecting ecosystems, biodiversity, and human well-being on a global scale. The growth of industrialization, urbanization, and unsustainable consumption patterns has led to deforestation, pollution, climate change, and resource depletion. Amid these challenges, environmental awareness has emerged as a pivotal factor in addressing and mitigating the adverse impacts of human activities. An increase in the Environmental Awareness will reverse the exploitation of the environmental resources.[2] This survey aims to explore the role of environmental awareness in fostering sustainable practices, influencing policy decisions, and empowering communities to take proactive steps toward conservation.

Objective

The survey aims to assess people's awareness of key environmental topics, such as world environment day, policies and conservation principles. It also seeks to understand the motivations behind their actions to protect the environment. The results will help identify areas where education and awareness can be improved to promote more sustainable practices within communities.

Scope of the study

The study aims to understand public awareness and behavioral tendencies towards environmental conservation, focusing on sustainability practices and climate change mitigation. It investigates the factor influencing people's willingness to adopt eco-friendly habits and the role of educational campaigns in promoting environmental sustainability.

Sample

The survey was mainly focused among 15 to 45 years of age. Data is collected from participating via digital questionnaires, with a focus on urban and semi- urban populations to analyze varying perceptions and practices related to saving the environment. Total 97 useful responses were collected.

Data collection

The research paper is experiential study into the environmental awareness. We have circulated the Google form links to persons and asked them to participate in the survey, the respondent was ensured the confidentiality of the data . A total number of 97 respondents were filled all the information in the Survey.

Analysis

Out of 97 respondents, 48.5% are below the age of 30 years and 47.4% are below 15 years. Regarding education 69.1% are studying, 19.6% are graduates, 9.3% are postgraduates, 1% never studied and 1% hold a doctorate. In terms of gender, 4.1% are men and 95.9% are women. Residence data shows that 9.3% live in chawls, 84.5% in buildings and 7.7% in bungalows. For family income, 47.3% earn more than ₹15,000, while 38.1% earn less. About 97.9% have basic knowledge about the environment, 2% are undecided and 1.1% lack awareness. A significant 99% are willing to save the environment, with 64.9% ready to participate in environmental actions, 34% uncertain and 2% are unwilling. Additionally, 89.7% know that World Environment Day is celebrated on June 5.

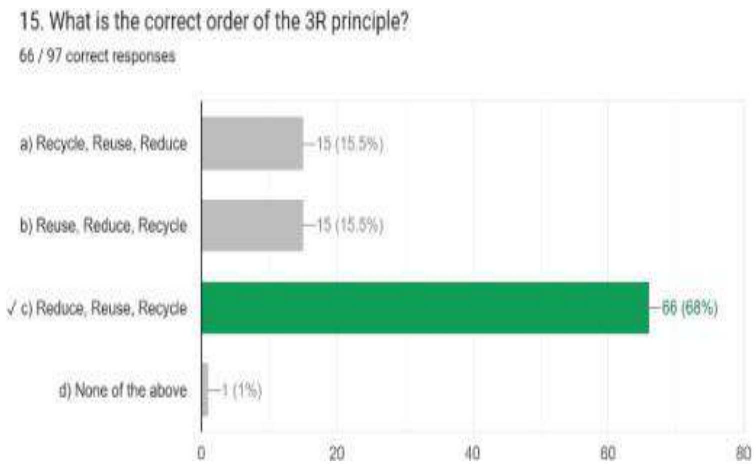
The fact that Earth is often called the "Blue Planet" due to the presence of water, known to 77.3% of respondents. A significant population 87.6% agree that the use of polythene bags, a non-biodegradable material causing pollution, should be discouraged, with many advocating for the use of cloth bags while shopping. Regarding environmental issues, 38.1% are highly interested, while 20.4% contribute occasionally. Awareness of water harvesting, which involves collecting rainwater in storage tanks, is evident among 73.2% of respondents. Additionally, 39.2% are extremely willing to change their lifestyle to minimize environmental damage. Also 51.5% of the people strongly agreed to use bicycle to travel somewhere when possible which will help in reducing the unnecessary emission from cars. A major part of declining environmental health is the unnecessary throwing of garbage. The majority of respondents (83.5%) correctly identified that all the listed items – a used syringe, a soft drink tin, and a food wrapper contribute to garbage. During the analysis it was found that majority of the surveyed population are not aware of measures of sustainable development. Only 38.1% people chose 'reducing the rate of surfaces run-off water' which is the correct answer.

Environmental Awareness Survey Results

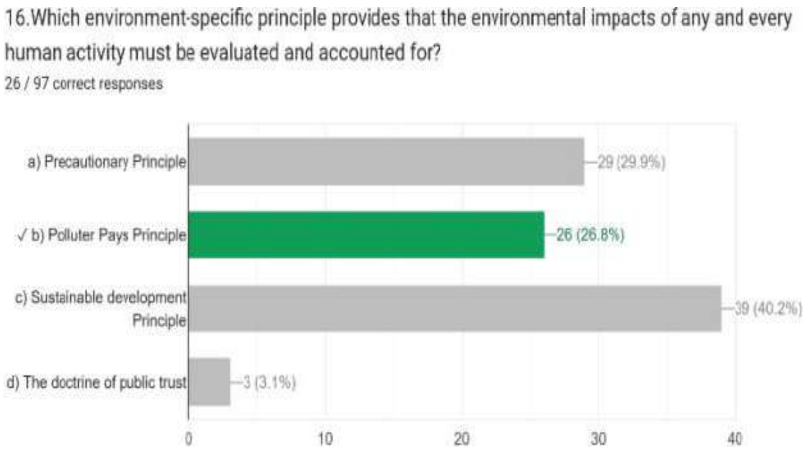
```
├── Water Usage
│   ├── 22.7%: Taking a 10-minute shower uses more water
│   └── 38.1%: Flushing the toilet uses more water
├── Composting Knowledge
│   └── 87.6%: Vegetable and fruit peels, tea leaves, eggshells, etc., are good for compost
├── Garbage Disposal
│   └── 61.9%: Landfill areas are correct for dumping garbage
├── Global Warming Awareness
│   └── 44.3%: Global warming has led to a rise in sea levels
└── Environmental Sensitization
    └── 0.4%: Mass media is the best way to create awareness
```

Correct Order OF 3R Principle: Most respondents correctly identified the 3R principle's order as Reduce, Reuse, Recycle, though a significant minority showed confusion by selecting incorrect sequences.

Principle That Provides the Environmental Impacts of Any Human Activity:

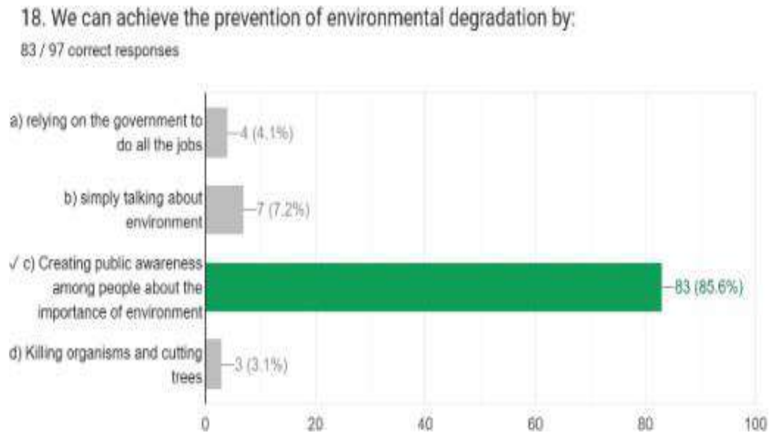


A significant number of respondents (40.1%) incorrectly chose the Sustainable Development Principle, while only 26.8% correctly identified the Polluter Pays Principle, reflecting confusion about environmental accountability principle.



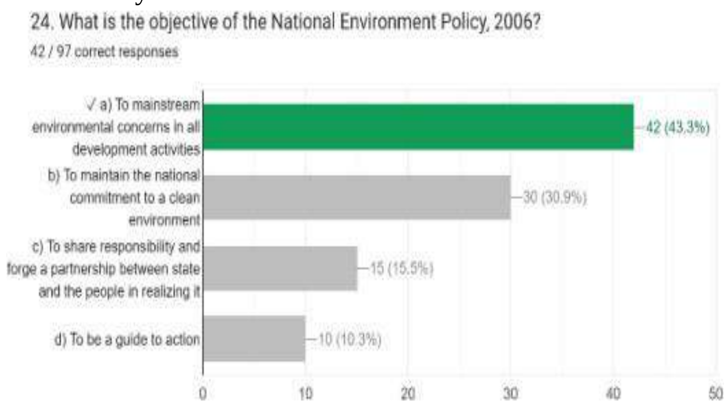
Achieving The Prevention of Environmental Degradation By:

85.6% people agreed to the statement that prevention of environment can be achieved by creating public awareness.



Objective of National Environment Policy 2006:

43.3 % of the people answered correctly.



Conclusion:

Pollution and Climate change has emerged as one of the most devastating environmental threat. The United Nation's Intergovernmental Panel on Climate Change (IPCC) stated that there is evidence that humans are affecting the global climate and highlighted a wide range of implications for human health[3]. The government policy in this regard is very explicit as environmental education has been made compulsory subject at school level as well as college level of education but implementation of this knowledge and attitude of young generation towards this matter is still a major concern[4].

The research concludes that there is a pressing need to enhance awareness about environmental changes and challenges. Promoting knowledge and encouraging proactive steps are essential to mitigate the impacts of human activities on the planet. By increasing environmental consciousness, communities can contribute to a sustainable and thriving environment for future generations and we can moderate the impact of human activities on the planet and ensure a healthy, thriving environment for generations to come. Awareness of such a crucial subject must be promoted as far as possible.

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Principal G M Momin women's College Bhiwandi

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Antimicrobial Drug Resistance in Poultry Farming

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Abstract

Antimicrobial drug resistance (AMR) in chicken farming threatens human and animal health worldwide. People can catch resistant bacteria through direct contact with animals eating contaminated chicken or from chicken waste that pollutes the environment. Each region faces its challenges. China has high resistance rates because farmers overuse antibiotics. India shows different resistance patterns between broiler and layer farms, which shows the need for specific rules. The rising global demand for animal protein makes effective teamwork across countries essential. Farmers give antibiotics to chickens to help them grow faster, stop them from getting sick, and treat diseases. This has caused resistant bacteria to pop up and spread. Using the wrong amounts of drugs meant for humans and misusing antibiotics make the problem worse.

The widespread use of antibiotics in chicken farming has led to the rise and spread of resistant bacteria. Farmers use these drugs to boost growth, prevent illness, and treat diseases. Wrong doses, overuse, and putting important medical antibiotics in feed and water have made things worse. Resistant germs from chickens can reach humans in several ways. These include touching the animals, polluting the environment, and entering the food supply. So, this review examines how antibiotic resistance affects chicken farming. To tackle this, experts are exploring and using several methods. These include more rigid biosecurity rules, new treatment options, stricter laws on antibiotic use, better tracking of resistance trends, and pushing for responsibility.

Many countries have passed laws to reduce antibiotic use in chicken farms to make chickens grow faster, as they know how serious this issue is. Still, this review's goal is to discuss the impact of antibiotic resistance in chicken production, focusing on new ways to control bacteria under study. These fresh approaches involve antimicrobial peptides, bacteriophages, probiotics, and nanoparticles.

Keywords: Poultry, Antimicrobial resistance, Human, Antibiotics, Probiotics

Introduction

The introduction of antibiotics in poultry began in the 1950s, primarily for increased animal fattening, decreasing mortality rates, and increasing productivity (Marshall & Levy, 2011). Antibiotics were utilized to treat infections, as preventative medicine, and as an agent that improves growth. This assisted farmers in controlling diseases and making the most out of feeds as the production timelines were quite high (Wegener, 2012). With time, antibiotic application in animal husbandry became the order of the day, as was poultry farming. Tetracyclines, sulphonamides, and macrolides were commonly ingested by entire poultry flocks via feed or water (Van Boeckel *et al*., 2019). There have been rising concerns about the loss of efficacy of such mass medication; thus, such tactics are known to be the leading cause for the development of antimicrobial resistance, an evolutionary tactic employed by some bacteria, allowing them to withstand the effects of antibiotic agents. This phenomenon poses a threat to animal as well as human health (World Health Organization, 2020).

This review enlightens the progression of AMR in the poultry industry, arranged in a chronological frame to help grasp the history of the occurrences, evolution, and contemporary status of AMR in the sector. Such an analysis seeks to explain the chronology of events from the first use of antibiotics in the poultry industry to the most recent regulatory and scientific attempts to conquer AMR to corroborate how the contemporary AMR scenario came about (Van Boeckel *et al*., 2019; WHO, 2020). This strategy not only calls for immediate action against AMR but also emphasizes the need for more science, technology, and policy changes to protect both animals and humans (FAO & OIE, 2020).

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Early Use of Antibiotics in Poultry (1950s–1980s):

The first use of antibiotics, which many people believe started in the 1950s, can be seen as a turning point in the global poultry industry, including India. Antibiotics of various varieties, such as penicillin, chlortetracycline, sulfonamides, and neomycin, were used solely for the therapeutic purpose of outbreak prevention and management of poultry. However, subsequent decades saw antibiotics as growth promoters rather widely (Sharma *et al*., 2017). Over the years, some antibiotic drugs have also been effective against major poultry infections such as *Salmonella, Colibacillosis,* and *Fowl Cholera*.

The Indian poultry industry expanded rapidly over the 1970s and 1980s, especially in the commercial sector. Antibiotic use helped add more buoyancy to the demand for poultry products with greater productivity and intensive farming practices. It enabled large numbers of poultry to be farmed in small spaces, which was necessary for satisfying the rising urban demand for eggs and chicken meat (Vijayakumar *et al*., 2019). Antibiotic use became highly essential in India because the poultry sector had significant functions in the rural areas to the nutritional needs of both humans and the issue of poverty alleviation.

The Rise of Antimicrobial Resistance in Chicken and India

After it was realized that antibiotics were indeed useful, questions regarding the dangers of antimicrobial resistance (AMR) in poultry farming started coming up. In the 1980s, evidence from developed as well as developing states revealed that the application of antibiotics in animal farming led to increased occurrences of antibiotic-resistant bacterial strains (Ghosh *et al*., 2018). In India also, the same problems evolved during the 1990s when multi-drug resistant (MDR) strains of *Salmonella* and *Escherichia coli* were increasingly isolated in poultry flocks (Kumar *et al*., 2021). Studies carried out during the 2000s reveal that antibiotic overuse in poultry led to the evolution of AMR but also transmitted resistant pathogens from poultry to humans through foodborne routes (Sundararaj *et al*., 2015).

Studies conducted in India reported that the use of tetracyclines and other antibiotics for growth promotion in poultry was one of the key factors behind resistance. High levels of antibiotic-resistant pathogens, including *Campylobacter* and *Salmonella,* were reported to be present in poultry farms and in retail chicken and duck products, triggering severe concerns over food safety and public health (Prakash *et al*., 2020; Rao *et al*., 2020). The close contact between humans and poultry in India's intensive farming systems facilitated the spread of resistant bacteria.

Regulatory Response in India

India took time to tackle AMR in poultry since its focus was on increasing poultry production to meet the growing demands both internally and abroad. However, by the late 1990s and early 2000s, international and national attention on AMR sparked off certain policies. The World Health Organization (WHO) and Food and Agriculture Organization (FAO) voiced the implications of antibiotic use in agriculture. Thereby, it increased the pressure on governments worldwide to bring in regulations related to the use of antibiotics. So, while India's Ministry of Agriculture did not come forth with strict regulations until later, the research of last decade only proved fast-growing efforts aimed at curbing an overuse of antibiotics in livestock. Working with the Indian Council of Agricultural Research (ICAR), the Indian government begins emphasizing proper management, antibiotic alternatives, and antibiotic residue monitoring in poultry products, as reported by (Vijayakumar *et al*., 2019). The enforcement is difficult due to the large and diversified poultry industry in the country: there is a commercial large-scale farming operation and a rural, small-scale one.

Social and Economic Cost of Antimicrobial Resistance:

In the late 1990s and early 2000s, researchers observing the win – win situation of using antibiotics particularly growth promoters and prophylaxis began to complain about the emergence of infections caused by Multi Drug Resistant bacteria. There were isolated instances when *Salmonella* and *E. coli* strains found in poultry meat were reported to have acquired resistance to antibiotics effective against treated human infections (Sundararaj *et al*, 2015). This finding however was even more unappetizing because of the potential for the germs to move along the food chain between birds and humans causing infections that are challenging to treat.

In India as in many other worlds the emergence of AMR coincided with growth of commercialising poultry animals, poultry meat emphasising the heavy use of antibiotics. Epidemiological studies conducted between the late 1990s and the early 2000s on the use of growth enhancers in livestock revealed that tetracyclines, penicillin and sulfonamides were causing animal husbandry not alone oriented to curing diseases (Prakash *et al*., 2020). Evolving strains of antimicrobial resistance *Salmonella*, *Campylobacter* and *E. coli* among poultry birds in India raised numerous food safety and public health alarm bells (Ravikumar *et al*., 2014).

Concerning the Increasing Risks Classes of Antimicrobial Resistance and the Focus on This Issue at the World Level:

Towards the end of the second decade of the twentieth century and the dawn of the twenty-first century, there was more or less universal acceptance of the threat of AMR to public health, which, in turn, contributed to the upsurge in the demand for policy change. "World Health Organization (WHO)", "Food and Agriculture Organization (FAO)" and other global agencies have released publications documenting the evidence against the rise of AMR and its scourge on health throughout the world regardless of economic status.

Rising Public Health Concerns and Scientific Investigations

By the time Oie and his colleagues elaborated their work, evidence of AMR was growing and so are public health concerns due to resistant pathogens borne by poultry to humans. Research conducted in the 2000s in India, for instance, showed how poultry meat was linked to the consumers acquisition of resistant bacteria. Research by Prakash *et al*. (2020) showed that antimicrobial-resistant strains of *Salmonella* and *E. coli* from poultry were often acquired as a result of dietary consumption, particularly in the cities with high poultry product consumption. The rise of infections attributable to such resistant strains proportionally increased the need for controlling the antibiotics usage particularly in the poultry sector.

Moreover, the Indian Council of Agricultural Research (ICAR) and other national research organizations paid heed to the issue of antibiotic usage in poultry and its association with AMR. In this regard, good husbandry practices were recommended together with the employment of vaccines and probiotics to minimize the unnecessary use of antibiotics, demonstrating the need for addressing AMR at the farm level (Ghosh *et al*., 2017).

Seeking Government Intervention in India

As the risks and worries about AMR heightened, demands for government action increased in India as well. The "Indian government" however began taking timid steps to control the use of antibiotics in poultry in the early 2000s. However, only in the 2010s did the country start being more consistent with the global standards on use of antibiotics in animals. The "Ministry of Agriculture" along with the "Indian Veterinary Research Institute" (IVRI) began stressing the importance of improved surveillance and control measures against AMR in animal husbandry (Kumar *et al*., 2021).

A reasonable awareness in regulations reached a point of no return with "National Action Plan on AMR (2017)" endorsement in India. The emphasis outlined in this plan was that livestock farmers ought to reduce the usage of critically important antibiotics for animals and promote "Good Animal Husbandry Practices (GAHP)" and antibiotic substitutes such as vaccine and probiotics (Patil *et al*., 2021). Despite this, there were problems in the implementation of the policies as there existed a lot of small scale poultry farms which still formed a significant part of the poultry sector in India.

Recent Developments and Ongoing Challenges

The recent decade has shown no less development on the issues of AMR in Indian poultry. More attention has also been directed towards control of antibiotic usage in poultry under "stewardship programs", through better biosecurity, less reliance on antibiotics, and use of alternatives (Sarkar *et al*., 2020). The studies within the last few years also highlight poultry and the antibiotics used in it, the level of use and the cause of resistance to them, to know how to minimize the use of these antibiotics (Rao *et al*., 2020).

Recent alternatives to antibiotics

In the past decade, multiple innovations and technologies have emerged to address antimicrobial resistance (AMR) in poultry farming. These advancements range from new treatment and diagnostic methods to genetic editing and AI systems designed to control the spread of diseases effectively.

Probiotics

Natural antibiotic alternatives have been the subject of considerable study. Probiotics, prebiotics, phytogenics, and synbiotics have been shown to have the potential of minimizing the incidence of poultry pathogens with health. Probiotics in the form of Lactobacillus and Bifidobacterium have several trials and have proven beneficial towards gut health further resulting in improved infections and minimized antibiotics. For example, Buhari et al.,2022 reported that strains of Lactobacillus supplementation in broiler diet enhanced gut health by reducing E. This decreases the incidence of E. coli and consequently leads to less application of antibiotics. Another type of prebiotic under the limelight today is "mannan oligosaccharides," which boosts immunity and inhibits pathogenic colonization (Shang et al., 2020). Phytogenic feed additives have also gained attraction, and studies like (Li et al.2019) emphasized curcumin's antimicrobial efficiency against poultry diseases. Other ingredients like ginger and garlic extract have also shown decreased antibiotic use by improving the health of the gut and the overall immunity of the animal. Synbiotics, which consist of both probiotics and prebiotics, have also been promising additives that prove to advance growth and support the resistance of infection in chickens, further allowing for the lowering of antibiotic use.

Nanotechnology is also being highly

regarded as an essential AMR solution for poultry farming. Nanoparticles and antimicrobial peptides (AMPs) are considered to be among the most powerful alternatives to antibiotics. Silver, zinc oxide, and copper oxide nanoparticles have been reported to have strong antibacterial activities against pathogens in poultry, such as Salmonella, Campylobacter, and E. coli. For instance, Zhang et al. (2020) proved that silver nanoparticles have bactericidal activity against Salmonella enterica. There are also naturally occurring antimicrobial peptides (AMPs) with broad-spectrum activity, which have been shown to be effective. AMPs isolated from poultry have been shown by studies by Ghosh et al. (2021), to impede pathogens like Staphylococcus aureus and Salmonella, which enable their potential replacement in feed with conventional antibiotics.

Precision Medicine and Genetic Research

Technologies for gene editing such as CRISPR-Cas9 are transforming the management of antimicrobial resitance (AMR) in the sense that they allow for the production of poultry strains that are resistant to prevalent infections thus reducing the need for antibiotics. Using CRISPR-Cas9, G. He et al constructed a strain of chickens that could be resistant to avian influenza virus infections reducing use of antimicrobials. Moreover, Whole Genome Sequencing WGS has also been adopted in AMR and in the investigation of bacterial epidemiology, for instance, in Sadiq et al. (2021) study on AMR Salmonella Retrieved from poultry in Pakistan. This approach aids in understanding resistance mechanisms, enabling more targeted AMR control strategies.

Advanced Diagnostics and Surveillance

Advanced diagnostic equipment and techniques are very important when it comes to the early prevention of AMR and it's to resistant organisms and their use of antibiotics as far as possible. Commercal Point-of-care diagnostics such as loop mediated LAMP, and lateral flow devices LFDS are also on the rise for swift field tests. As reported by Matías And Others 2021, There Were LAMP Based Tests Conducted on AMR Pathogens in Chickens LAMP Based Tests Were taking an hour to detect them.Detection of pathogens by biosensors is also on the rise; Choi et al. (2020) reported a biosensor with high determination for the salmonella DNA allowing the process to be done in real time thus aiding in reduction of antibiotics use.

Big Data, Artificial Intelligence (AI)

A growing trend is the application of AI and big data in the management of AMR, particularly in the context of poultry farming. Models that are predictive in nature utilize machine learning techniques and assess data related to farm processes and epidemiological studies forecasting occurrence of AMR and outlining appropriate interventions. For instance, Sharma et al. (2022) developed an AI-based model to predict AMR transmission in agricultural avian species and integrate biosecurity and vaccination strategies into the model's recommendations, encouraging reduced antibiotic reliance. Additionally, AI-based farm management systems, including precision farming techniques, enable efficient livestock management with minimal antibiotic use.

Improved Farm Management PracticesBeyond genetics and alternative therapies, improved farm management practices are essential for reducing antibiotic use and controlling AMR in poultry.Vaccination has proven to be a critical measure. For instance, Liu et al. (2021) showed that vaccines for diseases like Newcastle Disease and Salmonella significantly lowered disease incidence and the subsequent need for antibiotics. Effective biosecurity measures also play a role, with Yu et al. (2021) highlighting that limiting farm access, crew disinfection, and isolating new chickens help protect poultry from AMR pathogens and reduce antibiotic dependence.

Table 1: Common Antibiotics Used In Poultry Farming

Enrofloxacin	Fluoroquinolones	Treating *Salmonella*, *Campylobacter*, and other bacterial infections	Oral, Injection	Ali *et al*., 2021; Nasr *et al*., 2022
Sulfonamides	Sulfonamides	Controlling, *coccidiosis* and some bacterial infections	Oral	Bukhari *et al*., 2020; Zhang *et al*., 2020
Neomycin	Aminoglycosides	Treating gastrointestinal infections, especially *E. coli* and *Salmonella*	Oral	Hussain *et al*., 2021; De Zutter *et al*., 2021
Tylosin	Macrolides	Treating respiratory diseases, *Mycoplasma* infections, and some *Salmonella* strains	Feed, Injection	Zhang *et al*., 2020; Hernandez *et al*., 2021
Colistin	Polymyxins	Treating multi-drug-resi stant *E. coli* and *Salmonella*	Oral	Yu *et al*., 2020; Abed *et al*., 2022
Enrofloxacin	Fluoroquinolones	Treating *Salmonella*, *Campylobacter*, and other	Oral, Injection	Ali *et al*., 2021; Nasr *et al*., 2022

		bacterial, infections		
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Colistin	Polymyxins	Treating multi-drug-resi stant *E. coli* and *Salmonella*	Oral	Yu *et al*., 2020; Abed *et al*., 2022
Ciprofloxacin	Fluoroquinolones	Treating *Salmonella*, *Campylobacter*, and *E. coli*	Oral	Elbediwi *et al*., 2020; Shrestha *et al*., 2021
Lincomycin	Lincosamides	Treating *Mycoplasma* infections and some gastrointestinal pathogens	Oral	Hernandez *et al*., 2020; Diarra *et al*., 2019
Ceftiofur	Cephalosporins	Treatment of *E. coli*, *Salmonella*, and *Pasteurella* infections in poultry	Injection	De Zutter *et al*., 2021; Ali *et al*., 2021
Florfenicol	Amphenicols	Treating respiratory infections and some *E. coli* and *Salmonella* infections	Feed, Injection	Diarra *et al*., 2019; Redding *et al*., 2020
Oxytetracycline	Tetracyclines	Broad-spectru m antibiotic used for respiratory infections and gastrointestinal disorders	Oral	Zhang *et al*., 2020; Abdel-Mone im *et al*., 2021
Gentamicin	Aminoglycosides	Treating *E. coli*, *Salmonella*, and *Pseudomonas* infections	Injection	Abed *et al*., 2022; Hernandez *et al*., 2020
Macrolides (Erythromycin)	Macrolides	Effective against *Mycoplasma* and *Campylobacter* infections	Oral	Sundararajan *et al*., 2020; Diarra *et al*., 2019

Common Diseases in Poultry

Salmonellosis

In poultry, the major cause of Salmonellosis is the Gram-negative, facultative anaerobic bacterium of the family Enterobacteriaceae: *Salmonella enteric*. It has over 2,500 serotypes, which makes it one of the most common in poultry (Kwon et al., 2021). They are spread by the ingestion of contaminated food and water or contact with infected feces (Kwon et al., 2021). Some serotypes can also be spread vertically, from hen to egg (Jones & Richardson, 2019). Once consumed, *Salmonella* invades the intestinal epithelial cells and is capable of spreading into the blood, potentially leading to systemic infection (Kwon et al., 2021). Infected birds may exhibit gastrointestinal signs which may include diarrhea and vomiting, but acute infections can result in septicemia and death (Jones & Richardson, 2019). Amoxicillin, Enrofloxacin, Ciprofloxacin, and Tetracycline are some of the common antibiotics which have been reported to be used in controlling *Salmonella* infection in poultry.

Colibacillosis

Escherichia coli (E. coli) is a Gram-negative, rod-shaped bacterium that belongs to the normal gut flora, but there are specific pathogenic strains that can produce disease in poultry (Li et al., 2020). *E. coli* spread generally occurs through a fecal-oral route with contaminated feed, water, or environment (Li et al., 2020). Poor hygiene and overcrowding have been linked to highest risk (De Rauw et al., 2022). Pathogenic *E. coli* strain also have toxins which causes damage in the intestinal cells, and it may subsequently spread through the bloodstream, resulting in the whole-body infection (Li et al., 2020). The symptoms can be mildly assorted depending on the potency of the strain (De Rauw et al., 2022). Some of the antibiotics used include Tetracycline, Amoxicillin, Enrofloxacin, and Neomycin (Li et al., 2020).

Mycoplasmosis

Mycoplasma gallisepticum and Mycoplasma synoviae are the two primary causative agents of Mycoplasmosis in poultry. Among the two, M. gallisepticum is the more critical bacterium because it mainly infects the respiratory system, although M. synoviae might cause respiratory as well as joint infections. These bacteria do not possess a cell wall. Transmissions are either through aerosol droplets or direct contact among birds or contaminated equipment. Possibly, the bacterium may also be transmitted vertically from hen to chick (Liao et al., 2021).M. It causes chronic respiratory problems like infectious sinusitis and airsacculitis, and M. synoviae causes joint inflammation, arthritis, and lameness (Pei et al., 2020). The antibiotics typically prescribed are Tylosin, Lincomycin, and Tetracycline (Liao et al., 2021).

Campylobacteriosis

Campylobacteriosis caused by Campylobacter jejuni and Campylobacter coli are Gram-negative, microaerophilic bacteria responsible for Campylobacteriosis, which is a significant cause of foodborne illness globally (Wang et al., 2019). In poultry animals, it usually enters the animal through contaminated feed or water or from cadavers of infected birds; however, vertical transmission is also a possibility (Younis et al., 2021). Campylobacter penetrates the intestinal wall, secreting toxins that cause inflammation. This usually presents as diarrhea, dehydration, and, in some cases, systemic infections (Wang et al., 2019). Treatment involves Enrofloxacin, Erythromycin, and Tetracycline (Younis et al., 2021).

Clostridial Infections (Necrotic Enteritis)

Clostridial Infections (Necrotic Enteritis) is caused by Clostridium perfringens; this bacterium is a Gram-positive, spore-forming anaerobe responsible for causing necrotic enteritis in poultry animals. Traditionally, it is gut flora, but it gives rise to disease as a result of overgrowth due to factors like a poor diet, overcrowding, and lack of hygiene (Lister et al., 2020). It is mostly transmitted through contaminated feed and water sources (Kim & Lister, 2022). The bacterium releases toxins that damage the intestinal lining, provokes inflammation, necrosis, and digestive impairment, which lead to diarrhea, depression, and sudden death in worse cases (Lister et al., 2020). Amoxicillin, Tetracycline, and Metronidazole are mostly used treatments (Kim & Lister, 2022).

Fowl Cholera (Pasteurellosis)

Fowl cholera, which is caused by Pasteurella multocida, is a transmissible disease in multiple avian species (Fadl & Hume, 2020). The non-motile and Gram-negative bacterium usually inhabits the avian respiratory and gastrointestinal tract in poultry animals (Ganguly et al., 2022). It transmits through direct contact with an infected bird, by ingestion of contaminated feed or water and even through vectors like aerosols or insects (Fadl & Hume, 2020). Disease occurs as acute septicemia and exhibits symptoms such as ruffled feathers, respiratory distress, and lethargy, and sudden death usually results from this disease (Ganguly et al., 2022). Tetracycline, Chlortetracycline, and Sulfonamides are used most commonly for treatment (Fadl & Hume, 2020).

Avian Infections

Avian Infections, Caused by Streptococcus spp. are Gram-positive, non-motile bacteria residing in the respiratory tract of poultry, which cause diseases under stress (Ghanem et al., 2020). It spreads by direct contact with infected birds, droppings, or contaminated surfaces, and aerosol transmission is another mode of transmission as well (Abd El-Rahman et al., 2021). Streptococcus infections are known to cause septicemia, arthritis, and pneumonia. The signs include labored breathing, swollen joints, and lethargy among others, according to Ghanem et al. (2020). The main treatments usually include Penicillin, Erythromycin, and Tylosin (Abd El-Rahman et al., 2021).

Avian Chlamydiosis

Avian Chlamydiosis, caused by Chlamydia psittaci, avian chlamydiosis, or otherwise known as parrot fever, infects the respiratory system and other organs (Spinks et al., 2020). This intracellular bacterium is mainly transmissible through droplet form of the respiratory system or by direct contact with the excretion products of infected birds. Infected birds may harbor the bacteria symptomatically for long times (Everts & Spinks, 2021). Symptoms may be manifested as nasal discharge, conjunctivitis, lethargy, and breathing difficulty (Spinks et al., 2020). Amongst antibiotics that may be used are Doxycycline and Tetracycline (Everts & Spinks, 2021).

Conclusion

The potential health risks posed by antimicrobial drug resistance in chicken production to both human and animal health are highly alarming. The emergence of resistant bacteria is associated with the excessive use of antibiotics in chicken production, which can be acquired by humans through any route. Among the common poultry diseases linked to antibiotic misuse is *Salmonellosis*, *Colibacillosis*, *Mycoplasmosis*, and *Campylobacteriosis.* Among the different approaches that can integrate strategies towards the policy of antimicrobial moderation in poultry production include banning use of antibiotics to soften the resistance, searching for alternatives such as probiotics and nanotechnology based antimicrobial peptides, using precision medicine and genetic engineering like CRISPR-Cas9, improving surveillance and diagnostics, adoption Of big data and artificial intelligence, and promoting better farm management. Reduced transmission of resistant bacteria, increased animal health.

The objectives of these measures are to improve the health of chickens while minimizing the need for usage of antibiotics and more importantly the emergence of resistant pathogens. Antimicrobial resistance in chicken production has become a public concern, therefore it is necessary that all states engage in fight, introduce tougher policies and advocate for good practices regarding antibiotic use. Even though there is a risk of antimicrobial resistance arising within chicken production, so that risk can be managed by a very broad picture that consists of actions such as research activities, implementation of proper surveillance, development of the relevant policies, and the involvement of all the interested parties.

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Sustainable Practices in Ancient India and Egypt

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Abstract

The ancient Indian and Egyptian civilizations exemplify a fundamental concept of harmony with nature. Ancient Indian literature posits that it is the duty of all individuals within a civilization to safeguard nature. This clarifies the historical reverence for natural objects by people. Ancient Indian architecture, resource utilization, water management systems, packaging, health and wellness, and sports have all embraced sustainable concepts. The ideas of the three Rs are distinctly evident in ancient Indian traditions. In contrast, the ancient Egyptians established the principles of sustainable development through environmental conservation, sustainable agriculture, and the protection of both renewable and non-renewable resources. The construction of the Great Pyramids and the advancement of intricate irrigation systems developed sustainable practices that formed the basis for a prosperous future. The comprehension of their surroundings and climate was a pivotal factor in the evolution and sustainability of ancient Egyptian civilization for millennia. Ancient civilizations recognized the importance of balance between human needs and the environment, forming foundational concepts that resonate in modern sustainability efforts. Contemporary civilizations may derive important concepts for balancing progress with environmental conservation by analyzing their methodology. This research paper presents a comparative analysis of sustainable practices in ancient India and Egypt. It also enhances comprehension of historical sustainability techniques and their applicability to modern concerns, promoting interdisciplinary discourse that highlights the fusion of ecological and health viewpoints.

Key Words: Sustainability, Civilisation, India, Egypt, Agriculture

Introduction

historically, the civilizations of ancient India and Egypt have been characterized by their exceptional accomplishments in the arts and sciences, as well as their pioneering methods of sustainable practices. Both societies employed advanced farming methods and resource management practices that demonstrate a profound comprehension of their environment and the need of ecological equilibrium. In India, agricultural systems improved by methods including crop rotation, rainwater collecting, and organic fertilizers, which augmented soil fertility and mitigated the effects of droughts and floods (Peeyush Sharma et al.)(Andreas N. Angelakıs et al., p. 1285-1285). Ancient Egyptians developed sophisticated irrigation techniques that harnessed the Nile's yearly flooding to water crops and maintain their civilization's economic stability (Sarbjeet Kaur et al.)(Shubham Jain et al.). This investigation's research concern is the inadequate acknowledgment of the significance and relevance of sustainable practices in contemporary discussions on environmental conservation and resource management. Despite their historical importance, much examination of ancient civilizations emphasizes political and cultural accomplishments, frequently neglecting crucial ecological practices that facilitated their longevity and resilience. The main aim of this research is to thoroughly analyse and evaluate the sustainable practices of ancient India and Egypt, clarifying how these societies managed their natural resources and promoted environmental sustainability. This study aims to discern the fundamental principles of their methodologies, the socio-economic factors influencing their implementation, and the insights that modern societies can derive to tackle present issues with sustainability and climate change. This research is significant not only for academic purposes; comprehending the historical underpinnings of sustainable practices can enhance contemporary environmental policy and resource management techniques, providing novel solutions to current challenges. This study connects ancient wisdom with modern environmental science, highlighting the significance of sustainable practices in historical contexts and promoting their relevance in current global sustainability initiatives (Intergovernmental Panel on Climate Change)(Saikat Sen et al., p. 234-244). The conclusions of this research seek to greatly enhance interdisciplinary conversations on sustainability, integrating history, ecology, and cultural studies to foster comprehensive understanding.

Literature Review

The examination of past civilizations frequently uncovers significant insights on societal interactions with natural settings, demonstrating a persistent human effort to reconcile ecological sustainability with everyday existence. Among these civilizations, Ancient India and Egypt are notable for their inventive and sustainable methods, which have considerable implications for our comprehension of environmental management. Acknowledging the significance of these historic practices in the current environment, especially in relation to climate change and sustainable development, highlights the lasting human wisdom that continues to be relevant today. Many scholars have explored different facets of this subject, analysing agricultural practices, water management systems, and resource-utilization strategies that demonstrate a profound understanding of ecological equilibrium and conservation in both cultures. In Ancient India, the adoption of sustainable agricultural techniques, including crop rotation, organic fertilizers, and rainwater harvesting systems, is well documented. Textual evidence from literature such as the Artha shastra indicates a nuanced comprehension of ecological dynamics, in which agricultural methods were intricately connected to seasonal variations and soil fertility. In Ancient Egypt, the administration of the Nile River's annual inundation exemplified an early form of sustainable resource management, wherein the judicious use of river silt maximized agricultural yield while reducing environmental harm. The reciprocal relationship between the environment and agricultural practices highlights a crucial theme in the literature: the imperative of aligning human activity with the natural context. Additionally, both civilizations undertook significant water conservation efforts that are noteworthy in scholarly discussions. The establishment of wells, tanks, and irrigation canals in India, together with the advancement of basin irrigation systems in Egypt, underscores a sophisticated comprehension of hydrology and resource conservation. These approaches not only promoted agricultural sustainability but also demonstrate a heightened awareness of the interdependence between human existence and environmental health. The examination of these practices in archaeology, anthropology, and environmental studies elucidates the socio-economic frameworks and cultural values intrinsic to these societies. Despite extensive scholarship, there are still deficiencies in comprehending the complete range of sustainability practices in these ancient contexts. Although there is considerable research on agricultural methods, insufficient focus has been placed on the socio-political and spiritual factors that shaped these practices. Moreover, comparative studies that directly connect the sustainable practices of Ancient India and Egypt are scarce, presenting an opportunity for further investigation that may provide significant insights into trans-regional influences and exchanges.

The progression of sustainable practices in ancient India and Egypt demonstrates a deep comprehension of environmental management that evolved over thousands of years. Initially, both civilizations depended significantly on their river systems namely, the Nile in Egypt and the Indus in India for irrigation, which was essential for agricultural productivity. Evidence indicates that ancient Egyptians constructed advanced irrigation systems, using canals and basins to manage water effectively, thus enhancing crop yields and reducing water wastage (B. Guelpa). The Indus Valley Civilization demonstrated sophisticated urban planning and water management through drainage systems and reservoirs, promoting sustainable agricultural practices (Pulak Bisen et al.). As societies progressed, both civilizations integrated sustainability principles into their agricultural and economic practices. The ancient Egyptians employed crop rotation and intercropping, enhancing soil fertility and naturally managing pests, hence diminishing reliance on chemical interventions (Peeyush Sharma et al.). Conversely, traditional Indian agricultural methods, as documented in literature such as the Arthashastra, prioritized resource management in conjunction with stringent crop cultivation techniques to optimize productivity while preserving resources (Mausmi Rastogi et al.). During the Ptolemaic period, Egyptians implemented extensive agro-economic policies that acknowledged the interdependence of agricultural productivity and water resource management, essential for mitigating the challenges presented by the Nile's periodic flooding (Sarbjeet Kaur et al.). Comparable sustainability principles in ancient India resulted in comprehensive practices that preserved natural resources, including forests, typically governed by communal regulations and interventions (D. R. K. Saikanth et al.). Collectively, these historical frameworks demonstrate a profound heritage of sustainable behaviours that met present ecological requirements while establishing a platform for future generations to adapt and innovate. Ancient civilizations, especially in India and Egypt, demonstrated a sophisticated comprehension of resource management and environmental conservation through sustainable practices. In ancient India, techniques like traditional water harvesting systems, particularly the Kundi Bhandara method in Burhanpur, illustrate strategies for conserving water and optimizing its use in agriculture, underscoring their proactive approach to water management in arid environments (B. Guelpa). The incorporation of millets into agricultural practices emphasizes sustainability; their minimal water needs and nutritional advantages demonstrate an effective farming strategy with contemporary significance (Pulak Bisen et al.). Similarly, the irrigation systems of ancient Egypt exemplify advanced management of the Nile River's seasonal flooding, facilitating agricultural output that sustained substantial populations

The Egyptians employed technology like shadufs and saqiya systems to efficiently elevate water for agriculture irrigation, demonstrating a resilient and flexible response to environmental problems (Peeyush Sharma et al.) (Mausmi Rastogi et al.). Both civilizations demonstrated a profound interdependence with their own ecosystems. Evidence indicates that ancient Indian and Egyptian civilizations utilized many sustainability techniques associated with their spiritual beliefs, perceiving the stewardship of land and water as a sacred obligation. This cultural viewpoint boosted community engagement in conservation initiatives, guaranteeing that practices were both efficacious and socially validated (Sarbjeet Kaur et al.)(D. R. K. Saikanth et al.). Furthermore, their profound comprehension of biodiversity and its importance in agriculture is seen in the utilization of many crops and traditional medicinal herbs, which address both food security and health requirements. The sustainable practices of ancient India and Egypt provide significant insights that remain relevant in modern discourse on environmental sustainability. An examination of sustainable practices in ancient India and Egypt demonstrates the influence of methodological approaches on comprehending these historical societies. Archaeological techniques have been crucial; excavations in these civilizations have yielded tangible evidence of sophisticated farming practices and water management systems.

An examination of sustainable practices in ancient India and Egypt demonstrates the influence of methodological approaches on comprehending these historical societies. Archaeological techniques have been crucial; excavations in these civilizations have yielded tangible evidence of sophisticated farming practices and water management systems. In ancient Egypt, irrigation systems that harnessed the Nile's periodic floods demonstrated advanced water resource management, essential for maintaining agriculture in a dry climate (B. Guelpa). Research on the Indus Valley Civilization demonstrates comprehensive drainage and water conservation systems that signify the inhabitants' dedication to sustainable practices (Pulak Bisen et al.). Ethnohistorical methodologies, which combine historical documents with cultural studies, further elucidate the social dynamics associated with these practices. Textual research of ancient works like Kautilya's Arthashastra in India provides insights on resource governance, highlighting the state's responsibility in sustainable agriculture policies (Peeyush Sharma et al.). This is mirrored by analyses of Egyptian papyri that record agricultural methods and resource distribution, demonstrating a profound link between government and ecological equilibrium (Mausmi Rastogi et al.). Furthermore, environmental history methodologies emphasize how ancient civilizations modified their technologies in response to local climates and resources. Both communities commonly utilized natural fibers and organic materials in architecture and textiles, exemplifying an organic approach to sustainability (Sarbjeet Kaur et al.). By integrating these diverse methodological approaches, academics can attain a more nuanced comprehension of how ancient civilizations in India and Egypt effectively managed their resources and established sustainable practices that remain relevant today. This fusion of approaches provides valuable insights into their environmental stewardship and socio-economic frameworks (D. R. K. Saikanth et al.). An analysis of sustainable practices in ancient India and Egypt uncovers unique theoretical frameworks that emphasize the intricacies of resource management and environmental engagement in these civilizations.

Sociocultural approaches highlight how communities incorporated sustainable agricultural practices into their everyday routines, modifying methods like irrigation and crop rotation to enhance resource utilization. In ancient Egypt, dependence on the Nile for irrigation not only influenced agricultural output but also cultivated a culture of respect for natural cycles (B. Guelpa). In India, ancient texts like the Arthashastra delineate strategies for resource management that fostered ecological equilibrium (Pulak Bisen et al.). The ecological perspective offers additional understanding, revealing that both civilizations acknowledged the importance of harmonious relationships with their environments. Ancient Indian methods of rainwater gathering and earth bunding exemplify an early comprehension of sustainable water management, designed to mitigate regional fluctuations in precipitation (Peeyush Sharma et al.). Similarly, Egyptian farmers utilized basin irrigation methods to optimize water use while adhering to the natural course of the Nile (Mausmi Rastogi et al.).

Critiques based on political economic theories contend that although these practices incorporated sustainability aspects, they were also characterized by social conflict and hierarchies, potentially resulting in resource depletion. In Egypt, the ruling class's monopolization of resources frequently compromised the fair distribution of agricultural yields (Sarbjeet Kaur et al.). The decentralized structure of Indian village systems facilitated a community approach to resource management, although disparities remained apparent (D. R. K. Saikanth et al.). The interaction of these theoretical approaches enhances our comprehension of sustainability in ancient India and Egypt, highlighting both accomplishments and difficulties in their practices. The investigation of sustainable practices in ancient India and Egypt uncovers a wealth of ecological knowledge and resource management strategies that significantly align with modern sustainability initiatives. The literature research reveals that both civilizations developed advanced agricultural techniques and water management systems, demonstrating their profound comprehension of environmental care. Ancient India demonstrated creative techniques including rainwater gathering, organic fertilizer application, and millet farming, whilst ancient Egyptians excelled in irrigation methods utilizing the periodic inundations of the Nile. Collectively, these practices embody a comprehensive approach to agriculture that prioritizes adaptation to local ecological conditions, highlighting the civilizations' capacity to align human needs with environmental well-being.

Methodology

Investigating sustainable practices in ancient civilizations, namely India and Egypt, necessitates an examination of interdisciplinary techniques that integrate historical, archaeological, and environmental research. The study challenge focuses on comprehending how ancient societies employed sustainable tactics for effective natural resource management and how these practices might inform modern sustainability initiatives. This study aims to perform a comparative investigation of agricultural techniques, water management systems, and resource consumption in these civilizations, utilizing both textual and archaeological data to elucidate the intricacies of their activities. A mixed-methods approach will be employed, integrating qualitative analyses of historical texts and environmental studies with quantitative archeological data regarding resource management. Qualitative techniques will utilize existing literature, including historical manuscripts and environmental texts, to facilitate a comprehensive understanding of the cultural importance and practical implementation of sustainable practices in these communities (B. Guelpa). Moreover, archaeological techniques will be utilized through the examination of site surveys and excavations, as supported by prior research that effectively connected archaeological discoveries with ancient environmental practices in both cultures (Pulak Bisen et al.). This methodology is significant for its ability to connect theoretical frameworks with empirical data, facilitating a comprehensive knowledge of the reconstruction and interpretation of historical activities in a contemporary context. This method emphasizes the integration of many data sources to enhance discussions on ancient sustainability and contribute to the broader dialogue on resource management amid current ecological issues (Peeyush Sharma et al.). Furthermore, employing comparative research to discern similarities and contrasts between the two civilizations may reveal trans-regional impacts and illuminate the dissemination of sustainable practices over time (Mausmi Rastogi et al.). This methodological framework situates the research within a wider academic discourse, so highlighting the significance of historical sustainability as a reference for contemporary environmental policies and practices (Sarbjeet Kaur et al.). The research seeks to elucidate the significance of ancient methodologies for contemporary sustainability while contributing to a broader narrative that appreciates ancient ecological wisdom in fostering a resilient future for modern societies (D. R. K. Saikanth et al.). This methodological approach establishes a basis for clarifying the complex sustainability networks in ancient India and Egypt, thus filling a significant vacuum in the current academic literature (Shubham Jain et al.).

