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Chhatrapati Sambhaji Nagar**

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PRINCIPAL'S MESSAGE

It is a matter of great pride and pleasure to extend my heartfelt greetings on the occasion of the One Day National Conference on “Role of Science and Technology in Achieving Sustainability,” organized by the Faculty of Science and IQAC, Shri Siddheshwar Mahavidyalaya, Majalgaon, Dist. Beed. In the present era of rapid industrialization and technological advancement, the pursuit of sustainability has become a global priority. Science and technology play a pivotal role in addressing critical challenges such as climate change, energy conservation, environmental protection, healthcare, and sustainable use of natural resources.

Innovations in renewable energy, green chemistry, biotechnology, artificial intelligence, and smart agricultural practices are paving the way for sustainable development while ensuring economic growth and social well-being. This conference provides a meaningful platform for academicians, researchers, scientists, and students to exchange ideas, present research findings, and deliberate on innovative solutions for a sustainable future.

Such academic initiatives promote interdisciplinary thinking, strengthen research culture, and inspire young minds to adopt responsible and ethical scientific practices. I commend the Faculty of Science and IQAC for their dedicated efforts in organizing this conference. I am confident that the deliberations will lead to valuable insights and practical outcomes. I wish the conference great success and fruitful academic interactions.

Professor Dr. Mukund Devarshi

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SCIENCE AND TECHNOLOGY IN WATER RESOURCE SUSTAINABILITY

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Abstract

Water resource sustainability has emerged as a critical global concern due to increasing water scarcity, population growth, climate change, and environmental degradation. This research paper examines the role of science and technology in promoting sustainable water resource management. The study explores scientific understanding of hydrological systems, groundwater dynamics, water quality processes, and ecosystem interactions that form the foundation for sustainable water use. It further analyzes technological innovations such as smart water monitoring systems, advanced water treatment and purification technologies, wastewater reuse, and data-driven management tools. Using a systematic review of recent literature and selected case studies, the research highlights how science- and technology-based approaches improve water availability, efficiency, quality, and resilience to climate-related risks. The findings indicate that the integration of scientific knowledge with technological solutions significantly enhances water conservation and decision-making. However, challenges related to cost, accessibility, and institutional capacity remain. The paper concludes that strengthening the integration of science, technology, and governance is essential for achieving long-term water resource sustainability and ensuring equitable access to clean water.

Keywords: Water Resource Sustainability, Hydrological Science, Water Management Technologies, Sustainable Development, Climate Change and Water

Introduction:

Water is one of the most vital natural resources on Earth, forming the foundation of all ecological systems, human health, economic development, and social well-being. From sustaining life and food production to supporting industry, energy generation, and sanitation, water plays an irreplaceable role in human civilization. Despite its fundamental importance, freshwater resources are under increasing pressure due to rapid population growth, urbanization, industrial expansion, climate change, and unsustainable management practices. These challenges have intensified concerns about water availability, quality, and equitable access, making water sustainability one of the most critical global issues of the twenty-first century. In this context, science and technology have emerged as powerful tools to address water-related challenges and promote sustainable water resource management.

Water sustainability refers to the responsible use, protection, and management of water resources in a manner that meets present needs without compromising the ability of future generations to meet their own requirements. Sustainable water management aims to balance environmental integrity, economic efficiency, and social equity. It ensures the availability of clean and sufficient water for domestic use, agriculture, industry, and ecosystem preservation. The importance of water sustainability has grown significantly as freshwater resources are finite and unevenly distributed across regions. While some areas experience abundance, others face severe scarcity, leading to social conflicts, economic

instability, and environmental degradation. Sustainable water practices are therefore essential not only for human survival but also for maintaining biodiversity and ecological balance.

One of the primary reasons water sustainability is crucial is its direct link to human health and food security. Access to safe drinking water and sanitation is fundamental to preventing waterborne diseases and improving quality of life. Agriculture, which accounts for nearly seventy percent of global freshwater withdrawals, depends heavily on reliable water supplies. Unsustainable irrigation practices, over-extraction of groundwater, and pollution have already led to declining water tables and reduced agricultural productivity in many regions. Without sustainable water management, the ability to feed a growing global population is at serious risk. Science-based approaches, such as improved hydrological understanding and soil-water management, combined with technological innovations, offer opportunities to optimize water use and reduce wastage in agriculture and food systems.

In addition to climate change, rapid urbanization and industrialization have significantly contributed to the global water crisis. Expanding cities demand enormous quantities of water for households, transportation, and economic activities, often exceeding the carrying capacity of local water resources. Industrial processes consume large volumes of water and generate wastewater containing hazardous pollutants, which, if inadequately treated, contaminate rivers, lakes, and groundwater. The degradation of water quality reduces the availability of usable freshwater and threatens aquatic ecosystems. The combination of increasing demand and declining quality places immense strain on water resources, particularly in developing countries where infrastructure and governance frameworks are often inadequate.

Science and technology play a pivotal role in responding to the growing water crisis and advancing water sustainability. Scientific research provides insights into hydrological cycles, water quality dynamics, climate impacts, and ecosystem interactions, forming the basis for informed decision-making. Technological innovations, such as remote sensing, geographic information systems (GIS), smart sensors, desalination, wastewater recycling, and nanotechnology-based water purification, have transformed the way water resources are monitored, treated, and distributed. These tools enable real-time data collection, early detection of contamination, efficient allocation of water, and the development of alternative water sources, thereby reducing pressure on freshwater reserves.

Moreover, science and technology support integrated water resource management approaches that consider social, economic, and environmental factors. By combining data analytics, modeling, and digital platforms, policymakers and water managers can assess risks, plan for future scenarios, and implement sustainable strategies. Technology-driven solutions also enhance community participation and awareness by improving transparency and access to information. As water challenges become increasingly complex and interconnected, interdisciplinary scientific research and technological innovation are essential for building resilient water systems.

The importance of water sustainability cannot be overstated in a world facing an escalating global water crisis. Ensuring the availability of clean and sufficient water is fundamental to human development, environmental protection, and long-term sustainability. The growing pressures of climate change, population growth, pollution, and resource mismanagement demand urgent and effective solutions. Science and technology offer critical pathways to understand water systems, improve efficiency, protect water quality, and promote sustainable use. Exploring the role of science and technology in water resource sustainability is therefore vital for developing innovative, equitable, and resilient responses to one of the most pressing challenges of our time.

Research Methodology

This study adopts a **systematic and interdisciplinary research methodology** to examine the role of science and technology in achieving water resource sustainability. Given the complex and multifaceted nature of water sustainability, the research integrates scientific, technological, environmental, and socio-economic perspectives. A **qualitative-dominant mixed-methods approach** is employed, combining secondary data analysis with selected case studies to provide a comprehensive understanding of sustainable water resource management practices.

The research is primarily based on **secondary data**, collected from credible and authoritative sources. These include peer-reviewed journal articles, books, conference proceedings, reports published by international organizations, and government publications related to water resources, sustainability, and technological innovations. Scientific databases such as academic journals and institutional repositories were systematically reviewed to identify relevant literature published within the last decade. This time frame ensures that the study reflects recent scientific advancements and emerging technological trends in water resource sustainability.

A **systematic literature review (SLR)** approach was used to organize and analyze the existing body of knowledge. Keywords such as *water resource sustainability*, *hydrological science*, *water management technologies*, *climate change and water*, and *sustainable development goals* were used to retrieve relevant studies. The selected literature was screened based on relevance, quality, and contribution to the research objectives. This process helped identify key themes, research gaps, and methodological approaches used in previous studies, forming the conceptual framework for the present research.

In addition, **content analysis** was used to analyze policy documents, sustainability frameworks, and international guidelines related to water management. Policies and initiatives at global and national levels were reviewed to understand how scientific evidence and technological solutions are integrated into water governance. Special attention was given to policies aligned with the United Nations Sustainable Development Goals (SDGs), particularly SDG 6 (Clean Water and Sanitation). This analysis highlights the role of science and technology in shaping sustainable water policies and institutional responses.

In conclusion, the research methodology combines systematic literature review, case study analysis, and comparative evaluation to explore the role of science and technology in water resource sustainability. This methodological framework provides a robust and holistic approach to understanding how scientific knowledge and technological innovations contribute to sustainable water management and offers a reliable basis for discussion, analysis, and policy recommendations.

Results and Discussion

The findings of this study highlight the significant role of science and technology in enhancing water resource sustainability. Analysis of existing literature, case studies, and policy documents reveals that scientific knowledge combined with technological innovation has substantially improved water availability, quality, efficiency, and management across diverse regions. The results demonstrate that technology-driven water systems, supported by sound scientific principles, offer effective solutions to the growing global water crisis.

One of the key findings is the improvement in **water monitoring and assessment** through scientific and technological tools. Advanced hydrological modeling, remote sensing, and sensor-based monitoring systems have enabled accurate measurement of surface and groundwater resources. These technologies provide real-time data on water levels, flow rates, and quality parameters, allowing early detection of contamination and leakage. Studies reviewed indicate that regions adopting smart water monitoring systems have achieved

significant reductions in water losses and improved supply reliability. This result underscores the importance of data-driven decision-making in sustainable water management.

Another important outcome relates to **water quality enhancement** through technological interventions. Scientific understanding of chemical and biological contaminants has led to the development of advanced water treatment methods, including membrane filtration, nanotechnology-based purification, and biological treatment processes. The findings show that these technologies are effective in removing pollutants such as heavy metals, pathogens, and organic compounds, thereby improving access to safe drinking water. Wastewater treatment and reuse technologies have also emerged as critical tools, enabling the recovery of water for agricultural and industrial use while reducing environmental pollution. This supports the concept of a circular water economy, where water resources are reused efficiently rather than discharged as waste.

The study further reveals that science and technology play a crucial role in **improving water use efficiency**, particularly in agriculture and urban systems. Precision irrigation technologies, supported by soil science and climate data, have helped reduce water consumption while maintaining or increasing crop productivity. Case studies analyzed in this research indicate that the adoption of drip irrigation, smart scheduling, and sensor-based systems can significantly lower water demand compared to traditional irrigation methods. Similarly, urban water management technologies such as smart meters and leak detection systems contribute to reduced wastage and improved conservation practices.

In terms of **climate change adaptation**, the results show that scientific research and technological innovation enhance the resilience of water systems. Climate models and risk assessment tools enable better forecasting of droughts, floods, and extreme weather events. These insights support the design of adaptive infrastructure and early warning systems, reducing vulnerability to climate-related water risks. The integration of science and technology into water planning allows policymakers to develop long-term strategies that address both current and future challenges.

However, the discussion also reveals several **challenges and limitations** associated with the implementation of science- and technology-based water solutions. High costs of advanced technologies, lack of technical expertise, and inadequate infrastructure pose significant barriers, particularly in developing countries. Additionally, unequal access to technology can widen disparities between regions and communities. The findings emphasize that technological solutions alone are insufficient without supportive governance frameworks, public awareness, and capacity-building initiatives.

The results and discussion demonstrate that science and technology are essential drivers of water resource sustainability. They improve monitoring, treatment, efficiency, and resilience of water systems while supporting informed policymaking. Despite existing challenges, the effective integration of scientific knowledge and technological innovation offers a promising pathway toward sustainable and equitable water management. Future efforts should focus on enhancing accessibility, reducing costs, and strengthening institutional frameworks to maximize the benefits of science and technology in addressing global water challenges.

Conclusion

Water resource sustainability is a critical global challenge that demands urgent and integrated solutions. This study highlights the essential role of science and technology in addressing water scarcity, quality degradation, and climate-related risks. Scientific understanding of hydrological processes, water quality dynamics, and ecosystem interactions provides the foundation for sustainable water management, while technological innovations such as smart monitoring systems, advanced treatment methods, and efficient water-use

technologies enhance conservation and resilience. The findings emphasize that science- and technology-driven approaches significantly improve water availability, efficiency, and decision-making when supported by effective governance and policy frameworks. However, challenges related to cost, accessibility, and institutional capacity remain, particularly in developing regions. Therefore, achieving long-term water sustainability requires not only continued scientific research and technological advancement but also inclusive policies, capacity building, and stakeholder participation. Strengthening the integration of science, technology, and governance is essential for ensuring equitable access to clean water and safeguarding water resources for future generations.

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FISHERIES DEVELOPMENT PROGRAM ON MAJALGAON RESERVOIR IN MAHARASHTRA STATE, INDIA

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Abstract

Majalgaon Dam it's a second stage of Jayakwadi Project of Nath Sagar was constructed on the River Sindphana which is a tributary of River Godavari, in Beed District (Maharashtra, India) in 1987. The River Sindphana has been under constant threat of pollution by sewage and industrial wastes, disposal of dead bodies, deforestation, excessive use of fertilizers and pesticides, bathing and water development programmes. The dam has a catchment area is 3840 sq. km. It is of great Importance for the region because its water is used for human and cattle consumption, power generation, fish production and irrigation. A total of 24 species of phytoplanktons, 24 species of zooplanktons and 16 species of fishes were identified. i.e. *Catla catla*, *Cyprineus Corpio*, *Labeo Rohita*, Silver Carp, *Mrigal*, *Barbus*, *Ticto*, *Ophiocephalous*, *Mestembaleus armatus*, *Wallago attu* *Channa marulius*, *Labeo calbasu*, *Clarius batracus*, *Mystus cavasius*, *Chnna punctatus*, *Channa orientalis*. etc. Water quality of the dam was also studied for physico-chemical parameters including total dissolved solids, dissolved oxygen, free CO₂, BOD, COD, and total hardness etc. for one year (June 2023 to May 2024). Results reveled that water quality is normal and favorable for the cultivation of fishes.

Key words : *Limnology, fish production and socio-economic condition of fisherman.*

Introduction

India has a large network of river, canals, lakes and ponds, which contribute more than 30% of the total fish production. Majority of our people suffer from hunger and malnutrition. Fish is an excellent food for man and provides protein, fat and vitamin A and D, which are essential for the health of man. Fish is also provide source of vitamin B, it food rich in protein is specially preferred for containing essentially amino acid such as Lysine and methionine abundantly required for formation of phospholecithine in gray matter of the brain unsaturated fat in fish also reduce the risk of formation of high blood cholesterol. Phosphorus and several minerals are also present in it. They have good test and easily digestible. Besides being a rich source of food, fishery provides job opportunities also. By product of fishes i.e. fish manure, isinglass and several other production of commerce.

Considerable studies on fish diversity from different fresh water bodies of India have been carried out during the last few decades Hamilton Buchanan (1822), Day (1878), Mishra (1962), Jayram (1981) Thomus et.al. (1989), Talwar & Jhingrah (1991), Menon (1992), Rao et.al (1999). Sarkar and Banergee (2000), Mishra et.al. (2003). There are over 19000 reservoirs in India. Covering 3, 15,366 ha. And many more are under construction. (Suguman 2000) Reservoir Fishery in India is also important from social economic point of view as it has the potential of providing employment to about 2 million people (Khan Et.al.1999). According to Sreenivasan (1993) the Maharashtra is endowed with an area of 1, 79,430 ha. Under reservoir and the state produces 516 tones of fish of these area the state fisheries corporation was operating in 6,272 ha. Of reservoir and marketing the catches.

The present investigation was under taken to study the aquatic vertebrate animals with reference to fishes from Majalgaon dam reservoir water. It is a second stage of Jayakwadi

Project of Nath Sagar. It is irrigation project of Maharashtra state. It is situated in the latitude 16°01'68"N and longitude 73°02'26"E. It is multipurpose type like irrigation and power production and also fishing purposes

Table No. 1: Highlight of Majalgaon dam reservoir.

Name	Majalgaon dam Jaikwadi project Stage – II
Type	Multipurpose (Irrigation and Power production)
River	Sindhphana
Basin	Godavari
Location	2 Km. u/s of Majalgaon Dist-Beed (M.S.)
Year of start of Construction	1977
Year of completion	1987
Catchment area	3840 Sq.Km.
A.V. Rainfall in C.A.	800 mm.
Submerged area	7813 Ha.

Material and Method

The fishes were collected from the Majalgaon dam reservoir with the help of fisherman during the year June 2023 – May 2024. The specimen were preserved in 10% formalin and subsequently identified following work of Lagler (1956) Menon and Talwar (1972), Day (1878), Datta Munshi & Srivastav (1968), Jayram (1981) and Talwar & Jhingran (1991).

Result and Discussion

Fish as constitute economically a very important group of animals. A large number of dams and reservoir has been constructing during the recent year to provide water for irrigation and power production. These bodies of water offer immense scope for fish culture for successful fish farming in dam and reservoir.

The Sixteen species of the fish fauna in this study belonging to four order and six families are given in the table No. 2 among them order Cypriniformes was dominant with eight species to be followed by the Mastalimbeliformes, Osteoglossiformes, and Ophiocephaliformes each with one species. Valsangkar (1993) recorded 17 indigenous and 5 introduced fish species from Shivaji Sagar reservoir. Sakhare (2001) recorded 23 fish species belonging to 7 orders in Jawalgaon reservoir in Solapur district. Pawar and Madlapure (2002) recorded 16 fish species belonging to 5 order in sivur dam.

Fish Production on Majalgaon Dam

Table No. 2: Fish diversity from Majalgaon Dam reservoir

Class – Pisces	Family -3 – Siluridae
Sub-class – Teleostomi	Species – 8 – Wallago altu
Order 1 – Cypriniformes	Order – 2 – Mastaembeliformes
Family 1 – Cyprinidae	Family 4 – Mastamecembelidae
Speices – 1 – Catla Catla	Species 9 – M. armatus
Species 2 – Labeo rohita	Order 3 – Osteoglossiformes
Species 3 – Cirrhina mrigal	Family 5 – Notopteridae
Species 4 – Cyprinus carpio	Species – 10 – N. chital
Speices 5 – Silver carp	Order 4 – Ophiocephaliformes
Species 6 – Barbus ticto	Family 6 – Channidae
Family 2 – Bagridae	Speices – 11 – Channa Staitus
Species 7 – Mystus seenghala	

It was very difficult to find out the exact fish production of the Majalgaon Dam reservoir because fisherman never maintain the record noted of their catches. It was very

difficult to find out the growth rate of fish from the reservoir because of non availability of scientific data. The total production was approximately 4.5 tone and costs was in rupees 2.30 lakh per year.

Marketing of Fish

Fisherman themselves catch the fishes and sold them at distance market at Aurangabad, Hyderabad, Mumbai, Gulbarga, Nizamabad. They also sold fishes at local market Majalgaon. Nitrud, Talkhed, Patrud, Takarwan, Rajegaon, Dharur, Wadwani, Telgaon, Georai, Parli, Beed and Pathri. Fishes, after assembling, were sold to the merchant and send them to distance market. While transporting fishes, fishes are packed with ice in bamboo boxes.

Co-Operative Society

Manik Shah Fish Business Co-operative Society Bhatwadgaon Tq. Majalgaon Dist. Beed. State Maharashtra.

1 Date of Registration - 15 Dec. 1987. 2. Registration No. - BHR / MGN / RSR / CN / 1053. 3 Total no. of member - 41.

Socio-Economic Condition of Fisherman

The most important factor that influence the utilization and development of the fishery resources in the socio-economic condition of the fisherman.. This caused them to depend upon middle man for the marketing of their producer and naturally the major portion of the profit goes in the pocket of middleman. The fisherman of this society are belong to the casts such as, Bhoai – 90 % Fisherman & Muslims – 10 % fisherman.