Discussion

An examination of ancient civilizations uncovers an intricate relationship between natural resource management and sustainability practices, especially in the contexts of India and Egypt. Both societies employed highly adaptable farming methods specifically suited to their unique environmental contexts. Significant findings reveal that in ancient India, sustainable methods including crop rotation, intercropping, and rainwater collection were incorporated into daily agricultural activities, enabling people to optimize productivity while maintaining soil fertility (B. Guelpa). Conversely, ancient Egypt skilfully utilized the annual inundation of the Nile River via advanced irrigation systems, demonstrating a pragmatic use of environmental understanding to improve agricultural output (Pulak Bisen et al.). ancient methods not only enhanced food security in ancient cultures but also demonstrated an early comprehension of ecological balance. Comparative analysis with prior research indicates that although the principles of these methods were acknowledged, the particular methodologies and regional modifications warrant additional examination (Peeyush Sharma et al.). Moreover, the use of sustainable methods in water resource management, exemplified by subterranean canals in the Indus Valley, has been emphasized in literature, revealing a significant parallel with Egypt's basin irrigation systems (Mausmi Rastogi et al.).

This comparative analysis of agricultural sustainability illustrates that both civilizations evolved as leaders in environmental management. The implications of these findings are diverse; academically, they enhance our comprehension of sustainability in historical contexts, while practically offering useful insights for modern resource management (Sarbjeet Kaur et al.). The research enhances current dialogues on environmental resilience and resource conservation methods by identifying ancient activities that correspond with contemporary sustainability challenges. The recognition of these historical systems not only contextualizes present environmental policy but also emphasizes the necessity of incorporating traditional ecological knowledge into modern practices (D. R. K. Saikanth et al.). This method may improve global sustainability initiatives, especially in poor areas facing resource shortages (Shubham Jain et al.). Consequently, the findings establish India and Egypt not only as historical entities but also as exemplary models from which contemporary and future societies can derive significant insights regarding sustainable practices and resource management (Ajay Naik).

These results facilitate a more profound academic discussion regarding the progression of agricultural methods and their significance in contemporary environmental discourse (Apurva Avinash Gour). Recent years have seen an increasing acknowledgment of the significance of sustainable practices in historical contexts, highlighting how ancient civilizations skilfully addressed their environmental issues. This research reveals that ancient India and Egypt utilized complex resource management systems, demonstrating their profound comprehension of ecological balance and sustainability principles. Agricultural practices in India, including rainwater gathering and the development of drought-resistant crops, exemplify a sophisticated application of sustainability that corresponds with contemporary ecological practices (B. Guelpa). The Egyptians' elaborate irrigation systems, which utilized the seasonal floods of the Nile, demonstrate a complex method of properly managing water resources (Pulak Bisen et al.). The cross-cultural analysis reveals that although both civilizations encountered unique geographical and climatic challenges, their sustainable strategies displayed significant similarities, especially in their dependence on natural cycles and community participation in resource management (Peeyush Sharma et al.). Prior research has highlighted the inventive frameworks utilized by these cultures, emphasizing their capacity to implement sustainable practices in reaction to historical environmental challenges (Mausmi Rastogi et al.). The ramifications of these results surpass historical investigation; they highlight the importance of incorporating old knowledge into modern ecological initiatives. Modern cultures can derive crucial insights to tackle contemporary environmental concerns by analyzing the practical uses of historical methods (Sarbjeet Kaur et al.). The methodological significance of this research resides in its comparative approach, which enhances our comprehension of each civilization's sustainability practices and promotes an interdisciplinary dialogue between historical scholarship and contemporary environmental studies (D. R. K. Saikanth et al.).

This research elucidates how insights from ancient India and Egypt might inform modern strategies for achieving sustainability, in the context of current global issues related to resource depletion and climate change (Shubham Jain et al.). Furthermore, when policymakers and stakeholders seek to enhance environmental management techniques, integrating these historical perspectives may yield a more comprehensive knowledge of long-term sustainability principles (Ajay Naik). Ultimately, acknowledging and appreciating these old traditions reveals avenues for a sustainable future, integrating historical knowledge with contemporary ecological strategies (Apurva Avinash Gour).

Conclusion

An examination of sustainable practices in ancient India and Egypt has revealed the advanced resource management strategies utilized by these civilizations, demonstrating their deep comprehension of ecological equilibrium. The study included agricultural practices, water management systems, and community resource conservation, demonstrating the fundamental role of sustainability in their agricultural and socioeconomic structures. This research successfully tackled the fundamental issue of comprehending how historical sustainability practices influence contemporary environmental concerns. An examination of irrigation techniques, crop rotation, and traditional water harvesting reveals that sustainable practices in both civilizations were marked by innovation and flexibility, offering significant insights for modern ecological management (B. Guelpa). The ramifications of these findings transcend academia, highlighting the significance of ancient wisdom in shaping contemporary sustainability practices, particularly in resource-limited settings. This research emphasizes that the incorporation of traditional knowledge systems can improve contemporary agricultural policies and practices, hence fostering sustainability on a broader scale (Pulak Bisen et al.). Future study ought to concentrate on comparative studies that investigate the impact of these historical traditions on regional environmental policies, especially in places currently with analogous sustainable resource management difficulties (Peeyush Sharma et al.). Furthermore, it may be advantageous to explore the adaptation of these old techniques to modern contexts, thus connecting historical wisdom with present ecological strategies (Mausmi Rastogi et al.). This dissertation urges scholars and practitioners to reassess conventional ecological knowledge for its potential to alleviate contemporary environmental crises and improve global sustainability initiatives (Sarbjeet Kaur et al.). Interdisciplinary collaboration among historians, ecologists, and policymakers is advised to integrate historical practices into contemporary sustainability frameworks, enhancing food security and environmental protection (D. R. K. Saikanth et al.). This research advocates for greater exploration of the sustainable methods of ancient India and Egypt and their relevance to contemporary environmental management tactics.

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Exploring 1, 4-Dihydropyridines: Synthesis, Biological Activities, Therapeutic Potentials and Computational Studies

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Abstract:

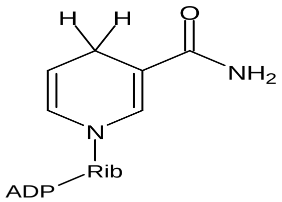
1, 4-dihydropyridines and their derivatives are the foremost notable class of Nitrogen-containing heterocyclic scaffolds and have been extensively used since they are occupying the highest position in the pharmaceutical industry because of its wider range of biological and medicinal uses.

One of the most straightforward and cost-effective techniques for creating biologically significant and pharmacologically beneficial 1,4-dihydropyridine derivatives is the conventional Hantzsch reaction, which was first described by Arthur Hantzsch. This review article will highlight the recent and green approach methodologies adopted to synthesize 1, 4-dihydropyridine derivatives with their anti-oxidant properties along with anti-bacterial activity, anti-fungal activity and computational studies. The study and distilled findings will be immensely instructive, valuable, and informative for researchers working in the domains of medicinal chemistry and drug development.

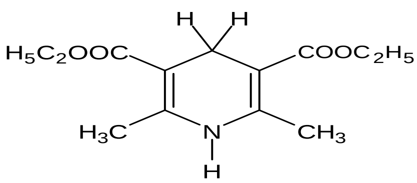
Keywords: Hantzsch reaction, Anti-oxidant, Anti-bacterial, Anti-fungal, Computational studies.

Introduction-

Because of their broad spectrum of biological and pharmacological actions, heterocyclic molecules containing nitrogen merit our attention [1]. One pyridine double bond can be semi-saturated with two substituents to produce five isomeric forms of nitrogen heterocyclic DHPs [2], among which 1,2-DHPs and 1,4-DHPs are the more prevalent and important [3]. Six-membered nitrogen-containing heterocyclic compounds known as 1, 4-DHPs (1,4-Dihydropyridines) are found in nature and are known to have biological activity [4]. DHPs, also referred to as Hantzsch esters, are considered to be synthetic-analogues of reduced Nicotinamide adenine dinucleotides (NADHs) [5], which are essential coenzymes for biological oxidation-reduction reactions and act as cell "powerhouses" [6].



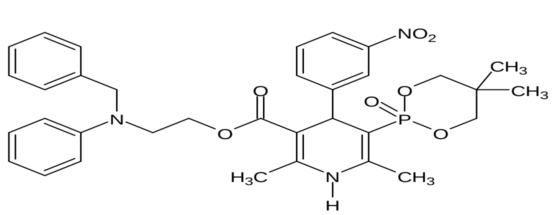
NADH

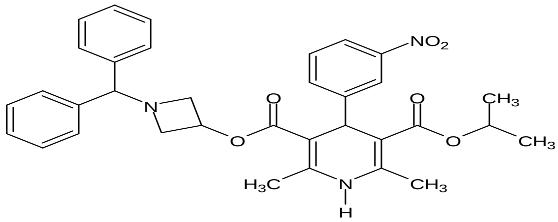


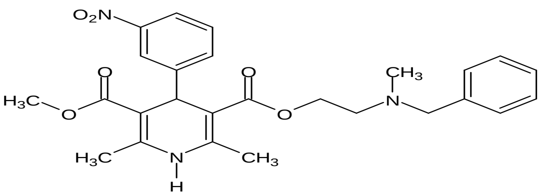
H - DHP (Hantzsch ester)

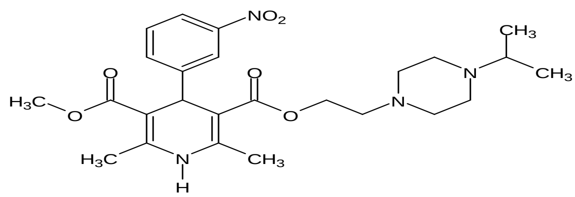
It has been noted that some DHP derivatives and formulations containing DHP have antioxidant activity, which contributes to their noteworthy pleiotropic benefits, which include antibacterial, anticancer, neuroprotective, and antiaging activities.

In recent decades, a number of DHP model compounds have been used in clinical studies due to their impressive range of pharmacological activities. For instance, the calcium channel blocker isradipine is used as a stand-alone treatment for hypertension or as a complement to all thiazides. Nisoldipine is prescribed for strokes, angina pectoris, and specific kidney issues. Nicardipine is a short-term drug that can be used orally or intravenously to treat angina and control blood pressure. Nimodipine is used to treat vasospasm and is recommended for subarachnoid hemorrhage and some other brain injuries [7]. These compounds frequently function as chemo-sensitizers in tumour therapy and as cerebral anti-ischaemic drugs for treating Alzheimer's disease [8]. Efonidipine, Azelnidipine, Nicardipine, Manidipine are few significant calcium channel blockers of 1, 4-dihydropyridine derivatives [9].


Efonidipine


Azelnidipine


Nicardipine

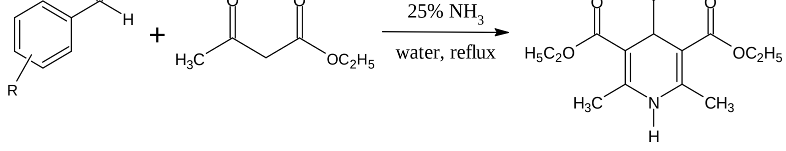

Manidipine

All 1,4-DHPs do not work as calcium antagonists; some of their benefits come from other pathways, like activating DNA repair, protection against mutagens, and directly scavenging free radicals. While few of the 1, 4-DHP derivatives are genotoxic in nature, others show gen-protective qualities [10]. Furthermore, it has been demonstrated that a number of 1, 4-DHP derivatives have strong antitubercular properties and can inhibit both Gram-positive and Gram-negative bacteria. Additionally, by blocking the respiratory chain, lacidipine, certain 3-chlorophenyl, and nitrophenyl 1, 4-DHP derivatives have been found to be harmful to Trypanosoma cruzi [11]. Following theoretical calculations by density functional theory (DFT) using the B3LYP, a number of dihydropyridine carboxylic acid derivatives demonstrated intriguing cytotoxic activity for the HCT-15 (human colorectal carcinoma) cell line [12], a few of these derivatives had higher potency. Interestingly, pancreatic β-cells in streptozotocin induced diabetic rats were used to assess the protective effects of a 1, 4-DHP derivative cerebrocrast. A novel long-acting hypoglycemic agent on insulin and blood glucose levels was found [13]. 1,4-DHP and its derivatives have historically been produced by the popular Hantzsch reaction, a one-pot multicomponent synthesis that involves reaction between β-ketoester, aldehyde, and ammonia, ammonium salts, or ammonia derivatives as source of nitrogen in ethyl alcohol or other lower alcohols while refluxing [14]. Although these described methods offer many advantages, they also have disadvantages, such as stringent reaction conditions, solvents that are not environmentally friendly, high reaction temperatures, prolonged reaction times, and low to moderate yields. Therefore, the development of simple, efficient, environmentally acceptable, and planet friendly processes are still necessary for the synthesis of molecules containing 1, 4 DHPs [15].

Synthesis:-

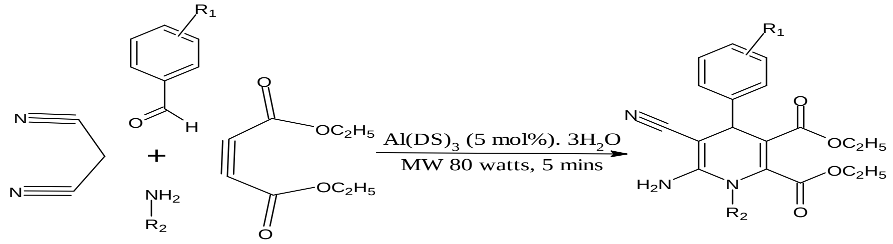
1) **Using water as solvent:**

The Hantzsch reaction for preparing 1, 4-dihydropyridines derivatives catalyzed by clay catalysts, particularly montmorillonite, has garnered much awareness in chemical synthesis in recent times, according to Adeleh Moshtaghi Zonouz et al. (2010) [16]. They are non-corrosive, recyclable, and reasonably priced. Ethyl acetoacetate, montmorillonite K10, ammonia 25% and 2-methoxy benzaldehyde in water as solvent were refluxed for 48 hours (ammonia was added many times during the reflux). This environmentally friendly method uses ammonia as a source of nitrogen to produce high yields while using water as a green solvent.

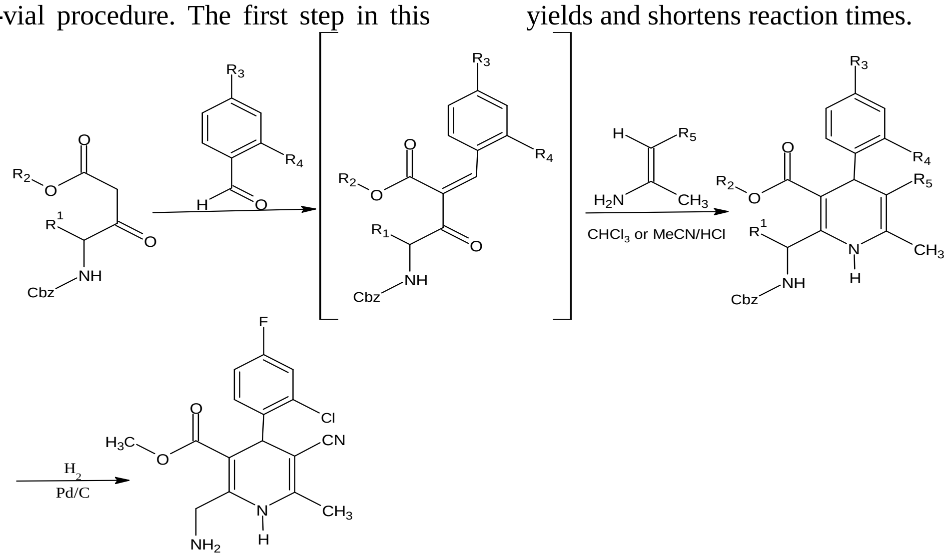


2) **Using Microwave irradiation:**

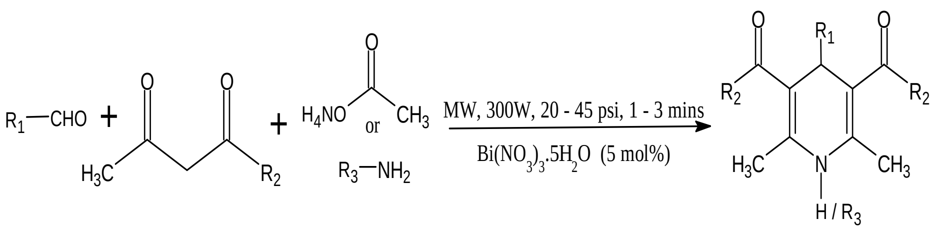
Asmita et al. (2024) [17] report that $Al(DS)_3$ [Aluminum tris (dodecyl sulphate) trihydrate)] catalyst was used to expose a mixture of specific aromatic benzaldehyde, diethyl acetylene dicarboxylate, aromatic primary amine and propanedinitrile to microwave irradiation at 80 watts for five minutes in water. An environmentally friendly one-pot, four-component reaction, single-step synthesis of a novel 1, 4-DHP scaffold was performed using $Al(DS)_3$ in water. This is an illustration of cost-effectiveness and waste reduction with gentle reaction parameters.



According to Felipe Luis et al. (2023) [18], the traditional one-pot three-component synthesis approach is not the best way to make asymmetric 1, 4-DHPs. This led to the introduction of a modified Hantszch synthesis, which is a microwave-assisted, two-step, one-vial procedure. The first step in this process was the condensation of 2-chloro-4-fluorbenzaldehyde with the glycine-derived β-keto ester, which resulted in the Knoevenagel adduct, which was not separated. Moreover, it has been demonstrated that MW-assisted synthesis improves yields and shortens reaction times.

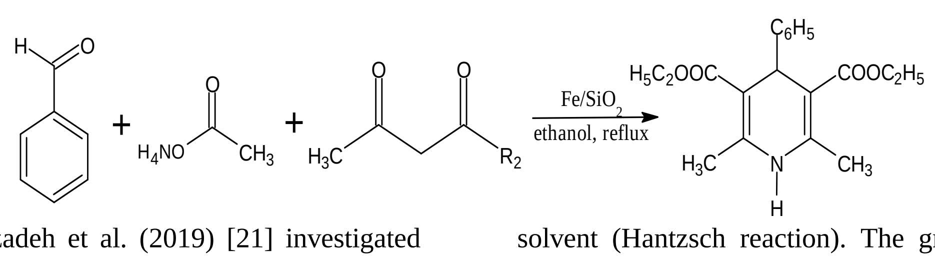


Debasish et al. (2012) [19] produced a number of 1, 4-dihydropyridines using a variety of aldehydes, 1, 3-diketo compounds, and ammonium ethanoate or amine under microwave irradiation with bismuth nitrate acting as a catalyst. The reaction produced excellent yields of the corresponding 1, 4-DHP derivatives.

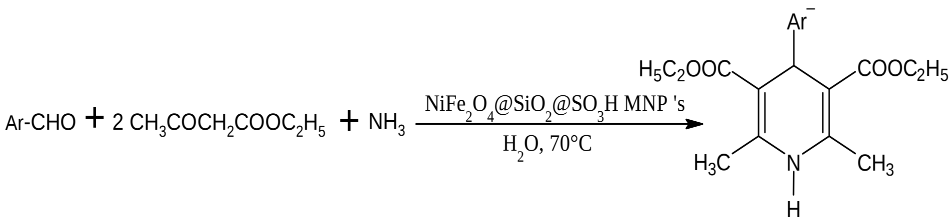


3**) Using heterogeneous nanoparticle catalysts:**

Ateeq Rahman et al. (2020) [20] devised a safe, cost-effective, and environmentally favorable method for synthesizing 1, 4-dihydropyridines in the presence of Fe/SiO_2 (NPs) in a shorter length of time using heterogeneous catalysts. A solution of aldehyde, ethyl acetoacetate, ammonium acetate, and ethanol was reacted under reflux conditions using Fe/SiO_2 as an efficient catalyst.

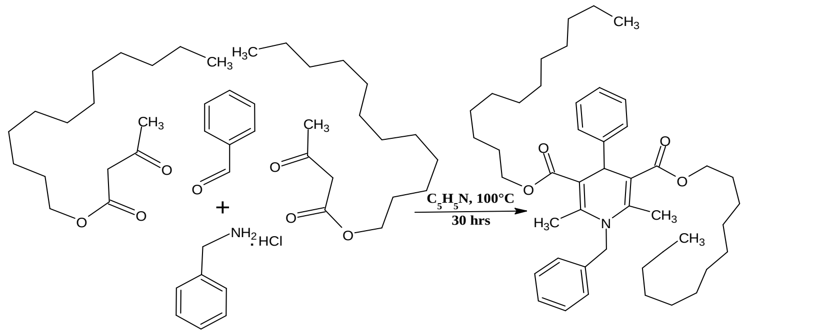


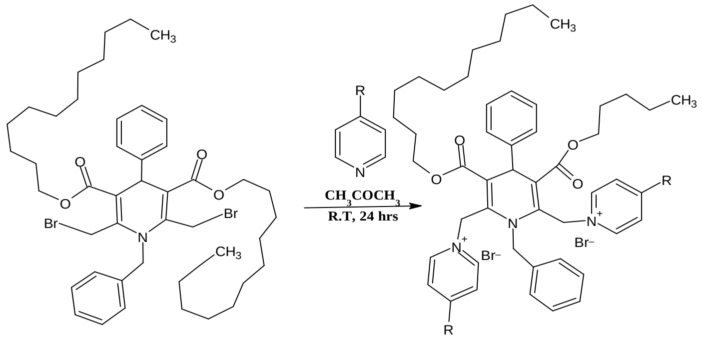
Behzad Zeynizadeh et al. (2019) [21] investigated the catalytic activity of Ni-nanocomposites in the multicomponent one pot condensation reaction of 1, 3- diketones (ethyl acetoacetate) , aromatic aldehyde and aqueous NH_3 in water as ecofriendly safe solvent (Hantzsch reaction). The green feature of this synthetic technique was explored further by looking into the regeneration of $NiFe_2O_4@SiO_2@SO_3H$ magnetic nanoparticles. The new approach offers notable benefits in terms of stability, simple separation of the magnetic nanocatalyst, mild reaction conditions, and the use of H_2O as an environmentally benign solvent.



4) **Using pyridine as a solvent:**

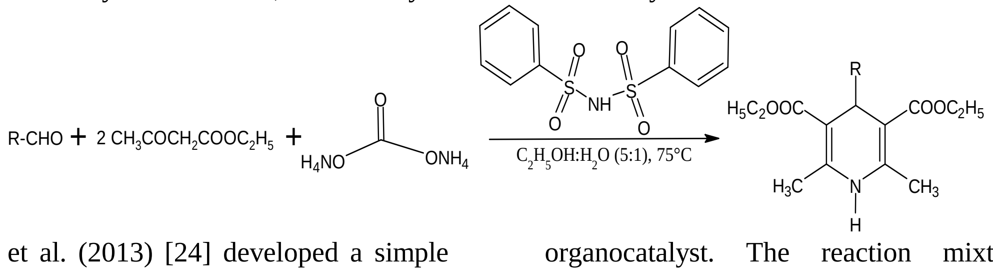
Anna et al. (2013) [22] demonstrated a method for synthesizing N-benzyl 1, 4-DHP. A solution of benzaldehyde, phenylmethanamine hydrochloride, and dodecyl acetoacetate in pyridine was refluxed for 30 hours. The oily layer was extracted with 1N hydrochloric acid after that it was transferred to an ice or cold water and extracted with dichloromethane, and then the solvent is evaporated, compound was crystallized and vacuum-dried. This was further reacted with 4 – substituted pyridine in presence of propanone at 25° C for 24 hrs to give the required product.



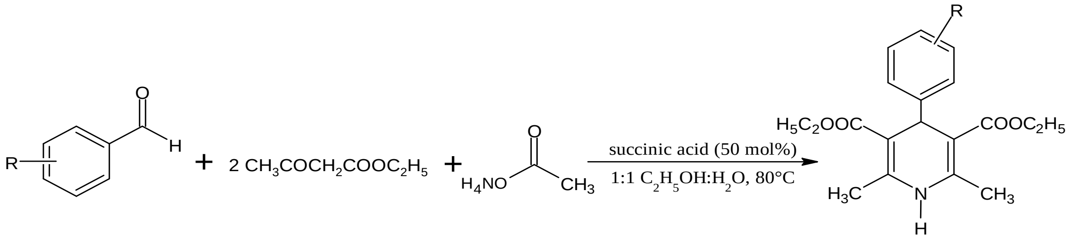


5) **Using Organocatalyst:**

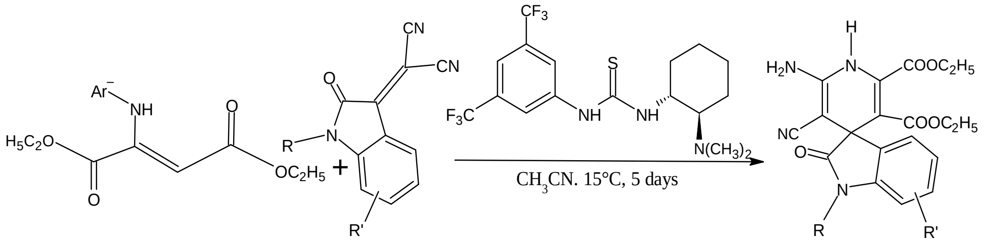
Ghoderao. S et al. (2024) [23] demonstrated a simple and cost-effective synthesis of 1,4-dihydropyridines increased output at 75 °C using an organocatalyst N-(phenylsulfonyl) benzene sulfonamide (NPBS) and an environmentally benign solvent. The initial synthesis of diethyl-2, 6-dimethyl-4-phenyl-1, 4-dihydropyridine-3, 5-dicarboxylate used NPBS as a catalyst to produce (1,4-DHPs) from ethyl acetoacetate, benzaldehyde and ammonium salt. This allowed us to determine the impacts of various ammonium salts. Compared to ammonium ethanoate, ammonium hydrogen carbonate, ammonium chloride or ammonium carbonate produced ammonia at an excellent to exceptional rate. At moderate temperatures, the current method provides economic and environmental benefits such as high yields, short reaction times, ease of setup, catalyst recycling, and reusability.



Patil Suresh et al. (2013) [24] developed a simple and effective multicomponent Hantzsch reaction that employs a minimum amount of butanedioic acid as a non-toxic, non-corrosive, and economical organocatalyst. The reaction mixture, which included substituted aryl halide, ethyl acetoacetate, and ammonium ethanoate in a 1:1 ethanol: water ratio, was supplemented with 50 mol% butanedioic (succinic) acid.

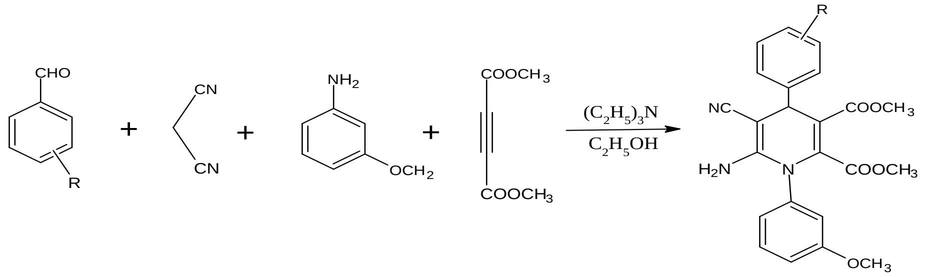


Fernando Auria-Luna et al. (2018) [25] created the first organocatalytic enantioselective method for the obtaining chiral 1-benzamido-1, 4-dihydropyridines. The final 1, 4-dihydropyridines were generated in substantial amount and exhibited interesting enantioselectivity even under mild circumstances.



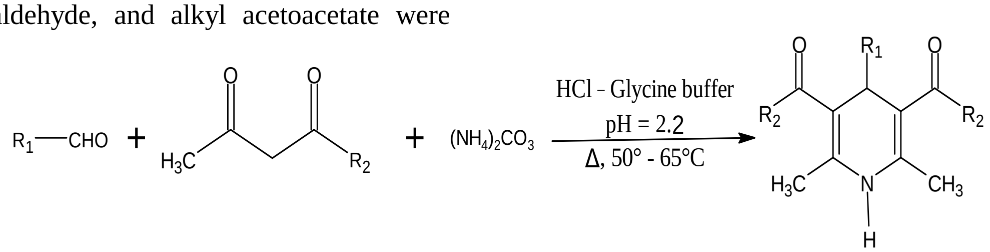
6) Using triethylamine as a catalyst:

In their 2019 study, Reddy Guda Mallikarjuna et al. [26] presented a novel method for creating 1, 4-dihydropyridine derivatives using a multicomponent reaction. This approach used a less toxic solvent condition and a cheap triethylamine catalyst. In the presence of triethylamine in ethanol solvent, methylbenzaldehyde was treated for 4–6 hours at 70–80°C with malononitrile, m-methoxy aniline, and dimethyl acetylene dicarboxylate.



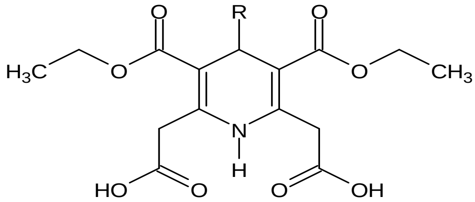
7) Using Glycine-HCl buffer as solvent and bio-catalyst:

Under buffering conditions, Ebrahimlo Ali Reza Molla et al. (2019) [27] have created a quick, easy, and environmentally friendly way to synthesize 1,4-DHPs. The reaction solvent and catalyst was a glycine-HCl buffer solution. Anhydrous ammonium carbonate, aldehyde, and alkyl acetoacetate were combined and agitated in a buffer solution (pH=2.2) at 50–65 ´C. The reported novel methodology's noteworthy features include: (a) high efficiency; (b) easy work-up; (c) shorter reaction times; (d) the removal of organic solvents, toxic reagents, and inorganic catalysts; and (e) recyclable performance, which may find use in green synthesis.

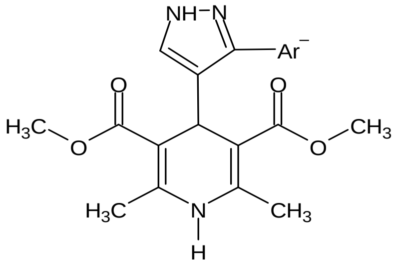


Antimicrobial Activity:-

The antibacterial activity of the recently produced compounds 1,4-DHP derivatives was examined by Malhi Dharambeer S. et al, 2022) [28]. *Escherichia coli*, *Klebsellia pneumonia*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* were chosen as Gram-negative bacteria while *Bacillus subtilis, Pseudomonas fluorescens,* and *Streptococcus pyogenes* were chosen as Gram-positive bacteria for this evaluation,. Fungal strains chosen include *Fusarium oxysporum, Aspergillus janus, Aspergillus niger* and *Pencillium glabrum*. The findings indicate that dicarboxylic substituted derivatives with carboxylic acid groups at second and sixth position of 1, 4 – DHP nucleus have a 2–3 fold increase in antifungal activity at 4 µg/ml, with certain compounds exhibiting greater action than the conventional medications, Amoxicillin and Flucunazole. By replacing the hydroxyl group alone or the carbonyl and hydroxyl groups together, more potent medications can be created.

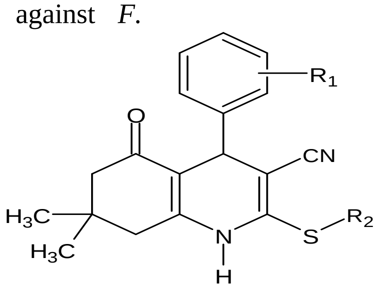


A.M.Vijesh et al, (2011) [29] carried out antibacterial activity for bacterial strains such as *E.coli, S.aureus, P.aeruginosa* and antifungal activity for fungal strains such as *A.flavus, C.albicans* etc. They observed that compounds containing ethyl ester group show good activity compared to ones containing methyl ester group. Also compounds having a combination of two heterocyclic systems such as pyrazole and dihydropyridine show enhanced activity.

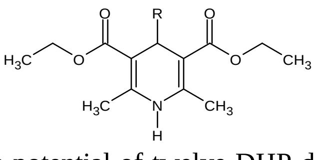


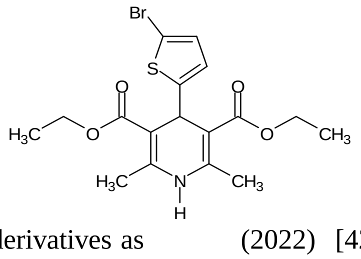
Similarly, Bhatt Aditya H. et al. (2017) [30], P.M.Singala et al. (2015) [31], Mithilesh et al, (2010) [32], Miyase Gozde Gunduz et al. (2011) [33], Sohal Harvinder Singh et al. (2014) [34], Akbarzadeh. T et al. (2010) [35], Shinde. D.W et al. (2020) [36] and Katarzyna Niemirowicz-Laskowska et. al (2018) [37] also carried out antimicrobial activity using bacterial strains like *E.coli, P.aeruginosa, S.aureus, B.subtilis* etc. and fungal strains *like A.niger, C.albicans* etc.

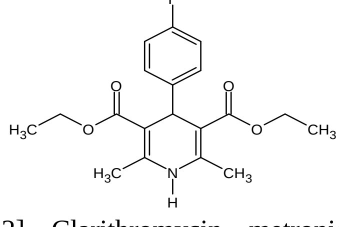
Using the Poison Food Technique in solid medium, [38] evaluated the effects of azoxystrobin and dihydropyridine derivatives on the Yang Guan-Zhou et al. (2018) fungal growth against *F. oxysporum, M. oryzae, S. sclerotiorum* and *B. cinerea*. Structure activity relationships (SARs) made it abundantly evident that changes in the location of alkyl groups in the aromatic phenyl ring had a significant impact on the insecticidal activity. The biological activity spectrum was significantly impacted when ethyl acetate group was replaced by the cyano group at the dihydropyridine core's third position and alkyl group at second position is replaced by thio alkyl group as given in general structure. These findings serve as a guide for future research into neonicotinoid pesticides and potential agricultural fungicides.



M. G. Sharma et al, (2017) [39], Partasarthi. D. et al. (2021) [40], Vanaja G et. al. (2020) [41] have carried out the antimicrobial activity of the synthesized 1, 4-DHP derivatives. The antibacterial activity of synthesized compounds was assessed against bacterial species such *as Escherichia coli, Salmonella typhi, Bacillus subtilis* and *Streptococcus pneumoniae* using Ampicillin as standard. Antifungal activity of these compounds was also checked against *Candida albicans*, *A niger* and *A. Clavatus* using Gresiofulvin as standard drug. It was also concluded that activity of dihydropyridines is depending on the substitutent present of the DHP moiety.

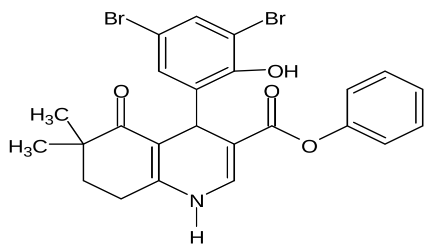


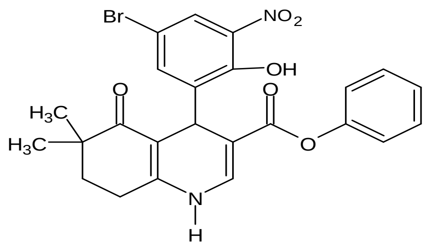




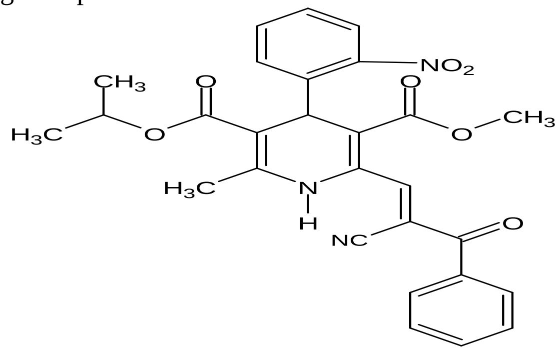
The potential of twelve DHP derivatives as novel antibacterial options against Helicobacter pylori has been examined by Andrés González et al. (2022) [42]. Clarithromycin, metronidazole, and levofloxacin resistance were demonstrated by the Minimum Bactericidal Concentration (MBC) and

Minimum Inhibitory Concentration (MIC) values of all DHP derivatives against three distinct antibiotic-resistant strains of *Helicobacter pylori*. The maximum activity against *H.pylori* was observed in these two compounds.

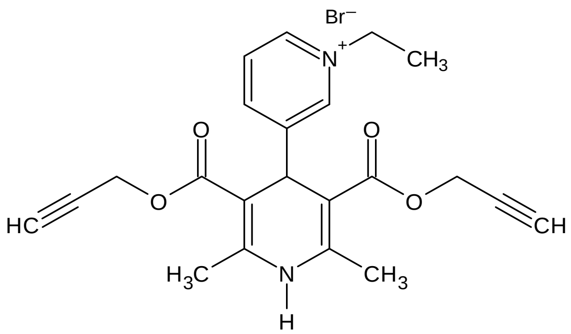




The antibacterial activity of 1,4-DHP was assessed by Olejnikova Petra et al. (2014) [43] using a broth micro dilution method on Gram-negative bacteria *Escherichia coli* and *Mycobacterium smegmatis* and Gram-positive bacteria *Staphylococcus aureus*. Using the agar macro-dilution technique, an antifungal experiment was conducted against filamentous fungi - *Botrytis cinerea* and *Aspregillus fumigatus*. The compounds synthesized displayed moderate antifungal activity but the following 2 – substituted dihydropyridine derivative displayed best antibacterial activity against M.smegmatis.

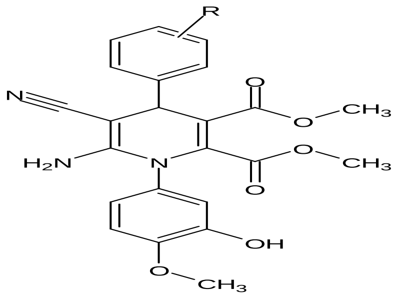


Rucins Martins et al. (2019) [44] evaluated the toxicity of 4-(N-alkylpyridinium)-1, 4-DHP derivatives using one eukaryotic (yeast) and six prokaryotic (bacteria) species. The microbes used in the study included *Micrococcus luteus, Klebsiella pneumoniae, Pseudomonas aeruginosa, Bacillus subtilis, Escherichia coli, Proteus mirabilis*, and *Saccharomyces cerevisiae*. It was revealed that toxicity of these DHP derivatives to bacterial species and eukaryotic microorganisms relies on the number of propargyl groups and length of the alkyl group at the N-alkyl pyridinium nucleus.

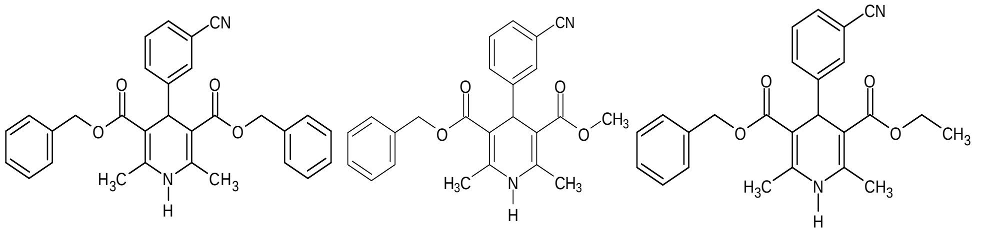


Anticancer Activity:-

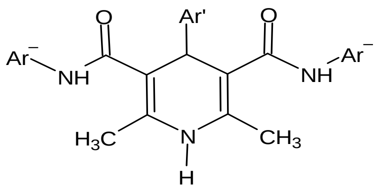
Guda Mallikarjuna R. et al. (2023) [45] obtained the U937s, SKOV3, HepG2, and B16F10 from the NCCS, Pune. According to the Mossman approach, the MTT assay - [3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide] was used to measure the cell toxicity. IC50 values when compared to control data computed using the appropriate regression methodologies, cause a 50% reduction in the cell population. When compared to the other cell lines under investigation, the 1, 4-DHP derivatives have shown encouraging cell toxicity effects against the HepG2 cancer cell line as per the cytotoxicity data, using etoposide as a reference. The DHP derivatives used had the following general structure



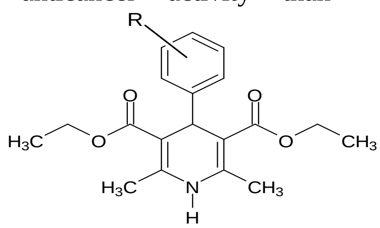
Using a variety of structures and computer modeling methodologies, Saad Mohammad et al. (2022) [46] chose 1,4-DHP derivatives and sent them for determination of anticancer potential. The 20 nitrile group compounds were tested against 60 cell lines such as leukemia, lung cancer, colon cancer etc. Longer alkyl chains at positions 2 and 6 of the DHP nucleus exhibit enhanced anticancer activity. A few compounds exhibit remarkable growth inhibiting effects against leukemia [HL-60(TB) and K-562], lung cancer (NCI-H522) and colon cancer (HCT-116 and HT29) cell lines. The compounds showing best anticancer potentials were:

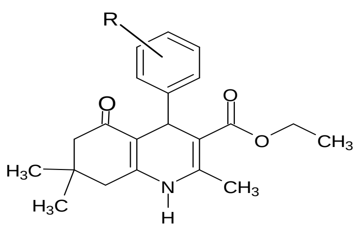


Razzaghi-Asl Nima et al. (2015) [47] procured samples of MCF-7, LS180, and MOLT-4 cells. Following exposure to artificial substances, cell viability was assessed using the MTT decline test. DHP derivatives with hydrogen acceptor or donor groups appeared to have a greater influence on 4 – position of C4-substituted aromatic ring for the LS180 and MOLT-4 cell lines. The general structure of compounds used by them for investigating anticancer activity is:

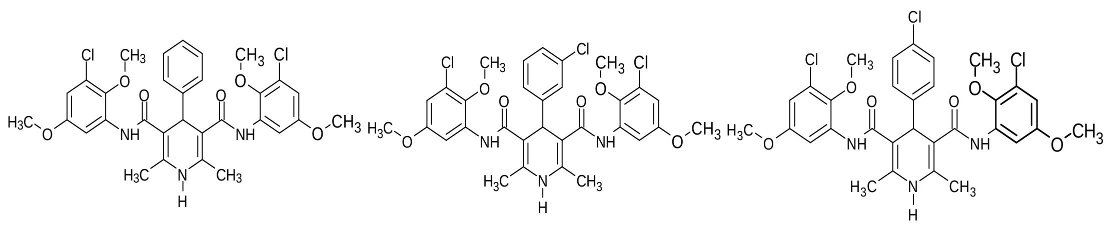


The cytotoxicity of asymmetric and symmetric 4-aryl-1,4-dihydropyridines to human cancer cell lines - MCF-7, HeLa 229, and U-251MG was evaluated by Oliveira Thaís A. S. et al. (2024) [48]. Hantzsch esters have higher anticancer activity than polyhydroquinolines, symmetric 1, 4-DHP ring may have a major impact on the anticancer activity against HeLa and MCF-7 cell lines. The general structures of symmetric and asymmetric 1, 4 – DHP's are:

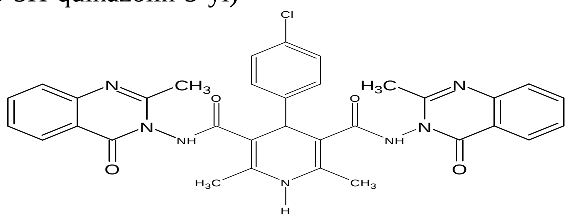




When Faizan Syed et al. (2024) [49] assessed the in vitro cytotoxicity of the synthesized 1,4-DHP derivatives against MCF-7 breast cancer cells, they discovered that all of them showed good activity in contrast to lapatinib, a standard anticancer drug,. The structures of the compounds are:

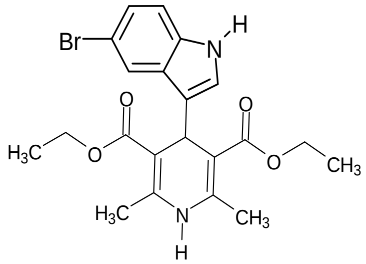


Using the MTT microassay, Kalam Sirisha et al. (2009) [50] evaluated the 1,4-DHP derivatives' in vitro anticancer properties. The compounds' growth-inhibitory properties were evaluated against the following cancer cell lines: A431 (skin), HT-29 (colorectal), and MCF-7 (breast). The derivative with the N-(2-Methyl-4-oxo-3H-quinazolin-3-yl) group at positions C-3 and C-5 and the 4-chlorophenyl group at position C-4 is equipotent against MCF-7 and HT-29 cell lines in comparison to regular methotrexate. The structure of compound synthesized and exhibiting highest anticancer activity is:



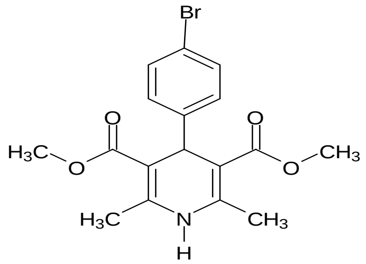
Antioxidant Activity:-

Using the DPPH free radical assay, Ahamed Mashood F. M. et al. (2024) [51] examined the antioxidant activity of 1,4-DHP derivatives. By dissolving 0.01 g in 100 mg/mL of solvent, a chemical stock solution was created. Various strengths, including 10, 20, 40, 80, and 160 µg/mL, were created. Two milliliters of DPPH were mixed with one milliliter of each sample solution, kept in a dark location, and allowed to react for half an hour at room temperature. The DPPH was lowered by the chemical, which also caused it to alter from deep violet to light yellow. After 30 minutes, absorbance values were recored at a wavelength of 517 nm using ascorbic acid as a standard. The antioxidant activity was calculated using a UV visible spectrophotometer to measure absorbance values. Comparatively speaking, this derivative's antioxidant activity is higher than the positive standard.



The total antioxidative capacity assay, which Lidija Milkovic et al. (2018) [52] demonstrated depends on the tested compounds' (1,4-DHP derivatives) capacity to scavenge hydrogen peroxide, thereby competing with enzyme peroxidase and inhibiting oxidation of a chromogenic substrate – Tetra Methyl Benzidine (TMB), was carried out with a minor modification. DHP compounds' capacity to scavenge was contrasted with that of uric acid, a common oxidant. To treat human osteoblast-like cells, DHPs with strong antioxidative properties were used.