Suggestions for Improvement of Fisheries and Socio-economic Condition of the Fisherman

For the development of fisheries that increases the fish production and socio-economic condition of fisherman following recommendations such as,

1. The fisherman community should be tread in modern methods of fish culture and fishing, so that production can be increased of the reservoir.
2. The well-equipped fish seed production center highly progressively of fish seed production.
3. They should be a constant cold storage plant to keep the fishes for sell in different seasons.
4. Fisherman should be provided with educational and health facilities, so that their children can be learnt and heath of fisherman should be normal.
5. Fisherman should be educated so that they can leave away their addiction.
6. Illegal fishing should be stopped, so that loss of fish can be checked.
7. Fisherman should have speedy transport facilities and storage facilities so that they can transport product quickly to the distance market.
8. Pollution due to agricultural waste and demonic sewage should be prevented.
9. In the future, stocking policy and total survey of the available stock is necessary.
10. Regularly the study of ecological as well as biological aspects should be done for efficient management of the reservoir.

Future Scope For Development of Fisheries of Majalgaon Dam Reservoir

At present study the future scope of the production increased at Majalgaon Dam reservoir such as –

1. Adequate stocking of fish seed is necessary. They were stocked C. mrigal, Cyprinus carpio. If fish seed of Ciprous, Rohu, Mrigal and Catla catla is stocked then it will increase the production.
2. Marketing should be done through the co-operative society only instead marketing through agents.

3. Fresh water prawn can be cultured along with Indian major carp.
4. Illegal fishing should be prevented.
5. Complete irradiation of weeds like Hydrilla, Vallisneria, Typha and Ipomoea from the tank. So that fishes can swim freely in the reservoir and netting operation will not be hampered.
6. Mixed fish culture should be adopted such as culture of Indian major carps and exotic carps to increase production.
7. Removal of predatory fishes is necessary.
8. It is suggestive to culture fresh water prawn along within major carps to increase production from the reservoir.
9. Fisherman should be educated for the development of reservoir fishery.

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ROLE OF RENEWABLE ENERGY TECHNOLOGIES IN ACHIEVING SUSTAINABLE DEVELOPMENT GOALS (SDGS)

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Abstract:

Renewable energy technologies play a critical role in advancing the United Nations' Sustainable Development Goals (SDGs), especially in addressing environmental, economic, and social challenges. Technologies such as solar, wind, hydropower, and bioenergy contribute significantly to SDG 7 by increasing access to affordable and clean energy, while also supporting climate action (SDG 13), economic growth (SDG 8), and improved well-being (SDG 3). The transition from fossil fuels to renewable sources reduces greenhouse gas emissions, enhances energy security, and promotes inclusive development. However, implementation faces barriers like high initial costs, technological constraints, and policy challenges. Overcoming these through innovation, investment, and supportive governance can accelerate sustainable development globally.

Keywords: Renewable energy; Sustainable Development Goals; Solar energy; Wind power; Climate action; Clean energy

Introduction:

Renewable energy technologies have emerged as central to achieving the **2030 Agenda for Sustainable Development** as adopted by the United Nations. The Agenda includes 17 Sustainable Development Goals (SDGs), with SDG 7 explicitly focusing on *ensuring access to affordable, reliable, sustainable, and modern energy for all*. Renewable energy sources—such as solar, wind, hydropower, geothermal, and bioenergy—offer environmentally friendly alternatives to fossil fuels that contribute to sustainable development on multiple fronts.

Energy is a foundational driver of modern societies; it powers homes, industries, transportation, and communication systems. Yet, conventional energy production relying on coal, oil, and natural gas has caused severe environmental degradation, air pollution, and increased greenhouse gas emissions. This has contributed to climate change, which poses significant challenges to sustainable development goals across the globe. Renewable energy technologies help address these challenges by providing clean energy, reducing carbon footprints, and fostering resilient energy systems.

The role of renewable energy technologies in achieving sustainable development is multifaceted. First, they directly support **SDG 7 (Affordable and Clean Energy)** through the deployment of solar photovoltaic (PV) systems in off-grid rural areas and the expansion of wind energy capacity in urban centers. Solar technology, for instance, has become more accessible due to falling costs and government incentives, enabling communities without grid access to harness clean power.

Second, renewable energy supports **SDG 13 (Climate Action)** by mitigating greenhouse gas emissions. Unlike fossil fuels, renewable sources emit little to no carbon dioxide during electricity generation, thereby reducing the energy sector's contribution to climate change. This reduction is vital to meeting the Paris Agreement targets and keeping global temperature increases below 2°C.

Third, renewable energy contributes to **economic growth (SDG 8)** and job creation. Investment in renewable energy infrastructure creates employment opportunities in manufacturing, installation, maintenance, and research sectors. Countries heavily investing in renewables—such as solar and wind—have demonstrated significant job market growth within their renewable sectors, which has broader socioeconomic benefits.

Fourth, access to clean energy improves public health and well-being (**SDG 3**) by reducing air pollution associated with burning fossil fuels. Cleaner air reduces respiratory and cardiovascular diseases, lowering health care costs and improving quality of life.

Despite its benefits, renewable energy deployment faces several barriers. High initial capital costs, technological limitations, intermittency issues (solar and wind availability), and inadequate policy frameworks impede swift adoption in many developing regions. To overcome these challenges, governments, private sectors, and international organizations must collaborate to provide targeted incentives, facilitate technology transfer, and strengthen regulatory frameworks.

In summary, renewable energy technologies are pivotal to achieving multiple SDGs, making the transition from conventional energy systems a global priority. Their contributions extend beyond clean energy access to encompass climate mitigation, economic development, and improved human health outcomes—each central to the broader agenda of sustainable development.

Computational Details (Methodology)

To evaluate the impact of renewable energy technologies on the attainment of SDGs, this research adopts a mixed **qualitative and quantitative approach**. The methodology comprises three major phases: data collection, indicator selection, and analytical modeling.

Data Collection and Sources

The study collects data from global and regional energy databases including:

- International Renewable Energy Agency (IRENA) statistics
- United Nations SDG indicators database
- World Bank energy sector data
- National renewable energy policies and reports

Quantitative metrics such as renewable energy capacity (GW), percentage of electricity from renewables, CO₂ emissions reduction, and energy access rates were compiled for a representative sample of countries across developed and developing regions.

Indicator Selection

Key indicators are aligned with relevant SDGs, particularly those closely associated with energy and sustainability:

- **SDG 7 Indicators:** Renewable energy consumption percentage, energy access rate, and average cost per kWh of renewable electricity
- **SDG 13 Indicators:** Annual CO₂ emissions per capita, percentage reduction in fossil fuel usage
- **SDG 8 Indicators:** Employment rate in the renewable energy sector, number of renewable energy projects funded
- **SDG 3 Indicators:** Air quality index and incidence of energy-related respiratory diseases

These indicators help quantify the extent to which renewable energy adoption correlates with improvements in targeted SDG outcomes.

Analytical Modeling

The following analytical methods were implemented:

Descriptive Statistics

Descriptive statistics provided an overview of renewable energy capacity trends, adoption rates, and economic impacts across regions.

Correlation Analysis

Correlation analysis was conducted to examine relationships between renewable energy uptake and SDG indicators such as emissions reduction and employment growth. Strong positive correlations indicate areas where renewable energy significantly influences SDG progress.

Comparative Analysis

Comparative analysis was conducted between countries with high renewable adoption (e.g., those with >40% renewable share) and those lagging. This helps identify best practices and key policy interventions that enabled success.

Results and Discussion

Results indicate a significant positive relationship between renewable energy technologies and progress toward various SDGs.

Renewable Energy and SDG 7

Countries with substantial renewable energy integration show marked improvements in universal energy access. Solar micro-grids in rural regions have dramatically increased electrification rates where extension of traditional grids was economically unfeasible. Wind and hydropower integration in national grids has stabilized energy supply, reducing outages and increasing reliability for industrial and residential users.

Renewable Energy and Climate Action (SDG 13)

Adoption of renewable energy has been shown to reduce greenhouse emissions significantly. Nations shifting away from coal and oil toward renewables report lower per capita CO₂ emissions, illustrating the positive impact on climate goals. Solar and wind power, in particular, stand out because of their scalability and low operational emissions.

Economic and Employment Benefits (SDG 8)

Investment in renewable technologies correlates with job creation in manufacturing, installation, operations, and maintenance sectors. For example, large-scale solar farm projects not only provide construction phase jobs but also long-term technical positions, thereby contributing to **inclusive economic growth**.

Health and Well-Being (SDG 3)

Reduction in air pollution owing to fewer fossil fuel emissions supports public health. Cleaner environments decrease the incidence of respiratory diseases, leading to improved health outcomes and reduced healthcare costs.

Barriers to Adoption

Despite these benefits, several barriers persist:

- **High Upfront Costs:** Initial investment for renewable infrastructure remains a hurdle, especially for developing countries.
- **Intermittency Challenges:** Solar and wind are variable energy sources requiring storage solutions and grid upgrades.
- **Policy and Regulatory Limitations:** Inconsistent or inadequate policies slow progress.

Effective policy frameworks, financial incentives, and international cooperation are essential to overcoming these challenges.

Conclusion

Renewable energy technologies are indispensable tools in achieving Sustainable Development Goals. They directly support **affordable and clean energy (SDG 7)**, contribute to **climate action (SDG 13)** by reducing emissions, foster **economic growth (SDG 8)** through job creation, and improve public health by reducing air pollution. The transition

toward renewable energy is complex, with economic and technical barriers that require coordinated policy action, technological innovation, and investment. Continued global cooperation in research, financing, and implementation will accelerate progress toward the SDGs. Ultimately, scaling up renewable technologies is not only an environmental necessity but also a strategic pathway toward equitable and sustainable development.

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A SURVEY ON ROLE OF COMPUTER IN ENVIRONMENTAL SUSTAINABILITY

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Abstract

Environmental sustainability has emerged as a critical global concern as climate change intensifies, pollution levels rise, and natural resources continue to decline. This research paper examines the vital role of computer technology in advancing environmental sustainability. Computer-based systems support effective monitoring, analysis, prediction, and management of environmental processes, enabling informed and timely decision-making. Technologies such as data analytics, artificial intelligence, remote sensing, geographic information systems, and smart monitoring platforms allow accurate assessment of environmental conditions and optimize the use of resources. These innovations help reduce pollution, improve energy efficiency, promote sustainable agriculture, manage waste, and conserve biodiversity. By integrating computer technology into environmental planning and policy, governments and organizations can develop more sustainable and resilient systems. This study reviews relevant literature, evaluates current technological applications in environmental management, and highlights emerging trends in computer science that can further support sustainable development. The findings emphasize that computer technology is an essential tool for achieving long-term environmental sustainability and addressing complex ecological challenges in a rapidly changing world.

Keywords: Environmental Sustainability, Computer Technology, Artificial Intelligence, Data Analytics, Remote Sensing, Geographic Information Systems (GIS), Smart Monitoring Systems, Sustainable Development

Introduction

Environmental sustainability involves the protection of natural ecosystems, the conservation of finite resources, and the preservation of environmental quality to ensure the well-being of present and future generations. Rapid industrialization, urbanization, and population growth have intensified environmental problems such as climate change, biodiversity loss, deforestation, and various forms of pollution. Traditional conservation methods, though valuable, are no longer sufficient to address the scale and complexity of these challenges. In this context, technology—particularly computer technology—has become an essential component of modern environmental management.

Computer systems enable the efficient collection, storage, and processing of vast amounts of environmental data obtained from sensors, satellites, and monitoring networks. Advanced computational tools support predictive modeling and simulation, helping scientists forecast climate patterns, assess environmental risks, and evaluate the long-term impacts of human activities. Automation and intelligent control systems optimize the use of natural resources such as water and energy, reducing waste and improving efficiency. Furthermore, computer-based management systems assist governments, researchers, and organizations in designing, implementing, and monitoring sustainable development policies. By integrating data analytics, artificial intelligence, and digital decision-support tools, computer technology strengthens environmental protection strategies and plays a crucial role in achieving sustainable and resilient ecosystems.

Several researchers have highlighted connections between computing and sustainability:

- **Remote sensing and GIS:** Satellite data processed by computers have been widely used to monitor deforestation and land use changes. Studies show significant improvements in early detection of environmental degradation (Turner et al., 2015).
- **Smart energy systems:** Computer-based energy management systems in buildings reduce energy consumption by up to 30% (Smith & Patel, 2018).
- **Precision agriculture:** Use of computer analytics for irrigation and fertilizer application has resulted in reduced resource waste and increased agricultural sustainability (Zhang et al., 2020).
- **Climate modeling:** Supercomputers have enabled accurate climate simulations that help in policymaking and disaster preparedness (IPCC, 2022).

These studies emphasize the multifaceted role of computing in environmental sustainability.

The primary objectives are:

1. To investigate how computers support environmental monitoring.
2. To evaluate computer-aided systems for resource optimization.
3. To analyze the contribution of computer applications in pollution control.
4. To explore future trends where computing can enhance sustainability.

Methodology

This study adopts a qualitative research approach supported by region-level statistical data. Secondary data are collected from government statistical reports, Census of India publications, energy development agencies, and records of agriculture and environment departments. The data include indicators such as rainfall variability, groundwater levels, agricultural productivity, energy consumption, and pollution levels. Case studies focus on the application of computer-based technologies, including solar energy systems, digital irrigation technologies, and GIS-based land and water resource monitoring. A comparative assessment is conducted to examine environmental conditions before and after the adoption of computer-driven interventions, highlighting their impact on resource efficiency, sustainability, and overall environmental management.

Findings

The study reveals that computer technology plays a significant role in strengthening environmental sustainability. In environmental monitoring, computers process real-time data obtained from sensors, satellites, and digital records to track air quality, groundwater levels, soil moisture, rainfall patterns, and temperature variations. This continuous monitoring supports the timely identification of environmental risks such as droughts, floods, and water pollution. Climate prediction and modeling tools assist in analyzing rainfall variability and extreme weather events, which is particularly important for regions dependent on agriculture and natural resources. Smart resource management systems enhance efficiency in energy distribution through solar-based smart grids, optimize water supply using digital leak detection and irrigation management software, and improve waste management through automated monitoring and route planning systems. Computers also support pollution control by analyzing emissions from vehicles and industries, enabling data-driven regulatory and policy actions. Furthermore, digital platforms, mobile applications, and e-governance initiatives promote environmental awareness and encourage sustainable practices among citizens. Computer technology enhances environmental sustainability across multiple dimensions by improving the effectiveness of planning and management systems. First, efficiency is increased through advanced algorithms that optimize the use of energy, water, land, and other natural resources, reducing waste and operational costs. Second, computers provide high accuracy by processing large volumes of precise data collected from sensors, satellites, and monitoring devices, which minimizes uncertainty in environmental analysis and decision-making. Third, automation plays a crucial role by reducing human error and manual labor in continuous monitoring, data collection, and control systems, ensuring reliable and timely responses to environmental changes. Finally, computer-based systems offer strong scalability, allowing environmental solutions to be expanded from small, local

projects—such as village-level water management—to regional, national, and even global environmental planning and sustainability initiatives.

However, challenges include:

- Energy footprint of computing systems
- Electronic waste (e-waste)
- Digital divide limiting access in underdeveloped regions

Despite the significant benefits of computer technology in promoting sustainability, several challenges remain. One major concern is the high energy consumption of computing systems, data centers, and digital infrastructure, which can increase carbon emissions if powered by non-renewable energy sources. Another serious issue is the growing problem of electronic waste, as rapid technological advancements lead to frequent replacement of devices, creating disposal and recycling challenges that harm the environment. Additionally, the digital divide continues to limit access to computer technology in underdeveloped and rural regions, restricting the widespread adoption of digital environmental solutions. Addressing these challenges is essential to ensure that computer technology contributes positively to long-term environmental sustainability.

Solutions include promoting green computing, recycling of IT hardware, and decentralized training programs.

Case Studies

Case 1: Smart Cities Initiative -Cities like Singapore and Copenhagen use computer-based traffic and pollution monitoring systems to achieve lower emission levels and efficient public services.

Case 2: Precision Agriculture- Farmers using computer-driven sensors and GPS have reduced chemical use and increased crop yields sustainably.

Case 3: Climate Forecasting with Computers -Programs like NASA's Earth Observing System depend on computational models to forecast climate shifts and advise governments.

Conclusion

Computer technology plays a pivotal role in environmental sustainability. From monitoring ecosystems and predicting future conditions to managing resources more efficiently and encouraging sustainable behaviors, computers help create intelligent solutions to environmental challenges. Moreover, future developments in machine learning, IoT (Internet of Things), and cloud computing will further enhance the ability of societies to achieve sustainability goals. To maximize benefits, sustainable computing practices must be adopted alongside these technological advancements.

Recommendations

- Promote green computing practices
- Increase investment in environmental data infrastructure
- Encourage cross-sector collaboration among technology, and policy agencies
- Expand digital literacy to enable wider use of sustainability applications

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INNOVATIVE CONTRIBUTIONS OF COMPUTER SCIENCE IN ACHIEVING GLOBAL SUSTAINABILITY

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Abstract:

The increasing environmental crisis has led to an urgent need for sustainable practices across all sectors. Computer Science, with its vast array of tools and technologies, provides innovative solutions to address critical global challenges, from climate change to resource depletion. By leveraging data science, artificial intelligence (AI), machine learning (ML), and computational modelling, Computer Science enables precise resource management, efficient energy use, sustainable agriculture, and green technologies. Artificial intelligence (AI) has both positive and negative consequences on people and the environment, and much research and evaluation are now underway. The rise of artificial intelligence (AI) and its growing impact across multiple sectors warrants a study of its impact on the Sustainable Development Goals. This paper explores the transformative impact of Computer Science on sustainability, emphasizing the importance of interdisciplinary collaboration, emerging technologies, and scalable solutions for long-term environmental impact.

Keywords: Computer Science, Global Sustainability, Artificial Intelligence, Green Technologies, Data Science, Climate Change, Renewable Energy, Smart Systems

Introduction

As global environmental challenges intensify, the need for sustainable development has never been more urgent. Sustainability, in its broadest sense, aims to balance ecological health, economic development, and social equity. Achieving this balance requires a coordinated effort across industries, governments, and civil societies. Computer Science plays a pivotal role in this endeavour, providing the technologies, tools, and frameworks necessary for informed decision-making, predictive modelling, and resource optimization. This paper delves into the contributions of Computer Science to sustainability, focusing on key areas such as renewable energy, green computing, sustainable agriculture, and climate change mitigation.

Computational Solutions for Energy Efficiency and Renewable Energy

Sustainable energy solutions are critical to reducing carbon emissions and mitigating climate change. Computer Science enables significant advancements in renewable energy and energy efficiency by:



Fig.1 Smart Grid

- **Optimization Algorithms:** Advanced algorithms used to optimize power generation, distribution, and consumption. For example, in solar power, AI-based algorithms maximize energy output based on weather predictions and energy demand.

- **Smart Grid Technologies:** Computer science helps create “smart grids,” which use IoT (Internet of Things) sensors, machine learning models, and AI to manage electricity demand and supply efficiently, incorporating renewable energy sources like wind and solar.
- **Energy Storage Solutions:** Computational models play a crucial role in enhancing energy storage systems (like batteries), ensuring energy is stored and distributed efficiently, especially from intermittent sources like solar power.

Example: IBM's Green Horizons project uses AI and big data to optimize energy generation and reduce emissions from power plants.

Green Computing: Paving the Way for Sustainable IT

Green computing refers to the environmentally responsible use of computers and computing resources. The role of Computer Science in promoting green computing includes:



Fig.2 E-Waste Mgt. In Green Computing

- **Energy-Efficient Hardware and Software:** Designing low-power processors, energy-efficient software, and systems that reduce electricity consumption, contributing to lower overall environmental impact.
- **Sustainable Data Centres:** Data centres are among the highest consumers of energy globally. Innovations in cloud computing, virtualization, and energy-efficient cooling technologies can drastically reduce their carbon footprint.
- **Circular Economy in IT Hardware:** Computer Science can aid in extending the life cycle of electronic devices through repair, reuse, and recycling methods, reducing e-waste and the demand for raw materials.

Example: Microsoft's investment in carbon-negative data centres, which run entirely on renewable energy, reduces operational emissions and improves energy efficiency.

Artificial Intelligence and Machine Learning for Sustainable Agriculture

AI and machine learning are revolutionizing sustainable farming practices by improving resource management and boosting agricultural productivity:

Artificial intelligence (AI) is the replication of human intelligence in robots that have been trained to think and act like humans. The phrase can also refer to any machine that demonstrates human-like characteristics like learning and problem-solving.

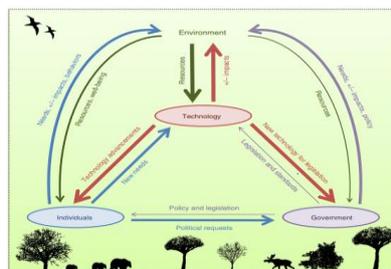


Fig.3 Interaction of AI and society.

- **Precision Agriculture:** AI-based systems help farmers monitor soil health, water usage, and crop diseases, enabling them to make data-driven decisions for efficient land use and resource management.

- **Automated Farming:** Robotics, AI, and machine learning are applied to automate tasks such as planting, harvesting, and irrigation, reducing water usage and labor costs while increasing yield.
- **Climate Resilience:** Machine learning models are also being used to predict climate impacts on crops, helping farmers adjust to changing weather patterns.

Example: AI-powered drones in precision farming can monitor crop health and provide real-time data to optimize inputs like water, fertilizers, and pesticides.

Big Data Analytics: Informing Sustainable Policies and Decision Making

Big data plays a key role in monitoring environmental changes and informing sustainability policies. Computer Science enables the collection, analysis, and interpretation of vast datasets through:

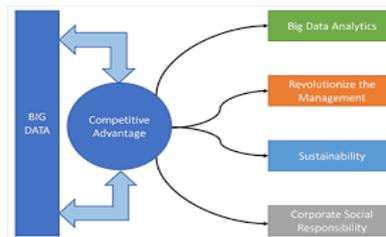


Fig.4 Impact of Big Data on Innovation.

- **Environmental Monitoring:** Satellite imagery, sensors, and IoT devices collect real-time data about air quality, deforestation, and ocean health. This data is analyzed to track environmental changes and predict future trends.
- **Sustainability Indexes:** Big data tools are used to measure the effectiveness of sustainability initiatives, allowing governments and organizations to track progress on the United Nations' Sustainable Development Goals (SDGs).
- **Disaster Preparedness:** Big data also assists in disaster risk management by predicting natural disasters, thereby reducing human and economic costs.

Example: NASA's Earth Observing System Data and Information System (EOSDIS) provides comprehensive satellite data that supports climate monitoring and disaster relief efforts globally.

Smart Cities: Combining IoT and Data for Sustainability

Smart cities utilize interconnected technologies to create urban environments that are energy-efficient, sustainable, and more liveable. Computer Science facilitates smart city innovations through:

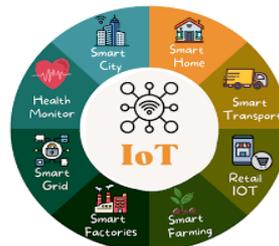


Fig.5 IOT Based Smart Cities.

- **IoT-Based Urban Infrastructure:** IoT devices help cities monitor and manage infrastructure such as traffic systems, waste management, and energy usage, reducing waste and optimizing resource use.
- **Smart Mobility:** AI and IoT are integrated into urban transportation systems to reduce emissions, improve traffic flow, and promote sustainable transportation options like electric vehicles and public transport.
- **Waste Reduction:** Smart bins and automated recycling systems use AI to improve waste collection efficiency, reduce landfill usage, and promote recycling.

Example: Singapore's smart city initiatives use data-driven approaches to optimize water and energy use, traffic management, and public health services.

The Role of Computer Science in Global Sustainability Collaboration

In the global effort to tackle climate change, Computer Science serves as a connector between countries, industries, and research communities. Digital technologies facilitate:



Fig.6 Sustainable Development Goals.

- **Collaboration and Knowledge Sharing:** Online platforms, cloud computing, and collaborative tools enable global researchers, governments, and organizations to share data and best practices for sustainability.
- **Environmental Simulation:** High-performance computing (HPC) allows researchers to simulate climate models and run large-scale environmental studies, informing policy decisions and global agreements on climate action.
- **Digital Advocacy:** Social media, data visualizations, and interactive web platforms are powerful tools for raising awareness about sustainability issues and driving collective action.

Example: The Earth Summit and COP climate talks are supported by digital platforms and simulations that provide data-driven insights into the progress of global climate agreements.

Conclusion

The field of Computer Science offers numerous tools and innovative solutions that are critical in addressing the world's sustainability challenges. From energy optimization and AI-driven agriculture to the creation of smart cities and the application of big data for environmental monitoring, Computer Science is an indispensable ally in the fight for a sustainable future. The integration of emerging technologies and interdisciplinary collaboration will be essential in scaling these solutions for a global impact, ensuring that sustainability is not just a goal, but a reality.

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CONSERVATION OF RATANJOT (*ARNEBIA EUCHROMA*) (ROYLE) I.M.JOHNST: THREATS, STATUS, AND STRATEGIES FOR SUSTAINABLE MANAGEMENT

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Abstract:

Arnebia euchroma (Royle) I.M.Johnst (Commonly known as Ratanjot) is a perennial medicinal plant of the family Boraginaceae, Native to the Trans-Himalayan and Western Himalayan regions. Traditionally Valued for its red pigment (Shikonin) and diverse ethnomedicinal applications, the species has experienced significant declines in wild population due to overexploitation, habitat degradation, and climate change impacts. The current conservation scenario necessitates integrated strategies combining in-situ protection, ex-situ propagation, community engagement, and sustainable use.

Introduction:

Arnebia euchroma (Royle) I.M.Johnst is an endemic medicinal plant of mountainous ecosystems, found across dry alpine and cold desert zones of the Himalayas (e.g., Ladakh, Himachal Pradesh, Uttarakhand) at high elevations. The plants has been traditionally used in Aurvedic, Unani, and local medicine system for treating skin ailments, inflammation, wounds, respiratory issues and as a natural dye source. Despite its ethnobotanical importance, *A. euchroma* faces significant conservation challenges attributable to unsustainable harvesting of its roots and increasing anthropogenic pressure. The limited regeneration rates and narrow geographical distribution further exacerbate its vulnerability

Classification:

Kingdom: Plantae

Clade: Angiosperms

Clade: Eudicots

Clade: Asterids

Order: Boraginales

Family: Boraginaceae

Genus: *Arnebia*

Species: *Arnebia euchroma* (Royle) I.M.Johnst

Synonym: *Macrotomia euchroma* (Royle) Paulsen

Common names: Ratanjot, Himalayan Alkanet



Plant Body

Habit and Habitat: Ratanjot is Perennial herb, native to high altitude alpine and cold desert regions of trans Himalayas, occurring at elevation of 3000-4500 m. it typically grows in rocky slopes, dry grasslands, and sandy or gravelly soils, under extreme temperature and moisture condition.

Description:

Root: thick, stout, perennial taproot, externally dark reddish-brown to purplish-black, rough, woody, brittle when dry.

Stem: Erect, branched, densely covered with stiff, whit, hispid hairs, herbaceous, slightly woody at base.

Leaves: Alternate, simple, Oblanceolate to linear-lanceolate, entire, apex acute to obtuse, base narrow, both surfaces densely pubescent with coarse hairs, Reticulate.

Inflorescence: Scorpioid cyme

Flower: hermaphrodite, Actinomorphic, Yellow with dark purple or black spots at the throat, short pedicel. 5 sepals, deeply divided, linear- lanceolate, persistent, hairy, 5 petals, hamopetalous, tube short, limb spreading, 5 stamens, epipetalous anthers included within corolla tube, Bicarpellary, syncarpous, superior ovary, deeply 4 lobed, style gynobasic, stigma capitate.

Fruit: Schizocarp, 4 nutlets, ovoid, Hard, Brown to Black, rugose.

Seed: One seed per Nutlet.

Threats to *Arnebia euchroma*:

Overharvesting and Root Exploitation: The primary driver of Ratanjot Population decline is the unsustainable extraction of roots for commercial and medicinal uses. These roots containing contain high concentrations of naphthoquinone pigments (e.g., shikonin), but harvesting directly removes the plant's perennating organ, preventing regeneration.

Habitat Degradation and Human Activity: Unplanned economic development, infrastructure expansion (e.g., roads), livestock grazing and land-use change contribute to habitat fragmentation, making population more scattered and less viable.

Climate Change Impacts: Modelling studies predict shifts in suitable habitats under future climate scenarios, with both contraction and distributional changes potentially affecting population stability. Coupled with human footprint pressures, this poses additional risks to persistence in natural ecosystems.

Conservation Status:

Although exact IUCN red list status is not consistently updated online, multiple regional assessments categorize *Arnebia euchroma* as critically endangered or at least highly threatened in the Indian Himalayan context due to population declines and high exploitation pressure. Regional surveys further reinforce that overharvesting remains the most significant threat, with certain protected areas documenting population reductions directly tied to root collection.

Ecological importance:

Arnebia euchroma plays an important role in alpine ecosystem by contributing to plant community structure and supporting pollinators during flowering seasons. Its presence also correlates with specific soil and microhabitat conditions, indicating its value as an ecological indicator species.

Conservation Strategies:**In-situ Conservation:****Protected area Management:**

Expansion and enforcement of protected zones that encompass *Arnebia euchroma* populations would reduce extraction pressure.

Medicinal Plant Conservation Areas (MPCA):

Designation of priority MPCA Zones has been recommended to provide legal backing and focused management for threatened species habitats.

Ex-situ Conservation and Propagation:

Cultivation Protocols: Development of standardize propagation techniques (tissue culture, seed nurseries) can supply cultivated material for industries, alleviating pressure on wild stocks.

Seed Banks and Botanical Gardens: Storing genetic material and maintaining living collections safeguard against complete wild loss.

Community engagement And Sustainable Use:

Alternative Livelihoods: Incentivizing local communities with sustainable harvesting practices, agro-cultivation support, and economic alternatives helps align conservation goals with socio-economic well-being.

Awareness and Education: Programs targeting traditional healers and harvesters about regenerations, harvesting limitation and legal obligations can reduce indiscriminate root extraction.

Policy and Legal Frameworks:

Legislation Enforcement: Strict regulation of wild harvesting through regional conservation laws and integration with national biodiversity strategies (e.g., India's Biological Diversity Acts) can reduce exploitation rates.

Monitoring and Evaluation: Periodic population surveys and monitoring of habitat health are crucial for assessing conservation outcomes and adaptive management.

Research Gaps and Future Directions:

Population Ecology Studies: Longitudinal studies on *Arnebia euchroma* demography and regeneration success are necessary to tailor conservation action to species-specific life history traits.

Climate Adaptation Modelling: Further investigation into climate resilience and predicted range shifts will help prioritize climate resilient conservation sites.

Economic Valuation and sustainable Harvst: Quantify the socio-economic value of Ratanjot within local rural economies can inform cost benefit analyses for conservation investments.

Conclusions:

Arnebia euchroma faces multifaceted threats from overexploitation, habitat degradation, and climatic pressure leading to endangerment of natural populations. Conservation success will depend on integrated strategies combining ecological, socio-economic, and policy measures aimed at both preserving wild populations and meeting sustainable use need. Strengthening in-situ protection, promoting cultivation, engaging local communities, and supporting research are essential components of a comprehensive conservation framework.

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SCIENCE AND TECHNOLOGY FOR RURAL DEVELOPMENT

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Abstract

In the case of developing countries, the significance of science and technology for rural development has been recognized to a much greater extent. In rural areas, there have been improvements in various areas such as the livelihood of the people, educational institutions, medical and health care centres, small scale industries, agriculture, sources of energy, water, housing, information technology, space technology, women and employment opportunities. Developments and progress in all these areas have been as a result of utilization of innovative techniques and science. Rural people have understood the benefits of computers and television. In India, agriculture is the main occupation in rural areas and people have become aware of advanced agricultural techniques, irrigation methods, seeds, fertilizers and so forth. In this research paper, the researcher has highlighted science and technology from an Indian perspective, characteristics, and examples of appropriate technologies, applications of science and technology, significance of science and technology, and role of science academies. There have been developments in the rural areas but much more awareness and thoughtfulness is required for the further development of the rural areas.

Keywords: Science and Technology; Rural Development; Economic Growth; Poverty Alleviation

Introduction-

The importance of science and technology (S&T) to rural societies has been recognised since long. Though enormous strides have been made in the area of S&T in India since 1947, there is an urgent need to deliver them to the neediest so that they are able to meet the challenges of a technologically sophisticated world. Advances in technology continue to create newer methods of communication and information management, which have produced profound impact on the society at large. They have offered unprecedented opportunities and challenges for scientific endeavours. Though science has a universal character, it is supported or constrained by practices, which are influenced by local customs and values. In rural areas, behaviour patterns and practices are deeply rooted in traditional beliefs and superstitions that are not easily displaced by science or modern approaches based on new knowledge. The S&T policies for rural development need to take into account the nature of the local environment to effectively deliver the benefits of S&T to the rural society. Herein lies the challenge for the management of rural natural resources and environment.

Rural areas need to explore the socio-economic implications of new technologies, especially to predict their impact on society, identify emerging opportunities, and serve as an early-warning system for natural disasters. The rapid growth and unprecedented influence of new technologies, especially the information and communication technologies, including the Internet, are raising global awareness about the power of technology as a whole.

There is also a need to bridge the 'digital divide' between the urban and the rural areas by making these technologies more and more accessible by improving connectivity, computerisation and content areas. Similarly, in the context of pollution, environmental degradation and the need for sustainable development, harnessing the potential of S&T for systematic and coordinated use of local resources is a matter of paramount importance.

S&T Schemes and Programmes

Rural development is determined by the efficient, scientific and optimum assessment, conservation, utilization and distribution of rural resources. Science & technology and rural development are thus inter-related and inter-dependent.

Let us now have a look at some of the developmental areas in the context of S&T inputs. In the field of agriculture, advances in agricultural technology have revolutionized agricultural production. These include the use of high yielding and disease resistant seeds, fertilizers, pesticides, improved implements, irrigation and drainage, crop rotation and cropping patterns, storage, processing and marketing.

Various programmes linking S&T and rural development have been launched in recent times. The major ones are as follows:

Science and Society Programme of the Department of Science and Technology (DST), the Government of India. It includes S&T Application for Rural Development (STARD).

- S&T Application for Weaker Sections (STAWS).
- S&T for Women.
- S&T for Practical and Strategic Needs of SC Population
- Empowering Tribal Groups through S&T
- Scheme for Young Scientists.
- Several other programmes are also available for the development of animal husbandry and fisheries, which are integral parts of agriculture in rural India. These include:
- Dairy Development Programme (DDP),
- Fodder Development Programme (FDP),
- Intensive Cattle Development Programme (ICDP) and
- Special Livestock Production Programme (SLPP).

Awareness regarding S&T inputs arising from the researches being done in genetics and breeding, botany, microbiology and biochemistry are made available to one and all under these programmes. Setting up of poultry, piggery, fisheries and sheep production units and rearing of cross-heifers by small and marginal farmers and agricultural labourers are encouraged through these programmes.

Special programmes have been launched for the development of hill areas, tribal areas, drought-prone and desert areas, command areas, etc. by adopting area-specific approaches. Notable among these are:

- Hill Area Development Programme (HADP),
- Tribal Development Programme (TDP),
- Intensive Agricultural District Programme (IADP),
- Drought Prone Area Programme (DPAP),
- Desert Development Programme (DDP),
- Command Area Development Programme (CADP) and
- Whole Village Development Programme (WVDP).

In the field of rural housing, suitable indigenous building materials and improved cost-effective construction techniques are being developed and made available to the rural masses. Indira Awaas Yojana (IAY) was launched in May 1985 as a sub-scheme of Jawahar Rozgar Yojana (JRY). It is being implemented as an independent scheme since January 1, 1996. The other two important schemes in this field are: Pradhan Mantri Gramodaya Yojana (Gramin Awaas) and Samagra Awaas Yojana, which came into effect from April 1, 1999. The National Mission for Rural Housing and Habitat was also set up on the same date to facilitate the induction of S&T inputs on a continuous basis in the rural housing sector.

Applications of science and technology

The main objective of the science and technology applications is to empower the knowledge of the people. It means developing the capability amongst the individuals to achieve their goals and objectives through the generation, acquisition and use of knowledge.

1. Energy: Energy is essential for agriculture for inputs such as fertilizers, for delivery of water and for transportation. It is also needed to bring about rural industrialization. The single largest source of energy continues to be firewood, and this will continue for quite some time. Therefore, large scale afforestation efforts are called for on scientific lines and involving the rural population to meet their fuel requirements. Biomass generation through the techniques of tissue culture is of great benefit. The non-conventional energy sources which are renewable, decentralized and non-polluting are particularly relevant to rural areas which are unlikely to obtain electricity for their needs for a long time to come. Biogas plants, smokeless stoves, solar cookers, pumps, solar water pumping systems, solar domestic lighting systems, community lighting and television systems and solar battery charging units are the sources of energy that have led to decentralization of rural industrialization leading to generation of employment and transformation of natural resources into products of higher value.

2. Water: Water is the most crucial single resource for the survival of human life. Every effort will have to be made to improve the availability of drinking water in rural areas; it is necessary to devise and implement scientific methods for water harvesting, conservation and recycling. Clean water supply in the rural areas has to be given the highest priority; remote sensing is a powerful technique utilized for water targeting. This effort calls for community participation, technology transfer, evaluation and assessment of existing rural water supply systems, studies on maintenance of water distribution system, development and rehabilitation of springs and use of hydraulic rams for water supply in hilly areas, use of solar energy for rural water supply, development of integrated package for water treatment, to make the water drinkable.

3. Housing: Several technologies have been implemented to develop low cost building materials, designs and construction techniques; there has been availability of non-erodible mud

Plaster for the protection of mud walls from rain.

4. Biotechnology: In the field of biotechnology, developments relating to bio-fertilizers, aquaculture, biomass production through tissue culture techniques, embryo-transfer technology to upgrade cattle, herds, etc. have enormous, potential for employment generation and increasing efficiency and productivity for activities in daily life in rural areas; mechanisms to make these effective on a large scale have to be taken into consideration.