Hasan Erdinç Sellitepe et al. (2019) [53] examined the antioxidant properties of 1,4-DHP derivatives using the DPPH technique. These findings showed that because the methoxy group releases electrons, its presence in the aromatic ring enhanced the scavenging activities. The compound with enhanced antioxidant activity was:



Inclay Suslu et al. (2016) [54] used a disposable pencil graphite electrode to measure the antioxidant activity of newly synthesized condensed 1,4-dihydropyridine derivatives. The oxidation potential value was ascertained using the cyclic voltammetry technique, and the derivatives' reduction potential values were ascertained using the differential pulse voltammetry technique. Nifedipine was employed as a reference medication to confirm the findings. Similar antioxidant properties were found when 1,4-DHP derivatives and traditional antioxidants were examined. Consequently, natural antioxidant shortages might be eliminated and synthetic antioxidants, such as 1, 4-DHP derivatives, could be used in their place.

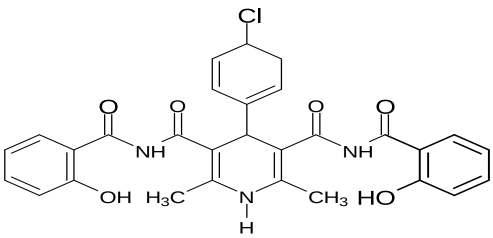
A.E. Abdalla et. al. (1998) [55], M. Akram Khan et. al, (2020) [56], Hao Sun et. al (2012) [57] synthesized 1, 4 dihydropyridines and tested their antioxidant activity by DPPH method.

As a less hazardous alternative to synthetically prepared phenolic antioxidants, Tirtis G. et al. (2000) [58] investigated antioxidants with a 1,4-dihydropyridine structure in liposomes under conditions akin to those seen in food preservation. Trolox^{TM} and Probucol^{TM} were compared to the antioxidant qualities of 2, 6 – dimethyl - 3, 5 – dialkoxycarbonyl - 1, 4-dihydropyridines with varying side chain length alkyls (CH_3 – $C_{16}H_{33}$) in the ester moiety by liposome peroxidation with transition metal-ion catalyst. For compounds with ethyl or butyl residues in the 3, 5-position of ester moieties, the greatest antioxidant activity is demonstrated. The investigated chemicals' capacity to integrate into liposomes is linked to their antioxidant activity. They also suggested that 1, 4 – DHP's are future lipid antioxidants due to their low toxicity.

Computational Studies:-

Dib Hanna et al. (2024) [59] acquired the target protein PIM – 1 kinase from the protein databank (PDB ID: 2OBJ). It was used to execute docking runs and visualize the docking postures and interactions. The structure of ligand was prepared and added to the database of dihydropyridine molecules in order to verify the docking process. Every ligand had as little energy as possible. It was docked using the default protocol. Their ratings and interactions were evaluated using the docking sites of amino acid residues.

A binding mechanism between 1, 4-DHP compounds and the COX proteins was demonstrated by Idhayadhulla Akbar et al. (2022) [60] during molecular docking investigations using Autodock vina. The COX-2 protein was complexed with SC-558 (PDB ID: 1CX2). Fourteen DHP derivatives were prepared, one of these was found to show profound analgesic activity which was endorsed by molecular docking results and its structure is:



Madar Jyoti M et al. (2021) [61] used molecular docking studies on the crystal structure of S.aureus Gyrase complex with ciprofloxacin and DNA (PDB ID: 2XCT) to show the mechanism of antibacterial activity as well as (PDB ID: 4PH9) for anti-inflammatory activity against cyclooxygenase 2 (COX 2) and details of 2 – D interactions of the synthesized 1,4-DHP derivatives.

Kolawole Abel Oyebamiji et al. (2016) [62] concentrated on developing a QSAR model that forecasts experimentally observed bioactivity from calculated molecular descriptors and on applying the Density Functional Theory (DFT) method to compute molecular descriptors that characterize the bioactivity of these chosen compounds. In order to estimate the free energy of binding and anticipate appropriate compound formation, the structures of these compounds after geometrical optimization are docked with MCF-7 (PDB: 1HI7). The free energy of interactions between the chemicals and the receptor (MCF-7) is connected with the bioactivities of the compounds.

The synthesis of new dihydropyridine derivatives, calcium channel blocking activity, docking, homology modeling and molecular dynamics study was presented by Madhu Sudhana Saddala et al. (2017) [63] using PDB ID: 1BL8.

Conclusions:

The different recent synthetic strategies exhibited can be used by organic chemists for crafting this drug moiety. The antimicrobial properties such as antibacterial and antifungal have been emphasized so as to give a thorough idea about the organisms that can be used for the studies and QSAR for 1, 4 DHPs have also been pointed out. The moiety has anticancer activity and some of the cancer cell lines used for 1, 4 DHPs, mainly MCF – 7, HepG2, MOLT – 4, HeLa, HT – 29, A431, SF – 295, M14 etc. Antioxidant activities can not only be ascertained by DPPH method (most popular), but other methods such as using hydrogen peroxide, cyclic voltammetry, differential pulse voltammetry and transition metal ion catalyzed liposome peroxidation can be used. Finally for computational studies, the researchers are familiarized with the type of target protein, their PDB ID along with other docking details for 1, 4 – DHP.

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Removal of Dyes by Using Agro Bio Waste Material as A`Low-Cost Adsorbent in Comparison With Activated Charcoal

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Abstract
Recently, there has been increased interest in using agricultural and plant waste products for dye removal by adsorption from aqueous solutions such as industrial effluents because of their natural availability and higher removal efficiency. Attention has been focused on various natural solid supports, which can remove pollutants from contaminated water at low cost. In the current study, we have tried to remove samples using two agro-biowastes (Sugarcane Bagasse and Groundnut shells).

Keywords: Methylene Blue, Adsorption, Activated carbon, Bio-waste

Introduction

Dyes are compounds that provide colour to various materials by modifying their internal structure often on a temporary basis typically utilised in water-based solutions dyes find extensive application in sectors like textiles paper and pulp and cosmetics it is estimated that there are more than 10000 distinct types of dyes and pigments utilised worldwide with the annual production of synthetic dyes exceeding 700000 tons however the release of these synthetic dyes into water bodies via industrial wastewater presents considerable environmental risks.

Literature Review

The contamination of industrial water particularly due to synthetic dyes posses a significant environmental challenge conventional methods for dye removal often utilise materials such as activated carbon (AC) which despite their effectiveness can be prohibitively expensive and limit the feasibility of large-scale water treatment initiatives recently there has been an increasing focus on utilising agricultural bio-waste materials as affordable and sustainable alternatives to activated carbon this literature review consolidates research on the application of agricultural waste as dye adsorbents evaluating their efficiency and sustainability in comparison to traditional activated carbon methods.

Agro Bio Waste as Adsorbents

A variety of studies have underscored the potential of agricultural waste materials for dye adsorption. Bharathi and Ramesh (2013) provided a comprehensive review highlighting the effectiveness of different agricultural wastes in removing dyes primarily due to their abundant availability and low cost. Karic et al. (2021) noted that biomass-based sorbents present an environmentally friendly and sustainable solution for dye removal reinforcing the role of agricultural bio-waste in wastewater treatment processes.

Comparison with Activated Charcoal

While activated carbon remains a widely used and effective adsorbent, its high production costs and the complexities associated with its regeneration present significant barriers to broader application. Moosavi et al. (2020) investigated the enhancement of activated carbon through the incorporation of magnetic particles to boost dye adsorption capabilities illustrating ongoing efforts to improve its performance. This advancement prompts consideration of whether agricultural bio-waste materials could similarly be enhanced or potentially function as independent cost-effective alternatives to activated carbon.

Mechanisms of Adsorption

Understanding the interactions between dyes and adsorbents is essential for optimising adsorption efficiency. Research indicates that factors such as surface area porosity and the presence of functional groups are critical in influencing these interactions.

The use of agricultural bio-waste as adsorbents offers a viable substitute for activated carbon. In the extraction of dyes from wastewater current studies demonstrate the potential of these materials. However, issues concerning standardisation consistency in performance and regeneration persist by tackling these challenges and investigating novel composite approaches; upcoming research can greatly enhance sustainable and efficient treatment methods.

Methodology Adsorbent Preparation Groundnut Shells and Sugarcane Bagasse are sourced, dried and stored into airtight plastic containers.

Adsorbate Preparation Dye stock solution is prepared and working range standard concentrations will be prepared from this stock

Batch Adsorption Method (Immersion method)

The Immersion method was carried out by mixing a pre-weighed amount of the adsorbent with aqueous dye solution of a particular concentration. They were agitated for a predetermined time interval at a constant speed.

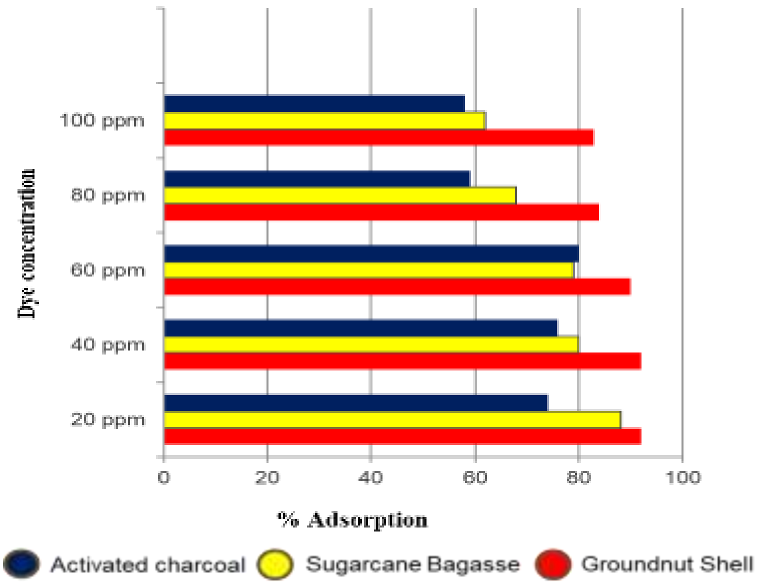
After adsorption was over, the mixture was allowed to settle and the supernatant solution was filtered using Whatman filter paper. The dye remaining unadsorbed was determined spectrophotometrically using a digital colorimeter. In the present studies, a series of batch adsorption experiments were conducted to determine the adsorption of Methylene Blue on Groundnut Shell (GS) and Sugarcane Bagasse (SB) powders was calculated using,

Percent adsorption (%) = $(C_0 – C_t) / C_0 \times 100$ Where,
C_0 = initial concentration of dye.
C_t = final concentration of dye.

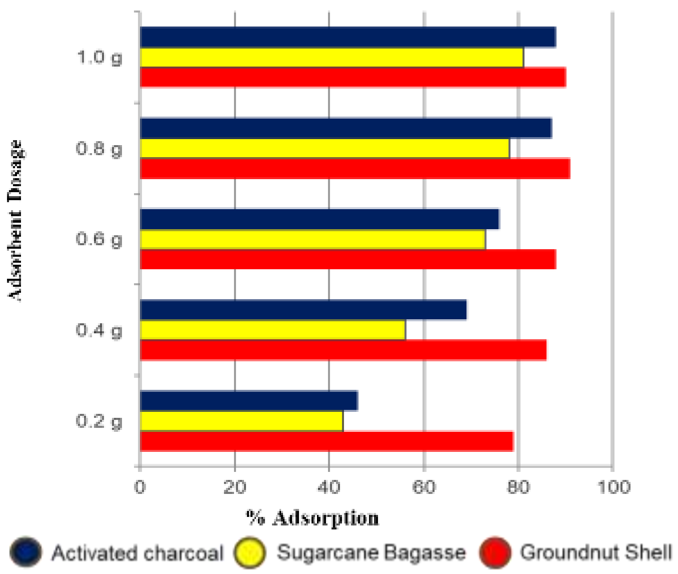
Optimization of operational variables viz adsorbent dosage, adsorbate concentration, contact time & temperature was carried out.

Data Analysis

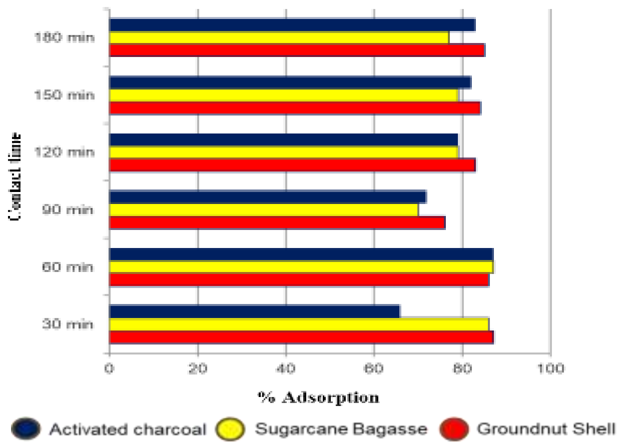
Percent adsorption vs Dye concentration



Percent adsorption vs Adsorbent Dosage



Percent adsorption vs Contact time



Discussion & Implications

The absorbent powders may be combined in various formulations for the purpose of dye removal. Investigations into the impact of pH changes could be conducted. The operational range for different parameters might be broadened. Additional dyes could be utilised in the experiments. Leaf litter from other garden plants could also be explored as a source for creating adsorbents. Furthermore, FTIR analysis could be performed on the adsorbent powders to identify their functional groups

Conclusion

We can conclude that Groundnut Shell and Sugarcane Bagasse serve as highly efficient adsorbents, demonstrating considerable promise in the elimination of impurities or contaminants via adsorption. This research emphasises that when processed appropriately, these two agricultural by-products can perform comparably to traditional materials like activated charcoal. While activated charcoal was utilised as a benchmark in this study, illustrating its effectiveness, Groundnut Shell and Sugarcane Bagasse present significant benefits in terms of availability, sustainability, and cost efficiency.

The decision to utilise groundnut shell and sugarcane bagasse as foundational materials for adsorbent development was influenced by their widespread and easy accessibility in agricultural areas. Often regarded as waste, these materials are plentiful and can be sourced in large volumes. Their use not only offers a cost-effective alternative to pricier adsorbents but also promotes environmental sustainability by transforming agricultural waste into valuable resources. By repurposing these natural by-products into adsorbents, we can potentially lessen the reliance on conventional and non-renewable materials.

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Interdisciplinary Approaches: Green Management

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Abstract

Environmental challenges like climate change, dwindling resources, and increasing pollution are urging businesses and policymakers to devise innovative pathways for sustainable development. The interdisciplinary approach of combining Green Management principles with Information Technology (IT) has emerged as a powerful strategy to address environmental concerns effectively. This paper explores how IT tools like Artificial Intelligence (AI), Big Data Analytics, and the Internet of Things (IoT) optimize green practices, reduce carbon footprints, and promote resource efficiency in organizational and industrial contexts. It provides a comprehensive review of literature, data-driven case studies, and analysis of it's role in implementing green initiatives. The study highlights the practical implications of adopting IT-enabled green management approaches in achieving the United Nations' Sustainable Development Goals (SDGs). This research provides insights for businesses, policymakers, and researchers on leveraging IT to create a sustainable, eco-friendly future.

Keywords: Green Management, Biochemical Approach, Information Technology, Sustainable Development, Environmental Innovation

Introduction

The increasing environmental degradation caused by rapid industrialization, population growth, and unsustainable practices has made sustainability a global priority. Organizations, industries, and governments are being urged to adopt eco-friendly practices to reduce their environmental impact while ensuring economic growth and technological advancements. This has led to the evolution of Green Management, which focuses on integrating environmentally responsible processes into business operations.Green Management encompasses a wide range of principles and practices, including:

Minimizing environmental impact: Reducing pollution, conserving resources, and mitigating climate change through strategies such as waste reduction, recycling, and renewable energy adoption.

Promoting social equity: Ensuring fair and equitable treatment of employees, local communities, and other stakeholders throughout the supply chain.Driving economic growth**:** Creating sustainable business models that generate economic value while minimizing environmental and social costs.Information Technology (IT) plays a significant role in enhancing and supporting Green Management. IT tools such as Artificial Intelligence (AI), Big Data Analytics, Cloud Computing, and the Internet of Things (IoT) provide innovative solutions for monitoring, analyzing, and optimizing green initiatives. These technologies enable organizations to implement energy-efficient operations, waste reduction strategies, and real-time monitoring of resources, thereby contributing to sustainability.This paper aims to explore the interdisciplinary connection between Green Management and IT, demonstrating how technology-driven strategies can transform organizations into environmentally sustainable entities. The study focuses on IT's role in enhancing energy efficiency, resource optimization, and waste management within green management frameworks.

Figure 1: Key elements of green management

Literature Review

Theoretical Foundations of Green Management

Green Management emphasizes integrating environmental considerations into organizational strategies and operations. The Triple Bottom Line (TBL) framework, introduced by Elkington (1997), underpins Green Management by balancing economic, social, and environmental objectives. Organizations implementing TBL practices report enhanced reputation, cost savings, and long-term resilience

Biochemical Contributions to Sustainability

Biochemical processes leverage biological and chemical innovations for ecological sustainability. Key contributions include:

Bioremediation: Microbial and enzymatic treatments to detoxify pollutants and restore ecosystems.

Bioengineering: Modification of biological organisms for industrial and environmental applications.

Biomimicry: Adopting natural processes to design sustainable materials and systems.

Role of Information Technology in Green Management

IT has revolutionized Green Management practices by offering tools for real-time monitoring, predictive analysis, and operational optimization. Key IT contributions include:

Artificial Intelligence (AI): AI algorithms can optimize energy consumption in buildings, predict energy demand, and automate systems for efficiency. Machine learning can analyze vast datasets to identify patterns and anomalies in environmental data, enabling proactive interventions.

Big Data Analytics: Big Data analytics can collect and analyze large volumes of data from various sources, such as energy meters, sensors, and weather stations, to identify trends and patterns in resource consumption. This data can be used to optimize energy usage, reduce waste, and improve resource allocation.

Internet of Things (IoT): IoT devices, such as smart sensors and meters, can collect real-time data on energy usage, water consumption, and environmental parameters. This data can be used to monitor resource consumption, identify inefficiencies, and implement real-time adjustments to optimize operations. For example, IoT sensors can monitor temperature and humidity levels in buildings to adjust heating and cooling systems automatically, reducing energy consumption.

Cloud Computing: Cloud computing enables organizations to access and share data and applications remotely, reducing the need for physical infrastructure. This can lead to significant energy savings, as data centers can be consolidated and optimized for energy efficiency. Cloud computing also enables the development and deployment of innovative green management applications and platforms.

Synergy Between IT and Biochemical Approaches

The integration of IT with biochemical approaches enhances the scalability and effectiveness of sustainable practices. For instance, IoT-enabled sensors improve the monitoring of bioremediation processes, while AI algorithms optimize resource usage in bioengineering applications. This synergy bridges gaps in existing practices, enabling measurable environmental benefits.

Methodology Research Design

This study employs a mixed-methods research design comprising qualitative and quantitative approaches. It includes:**A systematic literature review:** A comprehensive review of peer-reviewed journal articles, conference proceedings, books, and reports on Green Management, biochemical processes, IT applications, and sustainability.

Case study analysis: In-depth analysis of case studies of organizations that have successfully implemented IT-enhanced biochemical practices. This will involve identifying key success factors, challenges, and lessons learned.

Quantitative analysis of environmental performance metrics: Collection and analysis of quantitative data on energy consumption, waste generation, carbon emissions, and other environmental performance indicators before and after the implementation of IT-enabled biochemical practices.

Expert interviews: Conducting interviews with experts in the fields of Green Management, biochemistry, IT, and sustainability to gain insights into emerging trends, challenges, and best practices.

Data Collection: Data sources include:

Peer-reviewed journals, conference proceedings, and reports: Published research articles, conference papers, and reports from academic institutions, research organizations, and government agencies.

Case studies of organizations implementing IT-driven green practices: Case studies from industry reports, company websites, and academic publications.

Governmental and international reports on sustainability and IT adoption: Reports from organizations such as the United Nations, the World Bank, and the Environmental Protection Agency.

Data from publicly available sources: Data on energy consumption, waste generation, and other environmental indicators from government agencies, industry associations, and other relevant sources.

Analytical Techniques: The study employs:

Thematic Analysis: To identify patterns and themes in qualitative data from literature reviews and case studies.

Statistical Analysis: To analyze quantitative data on energy savings, waste reduction, and carbon footprint outcomes. This may include statistical tests such as t-tests, ANOVA, and regression analysis.

Content Analysis: To analyze textual data from documents, reports, and interviews to identify key themes, concepts, and perspectives.

Data Analysis

IT-Enabled Biochemical Innovations Smart Waste Management:

IoT-enabled waste bins monitor fill levels, optimize collection routes, and reduce fuel consumption.

AI-powered waste sorting systems can automatically identify and sort different types of waste, improving recycling rates and reducing the amount of waste sent to landfills.

Anaerobic digestion systems can be integrated with IoT sensors and AI algorithms to optimize biogas production and monitor system performance.

Bioremediation Monitoring and Control:

IoT sensors can monitor key parameters such as temperature, pH, and oxygen levels in bioremediation sites.

AI algorithms can analyze sensor data to predict treatment outcomes, optimize resource allocation, and identify potential issues.Machine learning algorithms can be used to develop predictive models for pollutant degradation and optimize the selection and application of microbial strains for specific contaminants.

Energy Optimization in Bioengineering:

AI algorithms can optimize fermentation processes by identifying optimal conditions for microbial growth, such as temperature, pH, and nutrient concentrations.

Machine learning can be used to predict product yields and identify bottlenecks in production processes.

AI-powered control systems can automate and optimize the operation of bioreactors, reducing energy consumption and improving process efficiency.

Precision Agriculture: IoT sensors can monitor soil moisture, nutrient levels, and pest infestations in real-time.

AI-powered drones can capture high-resolution images and analyze crop health, enabling precision application of fertilizers and pesticides. Bioengineering techniques, such as genetic modification and synthetic biology, can be used to develop crop varieties that are more resilient to drought, pests, and diseases.

Figure 2: IoT in precision agriculture.

Environmental and Economic Outcomes

Quantitative analysis reveals significant improvements in key metrics:

Parameter	**Before Implementation**	**After Implementation**	**Improvement**
Energy Consumption	500 MWh/year	350 MWh/year	30% Reduction
Carbon Emissions (tons/year)	1000	700	30% Reduction
Waste Recycled (%)	60%	85%	25% Increase
Operational Costs ($ million)	5	3.5	30% Reduction

Case Studies Case Study 1: Smart Grids in Renewable Energy

A smart grid integrating biochemical biofuel production and IT systems showed improved energy efficiency and reduced dependency on fossil fuels. Biofuel production from agricultural waste was optimized using AI-powered fermentation processes. Smart grid technology facilitated the integration of renewable energy sources, such as wind and solar power, with the grid, further reducing reliance on fossil fuels.

Case Study 2: AI in BioremediationA river cleanup project utilized AI to predict pollutant levels and microbial performance, reducing the cleanup time by 40%. IoT sensors monitored water quality parameters in real-time, and AI algorithms analyzed this data to optimize the application of microbial remediation agents, leading to faster and more effective pollutant removal.

Discussion and Implications Discussion

The findings highlight the transformative potential of combining IT with biochemical approaches in Green Management. Key insights include:

Enhanced Monitoring and Control: IoT and AI improve the precision and efficiency of biochemical interventions.

Resource Efficiency: IT tools optimize energy and resource usage in bioengineering processes, reducing waste and minimizing environmental impact.

Scalability: Cloud-based platforms facilitate the sharing of data and best practices among researchers and practitioners, accelerating the development and deployment of innovative biochemical solutions.

Improved Decision-Making: AI-powered analytics provide valuable insights for decision-making in environmental management, enabling proactive interventions and optimizing resource allocation.

ImplicationsFor Policymakers:

Formulate incentives for adopting IT-enabled biochemical solutions.

Invest in infrastructure for smart grids and IoT ecosystems.

For Businesses: Integrate IT and biochemical practices to enhance operational sustainability.

Adopt AI-driven tools for energy and waste optimization.

For Researchers: Explore emerging IT tools and their applications in biochemical processes.

Conduct longitudinal studies on the economic and ecological impacts of these integrations.

Conclusion

The interdisciplinary approach of integrating IT and biochemical processes in Green Management offers innovative solutions to global sustainability challenges. By leveraging IT tools such as AI, IoT, and Big Data Analytics, biochemical approaches can achieve greater precision, scalability, and efficiency. This research underscores the importance of collaborative efforts among policymakers, businesses, and researchers in achieving sustainable development goals. Future research should focus on developing advanced tools and exploring uncharted applications of IT-enabled biochemical innovations.

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Interdisciplinary Approaches: Role of Social Media and Commerce in Sustainable Development

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Abstract

The concept of sustainable development is of paramount importance in addressing the interconnected issues of economic growth, social equity and environmental sustainability. In recent years, the role of interdisciplinary approaches in fostering sustainable development has become increasingly significant, particularly in integrating various fields such as biochemistry, information technology, commerce and social media. This paper explores the role of social media and e-commerce in advancing sustainable development goals (SDGs) by focusing on how biochemical approaches and technology can synergize to create more sustainable practices. The intersection between biochemical science and technology offers novel solutions for resource efficiency, environmental protection and social well-being, all of which are vital for sustainable development. By analyzing existing literature, methodologies and the role of information technology in commerce, this paper demonstrates the growing potential of these interdisciplinary approaches to contribute towards global sustainability. Moreover, the research provides insights into the challenges and implications of integrating technology and biochemical solutions in the pursuit of sustainable development.

Keywords: Sustainable development, biochemical approaches, social media, e-commerce, information technology.

Introduction

Sustainable development is a broad concept that encompasses the needs of the present without compromising the ability of future generations to meet their own needs. As global challenges such as climate change, resource depletion and social inequality intensify, interdisciplinary approaches become essential to finding viable solutions. Information technology (IT), biochemical research, social media and commerce are critical drivers of sustainability, offering innovative solutions and avenues for progress. Biochemistry, a field focused on the study of chemical processes within and related to living organisms, is playing an increasingly significant role in the sustainable development agenda by providing scientific foundations for more efficient, eco-friendly practices. The convergence of biochemistry with information technology and commerce, particularly through platforms like social media and e-commerce, can enhance collaboration and knowledge-sharing, promoting sustainability on a larger scale.

This paper examines the integration of biochemical approaches in sustainable development, particularly focusing on how social media and commerce, supported by information technology, contribute to environmental, economic and social sustainability. The following sections explore relevant literature, research methodologies, data analysis and the broader implications of these interdisciplinary approaches in fostering sustainability.

Literature Review

Role of Biochemical Approaches in Sustainable Development

Biochemical approaches have been integral to advancing sustainable development in recent decades. The field contributes through innovations in bio-based technologies, green chemistry and environmental biotechnology. For instance, biochemistry plays a key role in developing alternative energy sources such as biofuels, which can replace fossil fuels and reduce greenhouse gas emissions. Additionally, biochemical research supports the development of biodegradable materials, waste treatment processes and methods for increasing agricultural productivity with minimal environmental impact. According to Smith et al. (2021), the integration of biochemical processes in agriculture has enabled sustainable farming practices, helping to address food security issues while minimizing harmful environmental effects.

Role of Information Technology in Sustainable Development

Information technology has become indispensable in the context of sustainable development due to its ability to enhance data collection, analysis and dissemination of sustainability-related information. Technologies such as the Internet of Things (IoT), Artificial Intelligence (AI) and Big Data have contributed to resource optimization, improved supply chain management and better decision-making. In the realm of sustainable agriculture, for example, AI and IoT are used to optimize water use, reduce waste and monitor environmental conditions in real-time, thus enabling more sustainable farming practices (Kumar et al., 2022). Moreover, IT has facilitated the creation of platforms that enable sustainable commerce, creating virtual spaces for the exchange of green products, services and ideas.

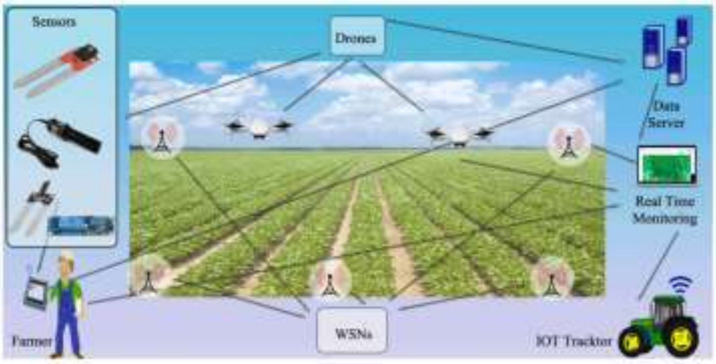

Figure 1: IOT-based smart agriculture monitoring system.

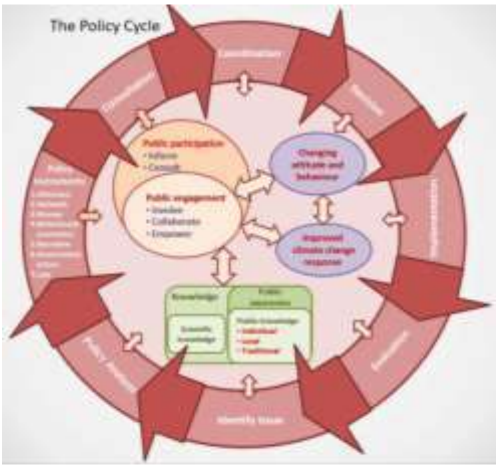

Figure 2: The Policy Cycle

Social media has emerged as a powerful tool in promoting sustainable development through awareness-raising and advocacy. Platforms like Twitter, Instagram and Facebook have become critical channels for disseminating information about environmental issues, sustainable practices and the SDGs. According to the research by Patel et al. (2020), social media platforms serve as an avenue for environmental organizations, businesses and individuals to engage with a global audience, fostering collaborative efforts toward sustainability. Additionally, social media facilitates the creation of online communities focused on promoting green living and sustainable consumer choices, amplifying grassroots movements for environmental justice.

E-Commerce and Sustainability E-commerce, as a significant part of the modern economy, can play a pivotal role in sustainable development. The increasing trend of online shopping presents opportunities for promoting sustainable products and services while encouraging consumers to make informed choices. E-commerce platforms allow businesses to reach a broader audience, enabling them to offer eco-friendly products that contribute to reducing carbon footprints. Moreover, sustainable packaging, logistics and green business practices have become key priorities within the e-commerce industry. According to Liu and Wang (2023), the integration of sustainability into the business models of e-commerce giants is a growing trend, reflecting the industry's acknowledgment of its responsibility to the environment.Methodology This research adopts a qualitative approach, focusing on existing literature to explore the intersection of biochemical approaches, information technology, social media and e-commerce in sustainable development. The methodology involves:

Literature Review: A comprehensive review of academic journals, books, reports and online sources related to biochemical science, sustainability, information technology and commerce. The review examines the contributions of these fields to sustainable development.

Case Studies: Several case studies are analyzed to explore the real-world applications of these interdisciplinary approaches. These include examples of companies utilizing green chemistry in their supply chains, IT companies using AI for sustainability and e-commerce platforms promoting sustainable goods.

Interviews: Interviews with industry experts, including biochemists, IT professionals and sustainability consultants, provide insights into the practical implications and challenges of integrating these disciplines for sustainable development.

Data Analysis The data gathered from case studies and interviews indicate several key trends:

Integration of Biochemical Innovation and Technology: Many industries are increasingly adopting biochemical processes that are facilitated by information technology. For example, biotech firms utilize AI to optimize the production of biofuels, while IoT systems track and manage the environmental impact of chemical processes.

Social Media's Role in Advocacy: Social media has proven to be a valuable tool for environmental campaigns. Not only does it help raise awareness about sustainable practices, but it also mobilizes consumer behavior by influencing purchasing decisions, particularly when it comes to eco-friendly products.

E-Commerce Driving Sustainable Choices: E-commerce platforms are increasingly implementing green logistics practices, offering sustainable alternatives and promoting the use of recyclable materials. The data suggests that online platforms are leveraging their global reach to influence consumer behavior toward more sustainable options.

Challenges: The primary challenges identified include the high costs of implementing green technology and the need for more effective collaboration between industries, governments and consumers. Despite the technological advancements, there remains a gap in the widespread adoption ofustainable practices, particularly in developing regions.

Discussion and Implications

The findings of this study demonstrate that interdisciplinary approaches, particularly the integration of biochemical methods, information technology and commerce, hold significant promise for sustainable development. The biochemical innovations that reduce environmental impact can be greatly enhanced by IT-driven solutions, such as AI and Big Data, which enable more efficient resource management. Furthermore, the power of social media in advocating for sustainability cannot be underestimated. It provides a platform for global communication, allowing individuals and organizations to share knowledge, promote sustainable behaviors and influence policy.

E-commerce platforms, with their ability to reach a global consumer base, can promote sustainability by encouraging green purchasing choices and reducing the carbon footprint through optimized logistics. However, while progress has been made, the challenges of cost, access to technology and the need for better coordination between stakeholders remain significant barriers to achieving full sustainability.

The implications of this research suggest that policymakers, businesses and environmental organizations need to continue investing in technological solutions and fostering interdisciplinary collaboration. Governments can provide incentives for businesses to adopt sustainable practices, while IT companies can further develop tools that enable better monitoring and management of environmental impacts. Social media campaigns can also be leveraged to drive consumer demand for sustainable products and services.

Conclusion

In conclusion, the interdisciplinary approaches integrating biochemistry, information technology, social media and e-commerce are essential for advancing sustainable development. These approaches offer novel ways to address the environmental, economic and social dimensions of sustainability. However, significant challenges remain in terms of access to resources, technology and policy implementation. Nevertheless, the potential of these fields to contribute to a more sustainable future is immense and continued efforts to integrate these disciplines will be critical in achieving global sustainability goals.

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Technological Innovations and Sustainability in Life Sciences and Chemistry: Nanotechnology and Nano-Catalyst with Greener Approach

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Abstract

Sustainable development has become a central focus in the global conversation regarding environmental, economic and social progress. In the context of life sciences and chemistry, technological innovations such as nanotechnology and nano-catalysis play a significant role in fostering sustainability. These advancements, particularly in biochemical applications, present novel ways of addressing environmental concerns, reducing energy consumption and optimizing resource usage. Nanotechnology, through its ability to manipulate matter at the molecular level, enables the creation of efficient, sustainable materials and processes. Nano-catalysts, on the other hand, enhance the efficiency of chemical reactions, reducing the need for harmful chemicals and energy-intensive processes. Coupled with advancements in information technology (IT), these innovations facilitate real-time monitoring, data analytics and optimization of sustainable practices across various sectors. This paper explores the role of nanotechnology and nano-catalysts in promoting greener approaches to sustainability, focusing on the biochemical and environmental benefits. It examines the intersection of life sciences, chemistry and IT, providing a comprehensive review of the contributions of these interdisciplinary fields to sustainable development. The findings suggest that the convergence of these technologies holds immense potential for reducing environmental footprints while advancing global sustainability efforts.

Keywords: Nanotechnology, nano-catalysts, sustainability, biochemical approaches, information technology.

Introduction

Sustainable development has become a fundamental goal worldwide, calling for solutions that harmonize economic, social and environmental considerations. In life sciences and chemistry, technological innovations such as nanotechnology and nano-catalysts present promising solutions for addressing key challenges in sustainability. Nanotechnology enables the manipulation of materials at the nanoscale, leading to the development of more efficient and eco-friendly processes. Nano-catalysis, which involves the use of nanomaterials to enhance chemical reactions, offers sustainable alternatives to conventional industrial processes that often involve toxic chemicals and high energy consumption.

These innovations hold significant promise in various sectors, including energy, agriculture, waste management and pharmaceuticals, by improving efficiency and reducing environmental impact. Information technology (IT) also plays a vital role in facilitating the implementation of these technologies, enabling real-time monitoring, data analysis and optimization. This paper explores the intersection of nanotechnology, nano-catalysis, life sciences and information technology, focusing on their contributions to sustainable development. Through a comprehensive review of literature and data analysis, we aim to highlight how these interdisciplinary approaches can work together to achieve a more sustainable future.

Literature Review

Nanotechnology and Sustainability

Nanotechnology is the manipulation of matter on an atomic or molecular scale to create new materials and devices with enhanced properties. In recent years, nanotechnology has emerged as a key player in the pursuit of sustainability due to its ability to create materials and processes that are more efficient, less resource-intensive and environmentally friendly. Nanomaterials, due to their high surface area to volume ratio, exhibit unique properties such as improved strength, conductivity and reactivity. These properties make them ideal for use in energy storage, renewable energy production and waste management (Li et al., 2021).

In the field of energy, nanotechnology has led to innovations in solar cells, fuel cells and batteries, significantly improving energy efficiency and reducing the reliance on fossil fuels. For example, nanomaterials in solar cells increase light absorption and charge carrier mobility, enhancing their efficiency and reducing costs. Furthermore, nanotechnology contributes to energy storage solutions, such as super capacitors and lithium-ion batteries, which play a crucial role in managing renewable energy sources (Wang et al., 2020).

In waste management, nanotechnology facilitates the development of advanced filtration systems and sensors for detecting and removing contaminants. Nanomaterials like carbon nanotubes and metal oxide nanoparticles have shown promise in removing heavy metals, oils and organic pollutants from water and air, thus improving environmental quality (Choudhury et al., 2022).

Nano-Catalysis for Greener Chemistry

Nano-catalysts are materials that function as catalysts at the nanoscale to accelerate chemical reactions. They are designed to improve the efficiency of industrial processes by reducing the need for energy, chemicals and raw materials. Unlike traditional catalysts, nano-catalysts have a higher surface area, which increases their catalytic activity and allows for more efficient chemical reactions.

In green chemistry, nano-catalysis plays a crucial role in promoting more sustainable chemical processes. For example, nano-catalysts have been used to replace toxic solvents in reactions, reduce energy consumption and minimize waste production. In the petroleum industry, nano-catalysts are used to enhance the efficiency of refining processes, reducing the environmental impact of fossil fuel extraction and processing (Li et al., 2021).

Furthermore, nano-catalysts are employed in various applications such as water treatment, biomass conversion and carbon dioxide reduction. Their ability to catalyze reactions at lower temperatures and pressures reduces energy requirements and minimizes the generation of harmful byproducts (Sahoo et al., 2021). The integration of nano-catalysis into industrial processes is a critical step toward achieving the goals of sustainable development by reducing the environmental footprint of chemical manufacturing.

Role of Information Technology in Advancing Nanotechnology and Nano-Catalysis

Information technology plays an integral role in advancing nanotechnology and nano-catalysis by enabling real-time monitoring, data analysis and process optimization. The integration of IT with nanotechnology has led to significant advancements in the design, development and application of nanomaterials and nano-catalysts.

In nanotechnology, IT is used in computational modeling to predict the behavior of nanomaterials, thus aiding in their design and optimization. Machine learning and artificial intelligence (AI) algorithms are increasingly being used to analyze large datasets and optimize the synthesis of nanomaterials for specific applications. Additionally, IT tools facilitate the scaling up of nanotechnology processes from the laboratory to industrial scale by providing insights into process efficiency and product yield (Singh et al., 2020).

For nano-catalysis, IT enables real-time monitoring of catalytic reactions, allowing for more precise control over reaction conditions. Sensors and IoT devices are used to measure temperature, pressure and concentration during catalytic processes, ensuring optimal performance and minimal waste. Furthermore, data analytics tools are employed to optimize catalyst design and reaction pathways, enhancing the overall efficiency of chemical processes (Xu et al., 2020).

Methodology

This paper employs a qualitative research methodology, utilizing a combination of literature review, case studies and expert interviews to explore the role of nanotechnology, nano-catalysis and information technology in promoting sustainability. The following steps outline the methodology:

Literature Review: A thorough review of academic journals, books and research reports was conducted to gather information on the latest advancements in nanotechnology, nano-catalysis and their applications in sustainability. The literature review focused on identifying key trends, challenges and innovations in these fields.

Case Studies: Case studies of companies and research institutions that have successfully implemented nanotechnology and nano-catalysis in sustainable processes were analyzed. These case studies provide practical examples of how these technologies can be applied to real-world problems.

Expert Interviews: Interviews were conducted with experts in nanotechnology, nano-catalysis and information technology to gain insights into the current state of research and development in these areas. These interviews provided valuable perspectives on the potential and challenges of integrating these technologies for sustainable development

Data Analysis The data analysis revealed several key findings:

Efficiency Gains through Nanotechnology: Nanotechnology significantly enhances the efficiency of various processes, particularly in energy production and waste management. Nanomaterials, due to their unique properties, enable the development of more efficient solar cells, batteries and filtration systems, leading to reduced energy consumption and improved environmental outcomes.

Greener Chemical Processes through Nano-Catalysis: Nano-catalysis plays a crucial role in reducing the environmental impact of chemical processes. The high surface area and reactivity of nano-catalysts make them highly efficient, reducing the need for energy-intensive processes and harmful chemicals. Additionally, nano-catalysts have been successfully used in various green chemistry applications, such as water purification and biomass conversion.

IT Enabling Optimization: The integration of IT with nanotechnology and nano-catalysis has resulted in significant advancements in process optimization. Real-time monitoring, data analytics and computational modeling have allowed for more precise control over chemical reactions, leading to improved efficiency and sustainability.

Challenges and Barriers: Despite the promising potential of nanotechnology and nano-catalysis, several challenges remain. These include high production costs, scalability issues and concerns over the environmental impact of nanomaterials. Additionally, regulatory frameworks for the safe use of nanotechnology are still under development, which hinders widespread adoption.

Discussion and Implications

The findings of this study highlight the significant role that nanotechnology and nano-catalysis play in promoting sustainability across various sectors. Nanotechnology's ability to create more efficient materials and processes has led to significant advancements in energy production, waste management and environmental remediation. Similarly, nano-catalysis offers greener alternatives to traditional chemical processes, reducing energy consumption and minimizing waste.However, several challenges must be addressed to fully realize the potential of these technologies. The high costs of nanomaterial production and scalability issues present barriers to widespread adoption. Additionally, regulatory frameworks need to be developed to ensure the safe use of nanomaterials in industrial applications.

From a policy perspective, governments should invest in research and development of nanotechnology and nano-catalysis, providing incentives for industries to adopt these greener technologies. Furthermore, international collaboration is necessary to establish global standards and regulations for the use of nanotechnology in sustainable practices.

Conclusion

In conclusion, nanotechnology and nano-catalysis offer promising solutions for advancing sustainability in life sciences and chemistry. These technologies enable more efficient use of resources, reduced environmental impact and greener chemical processes. When combined with information technology, they have the potential to optimize sustainability efforts across various sectors. However, further research, investment and collaboration are needed to overcome the challenges associated with these technologies and ensure their widespread adoption. By continuing to innovate and integrate these technologies, society can move closer to achieving the goals of sustainable development.

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A Rapid, Validated HPLC Analytical Method for Simultaneous Quantitation of Phytoconstituents in *Asteracantha Longifolia (L.)* Nees

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Abstract:

Asteracantha longifolia (L.) Nees a small, spiny weeds found in marshy places. It has effective antitumor, hypoglycemic, aphrodisiac, antibacterial, free radical scavenging, lipid peroxidation, and hepatoprotective properties1. *Asteracantha longifolia (L.)* Nee is an essential herb in many traditional and herbal medicines. Active phytoconstituents like Betulin, Lupeol, Stigmasterol, and β-sitosterol are reported to accord the herb importance as a medicinal plant in modern and traditional medicine. The plant's usefulness in many traditional medicines has made it crucial to quantify the essential phytoconstituents. However, prior art analytical methods profoundly lack rapidness and simultaneous quantitation of different phytoconstituents. This research work has validated the analytical method for simultaneous quantitation of Betulin, Lupeol, Stigmasterol, and β-sitosterol with HPLC- PDA, in line with the guidelines by ICH.

The research deals with a systematic approach to developing, optimizing, and validating a chromatographic method. The optimized chromatographic conditions resulted in the best separation for four phytoconstituents.

Furthermore, method validation parameters like Specificity, LOD (0.07µg/mL) and LOQ (0.2µg/mL), Linearity, Precision, Intermediate Precision, Recovery, and Range are found to be within limits laid by ICH.

Keywords: *Asteracantha longifolia (L.)* Nees, Betulin, Lupeol, Stigmasterol, and β- sitosterol

Introduction

Asteracantha longifolia (L.) Nees is one of the aquatic weeds and wetland herbs observed to have immense medicinal value[2,3]. It is a common weed widely distributed in[4] India, Srilanka, Burma, and Nepal[5]. It is a leafy vegetable in some states of India, like Odisha, Chhattisgarh, and West Bengal[2,3]. The plant seeds, roots, and leaves are used for medicinal purposes. Seeds are aphrodisiacs and semenogogue, while roots and leaves are natural diuretics [5,6]. The use of a boiled extract of the aerial part of the tender plant as a haematonic[2] is reported. The ethanolic extract increases hemopoietic parameters and acts as a hepatoprotective agent[7]. Many reports depict the application of *Asteracantha longifolia (L.)* Nees, for genital tract diseases in males and females[2,8]. The plant is prescribed and commercially a common ingredient in Over Counter (OTC) [9]. Different works of literature report the herb to contain phytoconstituents like Betulin, Lupeol, Stigmasterol, β-sitosterol, linoleic acid, and oleic acid, along with other fatty acids[3,5,9,10]. Several analytical works evaluate the phytoconstituents Betulin, Lupeol, Stigmasterol, and β-sitosterol separately or in combination with other phytoconstituent[11]. However, none of them reports a rapid, validated analytical method that can simultaneously quantitate Betulin, Lupeol, Stigmasterol, and β-sitosterol with the aid of HPLC-PDA and in line with the guidelines laid by ICH. Therefore, in this work, we developed and validated a rapid, sensitive analytical method capable of simultaneous quantitation of Betulin, Lupeol, Stigmasterol, and β-sitosterol.

Materials and Methods:

Material and method for plant collection:

A sampling of the plant material of AL from the western ghat of Maharashtra was conducted during its flowering season of September to November months. The herbarium of the sample was authenticated by St. Xavier's College, Mumbai, India[11].

Plant material preparation:

The collected plant was thoroughly washed and dried under shade at room temperature for 2- 3 weeks**.** The dried material was powdered and sieved (through an ASTM 80 mesh) to make a fine homogeneous powder and was then stored in an airtight container[12].

Experimental Details:

Chemicals and Reagents: Lab-purified and standardized markers of Betulin, Lupeol, Stigmasterol, and β-sitosterol were used during the study. Reagents Acetonitrile, Methanol, and orthophosphoric acid (OPA)were purchased from Merck. Deionized water (resistivity 18.2 MΩ.cm) was obtained from a Milli-Q Plus system.

Standard Solution preparation:

Enough quantity of each marker was weighed separately to make a stock solution of about 1µg/mL concentration in methanol (stored at 2-8°C). Further, two sets of mixed standards were prepared in methanol in a range of 0.07µg/mL- 3µg/mL and 20µg/mL 60µg/mL.

Sample Preparation:

Dried Enough, homogenized fine powdered plant material was weighed to make a sample solution of about 2000µg/mL concentration in methanol. Next, the solution was subjected to ultrasonic extraction for about 60 minutes. The solution was then subjected to centrifuge at 3000 rpm for 20 minutes. Finally, the supernatant was filtered through a 0.22µm syringe filter to avoid any undesired powdered material.

Results

Development and optimization:

The development of an analytical method capable of a rapid, sensitive simultaneous quantitation of four markers was initiated with the insight of prior art. First, mobile phases with different eluents, modifiers, pH, and elution modes were verified. Stationary phases like Waters Ascentis Express 80Å, (50mm, 4.6mm, and 2.7µm), 3.5 µm, Kinetex 2.6 µm C18 100Å, LC Column 100 x 4.6mm, Ea, Zorbax RR StableBond C8, 4.6mm, 50mm, and Agilent Poroshell C8, 120Å, 75mm, 4.6mm, 2.7µm were also toggled with the combinations of isocratic and gradient elution. Finally, variations in retention time for the markers were critically recorded when parameters like temperature and mobile phase flow were altered.

Optimizing chromatography parameters like temperature, mobile phase flow, mobile phase composition, and stationary phase (particle size, length) exhibited a significant change in resolution and theoretical plates. An increase in temperature and mobile phase flow rate resulted in increased theoretical plates. However, it subsequently resulted in reduced resolution between the marker peaks. The best possible resolution (≥ 2) and theoretical plates (≥ 5000) were obtained with chromatography conditions.

Column: Agilent Poroshell C8, 120Å, 75mm, 4.6mm, 2.7µm Mobile phase A: Water containing 2mL/liter OPA

Mobile phase B: Acetonitrile containing 2mL/liter OPA Flow rate: 1mL/min

Column Temperature: 40°C

Wavelength: 200nm Gradient Elution:

Table 1: Gradient elution program for Betulin, Lupeol, Stigmasterol, and β-sitosterol

Time	0	5	10	15
% MP B	80	95	95	80

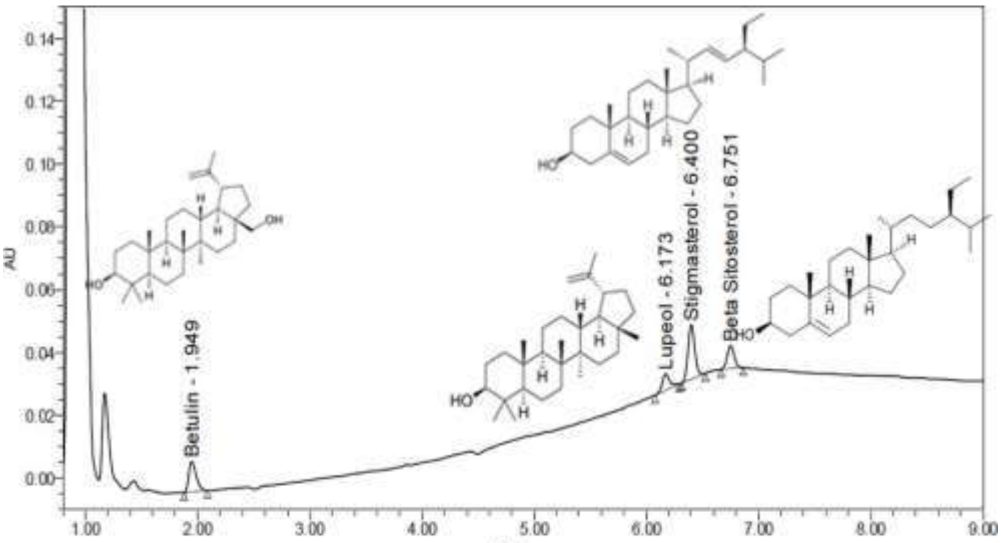

Figure 1. System suitability solution chromatogram for Betulin, Lupeol, Stigmasterol, and β- sitosterol.

System Suitability:

To govern the consistency and reproducibility of the optimized chromatography conditions and parameters and to have better control over the analysis, as per guidelines of the International Conference on Harmonization (ICH), system suitability criteria need to be laid out. The criteria comprise resolution, theoretical plates, peak symmetry, peak-to-valley ratio, %RSD of response, signal-to-noise ratio S/N, and tailing factor. Depending upon the applicability, the criteria are included in the protocol and adhere to be within the limit. In this validation, the %RSD of response from six replicates of each marker in system suitability solution (NMT 2) for Bracketing (NMT 5) and %RSD of resolution between Stigmasterol and β-Sitosterol (NMT 2) was laid as the limiting factor.

Table 2: System suitability criteria (%RSD for RT and Average response) for Betulin, Lupeol, Stigmasterol, and β-sitosterol

Criteria	Betulin	Lupeol	Stigmasterol	β-Sitosterol
RT (min)	1.95	6.17	6.40	6.75
% RSD (n= 6)	0.5	0.8	0.4	0.3
Avg Response (Area)	39.30	39.28	61.04	31.36
%RSD (n=6)	0.3	1.2	0.9	1.3
%RSD (Bracketing, n=10)	0.68	1.3	1.4	1.9

Linearity and Range: Linearity was performed in two ranges of each marker concentration (0.07µg/mL- 3µg/mL and 20µg/mL- 60µg/mL). The markers' maximum and minimum reported content is also available in the literature. In addition, a calibration curve comprising concentration in triplicate versus its peak response was plotted. % RSD for the peak response (≤ 2) and correlation coefficient for each marker concentration signifies good reproducibility of results and good correlation between obtained response and its concentration.

Table 3: Linearity (Concentrations vs. Response) for Betulin, Lupeol, Stigmasterol, and β- sitosterol in the Linearity range 0.07µg/mL- 3µg/mL and 20µg/mL- 60µg/mL.

Concentration (µg/mL)	Betulin	Lupeol	Stigmasterol	β-Sitosterol
0.07µg/mL- 3µg/mL				
0.07	1.27	1.07	2.07	1.05
0.2	3.66	4.06	6.42	3.45
1	18.84	20.02	31.04	14.86
2	43.44	43.86	68.07	31.44
2.4	50.14	49.72	77.52	35.25
3	67.00	65.79	102.11	47.16
R^2	0.997	0.998	0.998	0.997
Slope	22.19	21.8	33.08	15.4
Intercept	-1.3	-0.76	-0.49	-0.05
20µg/mL- 60µg/mL				
20	390.99	425.43	653.47	308.72
40	894.93	899.10	1385.91	625.62
48	1084.17	1082.86	1674.22	734.71
60	1474.00	1309.17	2008.07	949.44
R^2	0.995	0.997	0.996	0.998
Slope	26.7	22.29	34.2	15.9
Intercept	-160.6	-7.18	-8.0	-11.78

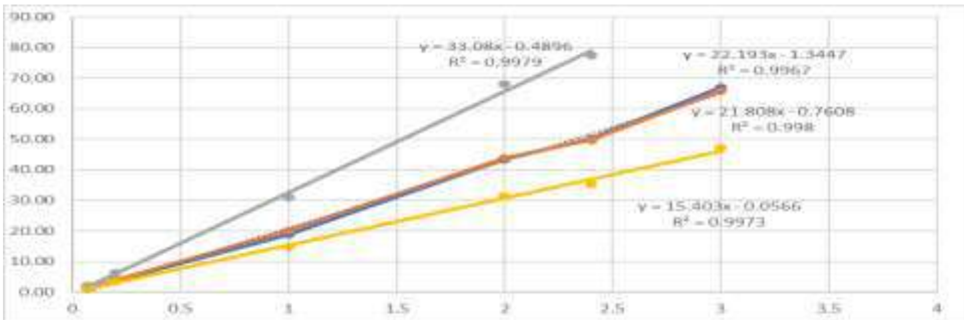

Figure 2. (Correlation of response vs. concentration in the Linearity range 0.07µg/mL- 3µg/mL)

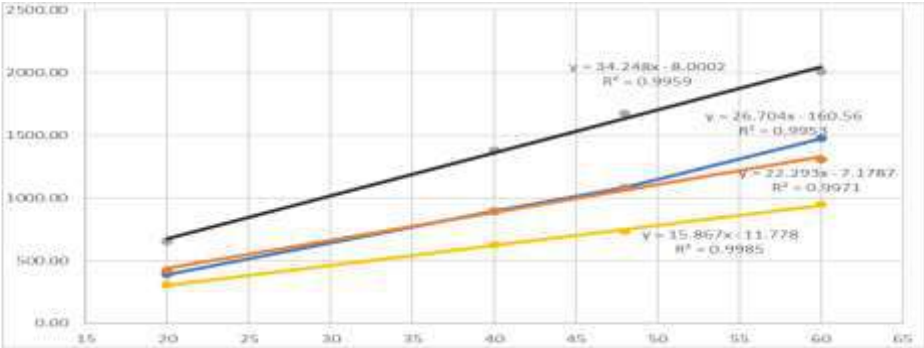

Figure 3. (Correlation of response vs. concentration in the Linearity range 20µg/mL-60µg/mL.)

LOD and LOQLOD and LOQ for each marker were derived from the slope of the linearity plot. LOD= 3.3σ/SOQ= 10σ/SWhere σ: Standard deviation of the responses and S: Slope of the linearity curve[13]For all markers, the LOD and LOQ for Betulin, Lupeol, Stigmasterol, and β-sitosterol are 0.07µg/mL and 0.2µg/mL.Precision: Intraday and inter-day system precision was performed with the mixed standard solution in 6 replicates. Three concentrations from the linearity range (1µg/mL, 2µg/mL, and 3µg/mL) were prepared and assessed in triplicate for repeatability and intermediate precision. In addition, the working concentration and LOQ (0.2µg/mL) concentrations were prepared and assessed in six replicates.

Table 4: Precision (Intraday and Intermediate) for Betulin, Lupeol, Stigmasterol, and β- sitosterol at concentrations 0.2µg/mL, 1µg/mL, 2µg/mL, and 3µg/mL.

Criteria	Betulin	Lupeol	Stigmasterol	β-Sitosterol
LOQ (0.2µg/mL)				
RT (min)	1.95	6.17	6.40	6.75
% RSD (n= 6)	0.68	0.78	0.54	0.42
%RSD Avg Response (Area)	0.33	0.74	0.82	1.1
1µg/mL				
RT (min)	1.97	6.16	6.38	6.71
% RSD (n= 3)	0.52	0.58	0.68	0.32
%RSD Avg Response (Area)	0.14	0.47	0.76	0.93
2µg/mL				
RT (min)	1.91	6.14	6.42	6.76
% RSD (n= 3)	0.28	0.35	0.42	0.31
%RSD Avg Response (Area)	0.19	0.27	0.36	0.33
3µg/mL				
RT (min)	1.93	6.19	6.45	6.68
% RSD (n= 3)	0.52	0.58	0.68	0.32
%RSD Avg Response (Area)	0.41	0.22	0.53	0.35

Repeatability and intermediate precision were found to be within acceptable limits.
Recovery*:*A recovery study at three levels of both the linearity level was carried out in triplicate and LOQ and working concentration in six replicates. The recovery for each marker at each concentration level was found within the range of 98.6%-102.34%.

Table 5: Recovery for Betulin, Lupeol, Stigmasterol, and β-sitosterol at concentrations 0.2µg/mL, 1µg/mL, 2µg/mL, 3µg/mL, 40µg/mL, and 60µg/mL.

Concentration (µg/mL)	Betulin	Lupeol	Stigmasterol	β-Sitosterol
0.2	99.71	101.42	99.52	99.82
1	99.19	102.30	99.40	98.60
2	99.78	99.33	100.22	99.66
3	99.16	99.56	100.14	101.52
40	100.16	101.58	102.34	100.11
60	101.71	98.94	99.71	101.56

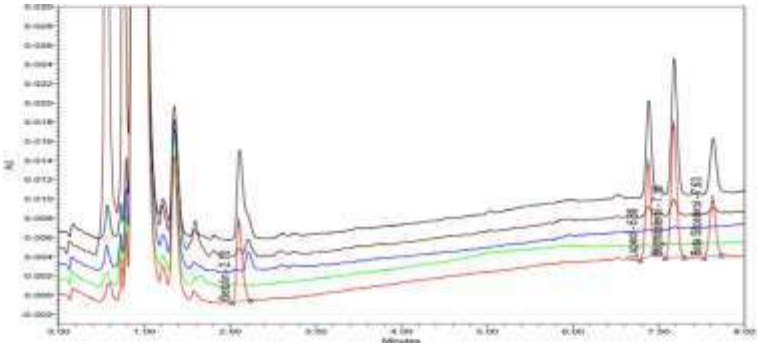

Figure 4. (Overlay of chromatograms for System suitability solution, Blank, As such sample, LOQ (0.2µg/mL) Spike solution and 100% (2µg/mL) Spike solution)

Specificity: The Unequivocalness of each marker peak in the mixed standard solution was investigated by determining peak purity. It is clear from the peak purity spectra from the system suitability for each marker that there is no coelution of any other peak along with the marker.

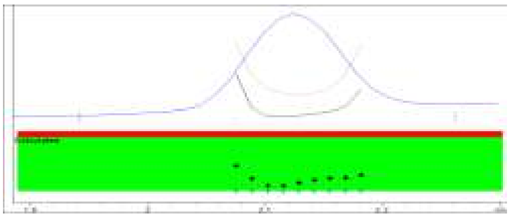

Figure 5. (Peak purity for Betulin)

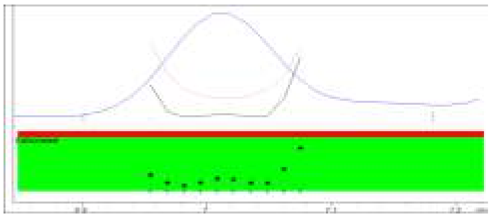

Figure 6. (Peak purity for Lupeol)

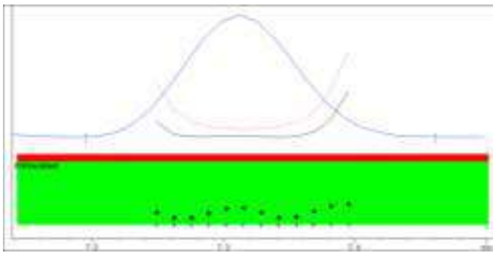

Figure 7. (Peak purity for Stigmasterol)

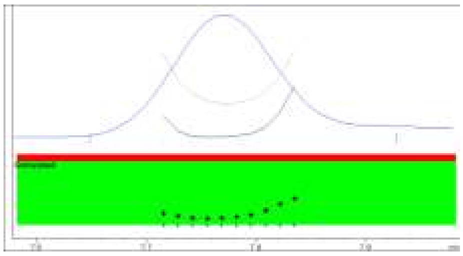

Figure 8. (Peak purity for β Sitosterol)

Evaluation of the markers in the OTC formulations: Various works in the literature report quantitation of the phytoconstituents of *Asteracantha longifolia (L.)* Nees, viz. Betulin, Lupeol, Stigmasterol, and β-sitosterol, separately or in combination with one phytoconstituent. The applied method here aids in evaluating the content of all four of them rapidly and precisely. Locally available Betulin, Lupeol, Stigmasterol, and β-sitosterol are reported to contain *Asteracantha longifolia (L.)* Nees were taken up for the study. The % w/w content for all four phytoconstituents found is as below.

Table 6: Content of Betulin, Lupeol, Stigmasterol, and β-sitosterol found in the OTC formulation samples and Plant Extract sample.

Sr. No.	Name of the Formulation	Name of the phytoconstituent			
		Betulin	Lupeol	Stigmasterol	β-sitosterol
01	Formulation-1	0.6%	0.04%	0.02%	0.07%
02	Formulation-2	1.3%	0.08%	0.06%	0.07%
03	Plant Extract	0.9%	0.07%	0.07%	0.07%

Discussion:

As described in the introduction, *Asteracantha longifolia (L.)* Nees are used in different forms like extracts, whole plants, and root seeds, owning to their medicinal use. Phytoconstituents like Betulin, Lupeol, Stigmasterol, and β-sitosterol enhance the medicinal properties. Therefore, standardizing these phytoconstituents to establish the actual content of the same in the locally vended OTC formulations is necessary. With the availability of quality information, the formulators can have better control over the finished product. The idea led to the development and validation of a rapid, sensitive analytical method capable of quantitating Betulin, Lupeol, Stigmasterol, and β-sitosterol simultaneously.

During the validation, the analytical method was subjected to various parameters per the quality guideline of ICH Q2. As a result, the marker exhibited Linearity over the range of 0.2µg/mL to 3µg/mL and 20µg/mL to 60µg/mL. R2 for the markers was found to be 0.996- 0.998.

LOD and LOQ values for the markers demonstrated the sensitivity of the analytical method and were found to be 0.07µg/mL and 0.2µg/mL, which are decently low. All the standards show 98.6- 102.34% recoveries with the applied method during the analysis. The % RSD value for intraday and inter-day precision of RT and replicative injections is NMT 2. It concludes the stability of the standards and repeatability of analytical results.

Conclusion:

All four phytoconstituents of *Asteracantha longifolia (L.)* Nees, viz. Betulin, Lupeol, Stigmasterol, and β-sitosterol were simultaneously evaluated by this rapid and validated analytical method. The method exhibited adequate performance for Linearity, Range, LOD- LOQ, Precision, Recovery, and Specificity. The method is decently simple and rapid, with an elution gradient of 15min for quantifying four phytoconstituents. It can be applied to estimate one or other phytoconstituent contents from other medicinal plants or formulations.

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Revolutionizing Lithium-Sulphur Batteries

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Abstract:

A lithium-sulfur battery is a promising rechargeable system due to the high elemental abundance of sulfur.This paper is highlighting Li-S advantages like it's high theoretical energy density, cost-effectiveness, and environmental benefits. Recent advances in materials science and battery engineering, including the development of nanostructured electrodes, advanced electrolytes, and innovative separators, have addressed many of these limitations, making Li-S batteries more viable for commercial use. With continued research, Li-S batteries have the potential to revolutionize energy storage systems, contributing significantly to the global transition towards cleaner and more sustainable energy solutions.

Keywords: LSB-lithium sulphur batteries, wh/kg- watt hour per kilogram, mAh- Milliampere hour, EVs- Electric vehicles.

Introduction:

The rising need for better ways to store energy has driven researcher's attention to focus on improving batteries. Traditional batteries like lead-acid and nickel-cadmium fall short because they can't store or deliver enough energy, and they have other limitations as well. In contrast, lithium-ion batteries (LIBs) stand out because they're more efficient, reliable, and powerful. As compared to older batteries, LIBs don't suffer from memory effect (a loss of capacity over time), and they lose very little charge when not in use (about 5% per month). In addition there's enough lithium in the Earth's crust to make over 12 billion electric vehicles, making LIBs a promising choice for the future[1]. Therefore , Lithium-based batteries have become a key area of focus for researcher's worldwide. While lithium-ion batteries (LIBs) offer higher energy density compared to sodium-ion batteries, they are not ideal for use in electric vehicles. With an energy density of 200–300 Wh/kg, LIBs fall short of meeting the requirements for emerging applications, such as electric vehicle electrification and advanced electronic devices. These limitations have driven researchers to explore alternative rechargeable batteries with higher energy densities and longer lifespans. Among these alternatives, lithium-sulfur (Li-S) batteries stand out due to their low cost, high theoretical capacity (1675 mAh/g), and exceptional theoretical specific energy (2600 Wh/kg), assuming the complete reaction of lithium with sulfur to form Li_2S. Notably, Li-S batteries have been successfully utilized in the longest and highest-altitude flights of solar-powered unmanned aircrafts [2],[3], [4].

Working Principle of Li-S Battery:

Like other secondary cells, lithium-sulfur (Li-S) batteries consist of four main components: a cathode (where reduction occurs during discharge), an anode (where oxidation occurs during discharge), an electrolyte (which facilitates ion migration between electrodes internally), and a separator (which prevents direct contact between the electrodes). The working principle of Li-S batteries differs slightly from that of conventional lithium-ion batteries (LIBs). In LIBs, lithium ions migrate from the lithium-based cathode to the anode through the electrolyte during charging and return to the cathode during discharge. In contrast, Li-S batteries are assembled in a charged state and initially operate through discharge. During discharge, lithium ions move from the lithium anode to the sulfur-based cathode through the electrolyte-soaked separator, reducing sulfur (S) to lithium sulfide (Li_2S) via a multi-step, multi-electron process. During charging, the reverse occurs: Li_2S is oxidized back to sulfur, and lithium ions return to the anode through the electrolyte.The reduction of sulfur (S_8) to Li_2S follows several sequential steps:

$$S_8 + 2Li^+ + 2e = Li_2S_8$$
+
$$3Li_2S_8 + 2Li + 2e = 4Li_2S_6$$
+
$$2Li_2S_6 + 2Li + 2e = 3Li_2S_4$$
+
$$Li_2S_4 + 2Li + 2e = 2Li_2S_2$$
+
$$Li_2S_2 + 2Li + 2e = 2Li_2S$$

This stepwise reduction highlights the complexity and efficiency of Li-S battery chemistry.

Difficulties ahead:

Despite there are numerous advantages of lithium-sulfur (Li-S) batteries, several challenges must be addressed before they can be widely adopted for large-scale applications. These challenges include:

(a) The high resistivity of sulfur and lithium sulfide (Li_2S).

(b) The "shuttle effect" of polysulfides, which causes capacity loss and efficiency issues.

(c) Significant volume expansion and contraction during the lithiation and delithiation processes.

(d) The use of a metallic lithium anode, which poses safety and stability concerns.

These issues are primarily associated with the electrodes or electrolyte. Optimizing these components through suitable modifications can significantly enhance the overall performance of Li-S batteries. The following sections provide an overview of key research advancements in cathode, anode, and electrolyte materials[5].

Cathode Material:

In lithium-sulfur (Li-S) batteries, elemental sulfur is used as the cathode. Sulfur exists in over 30 allotropes, amongst which the most common and stable form is cyclic octasulfur (S_8). However, sulfur has very low electronic conductivity (10–30 S/cm), which initially led to the use of conventional carbon materials, such as carbon black, to improve conductivity. Carbon blacks are typically produced through the thermal cracking or partial combustion of carbon sources, like natural gas, at high temperatures in an inert atmosphere or with limited oxygen. Other materials, such as graphite and bio-derived carbon, are also potential candidates for enhancing the conductivity of sulfur-based composites[5]. The sulfur loading in the cathode of lithium-sulfur (Li-S) batteries is influenced by the porosity of the matrix, which directly affects the cathode's performance. While the optimal pore size for optimal performance in Li-S batteries is not yet fully defined, general observations can be made:

(a) Mesoporous and macroporous carbon materials (with pores larger than 2 nm) allow for higher sulfur loading but tend to suffer from poor cycling stability.

(b) Small micropores (less than 0.5 nm) offers better sulfur utilization and cycling stability, but they are limited in terms of sulfur loading capacity.

(c) Large micropores (ranging from 0.5 nm to 2 nm) are generally unsuitable for designing sulfur-carbon composites due to their inadequate performance [6].

Carbon nanotubes (CNT) is an alternate device through which composite can be made efficiently.[7]. Cheng et al. demonstrated the loading of elemental sulfur onto carbon nanotubes (CNTs) by crushing sulfur powder in a ball mill along with CNTs. In this process, the CNT bundles acted as a conductive medium for the heavily sulfur-loaded CNTs. However, since the sulfur particles were placed on top of the nanotubes, the cycle life of the composite was limited, despite the robust conductive network provided by the interconnected CNTs. The group observed a discharge capacity of approximately 560 mAh/g. Additionally, free-standing 3D graphene structures were fabricated by Papandrea et al[8]. Subsequently, numerous researchers have focused on engineering the structure of graphene to further enhance the electrochemical properties of lithium-sulfur (Li-S) batteries. In this regard, nitrogen-doped 3D graphene has also been utilized as a host matrix for sulfur[9].

Electrolytes material:

The electrolyte plays an important role in the performance of lithium-sulfur (Li-S) batteries, as carbonate-based solvents have been found to be less effective in this context. While carbonate-based solvents do not cause significant issues with short-chain sulfur cathodes, ether-based solvents are considered as superior for Li-S batteries. This is just because ether-based solvents facilitates faster dissolution and redeposition of polysulfides, which leads to better sulfur utilization. However, these solvents do not prevent the formation of polysulfides. For optimal performance of Li-S batteries, two key factors must be carefully considered: The concentration of the electrolyte and The electrolyte-to-sulfur ratio[10].

Electrolyte concentration:

The dissolution of lithium polysulfides (LiPS) in the electrolyte is a significant issue in lithium-sulfur (Li-S) batteries, as it not only reduces the specific capacity but also decreases Coulombic efficiency. It is anticipated that the solubility of LiPS will decrease in the presence of a highly concentrated electrolyte due to the common ion effect[11]. To investigate the impact of electrolyte concentration on the electrochemical performance of cells, researchers conducted experiments using a highly concentrated (7 mol/L) electrolyte. They found that limited dissolution of lithium polysulfides (LiPS) in the concentrated electrolyte led to improved cycling stability. However, they also observed that the cell exhibited poor Coulombic efficiency with a lower concentration of electrolyte. It has since been established that highly concentrated electrolytes offer benefits for electrochemical performance, but they come with several drawbacks. First, a higher electrolyte concentration increases viscosity, which resulted in lower output voltage. Second, a higher concentration means a greater amount of electrolyte, which adds unwanted weight and reduces the overall energy density. Third, using a highly concentrated electrolyte is not cost-effective[12].

Electrolyte amount:

It is crucial to use an optimal amount of electrolyte to achieve higher energy density in lithium-sulfur (Li-S) batteries. A lower electrolyte amount results in reduced dissolution of lithium polysulfides (LiPS), which improves the cycle life. However, insufficient electrolyte can lead to slower lithium ion migration due to poor wetting of the separator. Conversely, cells with a higher electrolyte-to-sulfur (E:S) ratio experience lower gravimetric and volumetric energy densities. Nevertheless, using an excess amount of electrolyte can enhance the overall cycle life, as the electrolyte will deplete more quickly, and electrolyte depletion is a primary cause of cell failure[12] .

Zheng et al. have established that the optimal electrolyte-to-sulfur (E/S) ratio for lithium-sulfur (Li-S) batteries should be 20 µL/mg, corresponding to an electrolyte concentration of 50 g/L. Solid or polymeric gels have also been found to be suitable alternatives for use as an electrolytes. Solid electrolytes are superior to liquid electrolytes in several aspects, including reduced dissolution of lithium polysulfides (LiPS), better thermal and mechanical stability, and non-flammability. Typically, compositions derived from Li_2S-P_2S_5 solutions are used as electrolytes in all-solid-state Li-S batteries[13].

Conclusion:

Lithium-sulfur (Li-S) batteries represent an advanced energy storage technology that provides several benefits over traditional lithium-ion batteries, particularly in terms of energy density, cost, and sustainability. These batteries utilize lithium metal as the anode and sulfur as the cathode, offering a theoretical energy density of up to 500 Wh/kg, which is substantially higher than the energy density of lithium-ion batteries, typically around 250 Wh/kg.

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Review on Green Chemistry in Analytical Method Development and Validation: A Sustainable Approach

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Abstract:

The increasing concern for environmental sustainability has driven the need for green chemistry principles in analytical method development and validation. This study presents the application of green chemistry principles in the development and validation of analytical methods for pharmaceutical and environmental analysis. Novel approaches, such as solvent-free extraction, microextraction techniques were employed to minimize waste, reduce energy consumption, and promote eco-friendly methodologies. The developed methods were validated according to ICH Q2(R1) guidelines, demonstrating satisfactory specificity, accuracy, precision, and robustness. The results showcase the potential of green chemistry-based analytical methods to reduce environmental impact while maintaining analytical performance.

Keywords: Green chemistry, analytical method development, validation, sustainability, pharmaceutical analysis, environmental

Introduction

Development and validation of analytical methods form an essential part of ensuring the quality and safety of products. Traditional analyticalmethods, however, utilize hazardous chemicals and produce a tremendous amount of waste.Analytical method development and validation in line with green chemistry principles is a sustainable alternative.Principles of Green ChemistryGreen chemistry principles provide an approach to minimizeenvironmental impacts through chemical processes and product synthesis.The 12 principles of green chemistry include the following:

Protection

It is better to prevent waste than to treat or clean up waste after it has been created.

Atom Economy

Synthetic methods shall be designed to maximize incorporation of all materials used in the process into the final product.

Less Hazardous Chemical Syntheses

Wherever practicable, synthetic methods shall be designed to use and generate substances that possess little or no toxicity to human health and the environment.

Designing Safer Chemicals

Chemical products should be designed to achieve their desired function while minimizing toxicity.

Safer Solvents and Auxiliaries

The use of auxiliary substances (e.g., solvents, separation agents etc.) should be made unnecessary wherever possible and innocuous when used.

Design for Energy Efficiency

Energy needs of chemical processes should be acknowledged for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be carried out at ambient temperature and pressure.

Use of Renewable Feedstocks

A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

Reduce Derivatives

Minimize or avoid unnecessary derivatization, such as using blocking groups, protection/ deprotection, or temporary modification of physical/chemical processes (requiring additional reagents and often generating waste).

Catalysis

Catalytic reagents, ideally as selective as possible, are preferable to stoichiometric reagents.

Design for Degradation

Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.Real-time analysis for Pollution Prevention

Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances. Inherently Safer Chemistry for Accident Prevention Substances and the form of a substance used in a chemical process should be selected to minimize the potential for chemical accidents, including releases, explosions, and fires. Analytical method development is the process of developing a new analytical method or modifying an existing one to meet specific requirements. The objective of method development is to create a method that is accurate, precise, and reliable.

Steps in Analytical Method Development

Define method requirements: Determine the analyte, matrix, and desired performance characteristics.

Select the analytical technique: Select an appropriate analytical technique based on the method requirements.

Optimize the conditions of the method: Optimize the conditions of the method that may include sample preparation, chromatography, and detection.

Validate the method: Validate the method by checking whether the method will satisfy the performance characteristics required.Analytical method validation is a process of establishing that the analytical method is suitable for its intended purpose. The aim of the method validation is to confirm that the method is accurate, precise, and reliable.

Parameters for Analytical Method Validation

Specificity: The ability of the method to measure the analyte in the presence of other substances.

Linearity: The ability of the method to provide a linear response over a specified range.

Accuracy: The closeness of the measured value to the true value.

Precision: The closeness of individual measurements to each other.

Detection limit: The lowest concentration of the analyte that can be detected.

Quantitation limit: The lowest concentration of the analyte that can be quantitated.

Robustness: The ability of the method to withstand small changes in method conditions.

Steps in Analytical Method Validation

Planning the validation experiment: Defining validation parameters, type of sample, and the acceptance criteria.Prevalidation samples: Standards, blanks, and spiked samples are to be prepared.

Conduct the validation experiments: Specificity, linearity, accuracy, precision, and detection limit as well as the quantitation limit studies shall be conducted in the validation experiment Validation data analysis: The validation data is to be analyzed so that it would determine whether or not the method meets acceptance criteria. Record the validation outcome: Record the validation outcome and any deviations or problems encountered during the validation study.

Green Analytical Method Development

Green analytical method development is the designing and optimizing of analytical methods with reduced environmental impactTechniques for green analytical method development are as follows:

Solvent-free extraction: Extraction using techniques that do not involve the use of a solvent, such as microwave-assisted extraction, ultrasound-assisted extraction, and supercritical fluid extraction.

Miniaturization: The miniaturized analytical techniques and their corresponding miniaturized approaches are also included, for instance microextractiontechniques, microfluidic devices, etc.

Alternative solvents: Alternative solvents including ionic liquids, deep eutectic solvents, and bio-based solvents are used in analytical chemistry.Green Analytical Method Validation

The evaluation of the performance of the analytical methods with sustainability metrics forms part of green analytical method validation. The strategies applied to achieve green analytical method validation are:

LCA: This evaluates the entire life cycle environmental impacts associated with the a nalytical methods.

Alternative validation parameters: The use of alternative validation parameters, such as the "greenness" of a method.

Environmental impact evaluation of analytical methods: Using tools such as the national environmental method index (NEMI) and the analytical ecoscale to evaluate the environmental impact of analytical methods.

Methodology of a Green Chemistry Analytical Methods Development & Validation

Step 1: Define Method Requirements Identify the analyte and matrix.Choose the performance characteristics desired (sensitivity, selectivity, accuracy) Take into account the effect the method will have on the environment (solvent usage, energy expenditure)

Step 2: Select Green Analytical Tool for the Method,

Look into other analytical techniques (chromatography, spectroscopy)Dependent on the efficiency of the selected method, ensure that the required environmental impact is minimal

Utilize renewable energy sources as well as sustainable resources

Step 3: Refine the Conditions Above and Below the Method

Make solvent reduction a goal – come up with techniques that will lead to agent preparation while using minimal amounts of solvents and disposal of minimal wastesSeek for and compare other less hazardous solvents and reagents Enhance the use of chromatography and detection techniques to ensure less energy usage and minimal or no waste generation

Step 4: Assess Integrity of the Method

Investigate the method for specificity, linearity, accuracy, precision, detection limit, and quantitation limitEnvironmentally safe validation protocols should be used (normal volume, fewer solvents)

Different validation parameters can also be utilized (greenness metrics or life cycle assessment)

Step 5: Environmental Impact Analysis

Carry out a life cycle assessment to determine the environmental implications of the method. Evaluate the greenness of the method using metrics like E Factor. Determine potential for further environmental enhancement

Step 6: Record and Share Results

Record method development and validation results, including environmental impact assessments. Share results through peer-reviewed publications and presentations. Share method protocols and environmental impact assessments with the scientific community to promote sustainable analytical practices

Green Chemistry Metrics for Analytical Method Development and Validation

Environmental Factor (E Factor) : Measures the environmental impact of a method based on solvent usage and waste generation.

Green Chemistry Metric : Evaluates the environmental sustainability of a method based on criteria such as solvent usage, energy consumption, and waste generation.

LCA: Life cycle assessment is the method for environmental impact evaluation of a technique from raw material extraction up to waste disposal. This method, therefore, provides an analytical chemist with an opportunity to design and validate a green analytical method that meets its performance requirements withreduced impact on the environment.

Discussion

Advantages of Green Chemistry Analytical Method Development and Validation

Less Environmental Impact: Green chemistry analytical methods minimize the use of hazardous chemicals, reduce waste generation, and promote sustainability.

Safety Improvement: Green chemistry analytical methods reduce the risk of accidents and exposure to hazardous chemicals.

Cost Saving: Green chemistry analytical methods can reduce costs associated with chemical purchasing, storage, and disposal.

Better Analytical Performance: Green chemistry analytical methods can offer superior analytical performance, including greater sensitivity and selectivity.

Issues and Limitations

Few Green Analytical Methods Available: The need for more environmentally benign and sustainable green analytical methods continues to grow.

Lack of Standardization: There is still a paucity of standardization in the development and validation of green chemistry analytical methods.

Higher Upfront Costs: Green chemistry analytical methods may require higher upfront costs for method development and validation.

Limited Awareness and Education: There is a need for increased awareness and education on green chemistry principles and practices.

Future Directions

Development of New Green Analytical Methods: There is a need for the development of new green analytical methods that are environmentally friendly and sustainable.

Standardization of Green Chemistry Analytical Method Development and Validation: Standardization is needed in green chemistry analytical method development and validation.

Increased Awareness and Educational : There is a need for increased awareness and education about the principles and practices of green chemistry.

Integration of Green Chemistry into Regulatory Frameworks: Green chemistry needs to be integrated into regulatory frameworks.

Implications Regulatory Implications

Incorporation of Green Chemistry into Regulatory Frameworks: Regulatory agencies should incorporate green chemistry principles into regulatory frameworks.

Green Chemistry Guidelines and Standards Development: Regulatory agencies should develop guidelines and standards for green chemistry analytical method development and validation.

Industrial Implications

Adoption of Green Chemistry Principles: Industries should adopt green chemistry principles in analytical method development and validation.

Development of Sustainable Analytical Methods: The industries need to develop sustainable analytical methods with minimal environmental impact.

Academic Implications

Incorporation of Green Chemistry into Curricula: The green chemistry principles should be integrated into curricula by the academic institutions.

Research and Development of Green Analytical Methods : The research and development of green analytical methods should be conducted by the academic institutions.

Societal Implications

Enhanced Awareness and Education: There is a need for increased awareness and education on green chemistry principles and practices.

Societal Promotion of Sustainable Analytical Practices: Societal promotion of sustainable analytical practices is necessary to minimize environmental impact.

Conclusion

Developing analytical methods in green Chemistry and their validation provide a sustainable route toward product quality and safety. With green chemistry principles, analytical chemists can reduce environmental impacts, minimize waste, and promote sustainability.Promoting sustainability in analytical chemistry will only be possible through the adoption of green chemistry analytical methods. The development and validation of sustainable analytical methods should reduce environmental impact and enhance sustainability, thus securing a long-term future for analytical chemistry.

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A Comparative Study of Household Detergents – A Step towards More Effective Laundry

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Abstract

Commercially available detergents in the Indian market were studied for several quality parameters and environmental indexes. Water was used as a control. The comparative analysis data of all the brands were compiled the tests such as for, pH, solubility, wetting performance, foaming ability, emulsions stability, oxygen-releasing capacity, hard water test, alkalinity, and cleaning action. The study aimed to collect all the relevant information to compare parameters for performance and effectiveness of the available commercial detergents and help the consumer to make an informed choice of the detergent available in the Indian market and avoid being misled by manipulative marketing strategies that push out smaller and perhaps more polluting detergents.

Keywords: Foaming Ability, Alkalinity, Detergents, pH Test

Introduction

Detergents are defined as household chemical cleaning compounds that are significantly used for laundering and dishwashing purposes [1]. The demand for such products in India is on the rise due to the growing awareness towards health and hygiene coupled with the changing lifestyles of people as well as a considerable increase in per capita disposable income. At present, people are more concerned about sanitization in general than ever before. The critical development of the homecare items advertised is likewise ascribed to developing mindfulness among purchasers about close-to-home well-being and cleanliness [2]. Customers are spending more on these items than ever. The unmistakable utilization of cleansers in all the homecare items gives a persistent push to the interest in cleansers. Increasing awareness among people about health and hygiene as well as a considerable increase in per capita disposable income has boosted the sales of homecare products in India. Also, the advent of an e-commerce website, extensive marketing campaigns by national players, and the growing penetration of multinational players are further expected to support the growth of the detergents market in India.

The earliest known use of a natural, soap-like material was the powder of nuts from the Reeta (Sapindas) tree, a powder used by Indians since antiquity [3]. The Indian detergent industry has been in rapid development since the 1980s. Due to the increase in population, higher urbanization, spread of education, and rising levels of income and consumption, the overall growth of the detergent market has been about 15% per annum [5]. The market sources predict that the synthetic detergents would increase by the next decade at a growth rate of 25% per annum, with India becoming the world's fifth largest consumer market by 2025 (value $1.5 trillion). The India detergents market was valued at INR 42,827.4 crore in 2019 and is projected to reach INR 73,660.4 crore by 2027; it is expected to grow at a CAGR of 7.0% from 2020 to 2027 [6].

Surfactants are key components of detergents in general. Because of their presence in detergents, oil, and associated dirt particles become solubilized and can be rinsed away with clean water. Each molecule of detergent has (a) an ionic end, which is hydrophilic (water- attracting) and soluble in water; and (b) a nonpolar hydrocarbon chain that is hydrophobic (water-repelling) that can attach to nonpolar materials such as grease and oil [7]. These molecules form bridges between water and oil, breaking up the oil and forming an emulsion consisting of oil droplets suspended in water. Substances made up of such molecules are called surfactants. They reduce the surface tension of water, they reduce the interfacial tension between oil and water by adsorbing at the liquid-liquid interface.

The detergent market in India is segmented into three broad categories: Premium category; which includes Ariel, Surf Excel, etc., Mid-priced category; which includes Tide, Wheel, etc., and Mass market category; which includes Rin, Ghadi, etc. Per capita consumption of detergents in India is 2.7 kg per annum and is expected to grow to 7-9 kg per annum. Price is the most important factor in selecting a detergent for Indian consumers followed by brand image and cleaning action. India

Detergents Market - by Type: Anionic Detergents, Cationic Detergents, Non-ionic Detergents and Zwitterionic Detergents. Indian Detergent Market – by form: Powder, Liquid and Bar. Indian Detergents Market - by Application: Personal Cleaning, Laundry Cleaning, Household Cleaning, Dishwashing, Fuel additives and Biological reagent [9].

Laundry detergent, or washing powder, is a type of detergent (cleaning agent) used for cleaning laundry. Laundry detergent is manufactured in powder and liquid form. The manuscript gives the comparative analysis data of all the detergent brands available in the market. The compiled data of the tests such as pH, solubility, wetting performance, foaming ability, emulsions stability, oxygen-releasing capacity, hard water test, alkalinity, and cleaning action were checked to compare parameters for performance and effectiveness of the available commercial detergents

1. Materials and methods

A total number of Nine brands of marketed detergent powders were procured from the open market, and taken up for the study. Commonly used detergents were purchased from different shops in Shahad market located in Thane, Maharashtra, and were studied for their several quality parameters and environmental indexes. Water was used as a control. Detergent brands selected for this study are in the table below. All studies were performed at room temperature [10-12].

Table 1: Name of detergent used their manufacturing industry and the price per gm.

Serial Number	Brand Name	Manufactured by	MRP, by grams And USP
D1	**Ariel** Perfect Wash	Procter & Gamble Company, Mumbai	70gm, Rs. 10, Rs. 0.142 /gm
D2	**Surf excel** Easy Wash	Hindustan Unilever Ltd. Mumbai	80gm, Rs.10 Rs.0.125/gm
D3	**Tide** Double Powder	Procter & Gamble Company, Mumbai	80gm, Rs.10, Rs.0.125/gm
D4	**Rin** Bright Like New	Hindustan Unilever Ltd. Mumbai	95gm, Rs.10, Rs.0.105/gm
D5	**Ghadi** Detergent Powder	RSPL Ltd. Kanpur, U.P.	110gm, Rs.10, Rs.0.090/gm
D6	Active **Wheel** 2 in 1	Hindustan Unilever Ltd. Mumbai	50gm, Rs.6, Rs.0.12/gm
D7	**Ghadi** Machine Wash	RSPL Ltd. Kanpur, U.P.	70gm, Rs.10, Rs.0.142/gm
D8	**Surf excel** Matic Liquid	Hindustan Unilever Ltd. Mumbai	50ml, Rs.10, Rs.0.20/ml
D9	**Ezee** Liquid Detergent	Godrej Consumer Product Ltd. Guwahati.	40gm, Rs.10, Rs.0.25/gm

Fig. 1: Detergent samples taken for test

Methods and Procedures for detergent test

1. Solubility

The solubility test was done by taking 2% solution of each detergent in a conical flask. Each solution flask was heated in a water bath at 40 ^{o} C for 3 minutes. It was then left undisturbed for 2 minutes. The solution was filtered on pre-weighed Whatman filter paper 1 on a Buchner funnel using a vacuum pump.

(a) **(b)**

Fig 2: Detergent solution heated in (a) water bath and (b) left undisturbed

Fig 3: Filtration of detergent solution

The filter paper with residue was carefully picked up and dried in an oven at a temperature of 100 0C ±5 0C until a constant mass was obtained, and then the final weight was taken.

2. pH

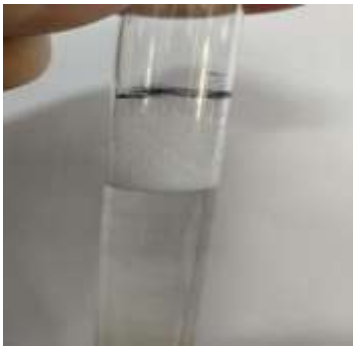
0.1% solution of different detergents was taken. A pH meter was calibrated using pH 4, 7, and 10 buffers.

Fig. 4: pH measurements of detergent solutions

Using the calibrated pH meter, the pH of each detergent was measured and recorded.

3. Foaming stability test

Foam stability was measured using Ross and Miles criteria. 10 mL of 0.1% detergent solution was taken in a test tube and shaken 10 times.

(a) **(b)**

Fig. 5: a) Foaming stability test and b) foam formed

The time for the disappearance of 2 mm foam was recorded and compared.

4. Wetting performance test

Wetting criteria was measured by taking1 gram cotton thread was weighed and placed on the surface of 200 mL of 0.1 % detergent solution taken in a beaker.

Fig. 6. Wetting performance test

The time taken by the thread to completely sink to the bottom of the beaker was noted.

5. Emulsion stability test

The test was performed by taking 5mL of 1% solution of detergent, to it was added 0.5 mL mustard oil, and vortexed for 1 minute. Time was recorded when the solution became clear. Water was taken as control.

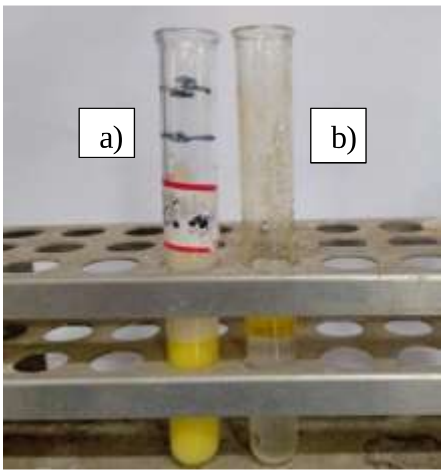


Fig. 7: Emulsion stability test a) Vortex sample b) Clear sampl**e**

6. Hard water test

For the hard water test (17), 15mL of 2 g detergent solution was taken in 3 test tubes.

Fig. 8: Hardness test

Tests were performed by adding 10 drops of 5% $MgCl_2$, 5% $FeCl_3$, and 5% $CaCl_2$ in the 3 different above test tubes, and observations were recorded.

7. Oxygen releasing capacity

50 ml of 1% solution was pipetted out in a conical flask. To this, 1 test tube of HCl was added and titrated against 0.1 N $KMnO_4$ till faint pink color persisted. x ml of O.1 N $KMnO_4$ = 8 * 0.1 * x / 1000 of O_2 in 50ml.s

Fig. 9: Oxygen releasing capacity

8. Alkalinity

25 ml of stock sample solution was pipetted out and titrated against 0.1 N HCl, till it became colourless (using Phenolphthalein as Indicator), that burette reading was taken as 'A' ml for determining Active Alkalinity. For the same solution, titration was continued with 0.1 N HCl, till the colour changed from yellow to orangish red (using Methyl Orange as an indicator). That burette reading was taken to be 'B' ml for determining Total Alkalinity. Active alkalinity (x) = A * 0.1 * 31 / 1000 g of Na_2O Total alkalinity (y) = B * 0.1 * 31 / 1000 g of Na_2O

9. Cleaning action

Various stains were applied on the cotton cloth and dried overnight. The clothes were pre-soaked for 15 minutes in 200 mL of 0.1% detergent solution and then stirred the cloth in the same solution by placing the beakers on magnetic stirrers for 15 minutes.

Fig. 10: Cleaning action test

The clothes were then washed with distilled water and finally dried.

Results and Discussion

1. Solubility

Surf excel matic (D-8), Ezee liquid (D-9), showed 100% solubility in water. Ghadi detergent powder (D-5), Rin (D-4), and Wheel (D-6) showed the least solubility among the given detergents (Figure 11). It can be inferred that all liquid detergents leave fewer residues hence water requirement is less while washing

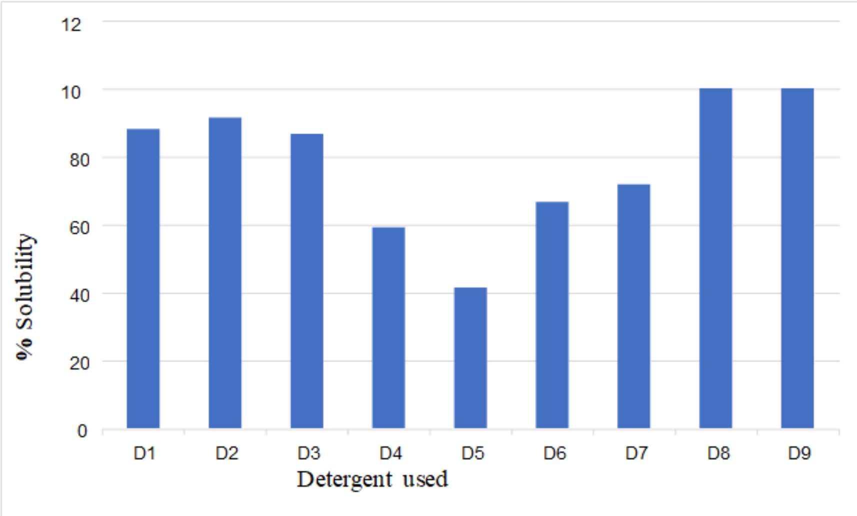


Fig. 11: Solubility of 2% detergents solution

2. pH

It was observed from Figure 12, that the solid detergents had an alkaline pH whereas the liquid detergents showed a nearly neutral pH. Neutral pH detergents are safe on hands and are aquatic environment friendly.