5. Information Technology: Use of information technology in sectors like agriculture, irrigation, energy, health, family planning, education, employment and transportation are vital for bringing about a major transformation in the rural sector. Information related to local resources, skills and expertise is important to carry out effective decentralized planning. The National Informatics Centre (NIC) was set up in 1975 by the Department of Electronics, it has developed a District Information System, and this established a centre in each district of the country. There are a large number of training and information transfer programs which have been based on the nationwide satellite communication network; this will assist in making available valuable information for district and local planning

6. Employment: Employment opportunities within the rural areas can be generated with inputs of science and technology in the areas of agricultural practices, animal husbandry, small scale industries, training and skill improvement of the rural people, education, awareness generation and popularization of scientific methods and approaches, biomass

cultivation, utilization and agro-processing through innovative biotechnological processes and health care centers.

7. Space Technology: There are a wide range of applications of remote sensing technology in areas of disaster warning for coastal fishermen, inland/marine fisheries, minor irrigation, water targeting for drinking water, wasteland identification, vegetation mapping, drought monitoring, etc. Already, with the use of space imagery ground water potential zone maps have been prepared for more than 370 districts which include 91 DPAP districts and 20 DDP districts. A new development relates to the forecast for better fish catches in the coastal regions by making use of the satellite data. It is expected that optimal utilization of space technology can result in better dissemination of information through satellite based communication and broadcasting. This will be of great relevance to remote areas.

8. Women: Women constitute half of the human resources and today, in India, carry out a very significant part of the farming operations. They are involved in field operations, plantation activities, livestock management, fisheries, sericulture, beekeeping, agriculture, forestry etc. It is essential to organize proper training programs for women and also to devise suitable implements which would reduce drudgery and improve their efficiency and productivity. Women can also be used as most effective disseminators and communicators for simple agricultural and post-harvest technologies and for health care delivery systems. Unless the women are fully associated in the developmental programs, the visible impact of these on society at large would not be felt. It is important that S and T relevant to programs is disseminated and implemented as it will have a major multiplier impact.

9. Technology Transfer: In India, there are large number of technologies available, for the effective implementation of the technologies, adequate science and technologies, manpower and infrastructure should be spread throughout the country. What are most urgently called for are proper mechanisms for transfer of technology and an appreciation of what technologies are needed and are appropriate. For this academic institutions, research laboratories, schools and colleges including agricultural medical and engineering institutions and voluntary organizations have all to be brought together through suitable networking. At present, most of the work is fragmented and compartmentalized making the impact much less than the potential.

10. Education: in India S&T improved our education system enough but there is need more so we have discuss here some important facts that are pointed by U.S. Department of education Reimagining the role of technology in education,2017. According to this national education technology plan updates various sections that are listed as:

- Section 1. Learning –engaging and empowering learning through technology.
- Section 2. Teaching –teaching with technology.
- Section 3. Leadership –creating a culture and Conditions for innovation and change.
- Section 4. Assessment –measuring for learning.
- Section 5. Infrastructure –enabling access and effective

Conclusions

Scientific approaches, studies and innovations are absolutely essential to solve the urgent problems that are being faced today in the rural areas. India being a very large country, with diverse geographical and ecological conditions, and varied socio cultural background of the rural population, a uniform prescription or model would be inappropriate for application in all the regions. The prescriptions will have, to be location specific, based on the local natural resources, using fully the skills of the local population to meet their aspirations and basic needs.

All the States and Union Territories have today has an organized institutional structure in the form of State S&T Council or Departments. These can act as focal points for

generating specific S&T programmes and activities for rural development. As mentioned earlier, the Central Science Departments and agencies have their own infrastructure spread over the different States. Therefore there can be a very close organic and live linkage between the Central S&T agencies and, the State structures for demonstration, dissemination of information, transfer of technology and extension. The task is not easy when one takes note of the highly variable socio-cultural patterns and complex problems. But it can be accomplished provided the scientific community is motivated and would accept the challenge, and if there is appropriate local involvement. As stated by our first Prime Minister, “It is Science alone that can solve the problems of hunger and poverty” We will have to work towards achieving this goal of harnessing science in all spheres of rural development, because ultimately the total national

Development would depend on the rapid progress of the rural areas. This will call for a joint effort of scientists, administrators and local people with the full support of the political structures.

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THE TAXONOMICAL ASSESMENT OF THE RUMEN CILIATE ELYTROPLASTRON BUBALI (DOGIEL, 1927) IN DOMESTIC GOAT (C.HIRCUS)

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Abstract:

To study the taxonomy of rumen ciliates from the genus *Elytroplastron* subfamily Diplodiniinae from rumen of Indian goat (*Capra hircus*) rumen samples were collected. The exhaustive taxonomic studies have been made in different parts of the world, but only a few such studies have been made in India. The present paper deals with the study of ciliates from the genus *Elytroplastron*. Morphology of the species with variations is described and body dimensions are recorded from the specimens taken at random (n=20) from different slides and compared with earlier reports.

Key words: Rumen, Ciliates, Diplodiniinae, *Elytroplastron*,

Introduction:

Dogiel (1927) first described *Elytroplastron bubali* as *Diplodinium (Polyplastron) bubali* from the rumen of water buffalo in Georgia. Thereafter Kofoid & Maclellan (1932) observed this species in Zebu cattle from India. On the basis of comparative study with the genus *Polyplastron* i.e. appearance of single long skeletal plate and also the presence of four contractile vacuoles along with dorsal midline of the body they proposed a new genus, *Elytroplastron* for this single species (Mermer *et al* 2003).

Several researchers Ogimoto & Imai (1981), Dehority (1993), Mermer *et al* (2003), and Zacarias *et al* (2022) have been reported from different host and localities since it's descriptions by Dogiel (1927) and Kofoid & Maclellan (1932). In India Banerjee(1955), M. Dasgupta(1935) and author (2007,) studied in ruminant hosts. Present paper deals with the morphometric study of *Elytroplastron bubali* from the domestic goat and compared with earlier study.

Material and Methods

During the present study rumen fluid samples were collected from 458 adult Indian goats *Capra hircus* slaughtered at abattoirs of Kannad, Dist. Aurangabad of Maharashtra State (India). After the removal of the stomach the rumen was slit open and 10-15ml of rumen fluid was collected in a glass vial then the immediately the glass vial was closed airtight and brought to the laboratory. It was centrifuged and preserved by adding 1:1 glycerine alcohol solution. To determine the intensity of the ciliates live specimen were examined under the microscope by taking drop of fluid on a clean glass slide. The permanent slides of the sample were made in duplicate stained by wet Tungstophosphoric Hematoxylin stain. Identification of genera and species of rumen ciliates were based on description published by earlier workers (Dehority,1993). All the measures of the ciliates were based on a study of 20 specimens (n=20) with an ocular micrometer.

Result and Discussion

Elytroplastron bubali, Dogiel 1927

Description of the species: - (Fig. 1)

The body of this species is large, heavy ellipsoidal. The adoral ciliary zone is relatively large comprises mouth. It is inclined ventrally at an angle of 25-30°. The left

ciliary zone is comparatively short than the adoral ciliary zone. The operculum is large, broad, extends anteriorly beyond the oral area. The body surfaces are smooth, dorsally it is more convex than the ventral surface, and ventral surface is slightly concave especially behind the oral area and just anterior to the anus. The greatest diameter measured in the middle of the body. The posterior end is smooth rounded without any caudal lobe or spine.

The oesophagus is narrow tubular, extends posterior into anterior third of the endoplasmic sack. The endoplasmic sack is relatively large occupies greater part of the body. The ectoplasm is thick well marked by distinct boundary layer. The rectum is a heavy, tubular structure found at the posteroventral end of the body beneath the right side of the body. The rectum opens through a narrow slit like anus extending from middle of the posterior end to the right side.

The macronucleus is an elongate, heavy rod shape body. It founds slightly to the right of the mid-line. The anterior end of macronucleus broader smoothly rounded. The posterior end is narrow, blunt ended. There is a small depression lies in the anterior dorsal side of macronucleus in which a small ellipsoidal micronucleus is situated. There are four contractile vacuoles lying along the left dorsal side of the macronucleus, one near the anterior end of the macronucleus, one at the level of micronucleus, one at the posterior one-third region of the macronucleus and one near the posterior tip the macronucleus.

There are four skeletal plates; two skeletal plates lie beneath the right surface. They extend diagonally from the edge of the adoral ciliary zone across the middle of the body. The first right dorsal skeletal plate made up of 6-7 rows of prisms. The second right dorsal skeletal plate is slightly narrower than the first. The third plate found beneath the left surface composed of 4-5 rows of longitudinal prisms. It extends from operculum diagonally across the left side. The fourth ventral plate extends only a short distance posteriorly from the ventral edge of the oral zone.

The body dimensions and other measurements of *Elytroplastron bubali* are given in table 1.

Table 1

The body dimensions and other measurements of *Elytroplastron bubali* are as below.
All measurements are in microns. (n=20)

Sr.No.	Parameters	Minimum	Maximum	Average
1	Body			
	Length	98.24	153.59	124.80
	Width	64.47	107.45	85.65
	L/W Ratio	1.28	1.71	1.26
2	Macronucleus			
	Length	55.26	98.24	76.29
	%Length to the Body	56.25	63.96	68.63
	Diam. Ant. End.	10.75	18.42	14.89
	Diam. Post. End	4.61	12.28	7.22
3	Micronucleus	4.61	7.68	6.22
4	Adoral ciliary zone (Mouth)	13.82	23.03	16.50
5	Left ciliary zone	10.75	18.42	14.12

Discussion

Dogiel (1927) was firstly described *Elytroplastron bubali* as *Polyplastron bubali* from the rumen of *Buffelus bubalus* from Georgia. Kofoid & Maclellan (1932) placed this species in a new genus *Elytroplastron* described as *Elytroplastron bubali* from *B.indicus* in

India, & Colombo. A comparison of the dimensions of the species described here and those given by earlier workers are given in table 2.

The table indicates that the species described here is larger in body length, width and length of macronucleus than the dimensions given by Kofoid & Maclellan (1932), Banerjee (1955), Ogimoto & Imai (1981), Dehority (1993) and Mermer *et al* (2003). However, the L/W ratio is smaller than the L/W ratio given by Kofoid & Maclellan (1932), Banerjee (1955), Ogimoto & Imai (1981), Dehority (1993) & Mermer *et al* (2003). The diameter of the mouth is also smaller than diameter of the mouth given by Kofoid & Maclellan (1932).

Table 2

Comparative body dimensions of *Elytroplastron bubali*

Parameters	Authors					
	Kofoid & Maclellan (1932)	Banerjee (1955)	Ogimoto & Imai (1981)	Dehority (1993)	Mermer <i>et al</i> (2003)	Present Study
Length	100-160 (132)	90-195	100-160	110-160 (132)	95.50-170.10 (132.66)	98.24-153.59 (124.80)
Width	67-97 (77)	50-125	76-100	67-97 (77)	40.30-116.50 (88.11)	64.47-107.45 (85.65)
L/W ratio	1.43-1.82 (1.69)	--	--	1.43-1.82 (1.69)	1.20-1.80 (1.51)	1.28-1.71 (1.26)
Ma.Nu.L	63-110 (83)	50-120	--	--	46.60-114.20 (81.39)	55.26-98.24 (76.29)
Mi.Nu. Dia	--	5	--	--	--	4.61-7.68 (6.22)
Mouth	28-40 (35)	--	--	--	--	13.82-23.03 (16.50)

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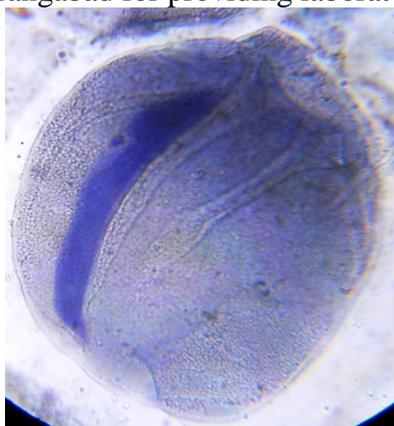


Fig.1 *Elytroplastron bubali*

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PHOTON INTERACTION CROSS-SECTION OF ELEMENTAL SOLIDS FE, CU AND AG IN THE ENERGY RANGE 0.360MEV-1.33MEV

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Abstract

The photon interaction cross-sections of thin uniform foil attenuators (Fe, Cu, Ag) were investigated in the 0.360–1.33 MeV energy range under a collimated narrow-beam geometry. Linear attenuation coefficient (μ), mass attenuation coefficient (μ/ρ), and total photon interaction cross-sections were determined for elemental foils of 0.15 cm thickness using an NaI(Tl) scintillation detector. Results show that with increasing photon energy, μ , μ/ρ , and σ_{total} decrease, whereas attenuation increases with atomic number.

Keywords: Linear attenuation, Mass attenuation, Total Photon interaction.

Introduction

The interaction of photon through material is of wide interest in industrial, medical and agriculture studies. With the advent of nuclear era, large number of isotopes and radiations generating equipments have come into existence. As a result, the protection from harmful radiation has become eminent. One of the important factors needed in radiation protection and shielding is the gamma ray attenuation coefficient. The present studies are aimed to protect individuals from harmful gamma radiation which has led us to present studies. Apart from this, the need of shield to protect against gamma radiation has further lead to extensive measurements on attenuation coefficient in different multi-elemental materials. There is an important parameter for characterizing the penetration and diffusion of gamma rays in the medium which is called mass attenuation coefficient. This parameter mainly depends on the photon energy, the nature of the material and the medium through which radiation passes. Till date, several investigators have carried out the systematic studies of attenuation coefficients by using narrow beam geometry [1- 3] from time to time. The accurate values of photoelectric cross-section for photon radiation in several materials are needed in solving various problems in radiation physics and radiation dosimetry. The photon cross-section data which are most often used are the compilation of reports from National Bureau of Standard, USA [4]. It is evident to note that most of the data are based on theoretical compilation and only a few are based on experimental measurements. Such a comparison is necessary to ensure that theoretically predicted values do indeed agree with experimental results [5]. This is particularly true in the case of low energy photons. Although a number of experimental measurements are reported in the literature [6], the work actually carried out is limited to a few energy points and materials. Further the experimental techniques used by different workers are not identical; hence it is difficult to inter compare the experimental results [7]. When photons are transmitted through a well collimated geometry properly aligned using LASER beam, the multiple scattered photons are not only minimized but also, prevented from reaching the detector and so are not measured. However, as the collimator size and sample thickness increases, the probability of multiple scattered photons reaching the detector increases. Thus, along with the unattenuated photons the multiple scattered photons are also measured.

The attenuation of gamma radiation through elements is interesting from its application point of view in industrial, medical and agricultural fields. Large numbers of

researchers have studied linear attenuation coefficient and mass attenuation coefficient of several elements with a view to understand the attenuation of gamma rays and provide the experimental data for various applications [8]. The attenuation of gamma rays in elements has been studied for variable energy and using narrow beam geometry. The study of attenuation coefficient of several elements can throw light on shielding properties and to find the density of materials. Taking into considerations the importance of gamma ray attenuation we have carried out systematic investigations of linear attenuation and mass attenuation coefficient of several elements such as Silver, Copper and Iron, for variable energy 0.360 MeV–1.33 MeV using narrow beam geometry technique. The elemental solids (moderate to high atomic numbers) under investigations are pure and have a thickness of 0.15 cm. The results obtained on linear attenuation, mass attenuation coefficient and total photon interaction cross-section of Silver, Copper and Iron are presented in the paper.

Experimental Section

The linear attenuation coefficient, mass attenuation coefficient and total photon interaction cross-section of Silver, Copper and Iron for varying energy have been measured using narrow beam geometry technique. The experimental set-up of narrow beam geometry used in the present measurement is shown in Fig.1.

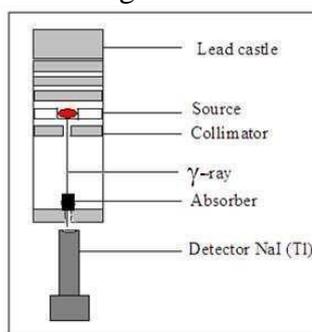


Fig.1 Schematic Apparatus used for the measurement of γ -ray absorption coefficient

The mono-energetic gamma radiations are derived from several radioactive sealed sources having photon energies ranging from 0.360 MeV to 1.33 MeV. The counting setup consists of source holder, incident and transmitted photon beam passing through collimators of Lead, well aligned. To minimize radiation exposure and background radiation contribution, the radioactive source was kept in a Lead source holder and placed subsequently in the Lead castle which is well shielded from all sides [9].

The transmitted photon beam is detected by a NaI(Tl) scintillation gamma photo spectrometer. The optimum voltage of 800 Volt was chosen to provide good resolution characteristic for the isotopes used. The detector was calibrated for various photon energies using radioactive isotopes Ba133, Cs137, Na22 and Co60. The photon transmission measurements were done under a narrow beam counting geometry employing high resolution scintillation detector. The NaI(Tl) detector was used in the present work. The NaI(Tl) scintillation detector used in the present work is 4.5 cm in diameter and 5.0 cm thick and is supplied by Nucleonix Enterprises, India. The experimental set-up consists mainly of two collimators of diameter 0.2 cm which is well aligned by LASER beam so as to provide a scatter free collimated photon beam. To establish the optimum collimation condition, the gamma ray spectra of Cs137 source were taken with the incident and transmitted collimated beam and were found to be identical and had unchanged energy resolution characteristic. The photon spectra thus taken establish that the energy of transmission photon did not change appreciably due to scattered or fluorescent radiation emanating from the collimators. A provision was made midway between the collimators to introduce absorbers which were in

the form of thin uniform foils. The entire system was arranged vertically over the NaI (TI) detector, ensuring that the central axis of incident and transmitted collimator are coaxial.

The source holder was kept over the collimator so as to allow, a narrow well collimated photon beam from the collimator incident normally on the thin absorber. The gamma spectrums from each source of photon energy 0.360 MeV to 1.33 MeV were recorded on the single channel analyzer pre set to record counts under the full energy absorption peak as shown in Fig 2.

The transmitted photons from the absorbers were accumulated for a set time so as to provide statistical variation within one percent. For absorption study of gamma ray, thin and uniform foils of high purity 99.9% of Silver, Copper and Iron were used in the present study.

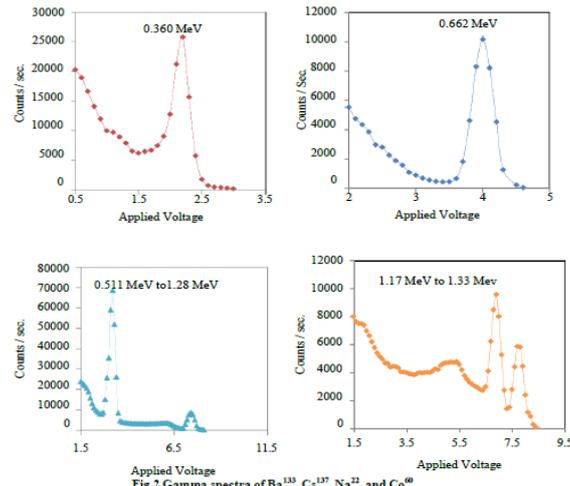


Fig.2 Gamma spectra of Ba¹³³, Cs¹³⁷, Na²², and Co⁶⁰

The areal densities of absorbers were obtained by comparing their weight measured on a micro balance, with their area. The counts under the full energy absorption peak of the recorded spectrum were taken without and with absorbers placed in sequence. The photon spectrum was recorded several times for each additional foil of thickness ranging from 0.15 cm to 1.50 cm. For each added foil thickness, average counts under the full energy absorption peak were obtained. The entire counting system was arranged in a dust free room to minimize contribution from scattered photon and also from contamination arising from the atmosphere and sealed radioactive sources stored in the laboratory. Care was taken to maintain, temperature variation due to environmental change as minimum so as to avoid any shift in the photo peak position of recorded gamma spectra. The average number of transmitted photon through different absorber foils were corrected for background and plotted against thickness to represent a linear curve on a semi-log graph paper. The slope of the graph provides the accurate value of linear attenuation coefficient μ (cm⁻¹) for specific gamma energy and absorber. Thus, experimental values of linear attenuation coefficient obtained using 0.2 cm diameter collimator were checked for contribution from scattered photons arising from different collimators of varying sizes.