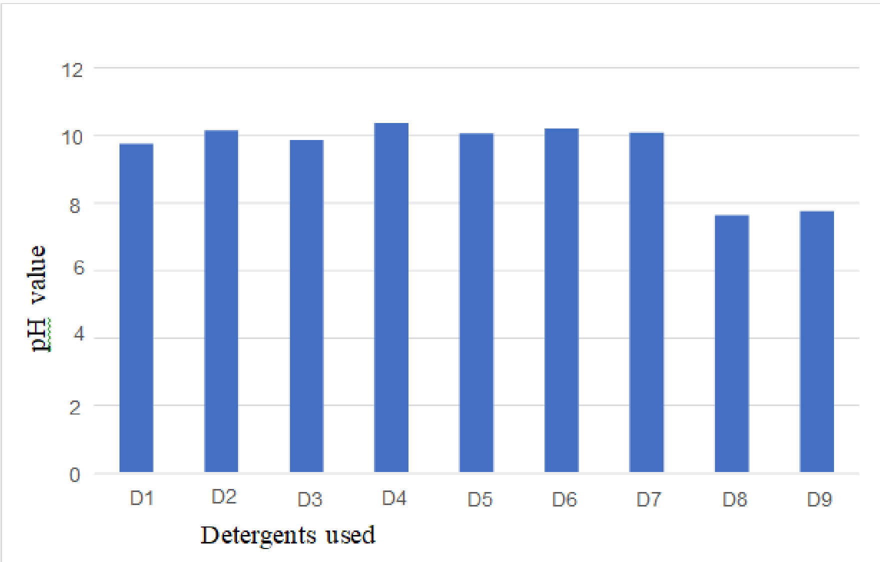


Fig.12. pH of 0.1 % wt of detergents solution

3. Foaming stability

For a good detergent, the foam should form easily and collapse fast so that less water is needed in washings.

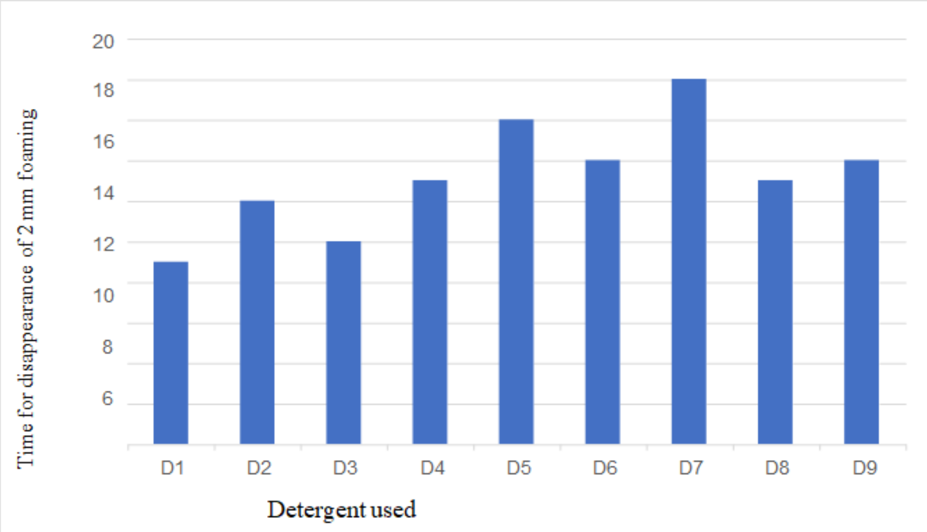


Fig. 13: Foaming of 0.1 wt % of detergent solution

Ghadi machine wash (D-7), Ghadi detergent powder (D-5), Wheel (D-6), and Ezee liquid (D- 9) take the most time for foam collapse, whereas Ariel (D-1), Tide plus (D-3), Surf excel (D-2), Rin (D-4) and (D-8) take comparatively less time, hence are more water-efficient (Figure 13).

4. Wetting performance

The less the time taken by thread to soak and sink in the detergent solution completely, the better it is for detergent wetting performance.

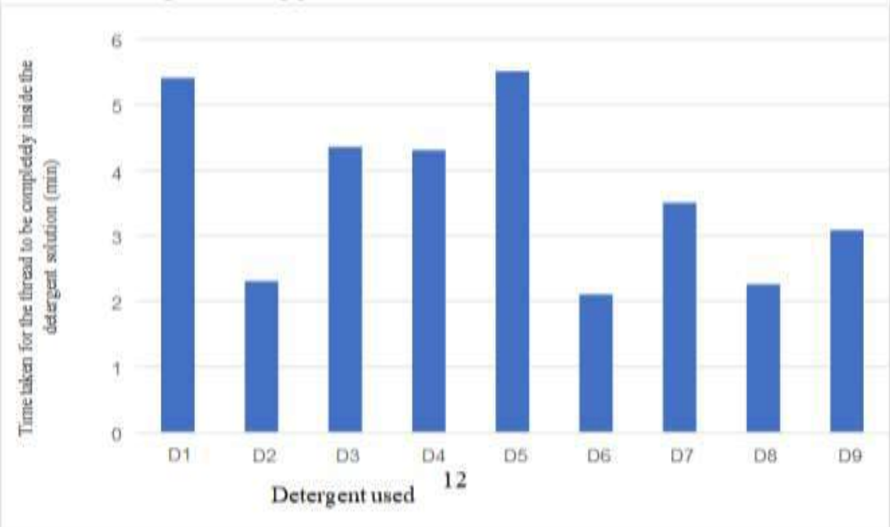


Fig. 14. Wetting performance test

The thread takes the least time to sink in Wheel (D-6), Surf excel matic liquid (D-8), Surf excel (D-2), and Ezee liquid (D-9). The maximum time is required for Ghadi detergent powder (D- 5), and Ariel (D-1). Ghadi machine wash (D-7), Rin (D-4), and Tide plus (D-3) gave a good wetting performance and, therefore are more energy efficient (Fig. 14).

3.5. Emulsion stability test

Good emulsion properties are crucial for a good detergent as emulsion formation is the basis of cleansing action.

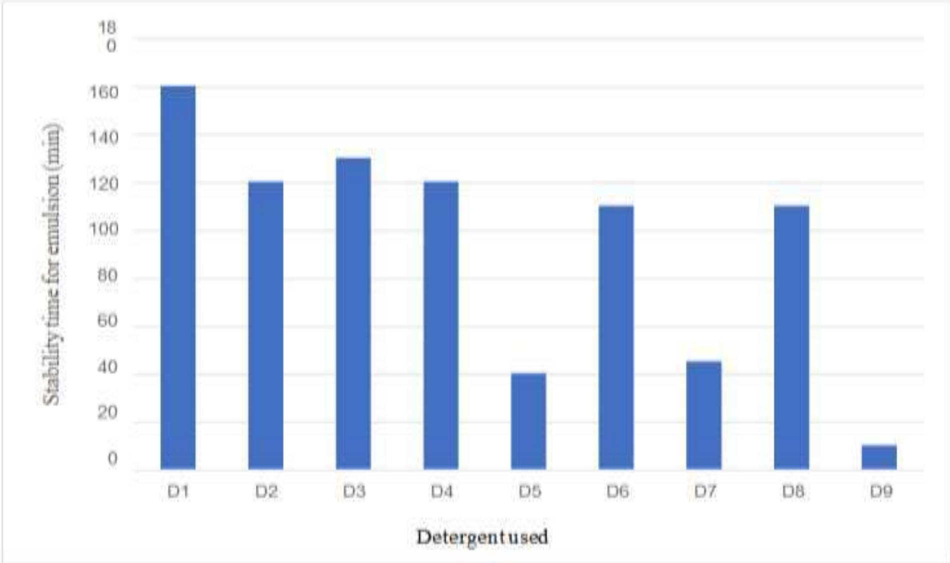


Fig.15. Emulsion stability test

It was observed that Ariel (D-1), Tide plus (D-3), Surf excel (D-2), and Rin (D-4) formed the most stable emulsions. Ghadi detergent powder (D-5), Ghadi machine wash (D-7), and Ezee (D-9) on the other hand formed the least stable emulsions (Figure 15).

6. Hard water test

A good detergent does not form scum and can be used effectively in hard water.

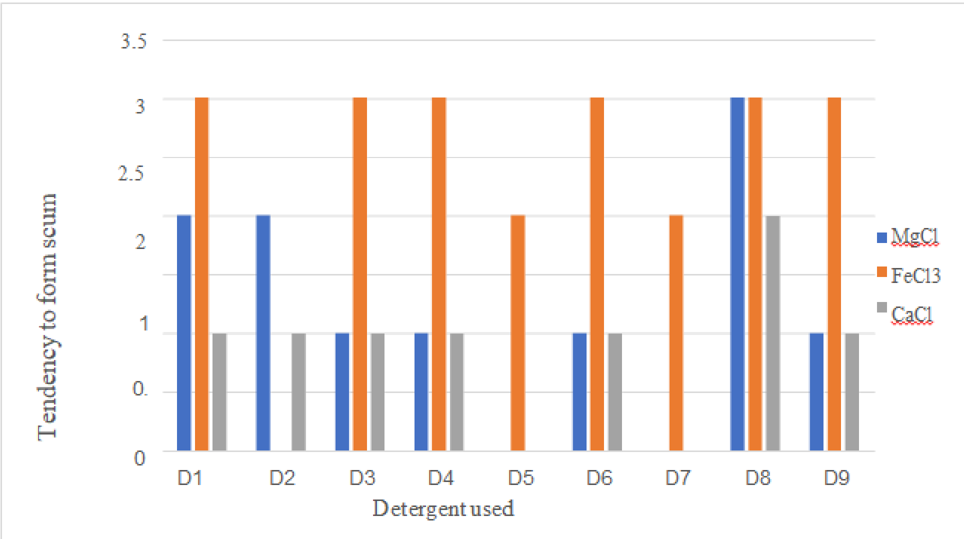


Fig.16. Hard water test of detergents solution

Surf excel (D-2), Ghadi detergent powder (D-5), and Ghadi machine wash (D-7) showed no or very slight precipitate/scum formation (Figure 16).

7. Oxygen releasing capacity

Nascent oxygen is generally used for bleaching/cleaning the cloth. The property of releasing oxygen has given detergents a tremendous advantage over soaps.

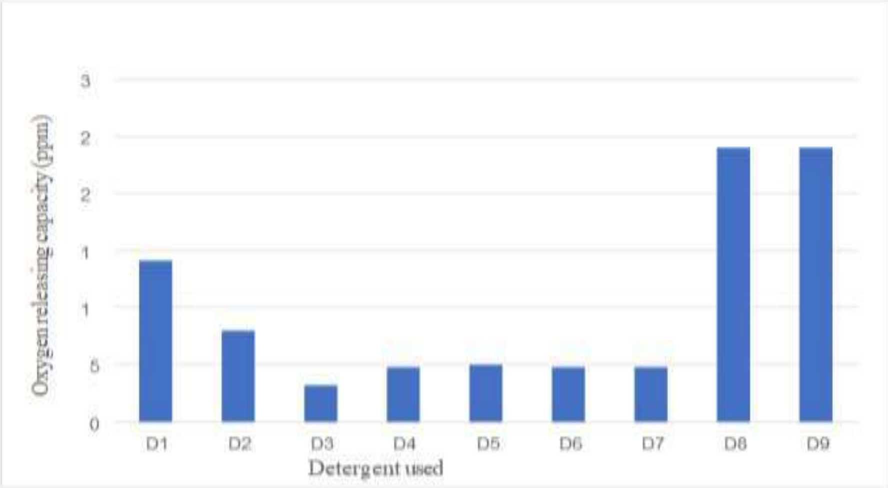


Fig.17: Oxygen releasing capacity

The detergent that releases more oxygen considered to be a better detergent. Surf excel matic liquid (D-8), Ezee liquid (D-9), and Ariel (D-1) have more oxygen-releasing capacity than other sample (Figure 17).

8. Alkalinity

The alkaline nature of the detergents is a key determinant of their effectiveness as a cleansing agent. Oil or grease can be removed from the cloth only in alkaline conditions, also mild alkaline conditions make the hard water soft and improve the detergency action. Effectiveness in hard water is the advantage that detergents have over soap. The alkalinity of a detergent is measured in terms of active alkalinity (or bicarbonate alkalinity) and total alkalinity (or carbonate alkalinity). Active alkalinity helps in water softening and total alkalinity helps in the removal of oil and grease. As the detergents are predominantly non-biodegradable, they are expected to show the same alkalinity after a long time when they are disposed of in water.

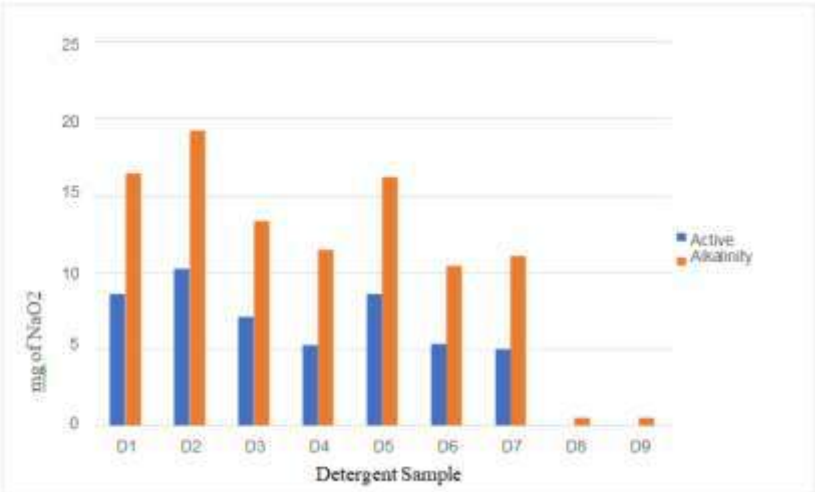


Fig.18. Alkalinity of detergent samples

As it is known that the detergents are predominantly non-biodegradable, this indicates that Sodium Lauryl Sulphate remains unaffected in the solution for a longer time.

9. Cleaning action

In terms of stain removal and brightness all selected detergents performed the best. Different types of stains were applied to cotton clothes liquid detergents showed less cleanliness. The Figures 17-20 illustrates the cleaning action of detergents.

Fig.19. Soya sauce stain and the cleaning action of detergents

Fig.20. Ketch-up stain and the cleaning action of detergents

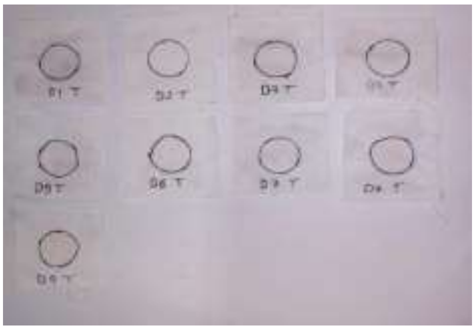


Fig.21. Tea stain and the cleaning action of detergents

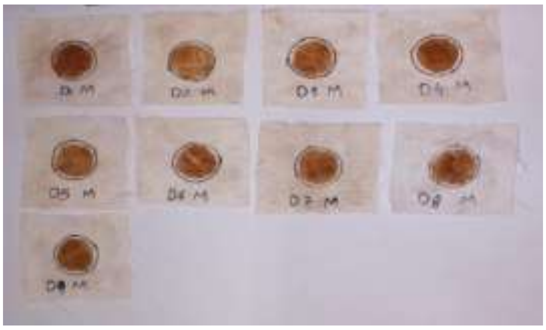


Fig. 22: Mud stain and the cleaning action of detergents

The table below summarizes the results obtained by different tests on detergents samples.

Table 2: Summary of the results obtained by different tests on detergents samples

Samples→ Tests ↓	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**
Solubility in %	88.08	91.42	86.67	59.18	41.41	66.61	71.8	100	100
pH (1-14)	9.74	10.13	9.84	10.35	10.05	10.18	10.07	7.62	7.73
Foaming stability in (minutes)	9	12	10	13	16	14	18	13	14
Wetting performance in (minutes)	5	2	4	4	5	2	3	2	3
Emulsion stability in (minutes)	160	120	130	120	40	110	45	110	10
Hard water ($MgCl_2$, $FeCl_3$, $CaCl_2$) in cm	2,3,1	2,0,1,	1,3,1	1,3,1	0,2,0	1,3,1	0,2,0	3,3,2	1,3,1
Oxygen-releasing capacity in (ppm)	14.14	8	3.2	4.8	5	4.8	4.8	24	24
Alkalinity: Active alkalinity→ Total alkalinity → In mg of NaO_2	8.6 16.43	10.23 19.22	7.13 13.33	5.28 11.46	8.6 16.2	5.08 10.4	5.03 11.55	0 0.5	0 0.5
Cleaning action	-	-	-	-	-	-	-	-	-

Conclusion

The purpose of this work was to compare the properties of commercially available detergents. The present study carried out a comparative analysis of detergents in terms of cleanliness. The parameters tested were: pH, solubility, wetting performance, foaming ability test, emulsion stability, oxygen-releasing capacity, alkalinity, and cleaning action. From the studies on commonly used detergents, it was concluded that many cheaper detergents like Tide (D-3), Rin (D-4), Ghadi (D-5), and Wheel (D-6), did not shown good results in all the tests, but were found to be good in cleaning performance when compared to costlier detergents like Ariel, Surf excel, Tide plus, etc. These detergents provide a good cheaper alternative for most of majority population. Most liquid detergents are easy on the hands though they are costlier when compared to powder detergent, are easily soluble. They have good oxygen releasing, pH, foaming stability, wetting characteristics and emulsion stability on an average. The study could help as an initiative to make the consumer more aware, so as to demand more effective detergents with good cleaning action.

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Thermal Impact on Organic Contents of *Eleusine coracana* L Seeds (Monocot Seeds)

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Abstract:

Now a days, climatic changes are responsible for lot many natural calamities. The rise in temperature due to global warming may cause loss of species, reduction in food production etc. These temperature changes may cause alteration in organic contents of plants produce. In view of this a study is carried out to check the effect of temperature variations on the organic content such as protein and carbohydrates in the seeds of *Eleusine coracana* L. It was observed that the duration and temperature range both affect the protein and carbohydrate content of the seeds.

Key words: Temperature, organic, protein, carbohydrate, *Eleusine coracana*

Introduction:

Belonging to the group of small seeded species of cereal crops or grains, the millets are annual plants. In India millets are grown for centuries including Ragi, Jowar, Bajra. They are sustainable crops that thrive in arid regions. India has been the forefront of popularizingmillets, with 2023 declared the "International Year of Millet". For millions of individuals, millets serve as their primary source of protein and calories. (Reddy et al, 2019). Temperature affects cellular, metabolic and growth rates of seeds. Millets such as Ragi has been introduced into India approximately 4000 Years ago. This grain is resistant to drought, pastes and pathogens and hence long storage capacity makes ragi an important crop in risk avoidance strategies for poorer farming communities It is adaptable to higher elevations. Ragi the finger millet belongs to family Poaceae with subfamily Chloridoideae. Finger millet is a key part of traditional Indian diet and is valued for its health benefits. It is rich in protein content and exceptionally rich in Calcium. It has also antidiabetic, antiulcer and antioxidant properties which makes it useful for patients. It also helps to combat malnutrition. These grains are non-glutenous food that is easily digestible and non-allergenic. The change in temperature due to global warming may cause some effects on the living things. In view of this a study has been undertaken to check the varying temperature effects on the primary metabolites in plans such as protein and carbohydrates.

Materials and Methods:

Seeds of *Eleusine coracana* were brought from the market. 10 gms of seeds were surface sterilized with 0.1% Mercuric chloride. Seeds were imbibed in distilled water and kept at varying temperature. They were studied for biochemical contents after the time interval of 1st day, 2nd day and 3rd day. The protein and carbohydrate contents were analyzed by following standard methods.

Results and Discussion:

Abiotic factors such as drought, salinity, temperature, etc were responsible for the proper growth of the plant with healthy seed formation with good content of its components. It was observed that abiotic stress such as drought, salinity increase the protein content significantly may be adaption to the stress (Omar N. Al Sammanai et at ,2020). Seeds were found to grow well with ideal temperature range at 15-20 ^{0}C for Barley (Akos Tapnawa et ai, 2023).

Standard value of protein is calculated as 1.76 mg/2 gm of seeds. When the seeds are sown in 4 -10^{0} C condition for all the 3 days the amount of protein content is increased on the first day as 1.35 mg as compare to 3rd day. Similarly, the rise in temperature ranges from 10-20^{0} C the amt of protein content maximum increase on the 1 day as 1.5 mg. Temperature condition of 20-30^{0} C for all the three days shows maximum rise on the 1st day as 1.49 gm. While at the temperature range from 30 -40^{0} C the protein content shows rise on 1st day as 1.45 mg. On the 2nd day at all the temperature ranges the amount of protein gets decreased. Again, the value of protein elevated on 3rd day but it is slightly lesser than the 1st day. The concentration of protein was found to be lowered on all the days in all the temperature ranges. Standard value of carbohydrate is found to be 1.8 gm /2 gm of seeds.

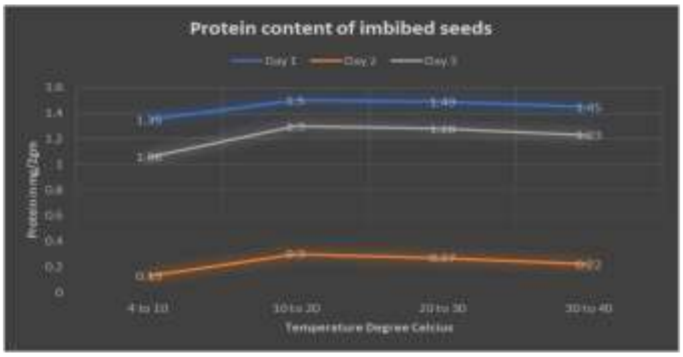

Fig. 1 Effect of various temperature ranges on protein content of Ragi seeds

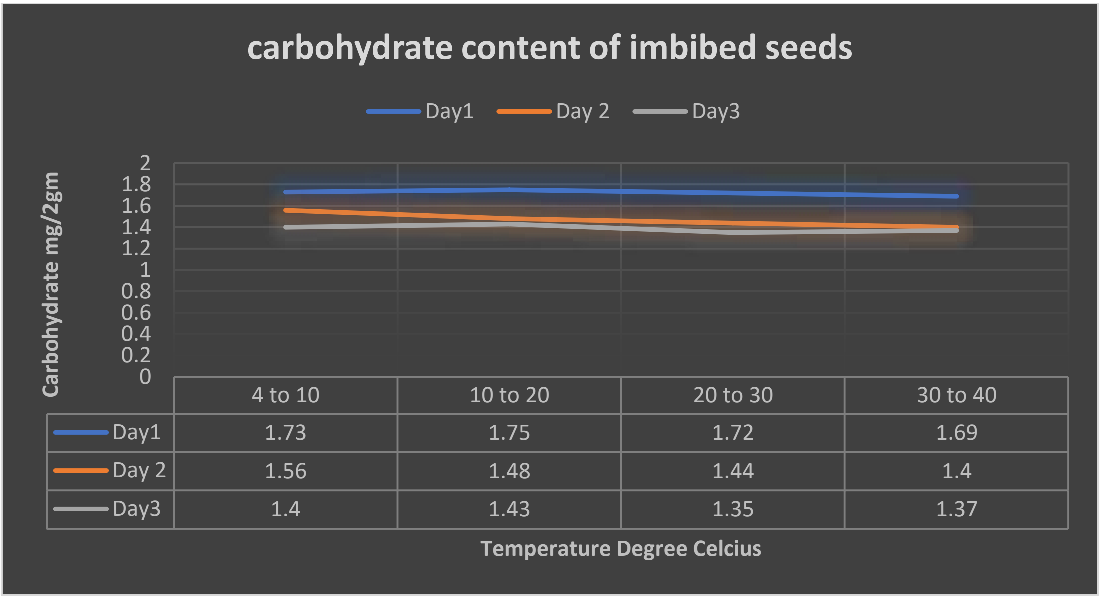

FIg. 2 Effect of various temperature ranges on Carbohydrate content of Ragi seeds

Imbibition of seeds of finger millets on different temperature ranges reduces its content as compare to the standard which was obtained on soaking seeds for 08 Hrs. at room temperature. The carbohydrate content was obtained as 1.73 mg at the temperature range at 4 to 10^0 C. which is maximum for all the 3 days. At 10-20^0 C temperature the content is again maximum as 1.75 mg on the 1st day. Similarly at 20-30^0 C and 30 -40^0 C the values obtained as 1.72 mg and 1.69 mg respectively which is maximum on the 1st day of all the three days of the experiment. Elevation in temperature causes breaking up of proteins and inactivation of essential enzymes. It also reduces starch and sucrose synthesis (Joseph C.V. Vu et al 2001) Decrease in protein and starch content was also noted in wheat and maize(Ian F Wardlaw et al 2002)

Conclusion:

From the above study it can be said that the temperature ranges seriously affect the protein content for the 2nd day of imbibition**.** Still all the ranges of temperature including more hrs. of imbibition affects the protein value of the seeds of finger millets. The carbohydrate content of ragi seeds was found to be reduced on the 1st day of imbibition than the standard value calculated after 08 hrs of imbibition at room temperature. The carbohydrates still go on decreasing as the days of imbibition increases at all the temperature ranges. It can be inferred that the room temperature such as 28^0 C for 08 Hr. imbibition is suitable for protein and carbohydrate content.

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A Greener Approach Towards Sustainable Development

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Abstract

The idea of sustainable development has become essential to solving the world's environmental, social and economic problems. A green strategy combines the ideas of resource efficiency, waste reduction and environmental protection to promote sustainability. The basic ideas of green chemistry and how they relate to the Sustainable Development Goals (SDGs) are examined in this study. It draws attention to current developments in green reactions, their uses across a range of sectors and governmental initiatives supporting sustainable practices. Societies may create a sustainable future by embracing green practices, which strike a balance between ecological protection and economic growth.

Keywords: sustainable development, green chemistry, environmental protection, green reactions, government initiative

Introduction

"Green Chemistry" is the universally accepted term to describe the movement towards more environmentally acceptable chemical processes and products [1]. It encompasses education, research and commercial application across the entire supply chain for chemicals [2]. Green Chemistry can be achieved by applying environmentally friendly technologies – some old and some new [3]. While Green Chemistry is widely accepted as an essential development in the way that we practice chemistry and is vital to sustainable development, its application is fragmented and represents only a small fraction of actual chemistry. It is also important to realize that Green Chemistry is not something that is only taken seriously in the developed countries. Some of the pioneering research in the area in the 1980s was indeed carried out in developed countries including the UK, France, and Japan, but by the time the United States Environmental Protection Agency (US EPA) coined the term "Green Chemistry" in the 1990s, there were good examples of relevant research and some industrial application in many other countries including India and China [4].

The idea of sustainable development has become essential to solving the world's environmental, social and economic problems. A green strategy combines the ideas of resource efficiency, waste reduction, and environmental protection to promote sustainability. The basic ideas of green chemistry and how they relate to the Sustainable Development Goals (SDGs) are examined in this essay. It draws attention to current developments in green reactions, their uses across a range of sectors, and governmental initiatives supporting sustainable practices. Societies may create a sustainable future by embracing green practices, which strike a balance between ecological protection and economic growth.

Principles of Green Chemistry:

The term Green Chemistry, coined by staff at the US EPA in the 1990s, helped to bring focus to an increasing interest in developing more environmentally friendly chemical processes and products. There were good examples of Green Chemistry research in Europe in the 1980s, notably in the design of new catalytic systems to replace hazardous and wasteful processes of long standing for generally important synthetic transformations, including Friedel–Crafts reactions, oxidations, and various base-catalyzed carbon–carbon bond-forming reactions. Some of this research had led to new commercial processes as early as the beginning of the 1990s [4].

The Principle of Green Chemistry contains 12 major principles:

1. Prevention: Avoid waste generation rather than treating it.
2. Atom Economy: Maximize the incorporation of all materials into the final product.
3. Less Hazardous Synthesis: Use methods that reduce or eliminate toxic substances.
4. Designing Safer Chemicals: Create chemicals with minimal toxicity.
5. Safer Solvents and Auxiliaries: Minimize or avoid the use of solvents and auxiliaries.
6. Energy Efficiency: Conduct reactions at ambient temperature and pressure to save energy.
7. Renewable Feedstocks: Use renewable raw materials whenever possible.
8. Reduce Derivatives: Avoid unnecessary modifications that require extra reagents.
9. Catalysis: Prefer catalysts over stoichiometric reagents.
10. Degradable Products: Design chemicals that break down into harmless substances.
11. Real-Time Analysis: Monitor and control processes to prevent pollution
12. Minimize Accidents: Use substances and methods that reduce accident risks.[2]

Government Policies and Global Initiatives:

Governments and international organizations have implemented policies to promote sustainable practices:

1. Paris Agreement (2015): A global framework to limit global warming below 2°C.[6]
2. UN Sustainable Development Goals (SDGs): Goals addressing climate action, clean energy, and sustainable production.
3. REACH Regulation (EU): Controls the use of hazardous chemicals.
4. Green Chemistry Program (USA): Encourages industries to adopt green chemistry.
5. India's National Action Plan on Climate Change (NAPCC): Promotes energy efficiency and renewable energy.

Latest Green Reactions

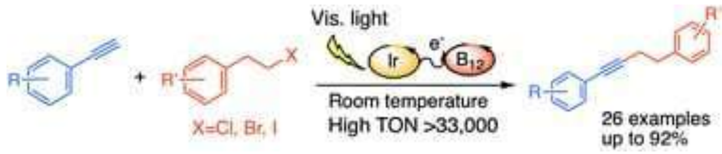
Recent advancements in green chemistry have led to innovative reactions and processes, including:

1. Biocatalytic transformations: Use of enzymes for eco-friendly synthesis, such as the enzymatic production of biodiesel
2. Microwave-assisted synthesis: Reduces reaction time and energy consumption
3. Solvent-free reactions: Reactions performed without solvents, minimizing waste.
4. Carbon dioxide as a solvent: Utilization of supercritical CO_2 as a green solvent in organic synthesis
5. Electrochemical synthesis: Reactions powered by electricity, especially from renewable sources.[8]

Advancement in Green Chemistry

Green chemistry has significantly advanced in recent years, focusing on sustainable development through innovative reactions and applications. Notable research from the past five years includes:

1. Visible Light-Driven C-C Coupling Reactions: Researchers have developed hybrid Cu_2O-Pd nanostructures that facilitate carbon-carbon coupling reactions of terminal alkynes under ambient conditions using visible light. This method enhances efficiency and sustainability in chemical synthesis.[10]



2. Sustainable Synthesis of Hydrogen Tungsten Bronze Nanoparticles: A novel, green approach utilizing mechanical energy has been introduced to synthesize H_xWO_3 nanoparticles at room temperature. These nanoparticles exhibit unique optoelectronic properties and improved photocatalytic performance, contributing to sustainable nanotechnology.[11]

3. Green Chemistry in Industrial Processes: Studies have highlighted the integration of green chemistry principles to enhance the sustainability of industrial processes, recommending actions to support widespread adoption.

4. Green Chemistry Innovations for Sustainable Development: Comprehensive analyses have been conducted on innovative practices in green chemistry and their influence on promoting sustainable development.

5. Advancements in Green Chemistry Education: Systematic reviews have explored the implications of education in green chemistry, emphasizing the need for effective teaching to address environmental concerns.

6. Green Chemistry and Sustainability Initiatives: The American Chemical Society's Green Chemistry Institute leads efforts to catalyze the implementation of sustainable approaches in chemistry and engineering globally.

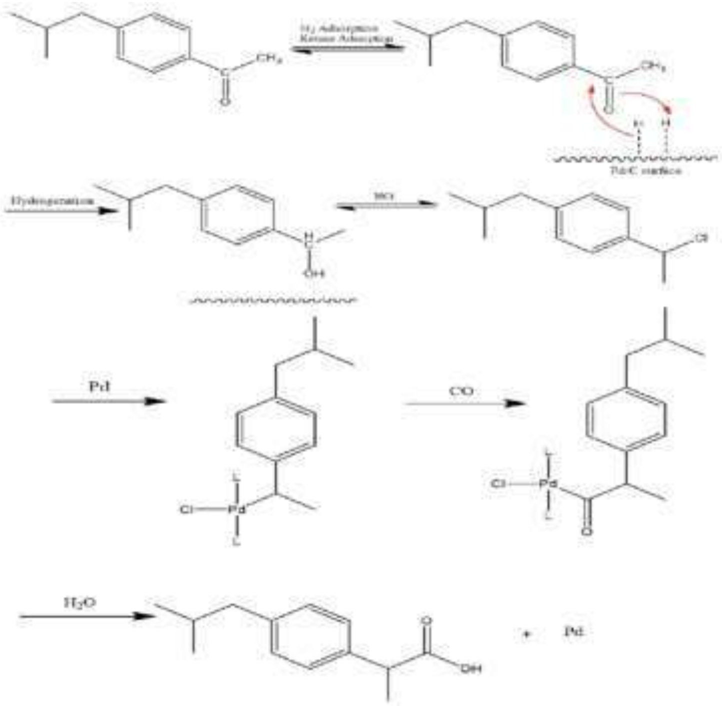
7. Integration of Green Chemistry with Sustainable Development Goals: Research has proposed studying how principles of green chemistry are integrated within the Sustainable Development Goals and relevant indicators.

8. Recent Advancements in Green Chemistry: Collections of recent work have been highlighted, showcasing the latest advancements in green chemistry.

9. Future Perspectives in Chemical Sciences: Scientific perspectives have identified unified priorities in green, circular, and sustainable chemistry concepts, emphasizing the future direction of chemical sciences.

Applications of Green Chemistry

1. Pharmaceutical Industry: Green chemistry principles are used to design safer and more efficient drug synthesis processes. For example, the synthesis of ibuprofen using the BHC process achieves 99% atom economy, significantly reducing waste.[5]



2. Agriculture: Development of bio-based pesticides and herbicides minimizes the use of toxic chemicals, reducing soil and water pollution. Biofertilizers derived from natural materials also promote sustainable farming practices.[9]

3. Energy Sector: Production of biofuels like biodiesel and ethanol from renewable biomass reduces reliance on fossil fuels. Hydrogen generation using green methods supports clean energy initiatives.[7]

4. Polymers and Plastics: Manufacturing biodegradable plastics, such as polylactic acid (PLA), reduces plastic waste. Green polymerization processes minimize the use of toxic catalysts and solvents.

5. Textile Industry: Eco-friendly dyes and pigments derived from natural sources reduce the use of hazardous chemicals. Waterless dyeing technologies save water and reduce pollution.

6. Cosmetics: Green chemistry is used to develop natural, non-toxic, and biodegradable ingredients for cosmetics and personal care products.

7. Food Industry: Development of green packaging materials, such as edible films, reduces environmental waste. Use of enzymes in food processing increases efficiency and minimizes waste.

8. Water Treatment: Green chemistry methods, such as photocatalysis and the use of biodegradable flocculants, are employed for purifying water without generating harmful byproducts.

9. Electronics: Development of lead-free solders reduces toxic waste in electronic manufacturing. Green solvents are used in cleaning and processing electronic components.

10. Paints and Coatings: Water-based paints and coatings eliminate the need for volatile organic compounds (VOCs), reducing air pollution. Development of self-cleaning and antimicrobial coatings improves product durability and hygiene.

11. Construction Materials: Fly ash and slag are used as green alternatives to Portland cement, reducing CO_2 emissions. Development of low-energy insulation materials improves building sustainability.

12. Automotive Industry: Use of bio-based lubricants and fuel additives reduces engine wear and environmental impact. Development of lightweight materials improves fuel efficiency.

13. Chemical Manufacturing: Catalytic processes reduce energy consumption and waste. Solvent-free and microwave-assisted reactions enhance efficiency.

14. Paper and Pulp Industry: Enzymatic bleaching processes replace chlorine-based methods, reducing toxic effluents.[7]

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Revolutionizing Healthcare: The Diverse Contributions of Inorganic Chemistry A Review

Ms. Tahreem Ashraf Momin[1], Dr. Jayashree Thakre[2], Dr. Shaziya Momin[3], Dr. Seema I. Habib[4], and Ms. Farah Qazi[5]
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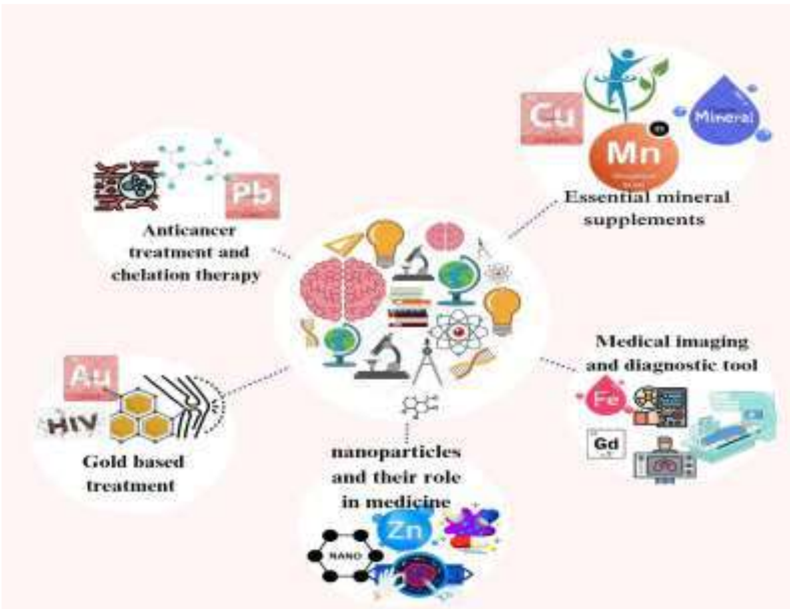
Abstract

The dynamic scientific research of inorganic chemistry has the ability to completely reshape healthcare. New solutions arise from the dynamic intersection of inorganic chemistry and medical science, with significant consequences for healthcare. The field of medical treatment and prevention has been transformed by the versatile nature of inorganic chemistry, which has produced unprecedented cancer treatments and breakthrough diagnostic techniques. This thorough analysis delves into the fascinating uses of inorganic compounds, ranging from the management of diseases like HIV and rheumatoid arthritis to intricate topics like metal toxicity and chelation therapy. Investigating many opportunities of inorganic chemistry as it relates to medicinal chemistry is the study's goal. The use of inorganic chemicals in medicine has been addressed, along with a description of the field's present state in nanomedicine.

Keywords: Medical sciences, Inorganic therapeutic agents, Radiopharmaceuticals, Cancer, Chelation therapy, Nanomedicine.

Graphical abstract



Introduction

The harmonious connection between inorganic chemistry and medical research emerges as a driving force for change in healthcare in the ever-evolving field of scientific study. This dynamic interaction changes the traditional models of medical treatment and prevention in addition to producing creative solutions. The subject of inorganic chemistry is driven towards unparalleled progress by its diverse character, which has resulted in ground-breaking therapeutics such as cancer treatments and innovative diagnostic methods. Beyond the obvious, the research explores complex topics such as metal toxicity and chelation therapy nuances. This analysis, which places a significant value on opportunities, aims to demonstrate the enormous potential of inorganic chemistry in the field of medical chemistry, providing an overview of the field's current status, particularly in with regard to nanomedicine. However, Comprehensive investigations into compounds that are typically outside the scope of organic chemistry are connected to inorganic chemistry research. A disruptive association between inorganic chemistry and medical research has transformed health care. The collaboration is prominent in the creation of novel solutions, from the redesign of diagnostic instruments to the emergence of the most advanced cancer compounds. With its many applications, such as the treatment of disease like HIV and rheumatoid arthritis, metal toxicity, and chemical therapy, inorganic chemistry's adaptability has reshaped the medical sciences. This paper gives a description of the current status of nanomedicine and illustrates the incredible methods in which inorganic materials have been employed in healthcare. Coordinate compounds, Main group element and organometallic compounds, Nanotechnology constitute important areas of inorganic chemistry due to the broad spectrum of uses. [1]. Metal ions affect inorganic materials, naturally forming chemical compounds in biological processes, and metal drugs can show various diseases through imaging and help in diagnostic methods [2][3]4[5]. Many coordinate compounds show biological activity against bacteria and mushrooms. The purpose of the study is to know the potential of Inorganic chemistry applied to medical chemistry. Figure 1 shows various applications of inorganic chemistry in medicine [6].

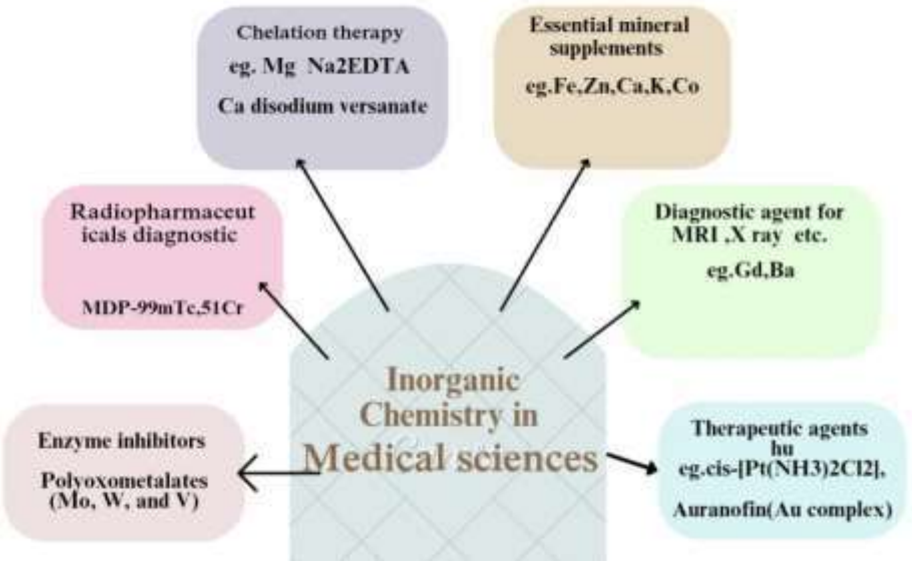


Figure 1: Classification of inorganic chemistry in medical sciences

Modern drug design has not yet largely investigated the potential of the use of minerals in medicine, but the therapeutic value of minerals is still under investigation. Branch of inorganic Chemistry explore the function of metal ions in human organisms, to their uniform control, and the effect of imbalances on the occurrence and progression of various diseases [7][8][9][10][11]. The mixture of ligand of piperaquine, acetaminophen and piperaquine, acetylsalicylic ions of Cu(II), Co(II), Zn(II), and Fe(II) have biological activity against Escherichia coli and Staphylococcus aureus [7][12]. The Ni and Cu ion of thiocarbamoyl dihydropyrazole have high inhibition activity against Candida strains [13]. The fluconazole (fcz) used as antifungals showed high affinity to coordinate Cu(II) and Zn(II) ions, resulting in the formation of polymer{[CuCl2(fcz)$_2$].5H_2O}n, and {[$ZnCl_2$(fcz)$_2$]·2C_2H_5OH}n, Which exhibit antibacterial activity against Candida strains[14]. Silver(I) compounds with pyridine ligands can be used to treat microbial pathogens that cause cow mastitis [15]. Amphotericin B act as antibiotic and treated mycotic infections [16] [17]. It has been shown that the biological activity of amphotericin B increases significantly when a drug forms a hybrid silver nanoparticle [18]. ZnO nanoparticle suspension (ZnO nanofluid suspension) is used as an antibacterial agent [19]. Vanadium compounds have been widely studied as insulin memetic drugs for diabetes[20][21]. Wilson, Menkes, diseases like Alzheimer's Mad Cow, and Amytrophic Lateral Sclerosis are among the conditions heavily impacted by metal proteins. [22][23][24]. Perhaps the most well-known application of metal anticancer is platinum, which is located at the centre of widely used cisplatin. Unlike most organic drugs, cisplatin has a simple structure and is ubiquitous in many cancer treatment regimens, but is reactive and labile, with side effects and systemic problems which make chemotherapy as painful and difficult for cancer patients as the disease itself [25][26]. The use and efficacy of this drug are limited due to the inherent and acquired cell resistance after long-term treatment, as well as many side effects, such as nervous tissue poisoning, nausea, cytotoxicity, electrolytic imbalance, anaemia and nephrotoxicity and. Although carboplatin and oxaliplatin were introduced to overcome the disadvantages of cisplatin, this has not been fully realized [27][28][29][30][31][32][33][34]. With ligand combinations and coordinate geometry having a significant influence on DNA binding preferences, cytotoxicity, and cell metabolism, the Rh(III) and Ir(III) compounds having octahedral geometry containing bidentate aromatic ligands show great promise as anticancer agents. [35], while Sadler and his team have synthesized osmium(II) arene with cancer cell cytotoxicity comparable to carboplatin and Cisplatin clinical drugs[35][36][37][38]. These Os(II) are believed to interact with DNA in same way as Ru which result in dispersion of double helix of DNA[38][39]. Unlike cisplatin, which causes DNA bending, it is believed that Os(II) arenes connection to the calf-thymus DNA cause to DNA unwinding. Like platinum compounds, ruthenium compounds have different oxidation states and better cell toxicity, resulting in the death of cancer cells. Furthermore, ruthenium complexes can mimic the binding of iron in biological systems [40][41]. Ru(II) complex RDC11 is an organometallic Ruthenium species that shows promising in vitro characteristics against cancer. When used in conjunction with cisplatin to treat xenografted A2780 tumor cells and U87 glioblastoma cells, it exhibits a 45% reduction in tumor volume when compared to control mice.

Because of their flexibility and suitability as ligands for quick and effective drug design, N-heterocyclic carbenes (NHCs) are also acquiring attention. [42][43][44]. N-heterocyclic carbon complex are gaining popularity for metal based drug and homogeneous catalysts in diverse C–C and C–N binding reactions. Since the manufacture and characterization of NHC-metal compounds (metal: Ag, Au, Cu, Pd, Pt, Ni and Ru), the role of NHC-metal compounds in materials science has been greatly improved, as well as effective catalysts for polymers, luminous and liquid crystal materials. NHCs have been applied to materials chemistry and have made it possible to function in a variety of ways, including to interfere by the reduction of enzymes, phosphates, topoisomerases, cell skeletal dynamics, and DNA damage. In more and more studies, many gold-NHC complex derivatives have been described as effective cancer agents that can cause the death of apoptosis cells and have a low impact on normal cell survival [45][46][47]. However, Boron neutron capture therapy (BNCT) has attracted considerable attention due to its non-invasive and binary approach to targeting cancer. BNCT shows promise in the treatment of high-grade gliomas, vulvar melanoma, neck and head cancers, cutaneous melanomas, extra mammary Paget's diseases of the genital areas, as well as vulvar melanoma.Nevertheless, solid cysts were susceptible to the cytotoxic effects of Ti complexes. Ti complexes can bind with DNA and resist the cell cycle. However, the distribution and transportation of Ti (III) species into cancer cells is important to the anticancer process [48].

Conclusion

Inorganic chemistry stands as a cornerstone in revolutionizing modern medicine, offering innovative solutions across diagnostics, therapeutics, and disease management. Its applications, from designing advanced anticancer agents to developing nanomedicine, demonstrate immense potential to address pressing health challenges like cancer, HIV, and rheumatoid arthritis. Additionally, the study of metal toxicity and chelation therapy provides critical insights for managing heavy metal exposure. As research progresses, the integration of inorganic compounds into healthcare promises groundbreaking advancements in disease prevention, treatment, and diagnosis, paving the way for a healthier and more resilient future.

Conflict of interest

The authors declare that they have no conflict of interest relevant to the content of this article.

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Endurance of Biodebris for Fabrication of Therapeutic- Antacids

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Abstract

Human endeavors are significantly altering natural environment generating debris and leads to loss of biodiversity. Bio-debris are organic waste produced in our ambience. These constitutes agricultural, forestry, municipal, industrial, human, animal and plant waste. These are inherent potential sources of enhanced products. Bioremediation framework mitigates environmental degradation of pollutants through sustainable strategies. It leverages these derived products to explore their applications in therapeutics with curing and healing effects. With versatility of our fabricated product. Bio-recovery have revolutionized its capabilities in human welfare.

Keywords: Bio-debris, Enhanced and Fabricated products, Bioremediation, Human Welfare.

Introduction:

Marigold *(Tagetes erecta)* is a species of flowering plant in the genus Tagetes native to Mexico and Guatemala. (1) Despite being native to the Americas, it is often called the **African Marigold**. (1) (2) This plant reaches heights of between 20 and 90 cm (7.9 and 35.4 in). This flowers were gathered as cultivating it for medicinal, ceremonial, decorative purposes or as an ornamental wear. Marigolds are cultivated widely in the Asian and African regions with higher adaptability and are used as cut flowers, loose flowers, and pot flowers. However, the most preferable type is loose flowers in many countries. Especially in India, they are extensively used for social and religious functions in the form of gajra and a variety of garlands. India began as the land of deities, and offering flowers has great value in worshiping the deities; this, in turn, generates a lot of floral waste. During the festive season, marigold flowers are specifically offered to many deities as offerings in favor of blessings. (3) After offering this flowers, once their purpose of worshipping is completed, they are then treated as waste. This waste are either thrown in water bodies are just exposed to environment leading to waste generation and creating an opportunities for growth various microbes. Tagetes species has lots of beneficial properties which can be used to develop for various medicinal or cosmetics application even from its floral waste.

*Tagetes erecta***,** a plant species, has rich source of secondary metabolites, including flavonoids, terpenoids, and carotenoids, with potential applications in pharmaceuticals, cosmetics, and agriculture. The plant comprises phenolics, syringic acid, quercetin, and a quercetagetin glucoside (4), vinyl, ethyl gallate and quercetin. (5)(6) Lutein, a xanthophyll, the primary pigment found in T. erecta and has two cyclic end groups and a C-40 isoprenoid structure. (7) Other carotenoids identified in the flower include zeaxanthin, violaxanthin, neoxanthin, phytoene, and phytofluene. It was detected that 18 active compounds which shows potential antioxidant, antimycotic and analgesic effects.

The secondary metabolites, including flavonoids, terpenoid and lutein, the extract obtained has potential to be used for detoxifier, medicine or as ophthalmic medication. The pigments of the erect tagetes are due to the presence of carotenoids, of which the main one is lutein, which is associated with the prevention of the development of age-related eye diseases such as cataracts and macular degeneration.(8) Whereas, flavonoids and terpenoids can be used as natural neutralizer.

Marigold As A Natural Neutralizer:

Gastroesophageal reflux disease (GERD) and acidity disorders affect millions worldwide, with limited natural remedies available. The secondary metabolites, including flavonoids and terpenoids, were extracted and characterized. The potential of secondary metabolites from marigold floral waste as a natural neutralizer for human detoxification were explored. It was found that the extract, rich in flavonoids and terpenoids, has ability to neutralize gastric acid, reduce inflammation, and protect the gastric mucosa. The secondary metabolites exhibited a pH-buffering capacity, maintaining a healthy gastric pH.

The flavonoids present in marigold flowers, such as quercetin, kaemferol, and isorhamnetin, possess antioxidant, anti-cancer, antimicrobial, and anti-inflammatory properties. The second metabolites found in the marigold which can be used as neutralizer is terpenoids found in marigold flowers, including α-terpineol, β-caryophyllene, and linalool, as this compounds also exhibit same properties as flavonoids like antioxidant, anti-cancer, antimicrobial, and anti-inflammatory properties. The combination of this both secondary metabolites can contribute too many medicinal and therapeutic properties making them as the most valuable ingredient in traditional medicine and cosmeceutical products.Flavonoids are characterized by their distinct three-ring configuration consisting of a benzene ring, a heterocyclic ring, and a third benzene ring. This unique configuration enables flavonoids to exhibit potent antioxidant, anti-inflammatory, and anti-cancer properties. Conversely, terpenoids are composed of repeating isoprene units, adorned with various functional groups that confer their diverse biological activities, including antimicrobial, anti-inflammatory, and antioxidant effects. These compounds synergize to impart marigold flowers with their remarkable medicinal and therapeutic properties.

Methodology

The conventional method for calcium and magnesium extraction process involves a few basic steps, which includes pretreatment of waste of marigold flower, drying, extraction of oxides of calcium and magnesium, precipitation and purification.

Collection, Pretreatment, Drying and Grinding of Waste Marigold flowers:

The waste flower were collected from temples and houses. After collection, the marigold flower were separated from rest of the flowers, leaves and stems. Separated marigold flowers petals are separated from the flower stalk and firstly treated with normal water to remove dust or other impurities. Then followed by drying under sunlight to majority of moisture from the petals for a day and remaining moisture is then dried at 50-60°C. Marigold flower were then weighed about 100 grams. Further they were grinded using motar and pestle to obtain fine powder so as to obtain or increase the surface area.


Fig.1 : Collection, Pretreatment and Separation of Marigold flower from Floral Waste

Ashing:

Ashing is most important step from converting the organic matter into ash. The grinded marigold flower waste powder is then ashed which in turn releases calcium and magnesium in the form of oxides. This ashing step is carried out using furnace or muffle oven.

The process of incinerating marigold waste is a complex, multi-stage operation that necessitates precise control over various parameters to produce ash of optimal quality. The initial step involves reducing the marigold waste to a fine, uniform powder, thereby enhancing its surface area and facilitating even burning. Subsequently, the powdered marigold waste is carefully loaded into a heat-resistant container, taking care to avoid overfilling, which could lead to uneven burning and compromised ash quality. The container is then positioned in a furnace or oven, where it is subjected to a precisely controlled temperature regime.

Temperature control is a critical aspect of the incineration process, as it directly impacts the quality of the resulting ash. The furnace or oven is set to maintain a temperature range of 500-600°C, which is optimal for the incineration of marigold waste. Throughout the process, the temperature is continuously monitored to ensure that it remains within the specified range, thereby guaranteeing efficient incineration.

The incineration process itself typically spans a duration of 2-4 hours, although this timeframe may vary depending on factors such as the moisture content of the marigold waste, the temperature of the furnace, and the desired level of ash quality. Once the incineration process is complete, the ash is allowed to cool to ambient temperature before handling.

Finally, the resulting ash is carefully weighed to determine its yield, which is an important parameter in assessing the efficiency of the incineration process. The ash can then be stored in a dry, cool environment for future use in various applications, including agriculture, industry, and research.

Throughout the incineration process, it is essential to follow proper safety protocols, including wearing protective gear, such as gloves, goggles, and a mask, and ensuring proper ventilation to prevent the inhalation of toxic fumes. Additionally, the furnace or muffle oven should be regularly maintained and inspected to ensure that it is functioning properly and safely.

Fig.2 : Ashing of Marigold flower in the furnace at 500°C

Fig.3: Ash marigold flower after ashing

Water Extraction, Filtration:

The process of extracting calcium and magnesium from marigold waste involves a meticulous sequence of steps. Initially, the dried marigold waste is ground into a fine powder to enhance its surface area, thereby facilitating efficient extraction. Subsequently, the powdered waste is mixed with distilled water in a predetermined ratio, and the mixture is stirred vigorously to ensure homogeneous dissolution of the calcium and magnesium oxides present in the waste.

Following the mixing and stirring process, the mixture is allowed to settle for a specified duration, enabling any undissolved particles to precipitate out. The supernatant is then carefully decanted into a separate container, leaving behind the precipitated particles. The decanted solution is subsequently filtered through a 0.45 μm membrane filter to remove any remaining impurities and particulate matter.

To further purify the solution, additional filtration steps may be employed, including activated carbon filtration and ion exchange resin filtration. These steps enable the removal of any residual impurities and ions, resulting in a solution with enhanced clarity and purity. Ultimately, the purified solution containing calcium and magnesium ions can be utilized in various applications, including agriculture, construction, and pharmaceuticals

Fig.4: Weighing of Precipitating agent

Boiling and Precipitation:

The boiling and precipitation process is a critical step in extracting calcium and magnesium from marigold waste. Initially, the filtered solution containing these ions is transferred to a heat-resistant container and heated to a temperature of 80-90°C. As the solution reaches its boiling point, it is stirred occasionally to prevent scorching and ensure uniform heating. The boiling process is continued until the solution reaches the desired concentration, typically 50-70% of the initial volume.

Following the boiling process, a precipitating agent such as sodium carbonate or oxalate is slowly added to the solution while stirring constantly. This induces the precipitation of calcium and magnesium ions as insoluble salts. The solution is stirred for an additional 10-15 minutes to ensure complete precipitation. The precipitated salts are then allowed to settle for 30 minutes to 1 hour before the supernatant is carefully decanted, leaving behind the precipitated salts.

The precipitated salts are subsequently washed with distilled water to remove any impurities and then dried in a vacuum oven at 60°C for 2 hours. This yields purified calcium and magnesium compounds that can be stored in a dry, cool environment for future use. Throughout the boiling and precipitation process, it is essential to maintain a controlled environment and follow strict protocols to ensure the production of high-purity compounds.

Fig.5: Boiling of solution at 80-90°C

Separation and Purification:

The separation and purification of calcium and magnesium compounds from marigold waste involves a series of meticulous steps. Following precipitation, the solids are separated from the liquid through centrifugation at 3000 rpm for 10 minutes. The resulting supernatant is then carefully decanted, leaving behind the precipitated salts. To remove any residual impurities, the precipitated salts are rinsed with distilled water.

The purification process commences with recrystallization, where the precipitated salts are dissolved in a minimal amount of distilled water to create a saturated solution. As the solution cools slowly, crystals begin to form, marking the initial stage of purification. The crystalline solution is then filtered through a 0.45 μm membrane filter to remove any remaining impurities. Finally, the filtered crystals are dried in a vacuum oven at 60°C for 2 hours, yielding high-purity calcium and magnesium compounds.

Fig.6 : Purified Calcium and Magnesium

Conclusion:

Marigold flower was been collected from household or temples waste, the stem leaves and flower petals were separated, washed and dried to remove dust of impurities, to remove moisture the floral waste is then dried at 60C for 1-2 hrs. later the floral waste were subjected to high temp around 5000 in furnace to obtain ash. After ashing the powder is then dissolved in distilled water and after mixing it is filtered out to remove the floral residue through Whatman filter paper, precipitating agent is then added to filtered solution and heated at 80-900. Solution is then centrifuged at 3000 rpm for 10 mins and the supernatant obtained is discarded, while the precipitated salt is rinsed by distilled water, the filtered crystal is then dried in hot air oven at 60C for 2 hours yielding high purity calcium and magnesium compounds

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Synthesis of Schiff Base under Solvent-free Condition: As a Green Approach

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Abstract

This study explores an environmentally friendly approach for synthesizing Schiff bases, a class of compounds with diverse applications. Traditional methods often involve harmful solvents and catalysts, raising concerns about environmental impact. To address these issues, we developed a solvent-free microwave-assisted synthesis of salicylaldimine Schiff bases. This green approach involves directly irradiating salicylaldehyde with various substituted aryl amines, eliminating the need for any additional solvents or catalysts. The successful synthesis of these compounds was confirmed through elemental analysis and thin-layer chromatography (TLC). This solvent-free method offers several advantages, including increased product yield, enhanced purity, and reduced environmental impact. The findings of this study demonstrate a promising alternative for the efficient and sustainable synthesis of Schiff bases.

Key Words: Schiff bases, solvent-free synthesis, green chemistry, aryl amines, salicylaldehyde.

Introduction

Schiff bases have been known since 1864 when Hugo Schiff reported the condensation of primary amines with carbonyl compounds. The common structural feature of these compounds is the azomethine group with a general formula RHC=N-R_1, where R and R_1 are alkyl, aryl, cyclo alkyl or heterocyclic groups. These compounds are also known as anils, imines or azomethines.

Schiff bases resulted from aromatic aldehydes *ortho-substituted* with a hydroxyl group have initially arouse the researchers' interest because of their ability to act as bidentate ligands for transitional metal ions.

Literature Survey

In studies concerning quantitative structure-antitumor activity relationship of a series of Schiff bases derived from variously substituted aromatic amines and aldehydes, it has been shown that azomethines from salicylaldehydes gave the best correlation. Schiff bases of salicylaldehydes have also been reported as plant growth regulators, antimicrobial and antimycotic activity. Schiff bases also have some analytical applications. Schiff Bases are characterized by the -N=CH- (imine) group which imports in elucidating the mechanism of transamination and rasemination reaction in biological system.

Microwave assisted synthesis, a green chemistry approach, is now a day widely practiced in the synthetic laboratories. Various green strategies have been worked out. One of the thrust areas for achieving this target is to explore alternative reaction conditions and reaction media to accomplish the desired chemical transformation with minimized by-products or waste as well as eliminating the use of conventional organic solvents, if possible. Microwave reactions under solvent-free conditions are attractive in offering pollution free reaction, low cost, shorter reaction time and high yields together with simplicity in processing and handling. The recent introduction of single-mode technology assures safe and reproducible experimental procedures and microwave synthesis has gained acceptance and popularity among the synthetic chemist community. In the present work, some Schiff's bases were synthesized by solvent free technique using microwaves. They were purified and characterized by means of spectral data and elemental analysis.

Experimental

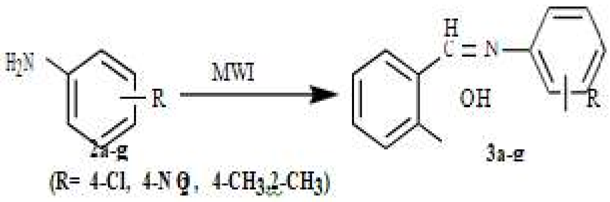
Melting points (mp) were determined and IR spectra were obtained on spectrophotometer. For microwave irradiation a domestic microwave oven was used.

General method for preparation of Schiff bases

A mixture of respective anilines and salicylaldehyde was taken in a 50 mL beaker and mixed well. The mixture was irradiated in a microwave oven at a power of 160 W for the specified time (**Table 1**). The reaction was monitored by thin layer chromatography (TLC) and spots were visualized in iodine chamber. After completion of the reaction, the reaction mixture was poured into ice water. The yellow solid obtained was filtered, washed, dried and recrystallized from ethanol. The spectral and analytical data of the compounds are given in Table 1 & 2.

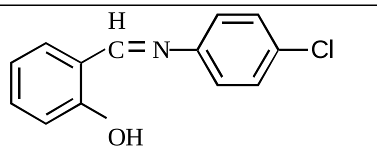
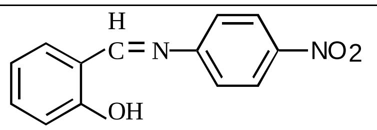
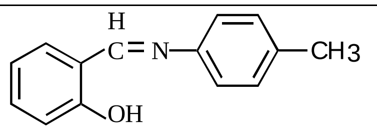
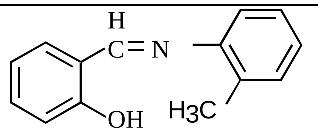
Results and Discussion

A series of salicylaldimine Schiff bases are prepared from salicyladehyde and substituted aniline by microwave irradiation in appropriate time (Scheme 1). It is observed that the condensation between a carbonyl compound and an amine leading to the formation of Schiff bases should be a facile reaction due to the good electrophilic and nucleophilic characteristic properties of the carbonyl and amine groups respectively.



The presence of the methoxy group in 4-methoxyaniline reduces the electrophilicity of the amine through resonance and the strong electron withdrawing property of the nitro group in 4-nitroaniline decreases the nucleophilicity of the amine group. The less nucleophilic amines such as 4-nitroaniline and less electrophilic aldehydes such as 2-hydroxybenzaldehyde were employed. Good results are obtained in the latter case. It was also observed that if one of the reactant is deactivated by its substituent, comparatively more reaction time is required to complete (TLC) the reaction. The structures of the target compounds were well characterized by IR. Analytical and spectral data of Schiff bass are depicted in Table 1.

Table 1: Analytical and IR Spectral data of Schiff bases 3a-d

S.NO.	Compound	Physical Data			IR Spectrum (KBr,cm^{-1})		
		Reaction Time (min)	**Yield (%)**	**mp^{o} C**	**νC=N**	**νC-O**	**νC-C (aromatic stretching)**
1	 **3a**	3	97	205	1614	1280	1588 1571 1498 1457
2	 **3b**	3	97	190	1600	1272	1565 1508 1484 1459
3	 **3c**	4	95	185	1615	1278	1560 1510 1482 1459
4	 **3d**	4	91	207	1614	1277	1572 1505 1474 1466

Conclusion

In this article, we are reporting a new eco-friendly route with good yield for the synthesis of Schiff bases by solvent free microwave irradiation, and the products can be purified by recrystallization using appropriate solvents. This solvent-free approach is nonpolluting and does not employ any toxic materials, quantifying it as a green approach for the synthesis of Schiff bases.

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Exploring the Efficacy of Herbal Fungicides in Controlling *Uncinula Necator* Causing Powdery Mildew Disease in Grape Plants

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Abstract

Powdery mildew disease caused by *Uncinula necator* is a significant threat to grape production worldwide. The excessive use of synthetic fungicides has risen environmental and health concerns. This study aimed to evaluate the efficacy of herbal fungicides as an alternative to synthetic fungicides in controlling powdery mildew disease in grape plants. Our results showed that herbal fungicides, particularly those derived from clove and cinnamon exhibited significant antifungal activity against U. necator. These findings suggest that herbal fungicides could be a promising eco-friendly approach for managing powdery mildew disease in grape plants

Key words: - Powdery mildew, *Uncinula necator*, antifungal activity, Herbal fungicide

Background

Grape is one of the most important fruit crops around the world. At present grape cultivation in India is about 155.3 thousand hectares with a total production 3357.7 thousand million metric ton. (Patel A, et al., 2024) Table grape cultivation is mainly concentrated in peninsular Indian states such as Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh. Maharashtra is a leading state in production of grapes amongst these states. (Ghosh et al.,2017). Total Area under grapes in Maharashtra is 86 thousand ha (almost 60%) and production is around 774 thousand tons (9 tons/ha) of grapes annually. Export of grapes from India is 108.58 thousand tons during 2011-12 valuing of Rs. 602.88 crores, out of which, nearly 80% (around 10% of the total production) is exported from Maharashtra (Shinde, 2016). During 2016, India had recorded fresh grapes export to worth, $219.5million, which is 2.8% of total grapes export). So, grape is emerging as important commercial fruit crop of India and the highest among fruit crops in earning foreign exchange. Grapes production is affected due to various pest and diseases. Diseases include anthracnose, downy mildew, powdery mildew and leaf spot. Powdery mildew, caused by *Uncinula necator* an obligate parasite of grapevine (Vitis vinifera L.), is one of the most important and destructive diseases in many countries of the world including India (Banihashemi and Parvin, 1995; BuiltandLafon, 1978; Cortesietal., 1997; Gadoury et al., 2001a and b; Thind etal., 2004). Under conducible environmental conditions it affects the grape production and yield quantitatively and qualitatively. Moreover, increase the production cost significantly by increasing the application of various chemical fungicides on regular basis (Built and Lafon, 1978; Calonnec et al., 2004; Evants et al., 1996; Pearson and Gadoury, 1987).Nearly 50 to 70% yield was reduced because of infestation by powdery mildew only (Mwamahonje et al., 2015). Powdery mildew can infect all green parts of the grapevine. This disease is most easily recognized by the dusty appearance or white powdery growth occurring in patches on both surface so leaves (Photoplate1.1a), fruit (Photoplate1.1b), and vines (Photo plate 1.1c). These whitish powdery patches consisting of conidia and conidiophores of the fungus may enlarge, coalesce and cover the whole area of spurs, canes, tendrils, panicles and berries have a white powdery appearance. Various chemical fungicides used for controlling powdery mildew are listed in Table 1.1. In the wake of organic agriculture and requirement of consumers for chemical residue free grapes, it is mandatory to develop safe and environmentally benign alternative strategies for the control of powdery mildew. As mentioned in previous three production) is exported from Maharashtra (Shinde, 2016). During2016, India had recorded fresh grapes export to worth, $219.5million,which is 2.8% of total grapes export (). So, grape is emerging as important commercial fruit crop of India and the highest among fruit crops in earning foreign exchange. Grapes production is affected due to various pest and diseases. Diseases include anthracnose, downy mildew, powdery mildew and leaf spot. Powdery mildew, caused by *Uncinula necator* an obligate parasite of grapevine (Vitis vinifera L.), is one of the most important and destructive diseases in many countries of the world including India (Banihashemi and Parvin, 1995; BuiltandLafon, 1978; Cortesietal., 1997; Gadoury et al., 2001a and b; Thind etal., 2004). Under conducible environmental conditions it affects the grape production and yield quantitatively and qualitatively. Moreover, increase the production cost significantly by increasing the application of various chemical fungicides on regular basis (Built and Lafon, 1978; Calonnec et al., 2004; Evants et al., 1996; Pearson and Gadoury, 1987).Nearly 50 to 70% yield was reduced because of infestation by powdery mildew only (Mwamahonje et al., 2015). Powdery mildew can infect all green parts of the grapevine. This disease is most easily recognized by the dusty appearance or white powdery growth occurring in patches on both surface so leaves (Photoplate1.1a), fruit (Photoplate1.1b), and vines (Photo plate 1.1c). These whitish powdery patches consisting of conidia and conidiophores of the fungus may enlarge, coalesce and cover the whole area of spurs, canes, tendrils, panicles and berries have a white powdery appearance. Various chemical fungicides used for controlling powdery mildew are listed in Table 1.1. In the wake of organic agriculture and requirement of consumers for chemical residue free grapes, it is mandatory to develop safe and environmentally benign alternative strategies for the control of powdery mildew. As mentioned in previous three articles, extracts of Cinnamon and Clove exhibited potent fungicidal activities, we thought of concentrating on the same for controlling powdery mildew in grapes.

(a)

Source:https://ohiograpeweb.cfaes.ohio-state.edu/image-galleries/diseases

(b)

Source:https://dengarden.com/gardening/Organic-Methods-of- Exterminating-Powdery-Mildew

(C)

Source: https://www.daf.qld.gov.au/data/assets/image/0006/51558/powdery-mildew-mango flower-250.jpg

Photo plate 1.1 Powdery mildew disease symptoms on grape (a) Leaves (b) fruit (c) vines.

Table 1.1 Fungicides registered in India for control of powdery mildew on grape.

Sr. No.	Active ingredient of Fungicides	Dose of Fungicides			PHI (Days)	Mode of action of Fungicide	Resistance risk
		a.i.(g)	Formulation (g/ml)/ %	Dilution in water (L)			
1	Azoxystrobin 23% SC	125 gm	500 ml	500 - 750	7	Respiration cytochrome bc1 (ubiquinol oxidase) at Qosite(cytb gene)	High
2	Benomy l50% WP	150 gm	300gm	625-700	-	Cytoskeleton and motor proteins	High
3	Dinocap 48% EC	108 gm	225 gm	750	21	Respiration uncouplers of oxidative phosphorylation	Not known
4	Flusilazole	0.004%	0.01%	As required	15	Sterol biosynthesis in	Medium

	40% EC			depending upon the stage of crop and type of plants protection equipment used		membranes	
5	Hexaconazole 5% EC	25-50 gm	500-1000 ml	500	14	Sterol biosynthesis in membranes	Medium
6	Hexaconazole 2% SC	30-60 gm	1.5-3.0L	500-750 depending upon crop canopy	14		
7	Hexaconazole 5% SC	25-50 gm	500-1000 ml	500	14		
8	Kresoxim-methy l44.3% SC	300-350 gm	600-700ml	500	07	Respiration complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site(cyt b gene)	High
10	Triadimefon 25% WP	0.0025 %	0.010%	750	25	Sterol biosynthesis in membranes	Medium
11	Carbendazim 46.27%	0.046% or 46g /100lit water	0.1%or 100 l/100lit Water	As required	30	Cytoskeleton and motor proteins (ß- tubulin assembly in mitosis)	High
12	Penconazole 10% EC	0.005% or 5 gm/100 Lt. water	50ml/100 Lt. water	Depending upon the requirement	30	Sterol biosynthesis in membranes	Medium
13	Sulphur 40% WP	1.22 kg	3.00 kg	1000	-	Multisite contact activity	Low
14	Sulphur 55.16 % SC	0.165% or165 g/100 Lt. water	0.30%or 300ml/100 Lt. water	As required	10		
15	Sulphur 80% WP	2-4kg	2.5-5.0Kg	750-1000	-		
16	Sulphur 85% DP	12.75-17 kg	15-20kg	-	-		
17	Lime Sulphur 22% SC	This liquid is used at one percent in conventional sprayers: Doses2- 5 lit/ha			Feb followed by two dustings in summer		

Materials and Methods

In vivo efficacy trials were conducted on Grapevines (Varity – Sonaka) by Randomized Block Design (RDB) method at Dhondgaonwadi, Taluka: Niphad, District: Nashik during October 2012 – April 2013. Eight treatments were run simultaneously as described in Table 1.2. Total 24 vines (6 rows x 4 columns) were taken per replication. Each treatment was applied in four replications and each replication had two vines (Figure 1.1). All other treatments of fertigation and insect/pest control remained same as per the guidelines of National Research Centre for Grapes, Manjari, Pune.

Water Volume Per Spray

Spray water volume was 1000 L/ha at full canopy and reduced as follows at lesser canopy volumes:

On the day of pruning the canopy was treated as 70 % and spray water volume used was 700 L/ha.

At 5 to 7 leaf stage of growth of most shoots, the canopy was treated as 80 % and spray water volume used was 800 L/ha.When there were more than 8 – 10 leaves on every shoot and few gaps in the canopy to pass the sunlight through the growth to the soil at 12 noon, the canopy was treated as 90 % and spray water volume used was 900 L/ha.100 % canopy did not have any gaps within to allow sunlight to pass through the growth up to the soil at 12 noon.

Table 1.2 Treatments used to control powdery mildew on grape vine.

Treatment	Label	Details
1	Master Control (MC)	Without any treatment
2	Reference Chemical Fungicide Control(RCF)	Hexaconazol at recommended dose
3	T1	Hexane Solvent Control, dose 2 ml/lit
4	T2	Hexane Cinnamon extract,dose2 ml/lit@ 8 ppm
5	T3	Hexane Clove extract,dose2ml/lit @16 ppm
6	T4	Methanol Solvent Control, dose 2 ml/lit
7	T5	MeOH Cinnamon extract,dose2 ml/lit@ 24 ppm
8	T6	MeOH Clove extract, dose2ml/lit @ 56 ppm

All the treatments were applied either through hand operated Knapsack sprayer with hollow cone nozzle or high volume, battery operated sprayer with hollow cone nozzle

		Rows										
Vines	17	18	19	20	9	10	11	12	1	2	3	4
1	T1				MasterControl(MC)Untreated				ChemicalFungicide(PC)Control			
2		T1R1A	T1R1B			MCR1A	MCR1B			PCR1A	PCR1B	
3		T1R2A	T1R2B			MCR2A	MCR2B			PCR2A	PCR2B	
4		T1R3A	T1R3B			MCR3A	MCR3B			PCR3A	PCR3B	
5		T1R4A	T1R4B			MCR4A	MCR4B			PCR4A	PCR4B	
6												
7	T2											
8		T2R1A	T2R1B									
9		T2R2A	T2R2B									
10		T2R3A	T2R3B			T1=Hexane Solvent						
11		T2R4A	T2R4B			T2=HexaneCinnamonExtract						
12						T3=HexaneCloveExtract						
13	T3					T4=Methanolsolvent						
14		T3R1A	T3R1B			T5=MethanolCinnamonExtract						
15		T3R2A	T3R2B			T6=MethanolCloveExtract						
16		T3R3A	T3R3B									
17		T3R4A	T3R4B									
18												
19	T4											
20		T4R1A	T4R1B									
21		T4R2A	T4R2B									
22		T4R3A	T4R3B									
23		T4R4A	T4R4B									
24												
25	T5											
26		T5R1A	T5R1B									
27		T5R2A	T5R2B									
28		T5R3A	T5R3B									
29		T5R4A	T5R4B									
30												
31	T6											
32		T6R1A	T6R1B									
33		T6R2A	T6R2B									
34		T6R3A	T6R3B									
35		T6R4A	T6R4B									

Figure 1.1 Layout of treatments to control powdery mildew.

1 Block = 24 vines; T=Treatment (There are six treatments T1toT6); R=Replication; each treatment is with 4 replications each replication is with 2 plants (A and B); Out of 24 plants, 8 plants indicated in block are test plants 10 Number of Sprays Around five sprays were taken at the interval of fifteen days and observations were noted after every seven days. Efficiency of formulations was measured in terms of percent increase in PM infection on leaves and bunches.

Disease ratings on bunches during the fruiting season was recorded separately. The bunches on canes randomly selected for disease ratings on leaves were observed for presence of the powdery mildew infection and rated in 0-4 scale as shown in Figure 5.2. Observations were recorded on leaves/fruits of the same age group canes, especially if recorded during early growth stages.

Calculations

Increased diseased area (IDA) on leaves was calculated by using following formula.

IDA=Initial infected area on leaves–Infected area after spraying formulations.

Percent increase in PM infection=IDA*100

Percent Disease Index (PDI) on berries was calculated using the following formula.

Sum of numerical ratingsx100

PDI= Number of leaves/bunches observed x Maximu

Figure 1.2Powdery mildew rating scale for leaves (Scale0-4).

PowderyMildew DiseaseRatingScale:

0=No infection

1=1-25%leaf/ bunch infection

2 =26 -59 %leaf / bunch infection

3 =50 -75 %leaf / bunch infection

4=>75 %leaf / bunch infection

Results

Grape plants were monitored during whole season after spraying fungicidal formulations and observed every seventh day. Considerable differences were recorded after spraying. This study indicated that percent increase in PM infection varies with treatments (Figure 1.3 and Photo plate 1.2). An impressive influence of MeOH Cinnamon and MeOH Clove was observed on *U. necator* when compared with NC (Figure 1.3).In untreated vines (NC), PM infection reached upto 89% while in chemical fungicide treatment it was around 68%.Amongst 6 herbal formulations, treatment T5 was found to be best in terms severity of infection, PM infection upto 24% MeOH while T6 treatment plot showed 29% PM infection. Both these treatment plots were respectively of methanolic extracts of *C. zeylanicum* and *S. aromaticum* (Figure 1.3).

Prominent phytotonic effects were observed on grape plants after spraying various herbal formulations. Ideal treatment plot was T5. Average length of berries was around 29 mm and breadth 17.4 mm (Photoplate5.3). Average 59 bunches wereseen on vines. Average weight of bunches was approximately 865 gm which was also maximum than any other treatment under study. Other herbal formulations treated plants also showed phytotonic effects (Table 1.3). It is clear from Figure 1.4 that % PDI also decreased in Treatment T5 when compared with other treatments.

Discussion

The conventional chemical control of powdery mildew is through repeated foliar applications of a combination of protect ant and systemic fungicides. But the intensive use of fungicides worldwide has resulted in an increased frequency of powdery mildew pathogens with reduced sensitivity to chemical fungicides. Therefore, safe alternative strategies are urgently required to combat the attack of PM in grapes.

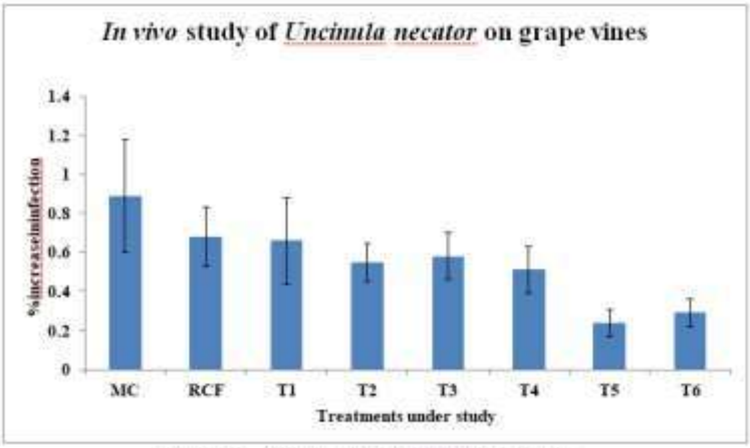
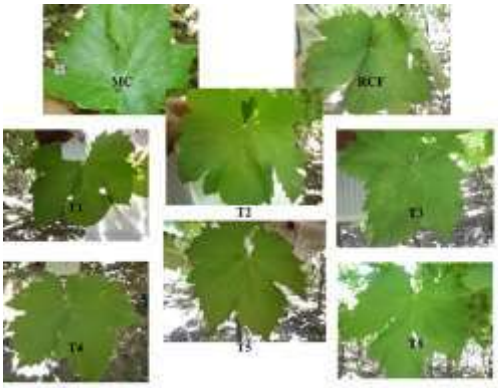


Figure 1.3 *In vivo* study of *U. necator* on grape vines.

MC: Without any treatment, **RCF:** Reference Chemical fungicide Control, **T1:** Hx Solvent Control, **T2:**Hx Cinnamon extract,
T3: Hexane Clove extract, **T4:** Methanol SolventControl, **T5:** MeOH Cinnamon extract, **T6:** MeOH Clove extract



Photoplate 1.2: Powdery mildew infections on leaves of grapes

Photoplate1.3: Powdery mildew infections on bunches of grapes.

Table 1.3Phytotonic effects of formulations on Grapevines

Treatment	Total number of buncheson vines	Weight of grape bunchesattimeof harvesting (gm)	Lengthof berries (mm)	Breadth of berries(mm)
Negative Control	47.5	509	24	15.6
Positive Control	58.0	695	26	16.4
T1	58.5	765	24	15.8
T2	57.5	675	26	16.4
T3	53.5	637	24	16.6

T4	53.25	713	27	16.8
T5	59	865	29	17.4
T6	47.5	513	24	16.4

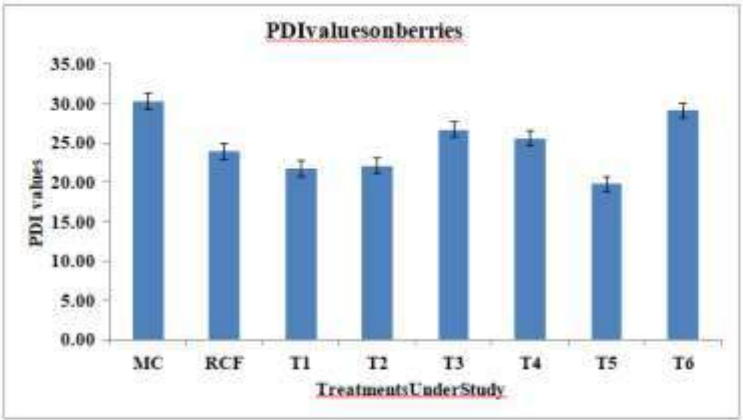


Figure 1.4 Percent disease index (PDI) values on grapeberries.

MC: Without any treatment, **RCF:** Reference Chemicalfungicide Control, **T1:** Hx Solvent Control, **T2:** Hx Cinnamon extract, **T3**: Hexane Clove extract, **T4:** Methanol Solvent Control, **T5:** MeOH Cinnamon extract, **T6:** MeOH Clove extract. In the light of the above, we have tried to use herbal extracts of *C. zeylanicum* and *S. aromaticum* against PM.Our results suggested that application of these extracts may prevent the infection of PM. It also exhibited phytotonic effect. These phenomena reflected that herbal extract can not only control PM infection but these are also helpful to grapes to increase production efficacy. Only care which we have to take is not to apply copper orsulphur based products after application of Hx or MeOH extracts of *C. zeylanicum*and *S. aromaticum*. It may develop whitish ring spots on the grape berries which are not desirable at the time of export.

Conclusion

MeOH extract of *C. zeylanicum* exhibited excellent activity against powdery mildew followed by MeOH extract of *S. aromaticum*, Hx extract of *C. zeylanicum* and *S. aromaticum*. Treatment T5 also exhibited pronounced phytotonic effect on grape vines.

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A study on impact of climate change on women's health in Mumbai city.

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Abstract:

Climate change refers to the long-term alterations in temperature and weather patterns over extended periods. These changes can result from natural factors or human activities. The paper aims to examine the impact of climate change on women's health in Mumbai city. As a densely populated megacity, Mumbai is vulnerable to heat waves, floods, and rising sea levels. Thus, factors such as urbanization, industrialization, and overpopulation contribute to climate change. Women in urban areas like Mumbai are particularly susceptible to the effects of climate change. A mixed-method approach, which includes qualitative and quantitative data, is applied to study the impact of climate change on women's health in Mumbai city. The findings indicate that women in Mumbai are aware of the changing climate and its effects on their health. Common health issues due to climate change include heat stroke, dehydration, respiratory diseases, waterborne and vector-borne diseases, depression, and anxiety. There is no single solution to mitigate the impacts of climate change on women's health in Mumbai city due to the multiple modes of exposure and complexity involved. However, empowering women to tackle these issues can help mitigate these effects and break the link between climate change and its negative consequences. Empowering women also contributes to achieving the Sustainable Development Goals and promote ecofeminism.

Key words: Climate change, Women's health, Mumbai city, Ecofeminism

Introduction:

Climate change means long-term alterations in temperature and weather conditions. These alterations may be natural or due to the result of various anthropogenic activities. Natural processes like volcanic eruptions, continental drift, astronomical cycles and anthropogenic activities leading to emission of greenhouse gases are the biggest culprits in the fluctuation of climate (IPCC, 2007). The black carbon which is the form of elemental carbon remaining after pyrolysis or incomplete combustion also plays an active role in climate change due to its ability to strongly absorb incoming solar radiations (Jacobson, 2001; Ramanathan and Carmichae, 2008; Surendran et al., 2013). Many studies have also focused on the land use and land cover as an important aspect in climate change in Indian cities (Nath et al.,2021). The development of urban areas results in decrease in the green areas, cropland and unused land leading to climate change in the form of high rainfall, extreme temperature, floods, and droughts posing human health risks (Bush et al., 2011, Yang et al., 2012). UNDESA (2018) have documented the fact that 53% of the population of India will be urban population, by augmentation of 416 million urban dwellers by the year 2050. The increasing urban population increases the load of vehicular traffic which in turn leads to increase in pollutant emissions and aerosol load in the atmosphere. The cities are more vulnerable to health crisis due to climate change and air pollution which are interlinked with each other.

The rapid increase in Earth's temperature, causing global warming and the melting of ice caps, leads to rising sea levels, species extinction, and changes in rainfall and humidity patterns. These factors are responsible for frequent natural disasters such as droughts, famines, floods, cyclones, hurricanes, typhoons, and mudslides, as well as slower-occurring disasters like desertification and the salinization of coastal areas. Pramanik, (2017) reported an annual rise in sea level between 2.5 and 3mm along the coastline of Mumbai. There is an average increase in the temperature by 2.4◦C from 1881 to 2015 in Mumbai as per the reports of NASA, (2015).

Mumbai, being one of the mega-cities of India, it shelters a large population. According to UN-HABITAT, (2010) and Mehta et al., (2019), Mumbai is documented as one of the world's most susceptible cities to climate change. Due to its coastal location, the city is particularly susceptible to climate-related events such as coastal flooding, heatwaves, and rising sea levels (IPCC-SREX, 2012). The city's diverse population, with significant socio-economic disparities, offers a comprehensive setting for understanding the impact of climate change on different segments of society, especially women. Climate change is a global crisis affecting various aspects of human life, including health. Women in urban areas like Mumbai are among the most vulnerable groups impacted by climate change. By understanding the challenges faced by women in Mumbai in dealing with climate change, we can develop more effective and equitable climate adaptation and health strategies. This research paper aims to explore the specific impacts of climate change on women's health in Mumbai city, highlighting the unique challenges.

Literature review:

Causes of climate change: Research indicates that the primary threats to rapidly developing cities today are climate change and various forms of pollution. India, which was predominantly rural, has seen significant urban growth. This urbanization and industrialization have brought about critical challenges related to climate action and sustainable development (Duijne, 2017; Singh . et al., 2021). The rapid pace of urbanization, industrialization, and population growth are major contributors to high aerosol levels, leading to severe air pollution across the Indian subcontinent (Kaskaoutis, et al., 2011; Ramachandran, et al., 2012; Krishna Moorthy, et al., 2013). Human activities have placed many valuable renewable resources under severe threat. Freshwater, a crucial resource for survival and the existence of life, is particularly affected. Water supplies are compromised by pollution, floods, and acidification. According to Bridget Mahoney (2016), approximately 663 million people lack access to safe drinking water.

Selection of Mumbai city to study impact of climate change on women: Mumbai was selected as a case study for three key reasons: it is one of the five most populous metropolitan areas in the world, it ranks among the most densely populated cities globally, and its urban development pathways offer both challenges and opportunities for sustainable urbanization similar to those faced by other rapidly growing Asian cities (Sperling, et al., 2016).

Why study impact of climate change on women? The swift growth of industrialization and the accompanying environmental pollutants, combined with the unregulated use of synthetic chemicals and frequent exposure to harmful substances both in the workplace and at home, adversely affect women's health. The interplay of biological, social, and economic factors worsens the health impacts of climate change on women. Women have unique health needs and vulnerabilities compared to men, which is aggravated by climate related stressors. Due to physiological differences between women and men, similar exposure to environmental pollution can have more severe effects on women (Mohapatra., et al., 2021). Therefore, it is crucial to stay vigilant and raise awareness about the harmful effects of pollutants on women's health. The World Summit on Sustainable Development, which took place in Johannesburg in 2002, identified climate change as an 'ethical' issue, emphasizing that it disproportionately affects women and children (Aureli and Brelet, 2004).

Studies reveal that women and children are the major consequence-bearers of natural disasters. Natural disasters lead to health issues and even deaths, loss of shelter, poverty, agricultural losses, loss of education and empowerment. Research also points out that during natural disaster the death rate of women and children is 14 times higher than that of men. The Asian Tsunami in 2004 took toll of 70% women (Soroptimist International of the Americas 2008), whereas another report highlights that 80% of the women died in Asian tsunami of 2004 (APWLD 2005). Prevalence of water-borne diseases increase after natural disasters leading to increase in the mortality and morbidity rates of women. The report of WHO in 2008 has revealed that after any natural disaster women are less likely to be given quality health care, hence women are more vulnerable to contract diseases post-disaster (WHO 2008). Women face cultural and religious restrictions, hindering their escape at the time of disaster. One of the reports indicated that during floods, many women did not leave their houses as it was considered culturally and socially inappropriate. Women who tried to escape died as they did not know how to swim (Rohr, 2006). The study by Barreca indicated that climate change which leads to temperature fluctuations, water-borne and air-borne diseases is responsible for infertility in women (Barreca, 2015).

Methodology:

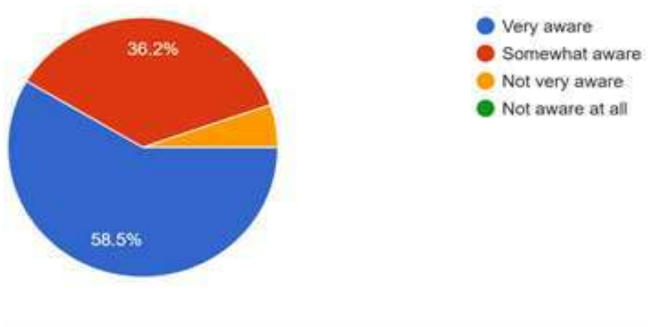
This study employed a mixed-methods approach, involving application of quantitative and qualitative research methods to provide an in-depth comprehensive understanding of the impact of climate change on women's health in Mumbai city. Quantitative data was collected in the form of surveys. Structured questionnaires were distributed to the representative sample of women in Mumbai. Qualitative data was gathered by conducting in-depth interviews with women to gather personal experiences and insights on how climate change has affected their health. Women aged 18 years and above residing in Mumbai were the participants of the study. The survey of 100 participants was done and 4 in-depth interviews were conducted. Stratified random sampling was done to ensure representation across different socio-economic strata and geographic locations within Mumbai. Informed consent from all the participants were taken before participating in the study. All the participants were ensured that their personal information will be anonymized.

Results and Discussion:

Study of Climate change on the health of women was conducted with the help of survey that was conducted for women residing in Mumbai city, about their awareness of climate change, its impact on their health, and their experiences with related health issues. The data was applied to understand the women's perception of climate change, the specific health concerns they face, and their coping mechanisms, providing valuable insights for public health interventions and policy development.

Analysis of Quantitative data

Figure 1



In the paper titled "The relationship between women's climate change awareness and concerns about climate change in Turkiye" it was reported that there is moderate awareness about climate change among women in Turkiye (Demir, R. et al., 2023) In comparison the awareness about climate change amongst women in Mumbai city was high. The survey indicated that 94.7% of the women from Mumbai reported that they were aware about the climate change. (Figure 1)

Figure 2

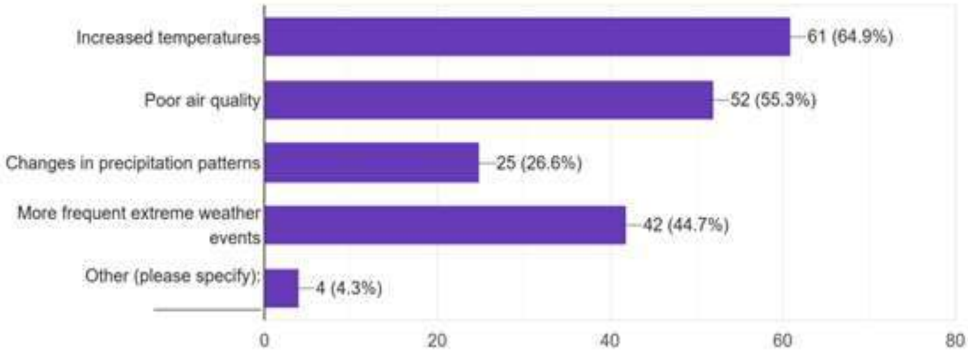


Figure 2 illustrates changes experienced by women in local environment related to climate change. 64.9% of the women of all the age group admit that they experience increased temperature, 55.3% of the women reported that they are affected due to poor air quality, 44.7% of the women admit that they have experienced frequent extreme weather events and 26.6% revealed that there are changes in the precipitation pattern in the city. The redevelopment of buildings in Mumbai city which is a part of rapid urbanization, indiscriminate land use, desertification are some of the factors responsible for these changes in the local environment.

Figure 3

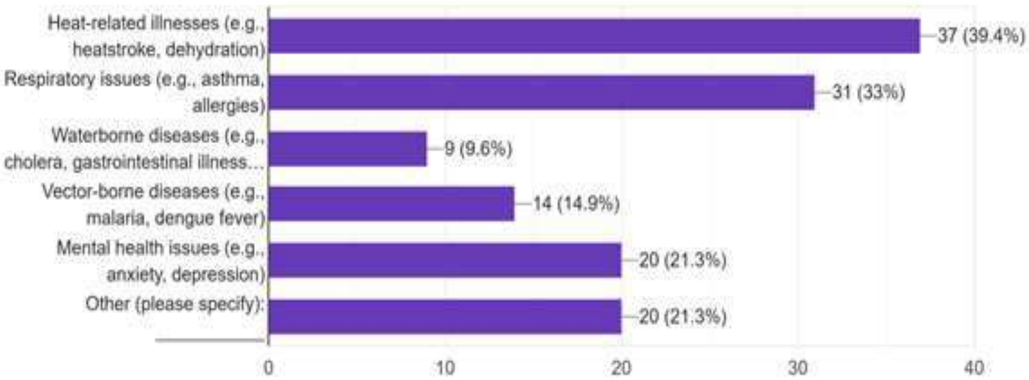


Figure 3 explains health issues experienced by women from different age groups due to climate change. 37% of the women revealed that they suffered from heat related issues in summer season and also in the month of October. The heat related issues reported were in the form of dehydration and heat stroke. Kaur and Pandey (2021) pointed out that due to increased heat waves there is elevation in temperature levels causing thermal discomforts and several health issues to urban residents.