Results and discussion

Linear attenuation coefficient

The probability of multiple scattered photon leads to the variation in the attenuation coefficient due to changes in thickness of multiple foil staging and variation in gamma ray energies. There is definitely some kind of correlation between absorber thicknesses due to attenuation coefficient gets affected. The linear attenuation coefficient μ (cm⁻¹) for collimator diameter 0.2 cm is calculated using following relation and experimental results are given in Table 1.

$$I = I_0 \exp [-\mu t] \quad 1$$

Where, I and I_0 are the photon intensities with and without absorber respectively, and 't' is thickness of the foil expressed in centimeter.

Table 1 Linear attenuation coefficient (μ) in the energy range (0.360 MeV-1.33 MeV) for Ag, Cu and Fe

Energy (MeV)	Ag	Cu	Fe
0.360	0.7045	0.5362	0.4777
0.511	0.5421	0.4365	0.3674
0.662	0.4844	0.3823	0.3225
1.170	0.3745	0.3052	0.2621
1.280	0.3362	0.2825	0.2445

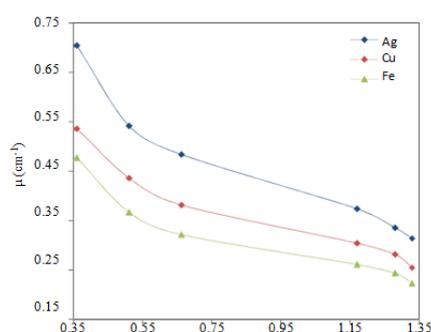


Fig 3 Plots of photon attenuation coefficient (μ) v/s photon energy (MeV) for Ag, Cu and Fe (0.2 cm collimation)

Table 1 illustrates the variation of linear attenuation coefficient as a function of gamma ray energy for collimator diameter (0.2 cm). From these results, it is seen that the linear attenuation coefficient decreases exponentially with increasing gamma energy and increases with atomic number of the absorber (for pure elements Ag, Cu, and Fe). The linear attenuation coefficient increases for all energies under study indicating identical trends in the results reported in the literature [10].

Fig 3 represents the variation of linear attenuation coefficient as a function of photon energy for collimator diameter 0.2 cm for Silver, Copper and Iron. From these plots it is observed that linear attenuation coefficient of all the elements under investigation decreases exponentially as photon energy increases.

Conclusion

In the present measurements results reported is predominantly experimental and therefore no comparison is needed. The experimental measurements described were preferred in collimation geometry and provide a set of data on attenuation coefficients, mass attenuation coefficients and total photon interaction cross section. From the above measurements, it can be concluded that the effect of multiple scattered photons in the measurements of attenuation coefficient of elemental solids is significant in Silver, Copper and Iron and can further be minimized by using well collimated narrow beam counting geometry. As most accurate values of attenuation are needed in radiation dosimetry, diagnostic and therapeutically applications attempt should be made to minimize multiple scattered contributions while evaluating the attenuation coefficient values correctly. Finally, it is concluded that the attenuation coefficient can be measured more accurately for health care, and radiation dosimetric applications.

From our studies on linear attenuation coefficient, mass attenuation coefficient and total photon interaction cross-section as a function of photon energy on various elements (Ag, Cu and Fe) it can be concluded that the collimator size largely affects the attenuation of

gamma ray in elements under investigation. The best results of attenuation coefficients are observed for 0.2 cm diameter of collimator. Based on our results, it can be concluded that

- 1) The linear attenuation coefficient increases exponentially with increasing photon energy.
- 2) The linear attenuation coefficient increases from moderate (Fe) to high atomic number (Ag).

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AN OVERVIEW ON E-WASTE FOR GOOD HEALTH

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Abstract

Electronic waste has become a rapidly growing environmental and public health concern due to the increased use of electronic devices. E-waste includes discarded electrical and electronic equipment such as Computers, mobile, televisions, and household appliances. Improper handling and disposal of e-waste release hazardous substances like lead, mercury, cadmium, and brominated flame retardants, which pose serious risks to human health and the environment.

This paper provides an overview of e-waste, its sources, health impacts, and management practices. It also highlights the importance of sustainable e-waste management for protecting public health and promoting environmental sustainability. The study emphasizes awareness, regulation, and technological solutions as key strategies for reducing the negative health effects of e-waste.

Keywords: E-waste, Public Health, Hazardous Materials, Environmental Pollution, Sustainable Management

Introduction

With rapid technological advancement and increasing dependence on electronic devices, the generation of electronic waste has grown significantly. E-waste refers to discarded or obsolete electrical and electronic equipment. While technology improves quality of life, improper disposal of e-waste has become a major threat to environmental and human health. Developing countries face greater risks due to informal recycling practices and lack of proper infrastructure. The toxic components present in e-waste can enter the air, soil, and water, leading to long-term health problems. Therefore, understanding e-waste and its impact on health is essential for ensuring a healthy and sustainable future.

Objectives :

1. Finding Sources and Composition of E-waste
2. Finding Health Impact of e-Waste
3. To Study E-Waste Management and Good Health
4. To Study Role of Awareness and Technology

Sources and Composition of E-Waste

E-waste originates from households, offices, industries, educational institutions, and healthcare facilities. Common e-waste items include computers, laptops, mobile phones, printers, televisions, refrigerators, and batteries. These devices contain valuable materials such as copper, aluminum, and gold, along with hazardous substances like lead, mercury, arsenic, and polychlorinated biphenyls (PCBs). When e-waste is dismantled or burned without safety measures, toxic substances are released, causing serious environmental and health hazards.

Health Impacts of E-Waste

Improper e-waste handling directly affects human health. Exposure to toxic metals can cause neurological disorders, respiratory problems, kidney damage, and reproductive issues. Children and pregnant women are particularly vulnerable, as toxic exposure can

impair brain development and lead to birth defects. Informal recycling workers often suffer from skin diseases, lung infections, and chronic illnesses due to prolonged exposure to hazardous materials. Contaminated air, water, and food further increase health risks among surrounding communities.

E-Waste Management and Good Health

Effective e-waste management is essential for protecting public health. Environmentally sound practices such as safe collection, segregation, recycling, and disposal reduce toxic exposure. Formal recycling facilities use advanced technologies to recover valuable materials while minimizing health risks. Extended Producer Responsibility (EPR) policies encourage manufacturers to manage end-of-life electronic products responsibly. Public awareness and community participation also play a crucial role in reducing improper disposal.

Role of Awareness and Technology

Education and awareness programs help people understand the health risks of e-waste and promote responsible consumer behavior. Computer-based tracking systems, digital reporting platforms, and smart recycling technologies improve e-waste collection and monitoring. Government regulations supported by technology ensure safer handling and compliance with environmental standards.

Conclusion

E-waste is a growing challenge that directly affects human health and environmental quality. Improper disposal exposes individuals and communities to hazardous substances, leading to serious health problems. Sustainable e-waste management, supported by technology, policy enforcement, and public awareness, is essential for ensuring good health. By adopting responsible consumption habits and strengthening recycling systems, societies can minimize health risks and move toward a safer and healthier environment.

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APPLICATION OF ORDINARY DIFFERENTIAL EQUATION IN PHYSICS

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Abstract

This article examines several applications of ordinary differential equations (ODEs) in specific industries and in everyday life. This project encourages the integration of ODEs into the undergraduate curriculum through the use of real-world analogies, primarily examining the dynamics of international transactions, although ODEs are often applied in areas such as population dynamics, electronics, and the physics of Featuring an arms race at the center and similar to predator-prey dynamics Richardson was a pioneer in the development of mathematical models for understanding wars and arms races between nations. The importance of imbalances in weapon strategies is emphasized in the study, which discusses the evolution of ODEs representing continuous progress between bilateral states or alliances in terms of their sufficiency. It also emphasizes the ability to represent complexity in a variety of educational contexts and promotes a best-practice understanding of how to use mathematics effectively. The analysis is a novel model for predicting decay behavior and population growth using differential equations. It teaches how to use well-known basic rules and concepts to develop ODE-based models and demonstrates versatility in many situations. This study highlights the critical role of ODEs in representing and predicting dynamic interactions, highlighting their importance in understanding, analyzing and possibly reducing social interactions and complex real-world conflicts. It emphasizes the bottom line.

Keywords: Ordinary Differential Equations (ODEs), Industries, Everyday Life, International Transactions, Arms Race and Differential Equations

Introduction

"Systems of ordinary differential equations (ODEs) are a useful tool for analyzing interactions between dynamic processes. They have been widely used in a variety of fields, including population dynamics, electronics, and physics." When it comes to teaching ODEs, graduate school textbooks often use the very famous example of predators, which depicts competition between carnivores and herbivores. We suggest that undergraduate courses incorporate relevant real-world applications into ODE: analysis of international relationships. Artists often paint a true picture of conflict, and it evokes strong emotions in us. One such was the Argentinian artist Candido Lopez, who lost his right arm in the same battle and used his left to write, 'After the Battle of Kurupayti It is said that Paraguay, Uruguay, Argentina, and Brazil participated in this conflict. The Museo Nacional de Bellas Artes in Buenos Aires has a work by Lopez, which can be viewed online. This study of countries or treaties using mathematical modeling Departing from an artistic approach by examining rational international relations, including disputes or wars between nations, works to reduce the possibility of war conflict or improve war effectiveness because they hear complex variables that can cause conflict and reduce suffering and economic loss. F.W. Lanchester, P.M. Morse, and G.E. Kimball for military or commercial interests."

"In this work, we examine models of international conflict, first developed by Louis Fry Richardson ,to explain the dynamics between two states or alliances on the verge of war. We return to the mathematical foundations of this work for educational reasons. Louis Fry Richardson (1881–1953, it was a pioneer in the analysis of international relations and arms

arm races using mathematical models. Richardson, who spent half his life studying the strategic foundations of war, sought to acquire quantitative knowledge at the beginning and development of war did so. Notable books such as 'Mathematical Psychology of War' (1919), 'General Foreign Policy, and 'Arms and Insecurity' are examples of his discoveries and analyses on conflict. Richardson is most famous for developing mathematical models of differential equations to explain arm races. It is popular. He suggested that if one country increases its armament, another country will follow suit, creating a vicious cycle of increased arms.

His model resembles the differential equation of the predator-prey model in that it deals with energy stability and includes an arms race in international relations. Richardson's research focused on estimating dimensions and system stability, which will be tested. This practical and helpful strategy for crafting ODEs, so it should be included as a classic example in the academic literature. To move forward, this research first uses the example of an arms race; it's a bit of a basic show before a full model is developed. Estimate other influencing factors between states or alliances, such as drought, aggression, and weapon destruction. We present examples, diagrams, and analyses that illustrate solutions, strategies, and phase diagrams for ODE systems, and they offer programmes such as Mathematica and Science Workshop. Students are left to work on simple assignments.

Objective of the study

1. Integration of ODE applications: To emphasize the practical application of ODE in international relations education and integrate it into the undergraduate curriculum.
2. To test Richardson's models: Richardson's mathematical models should be examined, especially when he identifies predator and predator power in international arms races.
3. To Explain ODE Formulation: Using mathematical analysis and graphics, describe how ODE problems are created and solved to reveal the dynamics among states as regards the spread of guns.
4. To showcase the versatility of ODEs: To draw interest to the ODEs' ability to forecast corrupt practices, population growth, and social complexity at the same time as promoting continuous development so that you can get a higher knowledge of society

Need of the study

"The research aims to meet the critical need for a broader understanding and integration of ordinary differential equations (ODEs) in academic curricula and real-world contexts, highlighting their important applications in international relations and life." Internal dynamics and conflicts presented in examples emphasize the development of deep insights to enable appropriate decision-making at various points in complex systems."

Recommendations of the study

1. Curriculum integration: Real-world ODE applications will be integrated into the curriculum to strengthen student understanding, with a special focus on international relations.
2. Wide application : Using ODEs to model social processes in situations beyond conflict, enabling predictive analytics beyond disciplinary boundaries.
3. Continuous improvement : Push for continuous development and adaptation of ODE-based models to address changing societal concerns and improve forecasting accuracy.
4. Interdisciplinary collaboration: Encourage interdisciplinary collaboration to use the ODEs to understand and reduce real complexities across disciplines.

Differential formula for one simple arm

The increasing availability of weapons is generally recognized as one of the major causes of conflict, as are unrealized goals such as territorial recovery or expansion. Our view

is based on the idea that if one country increases its arsenal, another does so out of balance — concerns of power. Let state Y represent the weapons, and let x(t) represent state X. The size of the weapons on the other side determines the rate at which one side’s weapons change. The relationship between dx/dt and y/dt is essentially a direct ratio of x or y, where the ratio of x to y is given by the constants k and l. The effectiveness of proliferation is reflected in these constants."

As a result, we can formulate the following system of differential equations

$$\begin{cases} \frac{dx}{dt} = ky \\ \frac{dy}{dt} = lx \end{cases} \quad (1)$$

This concept can be used to describe an alliance or relationship between two states that choose to defend themselves against potential attacks on each other. The solution for system (1) is straightforward to find and is given as follows:

$$x(t) = \sqrt{\frac{k}{l}} \cdot (Ae^{t \cdot \sqrt{kl}} - (Be^{-t \cdot \sqrt{kl}})), \quad y(t) = (Ae^{t \cdot \sqrt{kl}} + (Be^{-t \cdot \sqrt{kl}})) \quad (2)$$

Considering the starting circumstances,

$$x(0)=x_0, y(0)=y_0$$

We can acquire

$$\begin{cases} A = \frac{1}{2} (y_0 + \sqrt{\frac{1}{k} x_0}), \\ B = \frac{1}{2} (y_0 - \sqrt{\frac{1}{k} x_0}) \end{cases} \quad (3)$$

Estimating the values of k and l is feasible : As an example, while y stays a constant C,(1) implies that,

$$\frac{1}{k} = \frac{C}{\frac{dx}{dt}} = C \cdot \frac{dx}{dt} \quad (4)$$

In solving above equation

$$\frac{1}{k} x = C t + b \quad (5)$$

(5)indicates that, assuming x(0) = 0, b = 0 and

$$\frac{1}{k} = \frac{c}{x} t \text{ for } x > 0 \quad (6)$$

Thus, we get $1/k = t$ when X has captured Y, which means that $x = C$. Assuming that Y remains constant, the time it will take for X to capture the arsenal of country Y is $1/k$. Again, Richardson found that k is correlated with the industrial status of the country. In a more foundation-based model, we will present a detailed analysis with illustrations. Here we use the assumption that the degree to which each country stockpiles more weapons is the same, assuming that

$$k = l = 0.9$$

As an illustration. From(2) and (3), it is evident that the original condition

$$\begin{aligned} x(0) &= 20, & y(0) &= 0 \\ A &= 10, & B &= -10 \end{aligned}$$

$$\begin{aligned} \begin{pmatrix} x \\ y \end{pmatrix} &= \begin{pmatrix} 10 \\ 10 \end{pmatrix} e^{0.9t} + \begin{pmatrix} 10 \\ -10 \end{pmatrix} e^{-0.9t} & (8) x(t) &= 10 e^{0.9t} + 10 e^{-0.9t}, y(t) \\ &= 10 e^{0.9t} - 10 e^{-0.9t} & (7) \end{aligned}$$

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 10 \\ 10 \end{pmatrix} e^{0.9t} + \begin{pmatrix} 10 \\ -10 \end{pmatrix} e^{-0.9t} \quad (8)$$

The connection between the two countries is shown in Figures 1 and 2, with the starting conditions $x_0 = 20$ and $y_0 = 0$. We may see from Figures 1 and 2 that, when A

Fig 1: Remedies for the weapons race model (2.1)(x)

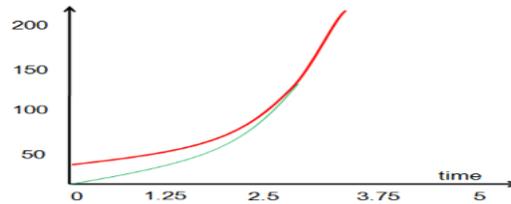
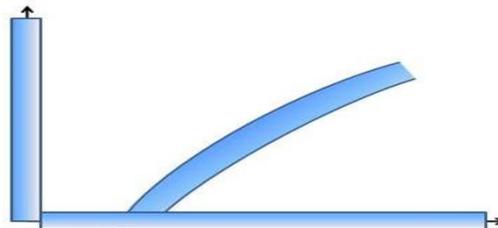


Fig 2: The arms race model's trajectory



The positive attributes of $x(t)$ and $y(t)$ appear to be an escalating arms race between non-causal X and Y, possibly leading to war. We see that the critical point $(0; 0)$ is a saddle point, which is always simple since the system has two real eigen values, $\lambda = \pm 0.9$.

Mathematica R, which shows that the arms of each country increase simultaneously (y and x). The direction of the vector $\begin{pmatrix} 10 \\ 10 \end{pmatrix}$ of the solution (6) is represented by a straight line through the origin seen in the phase diagram.

Utilizing Ordinary Differential Equations for Mathematical Modeling Applications

Mathematical modeling uses mathematical language to describe interactions and rules, generate valid mathematical relationships, analyze complexity, and then apply mathematical methods to deal with real-world data. This is a mathematical modeling process. Unlike mathematical computation, mathematical modeling consists of logical reasoning, induction, summary, and refinement. The ability to translate real-world data into mathematical relationships is important in mathematical modeling. The main goal of mathematical modeling is to deal with real-world data. The final step in numerical modeling is to verify the results. The correct answer is obtained only if the circumstances of the case itself are controlled.

Functions in mathematical modeling:

We can explore the relationship between mathematics and other disciplines in everyday life through mathematical examples. It can help students develop mathematical skills and understand practical mathematical applications, which in turn will stimulate their interest and commitment to learning the subject. (2) Teaching mathematical models is a means to acquire various skills such as mathematical expression, mathematical experimentation, collaboration and communication, mathematical thinking, and creative expression. It enables them to actively learn that their daily lives will be used in it. As you study the material, (3) "Development of students' creative and practical abilities" is the stated goal of higher education. Applying mathematics should not be limited to merely applying knowledge. Implementing and operating the gradient system. According to the author, the ability to develop mathematical models is a prerequisite for representing what mathematics really matters.