The analysis further confirms that, 33 % of the women reported, respiratory diseases like asthma, allergic cold and cough. The exposure to fine particles and elements in polluted air is responsible for the death of around 7 million people every year according to the estimates given by World Health Organization. The fine particulate matter is known to penetrate deep into the lungs and cardiovascular system leading to acute health problems like stroke, heart disease, chronic obstructive pulmonary diseases, cancer, respiratory infections including pneumonia (WHO, 2018). As the air pollution levels in most of the India's mega cities is increasing over last few decades, its consequential human health impacts in the form of asthama and cardio-respiratory illness have drawn the attention of many scientists. (Sarath and Ramani, 2014; Gautam et al., 2020; Shaw and Gorai, 2020).

While, 20% of the women have reported in the survey that they are suffering from anxiety and depression. A study conducted by Kioumourtzoglou and his team has pointed out that when people are exposed to raised levels of particulate matter 2.5 (PM 2.5) and ozone in the United-States, there is increase in the cases of stress and depression in the old and middle-age women (Kioumourtzoglou *et al.*, 2017).

Urbanization is also responsible for extreme precipitation in some areas of Mumbai leading to urban flooding. Urban flooding is mainly responsible for vector borne diseases like dengue, malaria and chikungunya. The present study indicates that 14.9% of the women had suffered from the vector borne diseases. Whereas 9.6% of women suffer from waterborne diseases like cholera and gastrointestinal issues. Women from upper and middle socio-economic groups experience fewer waterborne diseases. These women are more aware of the dangers of unsafe drinking water and take measures such as boiling water or using water purifiers. However women from low socio-economic background lack awareness, they do not have good sanitation facility due to which they are more prone to waterborne diseases.

Figure 4

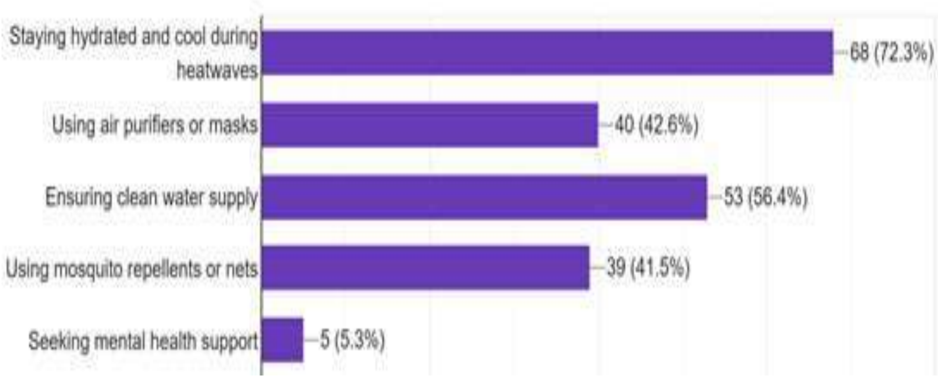
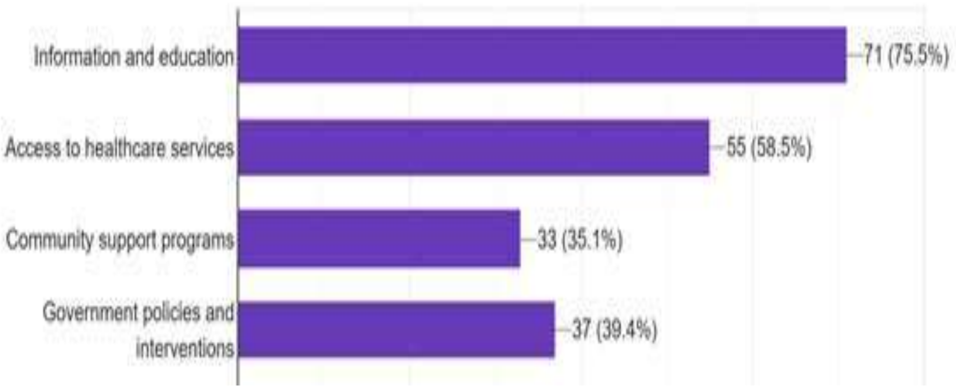


Figure 4 indicated the measures taken by the women to protect their health from the impact of climate change. 72.3% of the women from all the age groups informed that they prefer to stay hydrated and cool to combat the effects of heatwaves. 56.4% of the women ensure that the drinking water is of good quality that is, it is either boiled or taken from water purifier to avoid any waterborne diseases. 42.6% prefer to wear masks or use air purifiers to prevent respiratory diseases. Since the prevalence of vector-borne diseases are common in rainy and winter seasons in Mumbai, 41.5% of the women prefer to use mosquito repellents or nets to safeguard them from the mosquito bites. However, only 5.3% of the women seek mental health support. The reason behind very few women seeking mental health support is because they lack awareness about the mental health support programs that are offered, or due to the stigma and shame attached to seek mental health support while some of the women have financial barriers or time constraints.

Figure 5



When the participants of all the age groups were questioned about the additional support or resources that they need to better cope with the health impacts of the climate change, 75.5% said that they need more information and education with respect to climate change, its mitigation and adaptation. 58.5% are of the opinion that they need access to better health care services, 39.4% informed that the government should come up with the policies and interventions so that the impact of climate change can be reduced. 35.1% of the participants recommended community support programs to combat the imapct of climate change.

Analysis of Qualitative data

An in-depth interview was conducted with four women residing in Mumbai city, aged between 18- 60 years. The participants shared their experiences about the impact of climate change on their health.

Participant 1, is 24 year-old women with a Master's degree in Biological Sciences. She expressed her awareness of climate change impacts, having studied the topic during her undergraduate and post graduate programs. She keeps herself updated about climate change through newspapers and electronic media. She mentioned attending a climate change conference in Mumbai as a student. According to her, while many people attend such conferences and seminars, only few actively work to mitigate climate change effects.

When asked if she had personally experienced the impact of climate change, she affirmed that all women in her community are affected in some way. She described frequent health issues due to traveling in crowded public transport and highlighted that she had contracted tuberculosis last year, attributing it partly to the overcrowded conditions in trains and buses.

Analysis :- Participant1, highlights the widespread and gender-specific impacts of climate change. She acknowledges that climate change affects her and the women in her community. The mention of all women being affected suggests that climate change has a broad and possibly disproportionate impact on women in her community.

Participant 1 mentioned that she contracted tuberculosis due to the overcrowded public transport system. Research by Kharwadkar, S. and his team (2022) also indicates that in developing countries, climate change significantly contributes to individuals' vulnerability to tuberculosis. A scoping review by Maharjan, B. and colleagues (2021) reveals that climate change is a major factor influencing the pattern and burden of tuberculosis, a global issue predominantly affecting low and middle-income countries. In her book "Food, Farming and Health," eco-feminist, writer, and physician Vandana Shiva emphasizes that the indiscriminate use of chemical fertilizers has depleted soil nutrients, reducing the nutrients available for plants to absorb. The food we consume today is nutrient deficient, which in turn lowers the body's immunity. Consequently, overcrowding due to population migration and low immunity from excessive use of chemical fertilizers contribute to higher rates of communicable diseases such as tuberculosis (Shiva, V. 2018). Study by Gupta and his coworkers have reported that at least one in five women in Mumbai are underweight and 667 women per 100, 000 suffer from medically treated tuberculosis (Gupta et al., 2009).

Participant 2, is a 45-year-old school teacher. She mentioned that each season brings its own health issues: during the rainy season, there is an increase in Malaria, Dengue, and Chikungunya cases; in summer, people suffer from heat stroke and dehydration; and winter brings many respiratory disorders. She has observed a rise in vector-borne diseases among students and staff over the past two years. The school is located in an area prone to mosquito breeding during the rainy season. Since using mosquito repellents consistently is not feasible, she contracted dengue and was hospitalized for over 15 days.

When asked how she adapts to various health issues in different seasons, she explained that drinking boiled water is mandatory during the rainy season. To reduce the effects of heat waves in summer, she uses an umbrella while walking in the afternoon and keeps herself hydrated by drinking plenty of water and consuming water-rich foods.

Analysis: Participant 2 in her interview provides valuable insights into the seasonal health challenges faced by her community. In the interview it was noted that there is rise in vector-borne diseases among students and staff over the past two years, highlighting a growing health concern. The school's location in a mosquito-prone area exacerbates the issue during the rainy season. Inconsistent use of mosquito repellents led to her contracting dengue and being hospitalized for over 15 days. In the paper "Climate change: A driver of increasing vector-borne disease transmission in non-endemic areas," Paz S. (2024) asserts that changing climatic conditions will significantly contribute to morbidity and mortality from vector-borne diseases in non-endemic regions.

Participant 2 is found to follow certain practices, such as drinking boiled water to prevent waterborne diseases, using an umbrella to avoid heat, and staying hydrated by drinking plenty of water and consuming water-rich foods, highlight the importance of seasonal preparedness and adaptive strategies to mitigate health risks due to climate change.

Participant 3, is a 55-year-old full-time caretaker for senior citizens, has observed significant changes in climatic conditions over the years, including shifting seasons. Summers have become excessively hot and prolonged, while the rainy season in Mumbai now starts late, with periods of heavy rainfall followed by long dry spells. These changes have led to an increase in infections such as cold, cough, and fever. Every year during the rainy season, she suffers from gastrointestinal infections. She also mentioned feeling very depressed and helpless during the darker, rainy days.

Analysis: The participant was well aware of climate change and shared her experiences regarding its impact. She noted that cold, cough, and fever due to infections are very common with seasonal changes. Coming from a low socio-economic background and residing in a chawl system, there is limited awareness about boiling drinking water during the rainy season or using water purifiers. Poor sanitation facilities in her area often lead to gastrointestinal problems during the rainy season. Studies by Mertens, et al., (2019), Bhandari, et al., (2020), Bush, et al., (2014), Alam, et al., (2012), and Ajjampur, et al., (2010) have shown a positive association between climatic factors and the risk of diarrheal diseases.

The participant's experiences of depression and helplessness during the rainy season is likely due to the increased hours of darkness and reduced sunlight, potentially indicating Seasonal Affective Disorder (SAD). While there are few studies on SAD in India, this condition is more prevalent in Western countries during winters when days are shorter. Rothschild and Haase, in their research paper, highlight that climate change has significant and direct impacts on women's mental health. They reveal that climate change increases the risks of depression, suicide, violent victimization, and various other neuropsychiatric symptoms (Rothschild, J., & Haase, 2022). As mentioned in the literature review, a study by Kioumourtzoglou and his team found that increased exposure to particulate matter 2.5 (PM 2.5) and ozone in the United States is associated with higher rates of stress and depression among older and middle-aged women (Kioumourtzoglou et al., 2017).

Participant 4 is a 34-year-old clerical staff, working in Mumbai based college for the past five years. She commutes to work by train. Although she is not very aware of the direct implications of climate change, she mentioned that she constantly suffers from allergic colds and dehydration. Initially, she did not connect these health issues to climate change and pollution.

She shared one of her experiences during heavy rain and flooding which has led to all public transport come to a stand-still. She spent almost the entire night in the train, and when she tried to step out of the stand still train, she was molested by male passengers under the pretext of helping her to get down from the train. This scary incident left her very depressed and disturbed.

Analysis: Many women experience health problems due to climate change, but they often do not recognize the connection between their symptoms and the changing environment. With the ongoing redevelopment boom in Mumbai, air pollution has increased significantly. The deteriorating Air Quality Index leads to conditions like allergic colds. Additionally, people face heat waves, they have to travel long distances in harsh climates, causing dehydration and fatigue. Mumbai also experiences unpredictable downpours, leading to constant flooding. When flooding occurs, public transport comes to a standstill or slows down, making life more difficult for working women. They often remain in wet conditions without access to hygienic facilities, leading to infections. Physical abuse and crimes during such times is also very common.

Sidun and Gibbons, in their research paper "Women, girls, and climate change: Human rights, vulnerabilities, and opportunities," highlight that climate change disproportionately affects the lives and livelihoods of women and girls. They point out that climate change can damage the health in multiple ways. Due to women's precarity (unequal power) and physical susceptibility, climate change has a more detrimental impact on women compared to men. Challenges include displacement, interrupted education, food and water scarcity, economic instability, mental and physical health issues, reproductive injustice, gender-based violence, and exploitation (Sidun & Gibbons, 2023).

Conclusion and Recommendation:

Climate change is a global public health challenge that significantly impacts the lives and health of women of all ages in Mumbai. The modes of exposure and the complexity of these impacts of climate change vary, making it difficult to find a one-size-fits-all solution, especially for women in this city. Addressing this issue requires a multi-sectoral approach to policymaking and proactive implementation mechanisms to ensure a healthy life for women and future generations. Women are pivotal in this effort; their empowerment can help mitigate the effects of climate change and break the link between climate change and its negative consequences. Empowering women will also contribute to achieving the Sustainable Development Goals. The concept of ecofeminism, which connects ecology with feminism and encourages women's roles in environmental protection, should be promoted.

Limitations of the study:

- The study is limited to women as broad category.
- The study was confined to women residing in Mumbai city.
- The study is restricted to short term and direct implications of climate change on women's health.

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Evaluation of Paint and Heavy Metal Degrading Microorganism Found in Paint Scrap

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Abstract

Paints are widely used for surface protection and embellishment. Its chemical constituents, such as heavy metals and volatile organic compounds (VOCs), pose significant risks to the environment and health. In this study, we evaluated the capability of the microbial isolates to bioremediate paint waste and its heavy metals such as lead (Pb) and mercury (Hg). Samples of paint taken from the paint-scrape sites were screened for paint degrading microorganisms including Pseudomonas spp. Aspergillus niger, and Aspergillus flavus. The assessment of degradation efficiency was performed with spectrophotometry and weight reduction methods, and the results confirmed the strong activity of Pseudomonas aeruginosa as well as F1, F2Br and F1B, which are fungal isolates. Results showed that microbial isolates did not only degrade paint but also showed significant tolerance for heavy metals, and in most test conditions, significantly reduced Pb and Hg concentrations. The present study highlights the potential of microbial consortia for bioremediation, which can be used to manage paint waste and heavy metal contamination in an environmentally friendly manner.

Key words: Paint degradation, Bioremediation, Heavy metal degradation, VOCs, environmental pollution.

Introduction

Paints are a common substance used to both decorate and protect surfaces but, due to their composition, they can cause problems for the environment and the health of humans. The composition usually includes solvents, pigments, and binders. Oil-based and water-based paints both contain toxic metals such as lead, chromium, and cadmium as well as VOCs that can harm human health and the environment (Mendell et al., 2013; Gaitens et al., 2009). VOC exposure has been linked to respiratory conditions, allergies, and increased risk of cancer, while ingesting lead or mercury affects the kidneys, nerves, and neurodevelopment in children (Spanier et al., 2013).

Microbial contamination further complicates the longevity of paint by discolorations, odor and structural damage due to porosity and reduced physical resistance (Ogbulie & Obiajuru, 2004; Unger, 2001). Bacteria like *Pseudomonas* and *Bacillus* degrade paints through metabolic activity on organic constituents. Fungi like *Aspergillus niger* contribute to the same type of decay (Ashwini et al., 2018). The microbial degradation process is catalyzed by enzymes and thus requires better formulations of paints to inhibit the microbial activity (Cifferi et al., 2016).The Lascaux Cave incident exemplifies microbial threats to cultural heritage, wherein algae such as *Bracteacoccus minor* thrived due to environmental changes, thus making it a challenge to conserve the artwork while reducing microbial effects (Cifferi et al., 2016). Bioremediation provides a non-toxic means of clean-up with respect to the paint contaminated environments, degrading harmful chemicals using the action of indigenous or inoculated microorganisms without making any toxic byproducts. Some researchers proved that successful degradation of polyurethane coatings and oil-based paints by bacterial and fungal consortia exists (Rosado et al., 2013; Wojturska et al., 2017). Other conventional remediation methods are expensive and not environmentally sound such as incineration and chemical treatment. Bioremediation and low toxic constituents in paints are essential sustainable approaches for environmental health and effective long-term solutions.

Review of Literature

Paints are applied for surface protection and decoration, which are mainly made of binders, pigments, and solvents. The ingredients, especially pigments, contain heavy metals such as chromium, lead, zinc, and mercury, and are hazardous to the environment and health. VOCs in paints make the situation worse, causing air pollution and health problems like respiratory illness and cancer (Mendell et al., 2013; Gaitens et al., 2009). The most significant factor that influences paint deterioration is microbial activity, which causes eventual discoloration, loss of physical resistance, and porosity and hence weakening of structural integrity. According to some research, microbial degradation depends on many factors such as humidity, temperature, and pH (Unger, 2001; Maduka, 2019) .It is well known that the degradative role in paints is played by various microorganisms, notably, bacteria *Pseudomonas spp.*, *Bacillus spp.*, and *Micrococcus spp*. On the other hand, fungi like *Aspergillus niger* and *Penicillium spp.* also played a great role, thus degrading paints through an enzymatic breaking mechanism under aerobic and anaerobic conditions. This has led to the breakdown of most mixed microbial consortia degrading the process, leading to more efficient breakdowns of paint materials through complementary metabolic interactions (Jakubowski et al., 2015; Cifferi et al., 2016).Heavy metals used in paints are an environmental issue since this could lead to bioaccumulation within the ecosystems and may eventually cause severe health issues. Lead and mercury are examples of heavy metals normally used in paints, known to be associated with neurodevelopmental diseases, organ damage, among other health effects in the long run. The heavier metals emitted during the deterioration of paints further pollute the environment (Dewalt et al., 2015; Gupta et al., 2013). Microbial bioremediation is a sustainable practice that minimizes these adverse effects through the use of microorganisms to transform heavier metals into less toxic products. Such microorganisms include *Pseudomonas aeruginosa* and *Aspergillus spp*., which are known to degrade paint components and detoxify heavy metals in contaminated sites (Rosado et al., 2013; Mohsen Zadeh et al., 2012).Bioremediation being a cost-effective and ecologically friendly technology promises a lot for the solution to paint and heavy metal pollution. It is based upon the metabolic capabilities of microbes to degrade harmful components as well as reduce environmental toxicity. Despite the potential, an optimization of conditions is required to favor microbial activity and scale laboratory findings to more practical industrial applications. More needs to be done in terms of efficiency of microbial consortia and their interactions with pollutants for greater efficacy. However, this is an important aspect towards environmental mitigation by paints and heavy metals through sustainable solutions (Ashwini et al., 2018)

Material and Methodology

Sample Collection

Paint scrap samples were collected from Royal Tower, Bushar, Bhiwandi (Maharashtra, India, 2023). Samples were taken from the top 3–10 mm of extensively damaged areas with visible/invisible discoloration.

Isolation of Paint-Degrading Organisms

Samples were enriched in sterile nutrient and Sabouraud broths and cultured on nutrient agar and Sabouraud agar plates using a spread plate technique. Mineral Salt Medium (MSM) was prepared for bacterial and fungal isolates, supplemented with chloramphenicol and nystatin. Isolates were incubated at 35°C (7 days for bacteria) and 25°C (14 days for fungi).

Preparation of Mineral Salt Medium (MSM):

MSM was prepared in two 500 ml conical flasks, one for bacterial isolates and the other for fungal isolates, with chloramphenicol and nystatin added respectively. The medium composition per liter of distilled water was as follows: $MgSO_4 \cdot 7H_2O$: 10 g,, $CaCl_2 \cdot 7H_2O$: 0.2 g,KH_2PO_4: 13.6 g,$(NH_4)_2SO_4$: 2.4 g,$FeSO_4 \cdot 7H_2O$: 0.2 g,$Na_2HPO_4 \cdot 12H_2O$: 15 g.The medium was homogenized by heating in a water bath, sterilized by autoclaving at 121°C for 15 minutes under 15 psi pressure, and dispensed onto petri dishes to solidify. Pure isolates were inoculated onto the MSM surface using the streak plate method for bacteria and yeasts, and point inoculation for molds. Incubation was performed for seven days at 35°C for bacteria and fourteen days at 25°C for fungi.

Characterization and Identification of Paint-Degrading Isolates

Microscopic and Biochemical Tests:

Standard methods were used for characterization, including Gram staining, motility, catalase, urease, citrate utilization, sugar tests, and indole tests. Fungi were identified through macroscopic and microscopic examination, employing Gram staining for yeasts and lactophenol cotton blue staining for molds to observe morphological features. The isolates were identified by comparing their characteristics to those described in fungal atlases.

Gram Staining Procedure: A bacterial smear was heat-fixed on a slide, stained with crystal violet for 60 seconds, and rinsed gently. Lugol's iodine was applied as a mordant for 1 minute, followed by rinsing and decolorization with acetone alcohol for 3 seconds. Safranin was used as a counterstain for 1 minute. The slide was examined under oil immersion microscopy.

Lactophenol Cotton Blue Staining: Fungal samples were stained with lactophenol cotton blue by placing a drop of reagent on a clean slide, spreading the fungal culture, and covering it with a cover slip. After 5 minutes, the slide was observed under a low-power (40X) microscope to examine spore morphology and arrangement.

Screening for Potential Paint-Degrading Organisms

The isolated microorganisms were screened for paint degradation potential by inoculating them into nutrient broth, Sabouraud broth, and MSM broth containing 1 ml of paint sample at concentrations of 20, 40, 60, 80, and 100 ppm. Control samples contained media broth and paint without microorganisms. Nystatin and chloramphenicol were added to the media, which was autoclaved and incubated at 37°C on a rotary shaker at 160 rpm for 10 days (bacteria) and 21 days (fungi). Paint utilization was assessed by measuring turbidity using a spectrophotometer at 600 nm at one-day intervals.

Principle of UV-Visible Spectroscopy

UV-Visible spectroscopy relies on the absorption of ultraviolet and visible light by chemical substances, producing characteristic spectra. This occurs when electrons in a material absorb energy, transitioning from a low-energy ground state to a high-energy excited state. The absorbed energy corresponds precisely to the difference between these states, enabling the identification and analysis of substances based on their unique absorption patterns.

Microbial Remediation Using Paint-Coated Metals

Metal strips (1 cm × 5 cm) coated with oil paint were dried, weighed, and submerged in saline suspensions of isolates under sterile conditions. After seven days of incubation in petri plates, the strips were examined for microbial activity and reweighed to assess paint degradation.

Pollutant Removal by Paint-Degrading Bacterial Isolates

The efficiency of bacterial isolates in removing heavy metals was assessed in laboratory-scale batch cultures under shaking conditions at 150 rpm. Control bottles contained only paint-polluted samples without microbes. Isolates showing optimal paint degradation during screening were revived, sub-cultured, and grown on nutrient agar. A loopful of 24-hour-old isolates was inoculated into 10 ml sterile nutrient broth and incubated for 48 hours at 30°C with shaking at 150 rpm. Bacterial cultures were adjusted to OD 0.5. Media containing varying concentrations of lead (Pb) and mercury (Hg) (500, 1000, 5000 ppm) were prepared. Each medium was inoculated with 0.1 ml of bacterial suspension and incubated. Absorbance was measured on the 7th day to evaluate metal removal.

Pollutant Removal by Paint-Degrading Fungal Isolates

The efficiency of fungal isolates in removing heavy metals was evaluated in laboratory-scale batch cultures under shaking at 150 rpm. Control bottles contained paint industry effluent-polluted soils without microbial addition. Three top-performing fungal isolates from screening tests were revived, sub-cultured, and grown on Sabouraud broth. A loopful of 24-hour-old cultures was inoculated into 10 ml sterile nutrient broth, incubated at 30°C for 48 hours on a shaker at 150 rpm, and adjusted to OD 0.5. Media containing lead (Pb) and mercury (Hg) at 500, 1000, and 5000 ppm were prepared. Each medium was inoculated with 0.1 ml of fungal suspension and incubated. Absorbance was measured on the 7th day.

Agar Well Diffusion Method: Antibacterial activity was tested by pouring extract into wells on agar plates. Plates were incubated at 37°C for 24 hours, and the diameter of the clear inhibitory zones (in mm) was measured.

Results

Colony Characteristics of Bacteria And Fungi

For bacteria:

Table no.01. Colony characteristics of bacteria:

Sr. No	Organism	Size	Shape	Margin	Elevation	Color	Opacity
1.	P1	5	Rod	Irregular	Flat	Yellow	Opaque
2.	P2	4	Rod	Irregular	Concave	Cream	Opaque

For fungi:

Table no.02.: Colony Characteristics of Fungi:

Sr.no	Isolates	color	Hypha	Conidia/sporangia	rhizoid
1.	A.N	Black	Septate hyaline	Conidia	absent
2.	A.F	Yellow Green	Septate hyaline	Conidia	absent

Identification of isolates:

Figure 1:p1 *Psuedomonas aeruginosa*

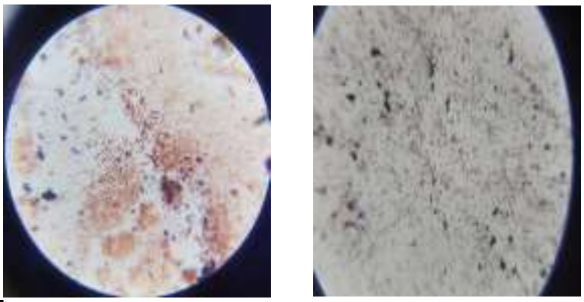

Figure 2 :p2 *Psuedomonas aeruginosa*

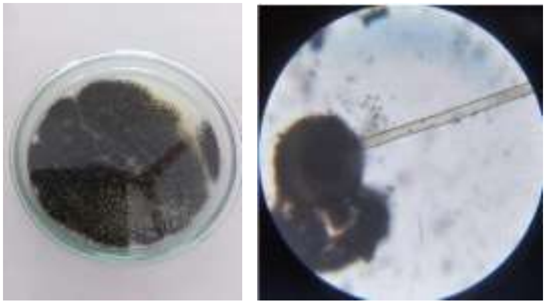

Figure 3 :*Aspergillus niger*

Figure 4 :*Aspergillus flavus*

Figure 5: *f1, f1B*

Figure 6: *f2 , f2 Br, f3*

Table no. 03 : Spectrophotometric Absorbance @620nm:

Isolates	7 days	14 days	21 days
P1	0.17	0.23	0.5
P2	0.3	0.19	0.55
P uk	0.1	0.25	0.32
A.N	0.19	0.46	0
A.F	0.1	0.16	0.19
F1	0.37	0.47	0.63
F1 B	0.01	0.14	0.42
F2	0.23	0.35	0.56
F2 Br	0.12	0.25	0.3
F3	0.26	0.27	0.3
100ppm			
Isolates	**7 days**	**14 days**	**21 days**
P1	0.52	0.65	0.82
P2	0.36	0.46	0.74
P uk	0.32	0.46	0.36
A.N	0.19	0.54	0.89
A.F	0.01	0.16	0.18
F1	0.82	0.81	0.96
F1 B	0.25	0.93	1.39
F2	0.63	0.57	0.93
F2 Br	0.63	0.73	0.84
F3	0.7	0.43	0.5

MSM 21 DAYs			
Isolates	**20 PPM**	**80 PPM**	**100 PPM**
P1	0.11	0.11	0.15
P2	0.01	0.02	0.02
P uk	0.04	0.16	0
A.N	0.01	0.19	0.36
A.F	0.1	0.12	0.2
F1	0.02	0.14	0.16
F1 B	0.03	0.17	0.26
F2		0.1	0.22
F2 Br		0.19	0.22
F3		0.17	0.18

Table no : 04 Microbial bioremediation of paint:

Isolates	Without paint	Oil paint	After 7 days
P1	6.151g	6.182 g	6.180 g
P2	6.295 g	6.308 g	6.01 g
P UK	6.427 g	6.469 g	6.452g
A.N	6.177 g	6.330 g	6.190 g
A.F	6.445 g	6.454g	6.452 g
F1	6.292 g	6.322 g	6.103 g
F1B	5.168 g	5.188g	5.221 g
F2	5.225 g	5.256 g	5.248 g
F2 Br	5.155 g	5.203 g	5.187 g
F3	5.357 g	5.420 g	5.388 g

Paint degradation by potential microbes

Table no : 05. Bioremediation of heavy metal: lead (Pb):

Isolates	Day 0			Day 7		
	500 ppm	**1000 ppm**	**5000 ppm**	**500 ppm**	**1000 ppm**	**5000 ppm**
P1	0.7	0.75	0.96	0.5	0.53	0.08
P2	0.55	0.65	0.7	0.53	0.36	0.07
P UK	0.65	0.89	1.2	0.53	0.36	0.06
A.N	0.55	0.96	1.3	0.08	0.06	0.06
A.F	0.45	0.53	0.96	0.09	0.07	0.06
F1	0.41	0.65	0.85	0.11	0.13	0.1
F1 B	0.25	0.46	0.65	0.12	0.09	0.05
F2	0.55	0.96	1.25	0.06	0.05	0.05
F2 Br	0.57	0.69	0.85	0.12	0.05	0.11
F3	0.45	0.75	1.2	0.36	0.14	0.05

Table no :06. Bioremediation of heavy metal: mercury(Hg):

Isolates	Day 0			Day 7		
	500 ppm	1000 ppm	5000 ppm	500 ppm	1000 ppm	5000 Ppm
P1	0.96	1.3	1.3	0.46	0.36	0.16
P2	0.72	0.85	0.95	0.39	0.32	0.11
P UK	0.96	1.4	1.9	0.49	0.44	0.15
A.N	0.35	0.4	1.5	0.16	0.13	0.07
A.F	0.3	0.55	1.2	0.18	0.11	0.07
F1	0.4	0.85	0.96	0.14	0.12	0.05
F1 B	0.5	0.65	1.06	0.24	0.22	0.06
F2	0.56	0.87	0.95	0.12	0.09	0.08
F2 Br	0.39	0.69	0.88	0.11	0.09	0.06
F3	0.1	0.16	0.25	0.09	0.11	0.06

Bioremediation of heavy metal

Discussion

The paint degrading microorganisms isolated from the paint scrap samples include different microbial isolates of bacteria and fungi where seven fungal and three bacterial isolates were predominant in their activity. The paint scrap bacterial degraders includes., *Pseudomonas spp* while the fungal paint degraders includes *Aspergillus niger, Aspergillus flavus,* and few unidentified spp.(table no. 01)

The activity of isolates on degradation of paint was evaluated after 21 days of bioremediation by analysis of spectrophometer absorbance (620 nm). The results of the screening tests indicated that some of the isolates were capable of degrading paints, hence were inferred to be able to degrade the effluent of paint or polluted soils. The most prominent bacterial isolates is *Pseudomonas* spp,,the most prominent in growth and proliferation where as the most prominent fungal isolate in the screening test were isolate F1 B , F1 , F2 ,F2 Br having the most rapid growth and producing a lot of spores. Followed by Aspergillus niger. *Aspergillus flavus* showed the least ability to degrade paint.(table .no.03) The fungal isolate which showed highest degrees of growth indicated by high turbidities during the screening test for paint degradation is yet to be identified and bacterial isolate is *Pseudomonas aeruginosa* strain **CIFRI-AKSHG7.**

On evaluating the obtained values by alternate method to observe the paint degradation where the comparative difference in weight is noticeable in metal with coated oil paint and microbial remediated metal after 21 days. Where the major activity was shown by bacterial isolates *Pseudomonas spp* and fungal isolates F1, F2Br, F1 B and the least activity was shown by *Aspergillus flavus*. (table no 4)

In general, most contained lead (Pb), copper (Cu), zinc (Zn), and cobalt (Co), which are among the hazardous metals that are toxic at high amounts. Due to their inability to biodegrade, heavy metals frequently bioaccumulate in aquatic organisms.With an motive to degrade these toxic heavy metal an attempt was made on analysis of microbial degradation of heavy metals Pb and Hg .The absorbance of the both heavy metal (Pb, Hg),indicates reduction in absorbance with varied concentration (500,1000,5000 ppm) (table no. 5,6) and this implies that the isolates have high metal tolerance. .

The absorbance of Pb2+ after cultivation was revealed reduction which indicates removal of Pb2+ from solution (Rabie Ali et al,2020).Gradual Increment in the turbidity across ascending concentration of heavy metal implies that the organism is able to tolerate and thrive in the said environment probably because of it's ability to resist at the given concentrations. It may be concluded that the test organisms shows reduction in heavy metal to confirm it further analysis is need to be done.

Conclusion

The study isolated microorganisms capable of degrading paint and removing heavy metals from paint scrap. Bacterial isolates, such as *Pseudomonas aeruginosa*, and fungal isolates, such as *Aspergillus niger* and unidentified species, demonstrated significant activity. Spectrophotometric analysis confirmed effective paint degradation, with isolates such as Pseudomonas and fungal strains F1, F2Br exhibiting the highest efficiency. Heavy metal bioremediation tests showed decreased Pb and Hg concentrations at various concentrations (500–5000 ppm) with significant absorption. Further, microbial degradation of oil paint-coated metal strips with weight loss was established that the microbes can degrade organic compounds. The implications are on the use of ecofriendly industrial waste management and removal of heavy metals in heavy metal detoxification and bioremediation of environments with minimal secondary pollution costs for scalability in large remediation projects. The dual ability of degrading paint and removing metals positions microbial bioremediation as a sustainable and efficient approach to solving pollution from industrial effluents and contaminants.

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2. Degradation Of Paints And Its Microbial Effect On Health And Environment Padmini Pandey, U.V Kiran Research Scholar Department of Human Development & family studies, School for Home Sciences, Babasaheb Bhimrao Ambedkar University (A central university), Lucknow-226025 Associate Professor Department of Human Development & family studies, School for Home Sciences, Babasaheb Bhimrao Ambedkar University (A central university), Lucknow-226025
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Bioremediation of Marigold: Determination of Pigment Extraction and Sustainable Utilization of Residues

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Abstract:

This research explores the bioremediation of floral waste, specifically marigold residues, into eco-friendly and value-added products such as organic fertilizers, dyes, paints, and carotenoid extracts. The study emphasizes the sustainable transformation of floral waste to address the environmental pollution, enhance agricultural productivity, and promote green industries. Through the innovative production of marigold residue-based organic fertilizers, natural dyes, eco-friendly paints, and carotenoid extracts, this research provides practical solutions for waste management. The presence of key nutrients like Nitrogen, Phosphorus, and Potassium (NPK) in marigold residues, coupled with their use in dyeing, painting, and agrochemicals, underscores the potential for sustainable development and the promotion of green habits.

Keywords: Marigold, floral waste, biotransformation, organic fertilizer, eco-friendly dye, eco-paint, carotenoids, green chemistry, sustainable practices, waste management.

Introduction:

Floral waste, particularly from religious ceremonies and public events, is a growing environmental issue in India, where approximately 8.8 million tons of floral waste are discarded annually.[1] This waste, often containing pesticides, disrupts aquatic ecosystems and contributes to pollution. Marigold flowers, widely used for decoration and offerings, represent a significant portion of this floral waste. The transformation of marigold residue into useful products such as organic fertilizer, dyes, paints, and carotenoids offers a sustainable solution to this pressing environmental challenges.[1] This research explores the biotransformation of marigold residue and other floral waste into high-value, eco-friendly products, contributing to waste reduction, sustainable agriculture, and green industries.

Methodology:

Collection and Preparation of Marigold Extract:

Collection: Marigold flowers were collected from post-event decorations.

Drying: Flowers were dried under infrared lamps for 24 hours.

Processing: Petals were separated and crushed using a mortar and pestle.

Extraction: A marigold petal extract was prepared using a solvent mixture of ethanol and water.

Detection of NPK in Marigold Residue:

Nitrogen: Sodium fusion extract was tested with $FeSO_4$ and $FeCl_3$, forming a Prussian blue color indicative of nitrogen.

Potassium: Extract boiled with NaOH and tested with sodium cobaltinitrite, yielding a yellow precipitate confirming potassium presence.

Phosphorus: The extract was fused with Na_2O_2 and treated with ammonium molybdate to form ammonium phosphomolybdate, indicating phosphorus.

Flame Photometer Analysis: Potassium content was quantified at 105 grams per liter.

Carotenoid Extraction from Marigold:

Fresh marigold flowers (orange and yellow) were dried under IR lamps and finely ground.

Carotenoids were extracted using ethanol through maceration and centrifugation.

Quantification was done using UV-Vis spectrophotometry, yielding 29g/100g from orange and 39g/100g from yellow marigolds.

Eco-Dye and Paint Development:

Eco-Dye: Marigold petals were boiled for 30 minutes and mixed with alum (phitkiri). The solution was used to dye cotton fabric, yielding a vibrant natural colour.

Eco-Paint: Marigold extract was boiled for 20 minutes, mixed with alum, and tested for color stability. The resulting paint exhibited a natural reddish-orange hue suitable for artistic applications.

Results

Presence of NPK in Marigold Residue: The analysis confirmed the presence of essential nutrients—nitrogen, phosphorus, and potassium—making marigold residues a viable source for organic fertilizers. The potassium content, in particular, supports soil health and water retention.

Carotenoid Extraction: The extraction process from marigold flowers yielded significant amounts of carotenoids, which can be used in various industries such as food, cosmetics, and textile dyeing. The functional group analysis revealed the presence of esters, carbonyl compounds, and other bioactive compounds, enhancing the potential uses of marigold extracts.

Eco-Dye and Paint: The marigold-based dye produced vibrant colors, suitable for textile applications. The eco-paint showed excellent initial vibrancy, though with gradual fading over time, it proved to be a sustainable alternative to synthetic paints.

Discussion:

This study highlights the immense potential of floral waste, particularly marigold residues, in contributing to sustainable agriculture, eco-friendly textiles, and green art practices. The presence of NPK in marigold residues makes it an excellent candidate for organic fertilizer production, improving soil fertility and sustainability in agriculture. The carotenoids extracted from marigold flowers serve as natural pigments, reducing reliance on synthetic dyes in industries such as textiles, food, and cosmetics. The creation of eco-friendly dyes and paints presents viable alternatives to chemical-laden products, promoting environmental sustainability.[4] Furthermore, the use of floral waste for eco-printing and fabric dyeing demonstrates the potential for zero-waste practices in the textile industry.[9]

Conclusions:

Marigold residues can be effectively bio transformed into valuable, eco-friendly products such as organic fertilizers, natural dyes, paints, and carotenoids.

The findings support sustainable waste management practices, reducing pollution and promoting environmental sustainability.

The study emphasizes the potential for green entrepreneurship by providing sustainable alternatives to synthetic products in agriculture, textiles, and art.[1]

Encouraging the use of floral waste for these purposes fosters a culture of recycling and environmental responsibility

Applications:

Agriculture:

Organic Fertilizers: Marigold residues provide essential nutrients for soil enrichment, improving plant health and water retention.[7]

Industrial Uses:

Dyes: Natural pigments extracted from marigold and other flowers offer sustainable alternatives for the textile and cosmetic industries.[6]

Paints: Eco-paints made from floral extracts provide a green alternative for the art and construction industries.

Textile Industry:

Eco-Printing: Techniques using flower-based pigments offer sustainable solutions for textile dyeing, reducing chemical waste.

Environmental Benefits:

By utilizing floral waste for productive purposes, this research promotes waste recycling, pollution reduction, and resource optimization.[7]

Socio-Economic Impact:

The research promotes green entrepreneurship and job creation in waste management, eco-product industries, and sustainable agriculture.

Acknowledgement

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Characterization and Applications of Protease Derived from *Bacillus Species*

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Abstract

Protease enzyme is the group of an enzyme that catalyses the proteolytic reactions i.e. hydrolysis of proteins into a small polypeptide or single amino acids. This study aims to isolate the proteolytic enzymes producing organisms from the three different soil samples garden soil from B. K. Birla college Kalyan (GS), riverbank of Ulhas river Shahad (RS) and timber processing area from Umaya trading (TS). The serial dilution was performed to isolate the organism where 0.1 mL of sample was spread on the skim milk agar plate. Three isolate GS, RS and TS were selected for further study depending on the clear zone on the skim milk agar plate. The isolates GS, RS and TS were found to be *Bacillus* sp.by morphological and biochemical tests. Furthermore, the nutritional parameter of selective media like carbon and nitrogen source, physiochemical characteristics like pH and temperature & kinetic parameter were studied. It was found that lactose and tryptone were good carbon and nitrogen sources giving the highest yield whereas the optimum pH and temperature were found to be 7 and 60°C respectively. The unknown concentration of the crude enzyme was determined using a tyrosine standard curve. These enzymes gave better results for genomic DNA extraction from the bacterial cell, unhairing of goat skin, gelatine extraction from chicken feet and meat tenderization. Thus, they can be used in a different industry such as leather industry, gelatine extraction, and meat tenderization and can be applied in the biotechnological applications.

Key Words: Protease, Genomic DNA, Gelatine, Unhairing, Meat Tenderization, pH, temperature

Introduction:

Proteases, vital enzymes involved in hydrolyzing peptide bonds, hold significant industrial importance due to their wide-ranging applications in sectors such as detergents, food processing, leather tanning, pharmaceuticals, textiles, and bioremediation [1]. Accounting for nearly 60% of global enzyme sales, proteases, especially microbial ones, are preferred for their efficiency, scalability, and adaptability. Among microbial sources, *Bacillus* species like *B. subtilis*, *B. cereus*, *B. licheniformis*, and *B. clausii* dominate industrial production due to their ability to secrete extracellular proteases with desirable properties such as high stability at elevated pH and temperatures, making them ideal for challenging applications like detergent formulations [2, 5, 9].

In the detergent industry, *Bacillus clausii* produces Savinase, a highly stable alkaline protease used to remove stubborn stains [5]. Similarly, in the leather industry, enzymatic dehairing using proteases provides an eco-friendly alternative to traditional toxic chemicals, significantly reducing environmental hazards while ensuring effective processing [4]. Proteases are also employed in gelatin hydrolysis for silver recovery from X-ray films, peptide synthesis, and racemic amino acid resolution, further showcasing their versatility [5, 7]. Thermostable proteases from thermophilic bacteria, such as *Bacillus laterosporus*, enable high-temperature industrial processes, enhancing reaction rates, solubility of reactants, and reducing microbial contamination [10].

Protease production is intricately regulated by nutrient availability, particularly carbon and nitrogen stress, during the stationary growth phase. Although often linked to sporulation in *Bacillus* species, protease synthesis can occur independently, driven by stringent responses to amino acid deficiencies and changes in nucleotide pools [2]. Production strategies like fed-batch and chemostat fermentations enhance yields, while precise media manipulation during the exponential phase maximizes biomass and protease production [2].

Given their vast applications and industrial significance, this study focuses on isolating protease-producing bacteria from soil samples, purifying the enzyme, and investigating factors influencing its activity. The findings aim to expand our understanding of protease production and uncover novel enzymes with enhanced properties for industrial and environmental applications [7].

We identified *Bacillus* species from three distinct soil samples for this study. Protease was produced using the isolated. The purified enzyme was then used to test the proteolytic assay, estimate the amount of protein, and test various industrial applications such skin dehairing, gelatine extraction, meat tenderisation, and genomic DNA extraction. The isolates were used to examine how the production of protease was affected by the sources of carbon and nitrogen.

Material and Methods:

Source of Sample:

Three different soil sample was collected. Garden soils from B. K. Birla College, soil from bey of river (Ulhas River) and Timber processing area. The sample collection was done by the depth of 5-6 cm and store in zipper bag.

Isolation and Screening of protease producing Bacteria:

The soil samples were serially diluted in d/w from 10^{-1} to 10^{-6} dilutions. The diluted sample were poured onto sterile skim milk agar plate and incubate at 37°C for 48 hrs. The presence of microbes that produce proteases was shown by a clear zone of hydrolysis in skim milk. Depending on the zone of clearness, three isolates from each soil sample were sub cultured on sterile nutrient agar as pure culture.

The selected strains were inoculated on different sterilized nutrient agar slant media and incubated at 37oC to get a standard colony and labelled the sample as follows garden sample (gs), river sample (rs) and timber sample (ts). The isolated proteolytic strain was identified based on cellular morphology, gram stain, motility, endospore staining and biochemical tests such as carbohydrate test, IMViC test, starch hydrolysis, casein hydrolysis, gelatin hydrolysis, urease test, oxidase test, nitrate utilization test, TSI test according to the standard key of Bergey's manual of determinative bacteriology [15].

Protease Production:

Seed Medium Production: A loop full of culture from pure culture slant should be added to 25 ml of sterile nutrient broth in a sterile conical flask. The culture should then be incubated at 37 °C for 18 to 24 hours until its density reaches 08 at 600 nm. This culture should then be used as the inoculum for the production media. [14]

Production Medium and Culture Condition: The sterile YDP (Yeast Dextrose Pentose) medium use for enzyme production. In 100ml of sterile YDP medium add 1% seed medium is added. The flask was incubated at 30^{o}c for 2 days. Following the incubation period, the sample was centrifuged for 10 minutes at 100,000 rpm. Use the supernatant as crude enzyme sample for further procedure.[14]

Protease Assay:

Quantitative Assay: The Anson approach, with minor adjustments, was used to measure protease activity [13]. 1% casein was added to 0.1 M phosphate buffer (pH 0.7) to create the substrate. To two millilitres of the substrate (casein and phosphate buffer), one millilitre of the enzyme sample was added. An hour was spent incubating the reaction mixture at 50°C.

A white precipitate formed when 3 millilitres of 110 mM trichloroacetic acid (TCA) were added to terminate the reaction. After 15 minutes of centrifuging the tubes at 5000 rpm, a clear supernatant was left behind. The supernatant was then combined with two millilitres of 0.2 M sodium carbonate in 0.5 millilitres. The tubes were left at room temperature to incubate for 20 minutes. Following the addition of 0.5 ml of Folin-Ciocalteau's reagent, a bluish hue appeared. At 660 nm, the absorbance was measured, and a suitable blank was made for comparison.

Qualitative Assay: The activity of proteases was measured using a variation of the Anson approach. For one hour, the enzyme was incubated at 50°C with a casein-phosphate buffer substrate. Centrifugation was used to obtain a clear supernatant after trichloroacetic acid (TCA) was used to stop the reaction and form a precipitate. A bluish hue was produced by the reaction of the supernatant with Folin-Ciocalteau's reagent after it was combined with sodium carbonate and allowed to incubate. A reference blank was used to measure absorbance at 660 nm.

Protein Estimation:

Quantitative Estimation: By employing the Folin-Lowry method using Bovine Serum Albumin (BSA) as the protein standard at a concentration of 0.1 mg/ml, the protein content of the samples was ascertained. 0.02, 0.04, 0.06, 0.08, and 0.1 mg/ml were the values at which standard BSA was manufactured. To get a final volume of 1 ml, each concentration was diluted with distilled water (D/W). Four millilitres of an alkaline copper solution were added, and the tubes were then allowed to sit at room temperature for ten to fifteen minutes. After adding 0.5 ml of Folin-Ciocalteau's reagent, the tubes were left to incubate for another half hour at room temperature. At 660 nm, the absorbance was measured, and a suitable blank was made for comparison.

Qualitative Estimation: The approach developed by Biuret was used to estimate protein qualitatively. Test sample (two to three millilitres) was added to a dry and clean test tube. Thoroughly mix with an equal amount of 10% sodium hydroxide. Drop by drop, add 0.5% copper sulphate till purplish violet transforms.

Charactrization of Production Media:

Effect of Carbon Source: The impact of carbon sources, specifically lactose, fructose, and dextrose, is examined. After preparing the medium, it was autoclaved and inoculated with the culture-containing seed medium. The flask was incubated at 150 rpm and 37°C. Following the incubation period, the samples were centrifuged for 10 minutes at 10,000 rpm, and the protease assay was performed to determine the amount of enzyme that was generated. Plotting and tabulation of the results were done.

Effect of Nitrogen Source: The medium was made using the same composition as YPD media, but a different nitrogen source was used in its place. Tryptone, casein enzymatic, hydrolyse, and yeast extract are the three distinct nitrogen sources. The seed medium containing the culture was added to the prepared medium, autoclaved, and inoculated. 150 rpm and 37°C were the incubation conditions for the flask. Following the incubation period, samples were centrifuged for 10 minutes at 10,000 rpm, and the amount of enzyme generated was determined using the protease test. Graphs were plotted and the findings were tallied.

Purification of Protease Enzyme:

Ammonium Sulphate Precipitation: After gathering the crude enzyme sample supernatant in a flask, the clear supernatant was constantly swirled for two hours while 20%–80% finely powdered ammonium sulphate was added gradually. After centrifuging the mixture for ten minutes at 4°C and 10,000 rpm, the pellet and supernatant were separated. Ten millilitres of glycine NaOH buffer with a pH of 7.2 were used to dissolve the pellet. The pellet dissolved in buffer and the supernatant were then used as samples for protease and protein assays.

Dialysis: After the pellet had been dissolved in the glycine NaOH buffer, it was placed in the dialysis membrane, secured with clips at both ends, and dialysed against the same buffer. Estimates of the dialysed sample's protein content and protease activity were made. The dialysed sample was utilised for further purification.

High performance liquid chromatography: The isolated enzyme was subjected to a qualitative HPLC analysis. The dialysis membrane is used to obtain a purified sample after the crude enzyme sample was partially purified by ammonium sulphate precipitation. Following suitable phosphate buffer dilutions, the material was examined. Using a Waters-600-Pump-based HPLC system with a Waters 2489 UV/Visible Detector, the purity of the sample was examined. For data collection and mathematical computations, Water Empowered software (Version: Empower 2 software Build 2154) was utilised. Protease was separated chromatographically using a C18 hypersil column (4.6 mm × 250 mm; 5 µm particle size; Waters, USA). At a flow rate of 1 mL/min, acetonitrile water (70: 30 vv−1) was utilised as the mobile phase. A constant temperature of 30°C was maintained in the column oven. Using a UV-visible detector, the sample (20 µL) was injected and examined at 280 nm. Bhunia [6]

Application of Extracted Enzyme:

1. **Extraction of Genomic DNA from bacterial cell:** The following procedure was used to extract genomic DNA from bacterial cells. First, the test bacterial broth culture is made by inoculating a loop full test bacterium, in this case E. coli, in sterile nutrient broth for 24 hours at 37 °C. Using a conventional technique, genomic DNA was extracted. The enzyme sample that was isolated takes the place of proteinase K. followed by electrophoresis on an agarose gel.
2. **Skin Dehairing**: Research on skin dehairing was done on goats. Each experiment was run in two batches: one for the traditional lime sulphide method and one for enzymatic dehairing. Goat skin was dehaired using the dip method with crude protease and lime sulphite as a standard. A 4-by-4-cm piece of skin was cut, rinsed several times with distilled water to get rid of salt and other debris, immersed in the crude enzyme preparation and lime sulphide solution, and then incubated for 24 hours at 40°C while spinning at 180 rpm on a rotary shaker. A sample of enzyme-treated hide was taken out and carefully scraped to check for dehairing activity.
3. **Gelatin extractions:** Using a crude enzyme sample in place of acetic acid as a standard, the acidic extraction method was utilised to extract the gelatinThe small pieces of chicken foot were soaked in 0.2% (w/v) sodium hydroxide to remove any non-collagenous material before the gelatin was extracted. For forty minutes at room temperature (22–28°C), the mixture was shook and agitated. Three times, the alkaline solution was used. Alkaline treatment eliminated the unwanted ingredient90 minutes at a skin water ratio of 1:9 (w/v). Ts, softened the material's texture, and prepared it for gelatin extraction. A final extraction of gelatin was carried out in distilled water at 70°C for he samples were then steeped in acetic acid 0.2% (v/v) for 40 minutes for additional extraction. The acid solution was then drained and rinsed with running tap water until pH neutral. The extract was then dried in a hot air oven for one hour after being filtered through two thicknesses of cheesecloth. Gelatin powder was created by grinding the dry material.
4. **Meat Tenderization:** Both pre- and post-slaughter interventions can impact the tenderisation process, which starts as soon as an animal dies and is followed by endogenous proteolytic systems breaking down the muscle structure. To tenderise the meat, the crude enzyme that was extracted from isolates GS, RS, and TS was utilised.

Result and Discussion:

Screening of Protease producing Bacteria: On SKMA plates, bacterial isolates that showed zones of inhibition were isolated from garden, river, and timber soil samples. The colonies that possessed the greatest zones were chosen and kept. Through morphological, cultural, and biochemical investigations, isolates GS, RS, and TS were taxonomically identified. The isolates were negative for nitrate reduction, methyl red, and indole synthesis, however they tested positive for citrate, Voges-Proskauer, and TSI using dextrose, maltose, and fructose. Casein, gelatin, and starch might all be hydrolysed by them. It was determined that the isolates were *Bacillus sp*. based on Bergey's Manual of Systematic Bacteriology.

Protease Assay:

Qualitative Assay: Qualitative Assay: This method, which is based on the diffusion of enzymes into a gel matrix that contains casein, a hydrolysable substrate, is mostly used to detect extracellular proteolytic activity in bacteria. Protease production was checked on SKMA plates using the crude enzyme sample from GS, RS, and TS isolates. On SKMA plates, zones of clearance (Figure 5.3) show that the substrate is hydrolysed.

Quantitative Assay: Spectrophotometric techniques based on molar absorptivity differences were used to measure proteolytic activity in liquid-phase tests with natural or synthesised substrates. The protease assay used tyrosine as the standard and, with minor adjustments, followed Anson's procedure. When enzyme activity for crude enzyme samples was calculated, isolate TS showed the highest activity in comparison to GS and RS of the three isolates.

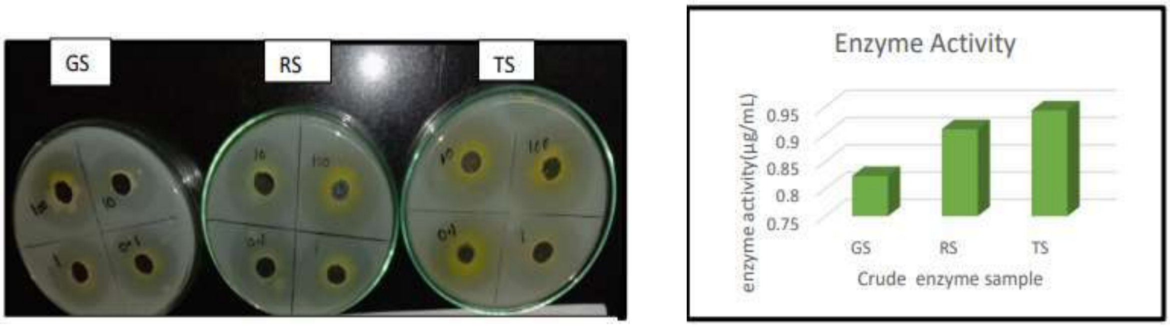

Figure 1: Qualitative assay of crude enzyme samples

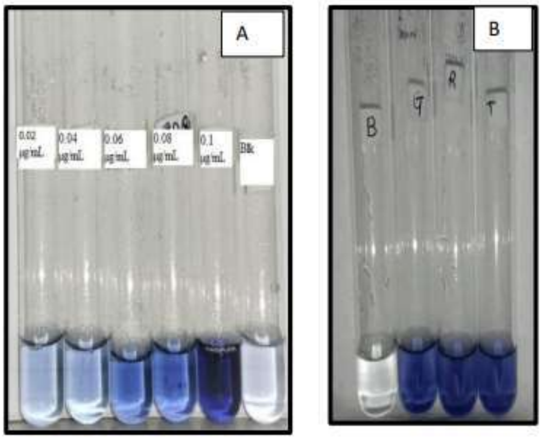

Figure 2: Quantitative Assay of Protease A) Standard Tyrosine Result B) Crude Enzyme Sample of Three Isolates

Figure 3: Qualitative estimation of protein

PROTEIN ESTIMATION:

Quantitative Estimation: Quantitative Estimation: Biuret's approach was used to qualitatively evaluate the presence of proteins in the crude enzyme samples. When protein was present, the colour changed to purple. Figure 4 displays the estimated protein content for the crude enzyme samples from each

Quantitative Estimation: Protein content in the crude enzyme samples was quantitatively estimated using the Folin-Lowry method, with BSA as the standard (0.01-0.1 mg/mL). The color change and density were measured using a colorimeter, and the protein amounts were tabulated in Table 1

Sample	Protein concentration (µg/mL)
GS	0.039159
RS	0.029159
TS	0.069159

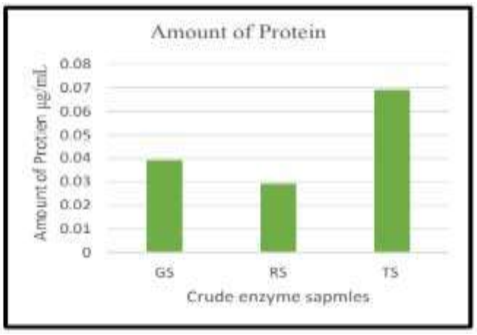

Table 1: Protein Concentration (µg/mL)

CHARACTRIZATION OF PRODUCTION MEDIA:

Effect of Carbon Source: Impact of Carbon Source: Dextrose, fructose, and lactose were used to examine the impact of various carbon sources on the synthesis of protease. With an enzyme activity of 0.977934 U/mL, lactose was found to yield the largest amount of protease in all three isolates (GS, RS, and TS). According to the graph, enzyme activity changed as carbon sources changed. Dextrose was found to be the most effective carbon source for the generation of proteases in earlier research, including [14]

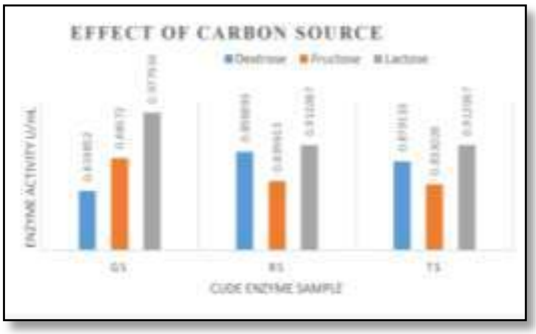

Table 1: Protein Concentration (µg/mL)

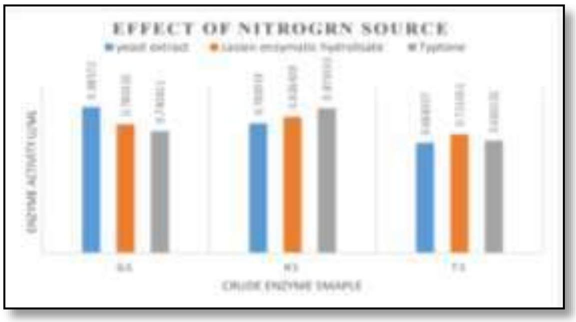

Table 2: Summary of Over All Purification Enzyme

Effect of Nitrogen Source:

Effect of Nitrogen Source: Using tryptone, casein enzymatic hydrolysate, and yeast extract, the effect of nitrogen sources on protease synthesis was investigated. The best sources of nitrogen for isolates GS (0.88572 U/mL), RS (0.826439 U/mL), and TS (0.721051 U/mL) were yeast extract, tryptone, and casein enzymatic hydrolysate, respectively. The graph illustrates how the enzyme activity changed with various nitrogen sources. Tryptone produced the most protease (9854 U/mL), making it the most efficient nitrogen source, according to Yassir Hussain (2015).

Purification of Protease Enzyme:

Protein purification requires careful selection of techniques to maximize enzyme recovery and minimize protein loss, with a focus on efficiency and minimal steps. It is essential for accurate enzyme assays and protein estimation.

Ammonium Sulphate Precipitation:

Ammonium sulfate precipitation, a salting-out method, was used as the first step in protease purification for isolates GS, RS, and TS. Partially purified proteins were dissolved in Glycine-NaOH buffer, showing higher enzyme activity and protein concentration than crude samples. For GS, 40% ammonium sulfate yielded a 12.59% recovery and a purification fold of 0.381796, the highest among the isolates. [14]used 80% ammonium sulfate,

Dialysis: Dialysis using Glycine-NaOH buffer (pH 7.2) was performed to purify the enzyme, reducing impurities compared to the crude sample (Fig.4.) Enzyme activity, protein estimation, and specific activity calculations showed the highest yield for the GS isolate.

High Performance Liquid Chromatography (HPLC): High-performance liquid chromatography (HPLC) was performed using acetonitrile as the mobile phase to analyze the dialyzed enzyme samples. The GS isolate showed the highest retention time, while the TS isolate had the largest peak area. Retention time, peak area, and height for all isolates were recorded in Table 3.

Table 3: Results of HPLC of enzyme sample

Sample	Protein conc. (mg)	Enzyme activity (U)	Specific activity (U/mg)	Purification fold	Yield
Crude Enzyme Extracted from Isolate GS					
Crude	0.039159	0.82371	21.03501	--	100
ASP	0.12915	1.037215	8.031088	0.381796	12.59199
Dialysed	0.599149	1.208471	2.016979	0.095887	14.67107
Crude Enzyme Extracted from Isolate RS					
Crude	0.029159	0.909513	31.1915	--	100
ASP	0.119159	1.076736	9.036128	0.289698	11.8386
Dialysed	0.499159	1.175537	2.355035	0.075502	12.92491
Crude Enzyme Extracted from Isolate TS					
Crude	0.069159	09.93834	13.56787	--	100
ASP	0.119159	1.037215	8.704462	0.64155	11.05372
Dialysed	0.499159	1.142603	2.289056	0.168712	12.17685

Table 4: Summary of Over All Purification Enzyme

Sample	Retention time	Area	Height
GS	1.650	36390	3925
RS	1.525	32317	2196
TS	1.642	106039	8737

Application of Protease Enzyme:

Extraction of Genomic DNA from Bacterial Cell:

The purified protease enzyme from isolates GS, RS, and TS was used in place of proteinase K for genomic DNA extraction from E. coli following the HiMedia protocol. Qualitative analysis showed genomic DNA bands on agarose gel comparable to those obtained with proteinase K, as shown in Fig. 5

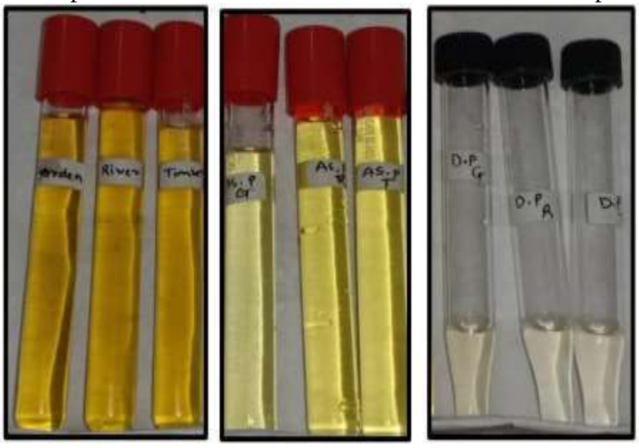

Figure 4: Protease Enzyme Samples A) Crude Enzyme B) Partially Purified Enzyme C) Purified Enzyme

Figure 5: Agarose Gel Electrophoresis of Genomic DNA Extracted From E.Coli. 1) DNA extracted using Proteinase k 2) DNA extracted using GS 3) DNA extracted using RS 4) DNA extracted using TS

De-Hairing of Skin: The crude protease enzyme was used for enzymatic dehairing of goat skin, a key step in leather processing. After 24 hours at room temperature, the enzyme-treated skin was smooth and white, outperforming conventional chemical methods (Fig. 6). This eco-friendly process avoids sodium sulfide and lime, reducing pollution and effluent COD, BOD, and TSS loads.

Figure 6: Dehairing of Goat Skin Using Extracted Crude Enzyme from Isolates GS, RS, TS A) Goat Skin Treated with Crude Enzyme B) Untreated Goat Skin

Gelatin extractions: The crude enzyme was used to extract gelatin from chicken feet, replacing traditional chemical or acid treatments. Protein estimation confirmed gelatin extraction (Fig. 5.26). The RS enzyme sample yielded the highest gelatin, surpassing acidic and other enzymatic treatments, as shown in Table 4.

Meat Tenderization: The crude enzyme was used for meat tenderization, softening chicken meat by breaking muscle fibers. Microscopic analysis confirmed muscle structure breakdown, as shown in Fig. 5.28.

Sample	Yield of Gelatin
Acidic treatment	30.44%
GS	31.88%
RS	36.56%
TS	33.87%

Table 5: Extracted Gelatine in percent

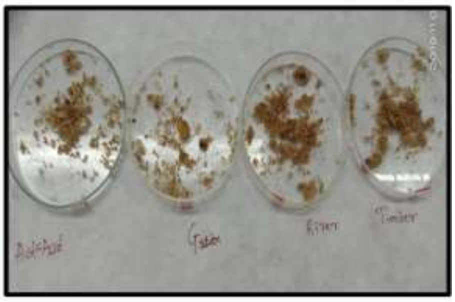

Figure 7: Extracted Gelatine

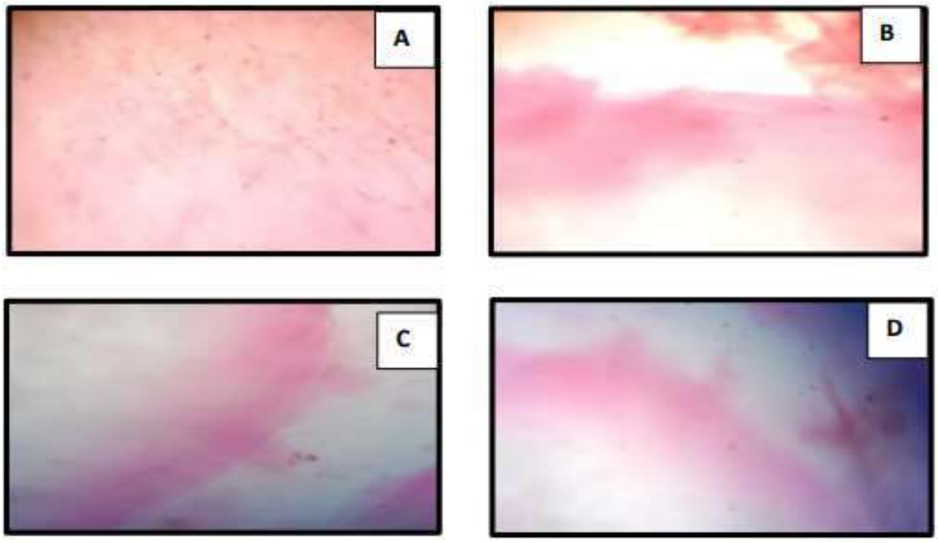

Figure 8: Microscopic Image of disrupted muscle fibre of tenderized meat A) Control using D/W B) Enzyme Sample GS C) Enzyme Sample RS D) Enzyme Sample TS

Conclusion:

Protease enzymes have versatile applications in industries, biotechnology, medicine, and cosmetics due to their specific characteristics. However, their high cost and specific features have limited their use. In the current study, *Bacillus* species were isolated from three locations, cultured in YPD media, and analyzed for protease enzyme production. Among the isolates (GS, RS, and TS), the TS sample demonstrated the highest protease activity and protein content.

The growth rate and generation time were assessed, with the GS isolate exhibiting the maximum values. Nutritional parameters, such as carbon and nitrogen sources, were optimized, with lactose and yeast extract identified as ideal sources. Enzyme kinetics revealed that the maximum Km and Vmax values were achieved at 120 minutes. The crude enzyme was characterized for stability, showing optimal activity at pH 7.0 and 50°C.

Purification of the crude enzyme was achieved through ammonium sulfate precipitation and dialysis, followed by HPLC analysis to assess protease activity and protein specificity. The purified enzyme demonstrated potential applications in various fields, including genomic DNA extraction, leather unhairing, gelatin extraction, meat tenderization, and other biotechnological and industrial processes. This study highlights the potential of protease enzymes in diverse applications.

Future Proposal:

1. The pH and temperature stability and its effect on enzyme studied in detail for the further least polluted industrial approach.
2. Nutritional parameter such as carbon and nitrogen source for large scale enzyme production and better yield
3. Study on a large scale of the enzyme uses in food industry.
4. Study of the enzyme for better product recovery in leather industry with less or no chemicals use.
5. Study on other biotechnological application and detailed study on genomic DNA extraction from bacterial cell.

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Synthesis Characterization and Antimicrobial Studies of Transition Metal Complexes of Bidentate Ligands

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Abstract:

A series of metal complexes of Ni (II), Co (II), Zn (II), Mn (II) and Fe (III), were prepared from Chalcones. The Chalcones were Prepared from 2'- Hydroxy acetophenones and 3,4-dimethoxy benzaldehyde. The synthesized metal complexes were characterized by molar conductivity, magnetic susceptibility, thermal analysis, FTIR, ^{1}HNMR, and UV-Visible spectra. The analytical data of these complexes showed metal ligand ratio as 1:2. The physicochemical study supports the square planar geometry around Zn (II), Mn (II) and octahedral geometry around Co (II), Fe (III) and Ni (II) ions. The molar conductance values of metal complexes suggest their non electrolytic nature. Antibacterial and Antifungal activities of ligands and its metal complexes were performed in vitro against *E. coli, S. typhi, S. aureus, B. subtilis* and against various fungi like *P. chrysogenum, A. niger, F. moniliformae*, and *A. Flavus.*

Keywords: Substituted Chalcones, Metal complexes, Spectral analysis, Antibacterial activity and Antifungal activity.

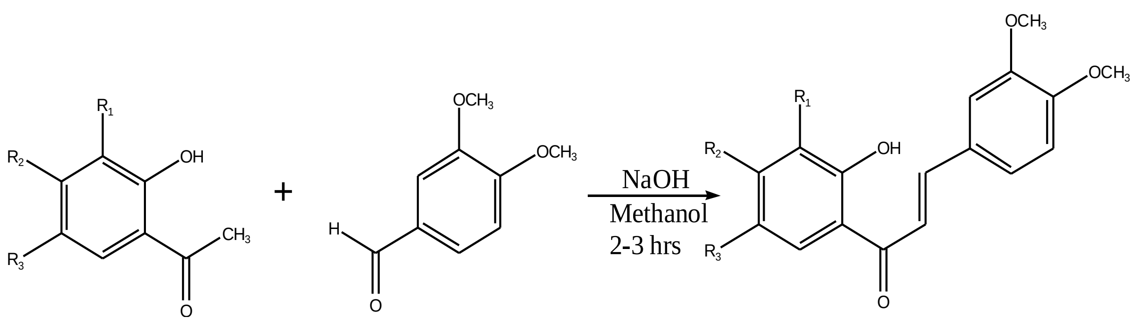
Introduction:

Chalcones have been reported to possess antibacterial[1], antifungal[2], anti-inflammatory[3], antitumor[4], and antioxidant activities[5, 6]. The presence of a reactive α-β unsaturated keto function in chalcones is found to be responsible for their antimicrobial activity, which may be altered depending on the type and position of substituent on the aromatic rings. Chalcones are also used as starting materials in the synthesis of many heterocyclic compounds[7-10]. The field of Chalcone Complexes is fast developing because of the wide variety of possible structures for the ligands depending on the aldehyde and ketone used. Many Chalcones and their complexes have been widely studied because of their industrial and biological applications.

Experimental:

General Procedure for the synthesis of Chalcones:

An equimolar mixture of substituted acetophenone and aromatic carboxaldehyde were taken along with double the mole of NaOH, dissolved in methanol solution. The reaction mixture was heated for 2-3 hrs. The progress of the reaction was monitored by TLC. After completion of the reaction the contents were poured in ice cold water and then acidified by dil. HCl. The solid obtained was filtered, washed with cold water. Then crude product was recrystallized from ethanol to give the corresponding product.



Where

Sr. no.	R_1	R_2	R_3
1	Cl	H	I
2	I	CH_3	Cl
3	I	H	Cl
4	I	H	Br
5	I	H	CH_3
6	I	H	I
7	Cl	H	Cl
8	H	OH	H
9	I	OH	I

Synthesis of Metal Complexes:

The ligand and the metal salt were taken in 1:2 mole ratio and dissolved in 50 ml methanol, refluxed for 2 hours. The solid mass separated was filtered and the residue was washed with hot methanol. These complexes were finally dried under vaccum desiccator over fused $CaCl_2$. Molar conductance measurements were carried out in 10^{-4} M in DMSO solution. The magnetic susceptibility measurements of the complexes in the solid state were made on Guoy balance at room temperature using $Hg[Co(NCS)_4]$ as standard. Diamagnetic corrections were applied using Pascals constant. The IR spectra of the metal complexes in KBr pallets in the range of 4000-350 cm^{-1} were recorded. UV-Visible spectra were recorded and TGA and DTA analysis of metal complexes were carried out.

Results and Discussion:

All the complexes are coloured solids, air stable and having good solubility in polar solvents like DMF and DMSO. The elemental analysis shows 1:2 (M: L) stoichiometry for all the complexes. The metal contents in complexes were analysed by gravimetric analysis. All the complexes show low conductance which indicates their non electrolytic nature. The magnetic measurements study suggests that the Co (II), Mn (II) and Fe (III) complexes exhibit paramagnetic be haviour whereas the Ni (II) and Zn (II) show diamagnetic behaviour.

^{1}H-NMR spectra

^{1}H-NMR spectra of synthesized ligand and its transition metal complexes were recorded in DMSO. The ^{1}H-NMR spectra of ligand showed signals at 2.7 (s,3H,-CH3), 7.20- 7.87 (m,7H, Ar-H), 12.10 (s,2H,Ar-OH) ppm. Whereas the ^{1}HNMR spectra of complexes show broad signals due to presence of metal ion and the conforma tion of each signal in the aromatic region is difficult dueto complex pattern of splitting.

IR spectra

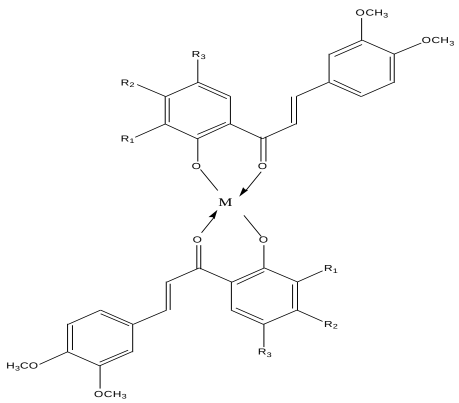
The FT-IR spectrum of the free ligand shows four characteristic bands at 3300 cm^{-1} (-OH stretch), 1538 (C=C Ar. str), 1640 (C=N str.), 1250 (C-O, Ar-OH). Whereas in the IR spectra of complexes there is one more additional absorption band appears at 420- 474 cm^{-1} range due to M-O bond.

Thermal analysis

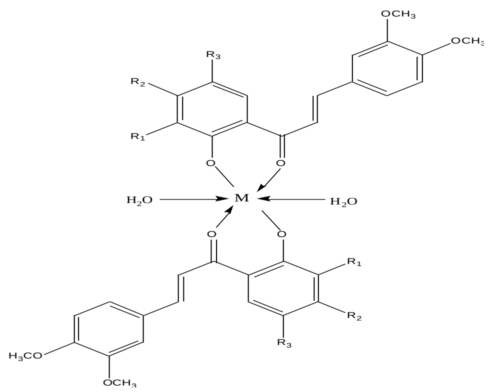
The thermogram of Ni (II), Fe (III) Co (II) com plexes confirms the presence two moles of coordinated water molecules where as there is absence of coordi nation of water molecule in Zn (II) and Mn (II) complexes. Hence from TGA it is clear that the complex under study contains two moles of coordinated water molecules which are coordinated to central metal ion [11].

Magnetic moment

The $\mu_{eff.}$ values at room temperature for Zn(II) complexes are in the range of 1.78-1.86 B.M. usually observed for square planar geometry [12, 13]. Ni (II) and Co(II) complexes have magnetic moment values in the range of 2.84-3.24 and 4.28-4.94 B.M. respectively.Whereas due to completely filled d-orbitals the Zn (II) ion complex is diamagnetic in nature.



M= Zn (II) and Mn (II)



M= Ni (II), Co (II) and Fe (III)

Antimicrobial Activity:

The antibacterial activity of the compounds was determined by agar diffusion method against various bacteria like *E. coli, S. typhi, S. aureus, and B. subtilis* atvarious concentrations such as 20, 50 and 100 µg /ml. The zone of inhibition was measured in mm and DMSO was used as solvent. Sterile nutrient agar was seeded with test organism and layered in sterile petri plate.

After solidification, agar cups were bored withcork borer. 0.1 ml of the compound solution was added to the cup with the help of micropipettes, one cup in the plates as filled with solvent. Standard penicillin (10v/ml) was used as reference drug. The plates were kept at low temperature (4 ºC) for 20 minutes to allow diffusion of the compound. Thenthe plates were incubated at 37 ºC for 24 hrs. After proper incubation the plates were observed for zone ofno growth (zone of inhibition of growth) around the cup. Similarly the same compounds were screened for theantifungal activity against different organisms like *P. chrysogenum, A. niger, F. moniliformae,* and *A. Flavus* by using poison plate method. The compound was mixed with sterile potato dextrose agar medium so as to get final concentration 2%. It was then poured in sterile petri plate and allowed to solidify. Spots of test organisms were placed on the agar surface. A plate without compound was prepared for control. The plates were incubated at room temperature for 48 hrs.

After proper incubation plates were observed for growth of the test organisms. The growth indicates thatthe compound is not antifungal while inhibition of growth of test organism indicates antifungal activity. The anti-fungal activities of the compounds were compared with standard Grysofulvin. The result of antimicrobial data of the ligand and complex shows that the complexes of the Schiff bases show enhanced activity than their corresponding ligand.

Table 2: Antimicrobial activity of synthesized compounds

	Bacterial Strain				Fungal Strain			
	Ec	**St**	**Sa**	**Bs**	**An**	**Pc**	**Fm**	**An**
L_1	15	9	26	19	-ve	+ve	-ve	-ve
$[L_1.Ni(H_2O)_2]$	9	11	22	13	-ve	+ve	-ve	-ve
$[L_1.Co(H_2O)_2]$	-	9	27	18	+ve	+ve	RG	+ve
$[L_1Mn]$	14	-	14	25	+ve	-ve	-ve	-ve
$[L_1,Fe(H_2O)_2]$	6	8	17	16	-ve	RG	-ve	+ve
$[L_1Zn]$	-	-	23	11	+ve	+ve	-ve	+ve
Pencillin	18	20	32	28	-ve	-ve	-ve	-ve
Grysofulvin	NA	NA	NA	NA	-ve	-ve	-ve	-ve

Ec-E.coli, St-S.typhi, Sa- S.aureus, Bs-B.subtilis; An-A.niger, Pc-P.chrysogenum, Fm-F.moneliformae, Ca-C.albicans; -ve: No growth of fungi, + ve: Growth of fungi, RG-Reduced growth, NA-Not Applicable, Zone of inhibition was measured in mm

Conclusion

From the result and the discussion and analytical data it is confirmed 1:2 stoichiometry and the electronic spectral data suggests that the Co(II), Ni(II), Fe(II) complexes have octahedral geometry whereas Zn(II) and Mn(II) complexes have square planar geometry. The antimicrobial studies show that the complexes of the corresponding Chalcones show more potent activity than their corresponding ligand.

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Evaluation of Antifungal Activity by Different Solvent Extracts of *Hygrophila Auriculata* Root

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Abstract

Plants have long been an important source of natural compounds for human health. Every portion of the plant, from the root to the fruit, contains several secondary metabolites that have significant therapeutic value for a range of conditions. Research has indicated that various phytochemical components found in botanical samples are what give them their antifungal properties. The medicinal shrub *Hygrophila auriculata* (Family: Acanthaceae) has been shown to have healing properties against a number of illnesses. The goal of current study was to evaluate *H. auriculata* root antifungal effectiveness against a few pathogenic fungi that are resistant to multiple drugs. The bioactive compounds present in *H. auriculata* root were investigated against ten fungal strains of *Aspergillus sps. H. auriculata* root were collected, air dried, grinded and extracted by using different solvents through sequential method (methanol, acetone, chloroform). These extracts were then tested for antifungal activity using agar well diffusion method. This plant extracts are a natural substitute for a number of antibiotics. Avoiding the potential health risks associated with synthetic antibacterial agents could be a perfect solution.

Key Words: *H. auriculata, solvent extracts, antifungal activity, bioactive compounds.*

Introduction

According to (Mahmood and Muhammad, 2013) antibiotics are a wonder medication used to treat microbiological illnesses brought on by either bacteria or fungi. It was believed that infectious diseases would vanish after antibiotics were discovered. However, several bacterial strains with multi-drug resistance have surfaced as a result of the overuse of antibiotics (Khan et al., 2011). Millions of people die each year as a result of severe side effects caused by certain antibiotics (Dubey et al., 2012). Consequently, there is an urgent need to identify natural antibiotics (Ghulam et al., 2015). This has led to the search of alternative antimicrobial agents. Plants usually create natural compounds, often known as phytochemicals, as secondary metabolites (Abdallah E, 2011). Because of their exceptional structural diversity and variety of pharmacological actions, they are extensively utilized in the pharmaceutical sector (Bereksi et al., 2018).

Numerous secondary metabolites, including saponins, tannins, alkaloids, alkenyl phenols, glycoalkaloids, flavonoids, sesquiterpene lactones, terpenoids, and phorbol esters, are abundant in medicinal plants and have antimicrobial qualities (Lewis and Ausubel, 2006; Kompean and Ynalvez, 2014). Flavonoids have antiviral, antiallergic, anti-inflammatory, antioxidant and anticarcinogenic qualities (Prior, 2003). Alkaloids have a variety of beneficial properties, such as antihypertensive and antitumor properties (Notka et al., 2004). Several works have been done to examine the antifungal effects of herbal plants extracts, including roots, barks, stem, leaves or flowers.

Hygrophila auriculata, is also known as *Asteracantha longifolia* member of the Acanthaceae family. *Hygrophila auriculata*, is described in ayurvedic literature as Ikshura, Ikshugandha and Kokilasha "having eyes like the Kokilaor Indian Cuckoo". It can be found all over India's tropical and subtropical regions. The herb is used internally to treat a wide variety of illnesses. Different categories of phytoconstituents, including phytosterols, fatty acids, minerals, proanthocyanins, alkaloids, enzymes, amino acids, carbohydrates, hydrocarbons, flavonoids, terpenoids, vitamins, and glycosides, which are present in this plant. Kokilaksha is a small plant that can reach a height of three to five feet. It has tiny thorns or hairy sections all over it. The stem resembles to that of sugarcane. The plant produces purple-coloured flowers. When the black seeds come into touch with water or saliva, they expand and get slimy. From September through November, flowers and fruits are visible.

The plant can be found in fields, marshlands, and next to water sources throughout India. The parts of this plant are widely used in traditional medicine for the treatment of various disorders, which include urinogenital tract, dropsy from chronic Bright's disease, hyperdipsia, vesical calculi, leukorrhea, gonorrhea, asthma, blood diseases, gastric diseases, inflammation, cancer, rheumatism, menorrhagea. This study was undertaken to carry out antifungal activity of *H. auriculata.* The bioactive compounds present in *H. auriculata* root were investigated against 10 fungal strains of *Aspergillus* species by using agar well diffusion method (Prasanna and Sridhar, 2016).

Materials and Methods

Plant Collection

H. Auriculata plant was collected from Shantingar, Bhiwandi, Maharashtra. Root was cut into small pieces and thoroughly washed with running tap water and then dried under shade. The dried root was grinded into fine powder using mechanical grinder. Those powdered samples were kept in the air-tight containers to prevent moisture.

Extract Preparation

Sequential extraction was carried out with the powdered sample using solvents of decreasing polarity by soxhlet apparatus. About 50 g of plant powder were extracted using 150 ml of solvents i.e methanol, acetone, and chloroform for 1 h. The extracts were collected, allowed to cool and concentrated by evaporating the solvents at room temperature. The concentrated residue was dissolved in their respective solvents as crude plant extracts.

Microorganisms

In the current study ten fungal isolates belonging to *Aspergillus* species were employed (NH-07, NH-13, NH-25, NH-15, NH-96, NH-70, NH-07, NH-01, NH- 18, and NH-09). SDA (Sabouraud dextrose agar) was used for the isolation and maintenance of fungal cultures. Pure culture was again sub cultured to maintain the purity of the isolated strain (Priya *et al.,* 2013).

Antifungal Activity

Antifungal activity of plant extracts was examined by agar well diffusion method (Cakir *et al.,* 2004). About 20 ml SDA was poured in petri dishes and allowed to solidify for 30 minutes. Fungal inoculum (20 µl) was spread over SDA plates with a sterile spreader. A total of 8 mm diameter wells were punched with cork borer into the agar and filled with plant extracts (30 µl) and solvent blank. Standard antibiotic (Fluconazole, concentration 1 mg/ ml) was used as positive control. Plates were incubated at 37˚C for 24 to 48 H for maximum growth of the microorganism. After incubation, the plates were observed for distinct zone of inhibition surrounding the disc.

Results and Discussion

In the present study antifungal activity of *H. auriculata* root was investigated by agar well diffusion method. The extracts showed varying degrees of antifungal activity against ten fungal strains of *Aspergillus sps.* The activity was assessed on the basis of zone of inhibition. The result evaluated that *H. auriculata* root inhibited the growth of total eight *Aspergillus sps.* whereas none of the extracts inhibited isolate number NH-07 and NH-25. Highest zone of inhibition was observed in NH-09 by chloroform extracts. The zone of inhibition appeared between 9 to 15 mm in diameter. Methanolic extract showed inhibition against 4 fungal isolates, chloroform extract showed inhibition against 6 fungal isolates however acetone extract inhibited only one isolate NH 18 (Table 1). In the previous work done by Anbalagan et al., (2017) antifungal activity of methanol and chloroform extracts of *H. auriculata* root showed zone of inhibition (11 mm) for both extracts at 30µg concentration against *Penicillium sp.* and *Candida albicans.* Tamuli et al., (2014) reported that the antifungal activity of ethanolic leaf extract of *H. auriculata* against *A. alternata, C. lunata and S. sclerotiorum* evaluated maximum zone of inhibition at 2% concentration of extracts. Bameta et al., 2019 observed antifungal activities of *H. auriculata* leaf and stem extracts against fungal isolates namely *A. niger, C. neoformans, S. cerevisiae and C. albicans*. Rios and Recio (2005) and Dave *et al*., 2018 indicated antibacterial activity of *H. auriculata.*

Table 1: Antifungal activity of *Hygrophila auriculata* root extracts

Solvent/ Isolate No.	Zone of Inhibition (mm)									
	NH-07	NH-13	NH-25	NH-15	HA-96	HA-70	NH-07	NH-01	NH-18	NH -09
Methanol	--	12	--	09	10	--	09	--	--	--
Acetone	--	--	--	--	--	--	--	--	10	--
Chloroform	--	--	--	13	12	14	--	8	11	15

In conclusion, *H. auriculata* root extracts in methanol, acetone and chloroform exhibited antifungal activity against 8 fungal isolates amongst the 10 tested. However further study is required to explore the use of these herbs in inhibiting more plant pathogens. Plant extracts can be a valuable source of antifungal agents due to their low cost, limited side effects, and extensive availability. Extensive research is needed to determine the antifungal activity of the other parts such as leaves, flowers, and stem of *H. auriculata*.

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Risk Assessment in Green Investments: A Comparative Study with Traditional Investments

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Abstract

Investments in eco-friendly projects such as renewable energy, sustainable development and climate change growth are becoming common with the changing global focus on green growth. However, green investments have some dissimilar risks such as regulatory, technological and market risks.

Factors that do not make them the same as a traditional investment. At the same time, green investments can offer substantial returns alongside positive impact on the environment.

In contrast, investments in well established industries are done under more strict regulations and technologies, but headwinds like increasing societal norms to ditch fossil fuels makes them climate risk prone. There is a noticeable risk shift in the comparison of both green and traditional investments,they each have different components that risk them thus, custom risk management methods are required.

This research examines the substantial regulatory, technological, market, ecological, and behavioral risks that come attached with both green and other forms of investment. Findings emphasized the cultivation of diversification, proactive assessment of market and policy developments and the application of highly sophisticated tools such as AI to support managerial decisions. If these risks are dealt with properly, investors can improve their portfolio by promoting stability, achieving the needed level of environmental sustainability, and simultaneously fulfilling financial goals. This research advances the existing discourse on the sustainable investment principles by bringing in useful information that can assist investors in a fast changing world of finance technologies.

Keywords: Green investments, traditional investments, risk assessment, sustainable finance, renewable energy,regulatory uncertainties, technological risks, market volatility, climate change, portfolio diversification, sustainability goals, environmental impact.

Introduction

Today, it is increasingly acknowledged that the world economy is changing and this change is largely driven by considerations of sustainability. Understood as investments in projects that are environmentally sustainable and obey the principles of environmental, social and governance (ESG) criteria, green investments have become a key element of this new paradigm. In contrast to conventional investments that tend to seek returns without regard to sustainability, green investments seek to attain a sustainable level of profit making while being sensitive to environmental and societal needs.

While pursuing this twin goal of financial and sustainability objectives is appealing, it also brings with it several challenges, especially in terms of risk profile. To illustrate, green investments are different from conventional ones in a sense that they often depend on new and changing technologies and are still evolving in terms of legal structures as compared to traditional investments. But at the same time, traditional investments are facing increasing threats due to climate change along with the rapid evolution of social norms.

The aim of the paper is to study the differences in risk associated with green and traditional investments, understand the determinants of these risks as well as the ways in which these risks can be minimized. By using comparative analysis and practical insights, this research aims to guide investment decision making in the context of a changing world.

Risk Factors in Green Investments

Green investments have great outright expectations but they have some specific risk factors, which an investor has to watch out for. One of the most prominent is the risk associated with regulatory and policy. A lot of green initiatives come with a lot of government support in the form of incentives such as subsidies or tax holidays, hence overnight policy changes can greatly reduce the attractiveness of these invisible hands economies. For instance, in Germany the scaling back of solar panel subsidies had the effect of eroding investor returns and market growth. This highlights the necessity of observing legislative changes.

By contrast, in economically emerging countries like China or in Africa where green economies are still decoiling, there is high market volatility. As green markets are new, there are many uncertainties in the markets and volatility is higher than the traditional markets. This is worsened by the lack of ample information and history, creating a problem for the investors to accurately estimate future expectations. Green technologies, which are fundamental prerequisites for the implementation of green projects, also carry some risk. The current technological boom can render previously available solutions unusable, while massive investments and production efficiency raise more questions than answers for investors.

On the one hand, environmental hazards can be seen as a negative incentive for green investments. Some projects, such as for solar and wind energy generation, are invariably weather dependent and therefore can be highly variable. To make things worse, it is an overreliance on such natural factors that cause operational risks, especially in regions where climate is never the same. Social and reputational risks such as greenwashing or the inability to meet stakeholders' content can equally affect the level of investors' confidence and the general success of the project.

With more knowledge about these risks, investors will be able to strategize better on how to deal with the other aspects of a green investment and optimally allocate their portfolios.

Economic and Operational Risks in Investments

The hunger to expand one's portfolio through both green and traditional investments makes it crucial to have a keen understanding of the economic as well as operational risks. The investor must understand that economic risk is the risk of a certain investment being sensitive to the economy considering the potential of factors such as inflation, interest rates and currency exchange rates. Such elements can greatly influence these on such investments: investment returns on equity, operational effectiveness, etc. For example, high inflation leads to purchasing power deterioration and potentially higher operating costs while changes in interest rates may affect borrowing costs and determining factors of available capital. Currency fluctuations add another risk to international investments because an unfavorable dollar exchange for the investment's currency may suppress the investment's overall returns.

In contrast, operational risk defines the risks that are parts of the internal inefficiencies or disruption of an organization's plans. A key anticipated risk includes the disruption of supply chains when in international networks. Events such as natural disasters, geopolitical tensions or pandemics create these interruptions causing delays and raising costs. Such operational risks also come as a result of poor management practices leading to wastage of resources and consequently making losses.

Similarly, the investment environment is altered by the risks associated with specific industries. For instance, for conventional investments, there is the risk of facing huge losses as a result of diminishing growth opportunities in particular industries, like, for instance, fossil fuels, in assets they have invested in. This is critical considering the changing trends within the world economy geared towards adoption of renewable energies and practices that promote sustainability. Those who invest in green industries too have to grapple with the same risks such as change in consumer taste and preferences together with the fast paced development of rival technologies.

Three, a legal and compliant stance is an issue that is common between all green investments and traditional investments. These risks do arise out of the possible threat of being sued, potential fines, and penalties imposed to the investment as a result of non compliance to domestic regional and international statutory regulations. For instance, breaching or failing to respect the environmental laws and regulations or ethical business practices will not only tarnish the investors image but also make the business lose funds. One risk that is greater in green investments is the legal risk as there is increased attention on issues of greenwashing and sustainability in general.

With a view of these risks, investors are able to come up with better plans to try and insulate themselves from the possible negative outcomes of the impact. The next step is incorporating risk management plans, restructuring portfolios and most importantly, understanding market and regulatory changes.

Risk Mitigation Strategies

1. **For Green Investments:**
   - Diversification across various green sectors (e.g., solar, wind, and sustainable agriculture).
   - Active monitoring of regulatory trends and stakeholder engagement.
   - Insurance solutions to address environmental and operational risks.
2. **For Traditional Investments:**
   - Hedging strategies to manage economic and market risks.
   - Due diligence and adherence to compliance standards.
   - Diversification across industries and geographies.

Performance Outcomes and Trends

- **Green Investments:**
  - Despite higher upfront risks, green investments show long-term potential due to increasing global sustainability commitments.

- ○ Examples: Growth of green bonds and renewable energy projects outperforming traditional energy stocks in recent years.
- ● **Traditional Investments:**
- ○ While offering stable returns, traditional investments face growing risks from climate change and shifting societal values.
- ○ Examples: Decline in coal and oil stocks as renewable energy adoption increases.

Conclusion

The green investments are changing the investment world and seem to be a evergreen opportunity to combine profits with social and environmental objectives. However, they have their share of specific risks such as regulatory risk, technology risk or market risk. Such risks require an ability to invest with a balanced look at risk and returns and strategy that focuses on investing in many markets, constant change and evolution and being flexible on risks.

Older investments, meanwhile, still have plenty of structures and risks that are low volatility, however, those investments are more and more at risk because of the new shift to sustainability. Investors in these said markets should always keep an eye on advancing social requirements and new laws so that the investment is managed, modern and secure within portfolios that are managed.

The study of green investments vis a vis traditional ones highlights the need for making use of flexible cushioning investment approaches. Though green investments are the future of sustainable investments, conventional investments still remain important in the diversification of the portfolios. As they are able to comprehend and deal with the specific risks involved, the investors can choose investments that maximize their returns and at the same time foster wider sustainability goals.

As the financial ecosystem continues to evolve, future researchers shall seek to focus of this study on other emerging phenomena like the use of AI and global policy initiatives in promoting the world investment market. By Such efforts , the way towards a more sustainable and financially stronger future is made more obvious.

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