Modeling ordinary differential equations using known special laws

Known theories and laws from various disciplines are used primarily in the installation process. Examples of these are as follows: Hooke's law of elastic deformations; Terry's Law; Aki Mead Act; the universal law of gravity; Newton's second law of motion; the rate of damage of air conditioning problems; biological sciences; economic studies; and an increase in population problems

Definition of derivative :The definition of a derivative is as follows:

$$dy - dx = \log_{\Delta x \rightarrow 0} f(x) + \Delta x - f(x) - \Delta x = \log_{\Delta x \rightarrow 0} \Delta x - \Delta y \quad (9)$$

At that point, the instantaneous change in x can be scaled to that of y if the function f(x) is different, as shown by the formula $\Delta x/\Delta y$. It is often used in the expressions ""development" and "increase" in demographic and biological studies. "Depletion" in the context of radiation and "margin" in economics

Establishment of ordinary differential equation models by specialized methods

This method basically involves specifying the relationships between microelements and then applying appropriate rules to the project to build the model. Suppose that in a real-world situation, a variable I meets the following criteria: I is a number associated with the transition interval [a, b] of the independent variable x; $I \approx \Delta I - i \approx f(N)$. If Δx is a fractional number that adds to the interval [a, b], then we can consider using differential equations to model fragmentation. Provision: The steps are as follows: An independent variable x based on the context Identify and compute its variable interval as [a, b]; Determine each interval [a, b] and write [x, x + dx]. Find the nearest value corresponding to a partial magnitude ΔI in this interval. Then, determine approximately the value of ΔI as the product of the values f(x) and dx with a continuous function of x, or $\Delta I \approx f(x) dx$, $f(x) dx = dI$. The element I of multiplication is dI, and integrate the two sides of the equation simultaneously to obtain the required quantity. It is possible.

General differential equations used in mathematical simulations

Ordinary differential equations can be used to develop a mathematical model of the current hunting and arrest of many corrupt police officers involved in crime, and thus a mathematical model and creation can be obtained using the differential equation if it is for ordinary use. A new model for quantifying corrupt individuals, with three stages based on the number of individuals involved, has been developed to quantify the total number of individuals involved. (1) Theoretical level Let t be time, XO be the total number of group members who have committed corruption at time t = 0, let r(x) be the control group, and let x(t) be the number of group members corrupted by the fact that they were employed in all activities. The mean growth rate, or r, refers to the growth rate of the total number of individuals involved in the transaction at time x0. These growth rates are representative of the factors involved. The variables xm and λ represent the maximum number and number of individuals involved in a corruption incident, respectively. μ and λ denote the resistance coefficient resulting from the analysis; i(t) and λ denote the proportion of the total population involved in the corruption case and the participants at t = 0. λ also denotes the average number of members of each corrupt group arrested within a month [4]. (2) In the research phase, the amount of potential corrosion decreases gradually as the amount of corrosion currently present increases. The number of individuals involved in this decay process at time t is determined by the combined activity x(t), the growth rate r(x) proportional to the number of individuals, and x(t), the continuous activity associated with and represented by t, one of which is xm. Moreover, there is a special functional relationship between x and t. According to the previous theorem, $r(x) = r - kx$, where k is the slope and $k > 0$. This means that r(x) is a linear function of x.

The population growth rate function can be used when $x = x_m$, since $r(x_m) = 0$ implies that the population growth rate is 0. As a result, k can be calculated as r / x_m (3). The following differential equations can be developed without taking into account the severity and complexity of the analysis, which may influence the findings.

$$\frac{dx}{dt} = r \left(1 - x - x_m \right) x, \quad X(0) = x_0 \text{ then} \quad (10)$$

$$\text{Equation is } x(t) = \frac{x_m}{1 + \left(\frac{x_m}{x_0} - 1 \right) e} \quad (11)$$

Considering the potential impact of experimental complexity on findings, the differential equation can be constructed with a subsequent choice of resistance coefficient.

$$\frac{di}{dt} = \lambda i (1 - i) - \mu i \quad (12)$$

$$i(0) = i_0 \quad (\lambda \neq \mu) \quad (13)$$

$$\text{Equation } ii(t) = \frac{1}{\frac{\lambda}{\lambda - \mu} + \left(i_0 - \frac{\lambda}{\lambda - \mu} \right) e} \quad (14)$$

Anti-corruption agencies in China can use this statistical framework to predict the number of corrupt individuals involved in future anti-corruption efforts. It is easy to see that there is a large similarity between the errors between the number of dishonest individuals observed in the actual task and the theoretically calculated number.

Population prediction models using ordinary differential equations

If all the components are included from the beginning, it is naturally impossible to make a prototype. Consequently, the matter can be simplified by starting with a simple mathematical model and then making incremental adjustments until an error-free mathematical model is obtained. The maximum number of items an artificial environment can support is indicated by the constant N_m , which is the one modeled mathematically by Malthus. Larger residences and more N_m are often associated with higher jobs in the country. According to Weyerhurst, the growth rate can be written as $r(1 - N_t/N_m)$, and as N_t increases, the growth rate gradually decreases. As N_t gradually approaches N_m , the slope will eventually approach zero. This concept can be used to model population forecasting. Consequently, Malthus's theory may be constructively applied to new models of population forecasting.

$$dN/dt = (1 - N/N_0)N \quad (15)$$

$$N(t_0) = N_0$$

These ordinary differential equations provide a reasonable mathematical model that can be solved with a variety of variables. The equation is:

$$N(t) = \frac{N_m}{1 + \left(\frac{N_m}{N_0} - 1 \right) e} \quad (16)$$

Combined with Malthus's related theory, this population forecasting model can be used to make valid population growth forecasts.

Conclusion

The conclusion of the study highlights the critical importance of ordinary differential equations (ODEs) as a powerful tool for describing the complex dynamics of dynamic systems under various conditions. ODEs provide a flexible analytical framework that can be consumed for everything from population growth forecasting to war strategy analysis to clarifying international relations. By examining mathematical models developed by Lewis Fry Richardson, especially when it comes to simulating international arms races, this study

highlights how differential equations can be used to represent complex situations, such as the emphasis on rising hostilities and power struggles. The study also shows how ODEs can be used in studies, showing how well they predict demographic trends, corruption, and other social issues. This mathematical model demonstrates how it links theoretical concepts to implementation and is useful for a better understanding of how mathematics interacts with real-world situations. To deal with complex social issues, our study suggests that ODE-based models should be further explored and improved. There is tremendous potential to harness the power of mathematical models to develop solutions that reduce conflict, predict social dynamics, and improve decision-making in various sectors. Research particularly emphasizes that ODE plays an important role in policy due to the complexity of its dynamics and its enormous impact on our daily lives.

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SUSTAINABLE DEVELOPMENT AND DEMOCRACY: A COMPREHENSIVE STUDY

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Introduction

In the 21st century, *Sustainable Development* and *Democracy* have emerged as two of the most significant concepts shaping national and global discourse. Rapid population growth, environmental degradation, social inequality, economic imbalance, and climate change pose serious challenges to humanity. Sustainable development offers a framework to address these issues, while democracy has evolved beyond a mere system of governance into a broader concept encompassing public participation, rights, accountability, and good governance. This research paper presents an in-depth study of the interrelationship between sustainable development and democracy, with special reference to the Indian context.

Objectives of the Study

1. To explain the concept and characteristics of sustainable development.
2. To examine the relationship between democracy and development.
3. To analyze the role of democracy in achieving sustainable development.
4. To study sustainable development and democracy in India.
5. To identify challenges and opportunities for sustainable development within democratic systems.

Research Methodology

The study is based on descriptive and analytical research methods. Secondary sources such as books, government reports, research articles, United Nations documents, and provisions of the Indian Constitution have been used.

Concept of Sustainable Development

The concept of sustainable development was formally defined by the Brundtland Commission in 1987 as: "*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*" Sustainable development rests on three fundamental pillars:

- Economic development
- Social development
- Environmental protection

A balanced integration of these three dimensions is essential for sustainable development.

Concept of Democracy

Democracy is a system of governance characterized by rule by the people, for the people, and of the people. It ensures fundamental rights such as equality, freedom of expression, rule of law, and protection of human rights. Modern democracy extends beyond electoral processes to include transparency, accountability, participation, and good governance.

Relationship between Sustainable Development and Democracy

Sustainable development and democracy are mutually reinforcing. Democratic systems provide citizens with opportunities to participate in decision-making processes, resulting in more inclusive, equitable, and long-term development policies. Transparency and accountability in democratic governance help prevent the misuse of natural resources and promote sustainable practices.

Development without democracy may occur, but it often tends to be centralized, unequal, and short-term in nature. In contrast, development achieved through democratic processes is more people-oriented and sustainable.

Role of Public Participation in Sustainable Development

Public participation is a cornerstone of democracy. Through institutions of local self-government, gram sabhas, civil society organizations, and non-governmental organizations (NGOs), citizens actively contribute to development processes. Community participation plays a crucial role in environmental protection, water management, and forest conservation, thereby strengthening sustainable development.

Good Governance and Sustainable Development

Good governance—characterized by efficiency, transparency, accountability, and participation—is essential for sustainable development. Corruption, weak policy implementation, and administrative inefficiency hinder development outcomes. Democratic governance, when aligned with good governance principles, creates a conducive environment for achieving sustainable development goals.

Sustainable Development and Democracy in India

India, as the world's largest democracy, provides a significant case study. The Indian Constitution emphasizes social justice, equality, and environmental protection. Article 48A (Protection and improvement of environment) and Article 51A (Fundamental Duties of citizens) form the constitutional foundation for sustainable development.

India has adopted the United Nations Sustainable Development Goals (SDGs) and has implemented various policies and programs aimed at poverty eradication, education, health, gender equality, clean water, and sanitation. Decentralization through Panchayati Raj Institutions and urban local bodies strengthens democratic participation and supports sustainable development.

Challenges to Sustainable Development in Democratic Systems

Despite democratic governance, several challenges persist:

- Rapid population growth and pressure on natural resources
- Economic inequality and social exclusion
- Lack of political will and long-term vision
- Preference for short-term political gains over sustainable policies
- Weak enforcement of environmental laws

Opportunities and Policy Measures

To overcome these challenges, the following measures are essential:

- Awareness and education for sustainable practices
- Active citizen participation
- Environment-friendly and inclusive policies
- Transparent and accountable governance
- Effective use of technology in governance and resource management

Conclusion

Sustainable development and democracy are complementary and interdependent. Democracy enhances inclusiveness, equity, and long-term orientation in development processes. For the successful implementation of sustainable development, democratic values, public participation, good governance, and environmental consciousness are indispensable. For a developing democratic nation like India, sustainable development is not merely an option but a necessity for future generations.

References (Indicative)

- Brundtland Commission Report (1987)
- Constitution of India
- United Nations Sustainable Development Goals (SDGs)
- Standard texts on Political Science and Development Studies



HYDROELECTRIC DAMS AND THEIR ROLE IN ALTERING AQUATIC BIODIVERSITY

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Abstract

Hydroelectric dams serve as major sources of renewable energy, contributing significantly to global power generation while minimizing greenhouse gas emissions. However, their construction and operation have far-reaching ecological consequences, particularly on aquatic biodiversity. This study explores how hydroelectric dams alter natural river systems through habitat fragmentation, water quality modification, and disruption of ecological connectivity. It also highlights sustainable management practices and engineering solutions that can mitigate biodiversity loss. The paper concludes by emphasizing the need for eco-friendly dam designs and continuous monitoring to ensure energy sustainability without compromising ecosystem integrity.

Keywords: Hydroelectric dams, aquatic biodiversity, habitat fragmentation, environmental flow, ecological restoration

Introduction

Hydroelectric power plants are considered a vital component of the renewable energy sector, providing approximately 16% of the world's electricity supply (World Energy Council, 2021). Despite their environmental benefits, dams significantly alter riverine ecosystems by changing hydrological regimes, sediment transport, and biological connectivity (Poff & Schmidt, 2016). These changes affect aquatic biodiversity, leading to habitat loss, altered community structures, and population declines in various fish and invertebrate species. Understanding the causes and developing sustainable solutions are essential to maintaining the ecological health of dam-impacted aquatic systems.

Causes of Aquatic Biodiversity Alteration

(a) Flow Regulation and Habitat Fragmentation: Dams obstruct the natural flow of rivers, creating artificial reservoirs that fragment habitats and isolate aquatic populations. Migratory fish species such as salmon, mahseer, and catfish are particularly affected, as dams block their spawning routes (Liermann et al., 2012).

(b) Changes in Water Temperature and Chemistry: Water released from reservoirs often differs in temperature, oxygen level, and nutrient content compared to natural flow. These variations disturb aquatic metabolism and alter the distribution of temperature-sensitive species (Olden & Naiman, 2010).

(c) Sediment Trapping: Hydroelectric dams trap sediments that would normally replenish downstream habitats. Sediment starvation leads to erosion of riverbanks and delta areas, reducing the availability of spawning substrates and nutrients for aquatic life (Vörösmarty et al., 2017).

(d) Disruption of Food Webs: Alterations in primary productivity due to changes in water flow and nutrient cycling affect the abundance of phytoplankton and zooplankton, leading to cascading effects across the entire food web (Anderson et al., 2018).

(e) Invasion of Non-native Species: Reservoir environments often favor invasive species that outcompete native fauna. For instance, tilapia and carp species introduced in dam

reservoirs frequently dominate native fish populations, reducing local diversity (Jackson & Mandrak, 2017).

Solutions and Mitigation Measures

(a) Fish Passages and Ladders: Installing fish ladders, elevators, or bypass channels enables migratory fish to cross dam barriers, restoring population connectivity and breeding success (Noonan et al., 2012). **(b) Environmental Flow Management:** Releasing water in patterns that simulate natural seasonal variations, known as “environmental flows,” supports life cycles of aquatic organisms and maintains riverine ecology (Arthington et al., 2018).

(c) Sediment Management: Controlled sediment flushing and bypass systems help restore downstream sediment balance, promoting habitat regeneration and nutrient flow (Kondolf et al., 2014).

(d) Habitat Restoration: Reforestation along riparian zones and restoration of wetlands near reservoirs can mitigate habitat loss and enhance biodiversity resilience (Nilsson et al., 2018).

(e) Sustainable Dam Design and Operation: Integrating ecological impact assessments into dam design, selecting less ecologically sensitive sites, and applying adaptive management principles are crucial for reducing biodiversity loss (Lehner et al., 2011).

(f) Continuous Monitoring and Research: Long-term biodiversity monitoring helps evaluate dam impacts and effectiveness of mitigation measures. This data-driven approach enables adaptive strategies that support both energy production and ecosystem conservation (Reid et al., 2019)

Conclusion

Hydroelectric dams, though vital for sustainable energy generation, significantly alter aquatic ecosystems through changes in water flow, temperature, and sediment transport. These impacts threaten biodiversity by fragmenting habitats and disrupting ecological processes. However, with the implementation of sustainable management strategies such as fish passage systems, environmental flow regimes, and habitat restoration, the ecological consequences can be reduced. Balancing energy production with biodiversity conservation is essential to ensure long-term ecological and economic sustainability

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REMOVAL OF CADMIUM (II) FROM WATER BY ADSORPTION ON CLP**Ratnadipa Ukey,****Samreen Fatima,****Mazahar Ahmed Farooqui,**

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Abstract

The removal of a high level of cadmium in drinking water by Cauliflower leave powder as a natural material is a simple way to remove water. The study revealed that Cauliflower Leave Powder were able to effectively remove a significant percentage of cadmium. Using a 0.4 gm sample size of Cauliflower leave powder could remove 89% of cadmium with an initial concentration of 100 ppm within 50 min. A significant increase in the removal of Cd (II) with an increase in the Cauliflower leave powder dosage and increase in temperature could be observed. There is a remarkable efficiency for Cauliflower leave powder in the range of cadmium concentration of 5 to 50 ppm. Time 45 minutes is the suitable contact time of adsorption that achieves the highest cadmium removal from water. The optimum pH for having the highest amount of cadmium removal was around 11.9. It is obvious that the 0.4 mg dose is the most efficient adsorbent dose, and the ideal temperature is 30-35°C.

Keywords: Adsorption, Cadmium, CLP**Introduction**

Water is one of the most important substances on earth. All plants and animals must have water to survive. If there is no water, there would be no life on earth. The world is entering the third millennium; the water issue has become one of the most important issues which take the concern of the whole world. Besides, water pollution affects the international relations between countries that share water resources and may cause wars. Water covers about 71% of the earth's surface, but only 2.5% of the earth's water is freshwater (1). According to World Health Organization WHO, water scarcity is affecting a one third of people in the world and the problem is continuously increasing because of the rising water demand (2). Therefore, people depend on polluted water which causes many diseases. The dependence of humans is mainly on their ability to manage the natural resources; therefore, new methods should be provided to purify water and increase its quality to encounter overpopulation. Water pollution came from any change in its chemical or physical properties and makes it inappropriate for various usages (3). There are different causes of water pollution like 1-Sewage and wastewater, 2-Mining activities, 3-Globalwarming, 4-Industrial waste (4). The sources of water pollution are different from one place to another (surface water pollution, Groundwater pollution, Nutrients pollution, microbiological pollution, Chemical water pollution and, pollution by metals). The inorganic contamination of water is different from organic one because they cannot be metabolized, therefore removal of inorganic contaminates depends on the formation of bonds between them and a solid surface (5). Many techniques used for removing of inorganic contaminate, that removal process must be simple, effective, and inexpensive (6). An example for the removal methods are (Chemical precipitation, Ion exchange, Cementation, coagulation and flocculation, Membrane filtration, Ultrafiltration, Reverse osmosis, and adsorption (7). The adsorption method offers flexibility

in design and operation it is economically effective for a dilute solution, and sometimes it is a reversible process (8). Cadmium compounds have varying degrees of solubility ranging from very soluble to nearly insoluble (9). The solubility affects their absorption and toxicity. The average concentration of cadmium in the earth's crust is between 0.1 and 0.5 (ppm), was discovered in 1817 simultaneously by Stormier and Hermann as an impurity in zinc carbonate. Cadmium is listed in the European Restriction of Hazardous Substances (10). Because of its toxicity and nickel-cadmium batteries have been replaced with nickel-metal hydride and lithium-ion batteries. Cadmium is an extremely toxic industrial and environmental pollutant classified as a human carcinogen (Group 1) -according to International Agency for Research on cancer. According to Environmental Protection Agency (EPA); and 1B carcinogen classified by European chemical Agency (ECHA). Cadmium and its salts are severe lung and gastro intestinal irritants that can be fatal by inhalation and ingestion. Acute ingestion of as little as 10 mg of cadmium chloride can cause pulmonary toxicity, such as pulmonary edema, emphysema, and bronchitis (11). This research aims to study the removal of Cd^{2+} which is a hazardous element in the environment at a high concentration by adsorption using Cauliflower leaves Powder as a natural, low-cost adsorbent. The parameters affecting the adsorption process as Cd^{2+} initial concentration, adsorbent doses, pH, temperature, and rate of stirring.

Materials and methods

Chemicals

All chemicals used were of analytical grade. A stock solution of Cadmium Cd^{2+} of concentration 1000 mg/l was prepared by dissolving 0.558g of $(CdCl_2 \cdot H_2O)$ in 1000 ml of distilled water. Dilute Cd^{2+} stock solution from 1000 mg /l to 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 mg/l was carried out by using distilled water under dilution law. The pH of solutions was adjusted to the required value by the addition of 0.1M NaOH or 0.1 M HCl at a fixed temperature of 308.15 K.

Preparation of adsorbent

Cauliflower Leaves (cleaned) washed good by filter water, then washed with distilled water, drying primarily by the sun, then dried by oven at a temperature of 323K, then grind by grinder and mixture then sieved through the sieve pore size of 0.4 – 0.3 mm the powder was then available to use in each experiment.

Apparatus and materials

A definite volume of metal ion stock solution with known initial concentration was stirred with a definite amount of Cadmium metal for a stipulated time on digital magnetic stirrer with temperature sensor and using Teflon magnetic stir bar of 2 cm length. Sample (0.5 ml) diluted to 5ml by distilled water and used for absorption. Spectrophotometer was used to analyze concentrations of the dissolved Cadmium. pH-meter was used to adjust pH of the solution.

Procedure

The experiments were performed by stirring Cauliflower leaves powder and 250 ml of Cadmium chloride solution ($CdCl_2 \cdot H_2O$). Different pH values of the solution ranged from 2-12 were studied. Experiments were carried out at different temperature 303, 308, and 313 K, stirring speed 1000 rpm, initial cadmium(II) ion concentration were 100 to 1000 mg/l and Cauliflower leaves powder dosage 0.1, 0.2, 0.3, 0.5, 0.6 to 1.0 the samples analyzed by using atomic absorption spectrophotometer.

Results and discussion

The efficiency of the adsorption process can be calculated from the change in % removal value with time, which can be calculated from the equation

$$\% \text{ Removal} = \frac{C_0 - C_e}{C_0} \times 100 \quad (1)$$

Also, the amount of metal absorbed can be calculated from the equation.

$$qt = (Co - Ct)/m \tag{2}$$

The ratio between the quantity absorbed and that remaining in solution at a fixed temperature at equilibrium was calculated from the equation.

$$qe = (Co - C)/m \tag{3}$$

where C_o is the initial cadmium ion concentration in solution in mg/l, C_e is the equilibrium concentration of cadmium ion in solution in mg/l. C_t is the concentration of cadmium ion in solution after the time of as much as t in mg/l, m is the mass of CLP in g and V is the volume of the solution

FT-IR studies

From Figures 1 and 2 we notice that band 3423 Cm^{-1} was shifted to 3467 Cm^{-1} , which is for the stretching (OH) group(12). In Cauliflower leaves powder and a new band was obtained in 551 Cm^{-1} , because of the adsorption of cadmium in the CLP on the surface.

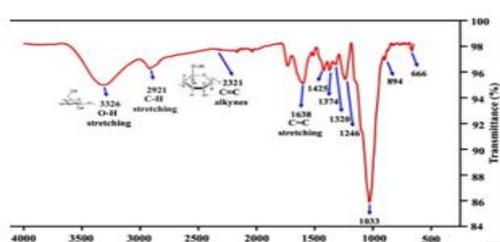


Fig-1

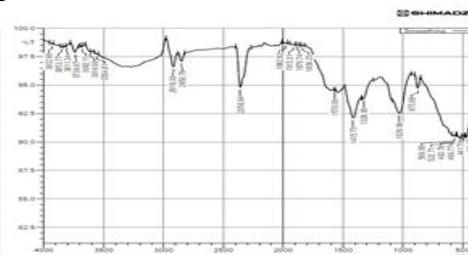
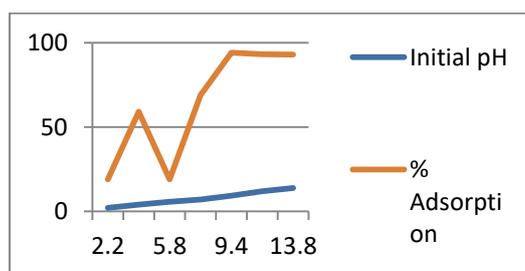


Fig 2

Effect of pH

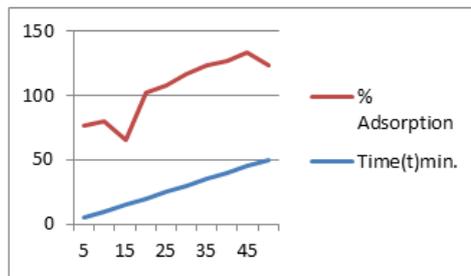
The percentage of cadmium removal is shown in Figures 3 shows the change of qt and % removal with time (45) min at different pH. The graph shows that the adsorption of Cd^{2+} on CLP surface increases in acidic solution at optimum pH= 9.4 Generally, the positive charges of the adsorbent surface decrease with increasing pH to 7 leading to the decrease in the repulsion between adsorbent and Cd^{2+} (13). Here it is observed maximum adsorption at 9.4 pH



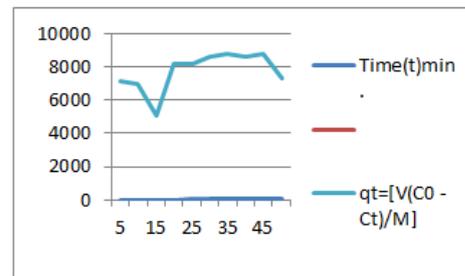
(Fig 3)

Effect of contact time

Figures (4 and 5) shows that percentage of removal records significant upward values with time and reaches a maximum at 45 min this give an indication that the concentration of Cadmium in the solution decreases rapidly within the first 30 min and the removal was completed at 45 min. The removal of metal ions can be derived into two stages: one in which the removal rate is very high. It is very important to determine the equilibrium time that is the contact time characterized by unchanging Cd^{2+} concentration in the solution was achieved after 30 min for all concentrations of solutions; (14) this period is denoted as the second stage of the adsorption. Depending on the concept of adsorption sites we can explain that the vacancy on it at first stage Cd^{2+} could easily interact with these sites. The adsorption capacity was almost constant for all concentrations and such it was considered as the equilibrium time of Cd^{2+} onto CLP.



(Fig 4)



(Fig 5)

Effect of adsorbent dose

Figures 6 and 7 shows that the removal percentage of Cd²⁺ ions increases as the number of absorbent increases. Absorption increased from 77.55 to 85.56 % with an increase in the absorbent dose from 0.3 to 0.7 g/10 ml. The number of adsorptive sites or surface area increases with increasing the weight of adsorbents which obtain many available exchange able sites which enhance the percent of metal removal. However, the sorption capacity (qt) decreases with the adsorbent dose because at a higher dose the solution ions concentration drops to a lower value and the system reaches equilibrium at lower values of (qt) indicating the adsorption sites remain unsaturated (it may be due to the overlapping of active sites at higher doses causing a decrease in the effective surface area resulting in the conglomeration of exchanger particles (15-16).

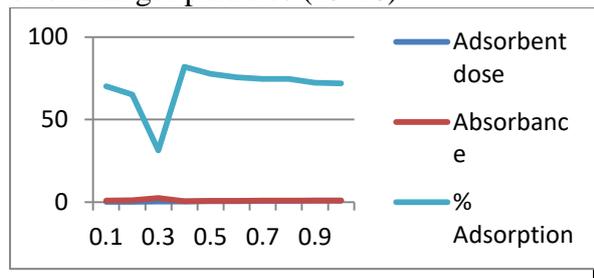
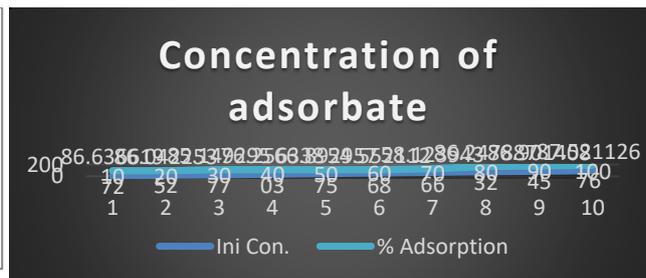


Fig 6



Conclusion

During This work, the investigation of adsorption of metal ions by CLP as a natural adsorbent show the following results. The CLP record an effective percentage removal for the Cd²⁺ metal using 0.4 gm sample size of CLP could remove about 89% of Cadmium with the initial concentration of 100 ppm within 60 min contact time. Also, a significant increase in the removal of Cd²⁺ could be observed with an increase in the CLP and an increase in the temperature. Time 50 min was the suitable contact time of adsorption. However, the removal rate did not remain the same at other contact times. The optimum pH for the adsorption of Cd²⁺ is found to be in the basic environment (pH around 11.9). It is obvious that 0.4 gm dose is the most efficient adsorbent dose and the best temperature is 313 K.

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GC-HRMS ANALYSIS OF PHYTOCONSTITUENTS IN METHANOLIC LEAF AND BARK EXTRACT OF ALBIZIA JULIBRISSIN DURAZZ

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Abstract

Albizia julibrissin Durazz. is a medium sized unarmed tree, 510 m tall, leaves 4-8 cm long found in outer Himalayan part of the India. The plant is traditionally used in Chinese medicine to treat the depression and anxiety. Pod extract of the plant shows antioxidant and antibacterial activity. Bark extract is applied to bruises, ulcers, abscesses, boils, hemorrhoids and fractures, and has displayed cytotoxic activity. Bark and root water extract showed anticancerous activity. Phytochemical investigation showed the presence of alkaloids, carbohydrates, proteins, flavonoids, glycosides, triterpenoids, saponins, steroids and tannins in bark and leaves methanolic extracts of the *Albizia julibrissin* Durazz. Resin and starch were absent in both the extracts of the plant.

Present investigation was designed to confirm the some of the bioactive constituents in leaf and bark methanolic extract of the plant. It revealed that the four compound present in the bark extract were Triallate; Vobassan-17-oic acid, 4-demethyl-3-oxo-, methyl ester; 3,6-Octadienoic acid, 3,7-dimethyl-methyl ester and Ceradran-dioland. Five compound were present in the leaves extract of the plant were 3-Methylmannoside; Propanoic acid, 2-chloro-, methyl ester; n-Hexadecanoic acid; n-Heptadecanol-1 and Hexadecanoic acid, 2,3-dihydroxypropyl ester. This GC-HRMS profiling can be used for biochemical marker and valuable tool for identification of this medicinally important plant.

Keywords - *Albizia julibrissin* Durazz., GC-HRMS, medicinal plant.

Introduction

Medicinal plants have been used as a source of drugs by mankind for several thousand years. In fact, ancient man was totally dependent on plants for his needs of treatment, prevention and other form of medicaments, thus, utilizing plants as drugs for millennia. Throughout the development of human culture, the use of medicinal plants has had magical-religious significance and different points of view regarding the concepts of health and disease which existed within each culture (Akinyemi, *et.al.*, 2018). Medicinal plants have been transformed into one of the oldest sciences in countries such as China, Greece, Egypt and India. However, the distribution of medicinal plants across the world is not uniform, and medicinal herbs are mainly collected from the wildlife population. Indeed, the demand for wildlife sources has increased by 8%-15% per year in Europe, North America and Asia in recent decades. The term medicinal plant refers to a variety of plants that have medicinal properties. These plants are a rich source of compounds that can be used to develop drug synthesis. The parts of medicinal plants that may be used are different types of seeds, root, leaf, fruit, skin, flowers or even the whole plant. The active compounds in most parts of the medicinal plants have direct or indirect therapeutic effects and are used as medicinal agents (Jamshidi-Kia, *et.al.*, 2018). People especially herbalists and traditional healers generate income from medicinal plants. Uganda is one of the developing countries where about 80% of the population largely depend on herbal medicine for treating various diseases (Namukobe, *et.al.*, 2011).

Albizia julibrissin Durazz. is a medium sized unarmed tree, 5-10 m tall, leaves 4-8 cm long found in outer Himalayan part of the India. The plant is traditionally used in Chinese

medicine to treat the depression and anxiety (Gilhotra and Dhingra, 2008). Pod extract of the plant shows antioxidant and antibacterial activity (Karim and Azlan, 2012). Bark extract is applied to bruises, ulcers, abscesses, boils, hemorrhoids and fractures, and has displayed cytotoxic activity (Lau, *et.al.*, 2007). Bark and root water extract showed anticancerous activity (Jin, *et.al.*, 2012).

Materials and Method

Collection of Plant Materials

Leaves and bark of *Albizia julibrissin* Durazz. were collected from Mahur forest (N.19° 42.548' E 078° 13.256') in Nanded district of Maharashtra. Specimen were identified and authenticated by Herbarium, Department of Botany, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (Accession No.-17397). Freshly collected leaves and stem bark of the plants were dried in shade and pulverized to coarse powder. The powder was stored in an airtight container and kept in a cool, dark, and dry place (Hassan, *et.al.*, 2014; Das, *et.al.*, 2014).



Fig 1.-*Albizia julibrissin* Durazz. Bark.



Fig 2.-*Albizia julibrissin* Durazz. Leaf

Method of preparation of methanol extract

The extraction was done by hot continuous method using Soxhlet apparatus. The 25 gm powder of leaves and bark were extracted using 250 ml methanol for 72 hours. The methanolic extract of bark and leaves of the plants were used for the further study (Vijayalakshmi, *et.al.*, 2012).

Gas chromatography-High resolution Mass spectroscopy (GC-HRMS)

It was carried out from sophisticated analytical instrument facility, Indian Institute of Technology, Pawai. 1 mg/ml extract dissolved in methanol was used for the analysis. Leaves of *Albizia julibrissin* Durazz. were used for this study (Phatak, 2015).

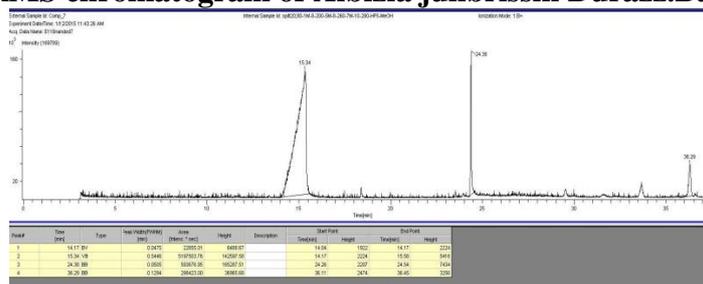
Results and discussion

GC-HRMS is combination of two techniques Gas chromatography (GC) and High Resolution Mass Spectroscopy (HRMS), which was used for the analysis of complex organic and biochemical present in methanolic bark and leaf extracts of the plants. It evaluates the possible compounds present in the methanolic extracts of the plant. This can be justified the medicinal use of the plant.

GC-HRMS analysis of *Albizia julibrissin* Durazz. bark extract.

GC-HRMS chromatogram detected the presence of four peaks in *Albizia julibrissin* Durazz. bark. These peaks were obtained at 14.17, 15.34, 24.38 and 36.29 min. This chromatogram also provided the area and height along with the starting point and ending point of height in terms of the min. of each peak (Fig No. 3). It was used for the identification of the compound in the extract.

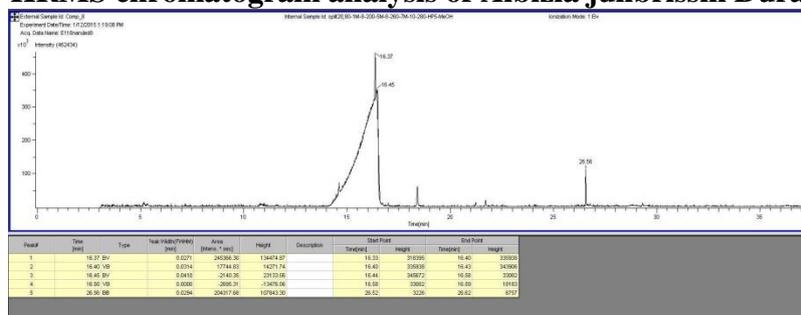
Fig No. 3- GC-HRMS chromatogram of Albizia julibrissin Durazz.Bark.



GC-HRMS analysis of Albizia julibrissin Durazz. Leaves extracts.

GC-HRMS chromatogram detected the presence of five peaks in Albizia procera Benth. leaves extract. This peak was obtained at 16.37, 16.40, 16.45, 16.58 and 26.56 min. This chromatogram also provided the area and height along with the starting point and ending point of height in terms of the min. of each peak (Fig. No. 4). This data was obtained through the high resolution mass spectroscopy instrument which is coupled with the GC-HRMS. It was used for the identification of the compound in the extract.

Fig No. 4- GC-HRMS chromatogram analysis of Albizia julibrissin Durazz.leaves.



Compound present in Albizia julibrissin Durazz.

Both these chromatogram of the bark extract and leaves extract of plant were analysed and NIST search were carried out for the each peak. It revealed that the four compound present in the bark extract were Triallate; Vobassan-17-oic acid, 4-demethyl-3-oxo-, methyl ester; 3,6-Octadienoic acid, 3,7-dimethyl-methyl ester and Ceradran-dioland. Five compound were present in the leaves extract of the plant were 3-Methylmannoside; Propanoic acid, 2-chloro-, methyl ester; n-Hexadecanoic acid; n-Heptadecanol-1 and Hexadecanoic acid, 2,3-dihydroxypropyl ester (Table No. 1). GC-HRMS analysis of Dalbergia lanceolaria subsp. paniculata (Roxb.) Thoth. Show the presence of one compound in the bark and eighth compound in the leaf of the methanolic plant extract (Wankhade, 2023)

Table No. 1 - Compound present in Albizia julibrissin Durazz.

Sr.No.	Bark	Leaves
1	Triallate	3-Methylmannoside
2	Vobassan-17-oic acid, 4-demethyl-3-oxo-, methyl ester	Propanoic acid, 2-chloro-, methyl ester
3	3,6-Octadienoic acid, 3,7-dimethyl-methyl ester	n-Hexadecanoic acid
4	Ceradran-diol	n-Heptadecanol-1
5		Hexadecanoic acid, 2,3-dihydroxypropyl ester

Conclusion

Through GC-HRMS different important biologically active phytoconstituents were identified from the leaves and bark methanolic extracts. GC-HRMS profiling can be used for biochemical marker and valuable tool for identification of this medicinally important plants. The presence of various chemical compounds confirms the application of Albizia julibrissin Durazz. for various remedies by traditional practitioners..

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ROLE OF BIOINDICATOR SPECIES AND BIOSENSORS IN ENVIRONMENTAL MONITORING: A REVIEW

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Abstract :

Environmental monitoring is widely recognized as an essential process for evaluating ecosystem conditions and understanding the effects of pollution, climate variability, and expanding human activities. While conventional chemical and physical monitoring techniques provide precise measurements, they often fail to reflect the biological consequences of environmental stress. In this context, bioindicator species and biosensors have emerged as reliable and complementary tools for environmental assessment. Bioindicator species respond naturally to changes in environmental conditions and therefore reflect long-term and cumulative ecological effects. Biosensors, which integrate biological components with analytical technology, enable rapid and sensitive detection of specific environmental contaminants. This review paper presents a comprehensive and human-centred synthesis of existing research on the role of bioindicator species and biosensors in environmental monitoring.

Keywords: Bioindicators, biosensors, environmental monitoring, ecosystem health, pollution assessment

Introduction:

The growing pressure on natural ecosystems due to industrialization, urban development, agricultural intensification, and climate change has made environmental monitoring more important than ever. Monitoring environmental quality helps detect pollution, assess ecosystem degradation and supports evidence-based environmental management. Traditionally, environmental monitoring has relied on physical and chemical measurements such as pollutant concentrations in air, water and soil. Although these methods are accurate and standardized, they often provide only short-term data and may not adequately reflect the biological impacts of environmental stressors.

Living organisms respond continuously to changes in their surroundings. These biological responses can reveal the combined and long-term effects of pollutants and other stress factors. Bioindicator species, therefore, offer valuable insights into ecosystem health by integrating environmental conditions over time. At the same time, technological advances have led to the development of biosensors, which provide rapid and sensitive detection of specific contaminants using biological recognition elements. This review explores how bioindicator species and biosensors contribute individually and collectively to environmental monitoring and highlights their role in achieving sustainable environmental management.

Bioindicator Species:

Bioindicator species are organisms whose presence, absence, abundance or physiological condition reflects the quality of the environment. These species are particularly sensitive to changes in environmental parameters such as pollution levels, temperature, pH, and habitat disturbance. Because they respond biologically to environmental stress, bioindicators are widely used to assess ecosystem health.

Plants such as lichens and mosses are commonly used as indicators of air quality. Their ability to absorb water and nutrients directly from the atmosphere makes them highly

sensitive to airborne pollutants, including sulfur dioxide and heavy metals. In aquatic ecosystems, organisms such as benthic macro invertebrates and fish serve as reliable indicators of water quality. Changes in species diversity and population structure often indicate pollution or habitat degradation. Amphibians are also considered effective bioindicators due to their permeable skin and life cycles that span both aquatic and terrestrial environments.

Several studies have emphasized that bioindicator species provide integrated information about environmental conditions over extended periods. Unlike chemical measurements that capture conditions at a specific moment, bioindicators reflect cumulative exposure and ecological consequences, making them valuable tools for long-term monitoring programs.

Biosensors:

Biosensors are analytical devices that combine a biological recognition element with a physical transducer to produce a measurable signal in response to a target substance. The biological component may include enzymes, antibodies, nucleic acids or whole cells, while the transducer converts the biological interaction into an electrical, optical or electrochemical signal.

Biosensors have gained prominence in environmental monitoring because of their speed, sensitivity and potential for on-site application. Enzyme-based biosensors are widely used for detecting pesticides and organic pollutants, while microbial biosensors can indicate the presence of toxic substances through changes in metabolic activity. Immunosensors and DNA-based biosensors provide high specificity for detecting pathogens, toxins and genetic material in environmental samples.

Recent advancements in nanotechnology and microelectronics have significantly improved biosensor performance. Modern biosensors are increasingly portable, cost-effective and capable of real-time monitoring and making them suitable for continuous environmental surveillance.

Role of Bioindicator Species in Environmental Monitoring:

Bioindicator species are effective tools for assessing environmental health. Their biological responses, such as changes in growth, reproduction, or population structure, reflect the long-term effects of environmental stressors. For example, reduced diversity of aquatic macro invertebrates often indicates poor water quality, while the absence of sensitive lichen species suggests deteriorating air quality.

Bioindicators are particularly useful in detecting chronic pollution and subtle ecological changes that may not be immediately evident through chemical analysis. However, their responses can be influenced by multiple environmental factors, which may complicate interpretation. Therefore, ecological expertise is essential when using bioindicator data for environmental assessment.

Effectiveness of Biosensors:

Biosensors have proven to be highly effective in detecting specific environmental contaminants at low concentrations. Their rapid response time allows for early detection of pollution events, which is crucial for timely management interventions. Biosensors are especially valuable in water quality monitoring, where they can detect heavy metals, pesticides and organic pollutants in real time.

Despite their advantages, biosensors may face challenges related to calibration, sensor stability and interference from complex environmental matrices. Regular maintenance and technical expertise are often required to ensure accurate results.

Integrated Monitoring Approaches:

An important outcome of this review is the recognition that bioindicator species and biosensors complement each other. Bioindicators provide ecological relevance and long-term integration, while biosensors offer precise and rapid pollutant detection. When used together, these approaches enhance the reliability and effectiveness of environmental monitoring programs.

Conclusion:

Bioindicator species and biosensors play vital roles in modern environmental monitoring. Bioindicators offer valuable insights into ecosystem health by reflecting biological responses to environmental stress, while biosensors provide fast and accurate detection of specific contaminants. This review highlights that integrating biological and technological approaches can overcome the limitations of individual methods and lead to more comprehensive environmental assessments. Such integrated strategies are essential for sustainable ecosystem management and informed environmental decision-making.

Recommendations:

1. Environmental monitoring programs should integrate bioindicator species and biosensor technologies to obtain both biological and analytical data.
2. Standardized protocols for selecting and interpreting bioindicator species should be developed to improve data comparability.
3. Continued research and innovation in biosensor technology are needed to enhance durability, sensitivity and field applicability.
4. Interdisciplinary collaboration among ecologists, technologists and policymakers should be encouraged to improve environmental monitoring strategies.

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ANATOMICAL STUDY HIBISCUS PANDURIFORMIS BURM.F (MALVACEAE)

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Abstract:

The present study on the detailed anatomical investigation of *Hibiscus panduriformis* Burm.f., an important species of family Malvaceae, with the aim of evaluating its taxonomic significance. Transverse section of Root, Stem, and Leaf were examined Manually (Hand section) and Double Staining techniques. These anatomical features provide reliable diagnostic characters for species identification and support the systematic placement of *Hibiscus panduriformis* within Malvaceae. The study highlights the importance of anatomical traits in resolving taxonomic relationships and contributes baseline anatomical data for future comparative and systematic studies.

Keywords: *Hibiscus panduriformis*, Plant anatomy, Root, Stem, Leaf, Malvaceae, Double Staining.

Introduction:

Hibiscus panduriformis Burm. f. is a shrubby species belonging to the family Malvaceae. The plant commonly occurs in dry and open habitats such as scrublands, roadsides, and fallow fields, showing good adaptability to semi-arid climatic conditions.

Hibiscus panduriformis Burm. f. is a less explored species with limited anatomical documentation, particularly from semi-arid region of Maharashtra. The present study aims to investigate the detailed anatomy of root, stem and Leaf of *Hibiscus panduriformis* to document its internal structural features. Plant anatomy provides valuable insights into the internal structural organization of plants and plays a significant role in understanding functional adaption and systematic relationships.

Such anatomical data will contribute to baseline information useful for comparative anatomical studies and future systematic investigations.



Plant Body

Ecology: In Marathwada region of Maharashtra, *Hibiscus panduriformis* Burm. f. is commonly found in dry scrublands, roadsides, and fallow fields, particularly in areas characterized by low and erratic rainfall. The species grows well in shallow, well-drained black cotton and sandy loam soils typical of the region. It is well adapted to high temperature, prolonged dry periods, and moisture stress, which are common climatic features of Marathwada.

Due to its hardy nature, the species contributes to vegetation stability in semi-arid ecosystem of Marathwada.

Materials And Methods:

Healthy and mature Specimens of *Hibiscus panduriformis* Burm. f. were collected from Majalgaon, kesapuri camp, sadola, from dist. Beed, kalamb from dist. Dharashiv (Osmanabad), and Pangaon from dist. Latur during field visits. Fresh Root, Stem, and leaf samples were fixed in 1% Formalin solution for preservation.

The transverse sections were prepared manually using a sharp razor blade. The section were stained using the double staining technique with safranin and fast green to differentiate lignified and non-lignified tissues. Permanent slides were prepared using DPX mounting medium. Anatomical observations were carried out under a compound microscope, and important structures were recorded and interpreted.

Process: transverse sections of root, stem, leaf, petiole were taken from preserved plant material. After that sections were kept in safranin for few minutes then rinse with water untill excess stain removed. Then passed into alcohol grades (15%, 30%, 50%, & 70%). Then it kept into fast green stain for 2 min, then again passed into 90% and Pure alcohol repectively. The kept in xylol for 1 min. and later mounted in DPX. And observed under microscope.



Collected and preserved plant material

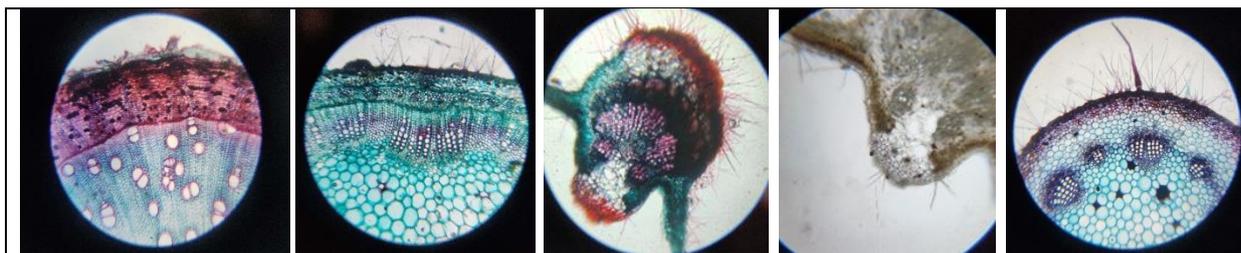
Results and Discussion:

Root: The transverse section of root showed well- developed secondary growth. The outermost region consist of multilayered periderm, differentiated into phellem, phellogen, and phelloderm. Phellem cells were compact, thick-walled, and subrized, providing protection against water loss. The cortex was reduced due to secondary growth. The vascular tissue was radially arranged with well-developed secondary xylem and phloem. Xylem consist of vessels, fibers and Parenchyma, while phloem showed sieve elements and parenchyama. These features indicate adaptation to dry environmental condition.

Stem: The stem exhibited a single layered epidermis followed by a multilayered cortex composed of collenchyma and parenchyma. Distinct sclerenchymatous patches were observed above the phloem, providing mechanical support. Vascular bundles were collateral, open, and arranged in ring. The presence of cambium indicated secondary growth. Secondary xylem was well developed with vessels and fibres, while secondary phloem showed sieve tubes and companion cells. Periderm formation was evident in mature stem regions.

Leaf: The leaf showed typical dorsoventral organization the upper epidermis was single layered with a thick cuticle. Mesophyll was differentiated into palisade tissue on the adaxial side and spongy parenchyma on the abaxial side. Vascular bundles were collateral and enclosed by bundle sheath. Presence of mucilage and trichomes were also noted.

Petiole: The outermost layer is a single layered epidermis covered with thin cuticle and bearing numerous trichomes. Beneath the epidermis collenchymatous hypodermis is present. The cortex is broad and composed of thin walled parenchymatous cells, the vascular system consists of collateral and open vascular bundles, arranged in a cresent shape. Xylem is oriented towards the inner side and shows well developed vessels, while phloem is located towards the outer side with a narrow strip of cambium in between, indicating the potential for secondary growth. The central region is occupied by ground tissue made of parenchyma.

**T. S of Root****T. S of Stem****T. S. of Leaf****T. S of Petiole**

Petiole: The pollen grains of *Hibiscus panduriformis* are spheroidal to sub spheroidal in shape and occur mostly as individual grains or in small aggregates. The pollen grain exhibit a yellow to light brown coloration under microscope. The exine is thick and prominently echinate, bearing numerous short spine uniformly distributed over the pollen surface. The pollen grains are possessing multiple circular pores distributed over the entire surface.

**Pollen Grains****Trichomes and Stomata**

Stomata: The leaf epidermis exhibits anomocytic type of stomata, characterized by guard cells surrounded by epidermal cells without distinct subsidiary cells

Trichomes: On the leaf surface star shaped stellate, non-glandular trichomes are observed. Each consists of central disc with several radiating arms.

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THE ROLE OF HISTORY AS A SCIENCE IN SUSTAINABLE DEVELOPMENT

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Abstract :

Sustainable development has emerged as a central global concern in the twenty-first century, addressing the interconnected challenges of economic growth, environmental protection, and social equity. While scientific and technological disciplines dominate sustainability discourse, history—often perceived as a humanities subject—plays a critical but underappreciated role in sustainable development research. This paper argues that history, when approached as a science grounded in systematic evidence, critical analysis, and causal explanation, is essential for understanding long-term human–environment interactions, development patterns, and policy outcomes. By examining historical methodologies, case studies of past development models, environmental transformations, and social systems, this study demonstrates how historical knowledge contributes to sustainable planning, policy-making, and resilience-building. The paper concludes that integrating historical analysis into sustainable development research strengthens interdisciplinary approaches and improves long-term sustainability outcomes.

History is simply understood as events in the past. With this understanding, there is an assumption that history cannot contribute to the broad development process. This article aims to provide a conceptual description of the role of history as a science in the context of development in general and sustainable development in particular which is adapted to the objectives of sustainable development itself. This article is a historical conceptual article written with a qualitative descriptive approach supported by the use of data collection methods in the form of library research. From the results of the discussion, it is known that the concept of sustainable development can be traced from various works of social history so that a more detailed concept can be formulated today. History as a science also has an important relationship and role in the development process and sustainable development itself which can be seen from the existence of historical functions that can lead to historical consciousness.

Keywords: History, Sustainable Development, Historical Method, Environmental History, Policy, Interdisciplinary Research

Introduction:

Sustainable development is commonly defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Since the publication of the Brundtland Report in 1987, sustainability has become a guiding principle for governments, international organizations, and researchers. However, much of the research in sustainable development emphasizes natural sciences, economics, engineering, and technology, often overlooking the contribution of history as a scientific discipline. History is frequently misunderstood as a mere record of past events. In reality, history functions as a science that employs systematic methods, critical evaluation of evidence, and analytical frameworks to understand patterns of change over time. When applied to sustainable development, history offers long-term perspectives that reveal how societies have managed resources, adapted to environmental changes, and responded to

development challenges. This paper explores the role of history as a science in sustainable development research. It argues that historical analysis is indispensable for understanding sustainability challenges, avoiding repeated mistakes, and designing informed policies. By examining the scientific nature of history, its relevance to sustainability, and practical case studies, the paper highlights the importance of integrating historical knowledge into sustainable development strategies.

Research Methods :

The 21st century is a time when the flow of information and the development of science and technology has occurred so rapidly that they gave rise to the phenomenon of information disruption. Such conditions will become increasingly settled and felt in almost all parts of the world, considering that information disclosure and the phenomenon of information disruption are unavoidable phenomena. This certainly has a broad impact on human life which can be seen when humans have experienced a wave of civilization, namely agriculture and industry, and are now dealing with third-world civilization, namely post-industrial civilization or post-industrial civilization [1]. This article is a conceptual study. It should be understood that historical research is literature research. Historical research aims to examine various events in the past through various sources, especially written sources. Therefore, this article is also supported by a qualitative descriptive approach with data searches carried out by literature studies. The writing is done through the process of extracting data from various reference sources that discuss various articles/writings related to various literature regarding the role of history as a science in sustainable development. These various sources are published in public media so that they can be accessed through various places (libraries) and internet media openly.

The Scientific Nature of History:

History qualifies as a science not because it conducts laboratory experiments, but because it follows systematic and rigorous methods of inquiry. Historians formulate research questions, collect evidence from primary and secondary sources, evaluate reliability and bias, and construct interpretations based on logical reasoning. This method parallels the scientific process used in other disciplines. Historical science relies on: Empirical evidence such as documents, archaeological remains, oral testimonies, and statistical records Critical analysis and source evaluation Cause-and-effect reasoning Comparative and longitudinal analysis These methods enable historians to identify patterns and trends across time, making history particularly valuable for sustainability research, which inherently requires long-term analysis.

History and Interdisciplinary:

Sustainable development is an interdisciplinary field, combining environmental science, economics, sociology, political science, and technology. History acts as a bridge among these disciplines by providing temporal depth. Historical research contextualizes scientific data, economic trends, and social changes, ensuring that sustainability strategies are grounded in real-world experience rather than short-term assumptions.

Sustainable Development: A Historical Perspective:

History and Its Role in Nation Development :

The development of historiography at the global and local levels in Indonesia itself has experienced significant developments. Various traditions of writing history/historiography carried out by several major civilizations have been able to have an impact on the lives of other nations. In this case, the works of historians from several major civilizations were then able to inspire and have an impact on the formation of the character and character of a nation as a nation that can stand on its own feet in its scientific development [3]. In the development of today's modern times, people who master information technology can become people who can determine the direction and orientation

of their knowledge. Scientific developments will then become more inclusive so that they can be accessed by a wide audience. In short, science and technology do not become the monopoly of a single group of people, as the past/history is only studied by the monks in historical temples. With the times, the information revolution occurred. Every aspect of science and technology then competes to be used and applied openly. Consequently, science and technology must be adaptive and then practical-appellative. This kind of development is also what history is trying to achieve as a scientific discipline. Thus, historical writing based on documentation and developing into developmental becomes very urgent to be considered by various parties. Not only that, the predictive nature of historical science is then required to be able to answer various interests of future orientation (to become what is known as future history). Therefore, not only geographic, history in modern times then developed no methodically

The contemporary world at that time demands that every discipline can be a tool and not just an end. The dictum that science works for the sake of science has been considered obsolete because it only creates a disparity between scientists and the reality of the society in which they live. For the science of history, various methodologies and curricula that are suitable in the process of supporting the linkage and equivalence of history as a science with aspects of science and technology and other developments of the times absolutely must be developed. The dictum of science works for science, making science isolated and giving rise to the phenomenon of the ivory tower so that it creates the impression of luxury and "counter-productive". As Benetton Croce said, the present or the contemporary must dominate selection and analysis. Especially from the point of view of the present-minded, the discipline of history must be able to increase quantitative and qualitative understanding of the surrounding problems, and help find solutions for a more ideal future. As a result, the science of history has not become a science that is dry, boring, and irrelevant to the present, especially in the 21st century. So, history with its social function must also provide information about the causes of a certain pattern of behaviour through history, we know the actions, thoughts, and struggles of humans in revealing their fate in the past. History supports the foundation for the personality of a nation in the form of conditions provided and inherited from experience. Historical knowledge provides the basis for determining the direction of the struggle into the future.

1. Evolution of Development Concepts

Development is not a modern concept; societies have pursued progress and prosperity throughout history. Ancient civilizations such as Mesopotamia, Egypt, and the Indus Valley developed complex agricultural systems, trade networks, and urban planning strategies. While these societies achieved remarkable growth, many also collapsed due to environmental degradation, resource depletion, or social inequality. The Industrial Revolution marked a turning point in development history. Rapid industrialization led to economic growth but also caused environmental pollution, urban overcrowding, and labor exploitation. Understanding this historical phase is essential for modern sustainability debates, as many contemporary challenges—climate change, deforestation, and inequality—have roots in industrial-era practices.

2. Lessons from Historical Failures and Successes

Historical case studies provide valuable lessons for sustainable development. For example: The collapse of the Mayan civilization illustrates the consequences of deforestation and water mismanagement. Traditional agricultural systems, such as terrace farming in Asia and Africa, demonstrate sustainable land-use practices developed over centuries. By studying both failures and successes, history informs present-day decision-making and encourages adaptive strategies.

Environmental History and Sustainability:

1. Human–Environment Interaction Over Time

Environmental history examines the relationship between humans and nature across different periods. It reveals how societies have shaped ecosystems and how environmental changes have influenced social and economic structures. Historical analysis shows that environmental degradation is not a new phenomenon. Soil erosion in ancient Rome, deforestation in medieval Europe, and water scarcity in early modern Asia all highlight long-standing sustainability challenges. These insights emphasize that current environmental crises are part of a broader historical continuum.

2. Climate History and Climate Change Research

Climate history plays a vital role in understanding contemporary climate change. Historical climate data derived from ice cores, tree rings, and written records help scientists reconstruct past climate patterns. These reconstructions demonstrate how societies adapted—or failed to adapt—to climate variability. By examining historical responses to droughts, floods, and temperature shifts, researchers can identify resilience strategies applicable to modern climate adaptation policies.

History, Society, and Sustainable Development

1 Social Equity and Development

Sustainable development emphasizes social equity and justice. History provides insight into the origins of inequality, marginalization, and power structures. Colonial histories, for instance, have left lasting impacts on economic development, resource distribution, and governance in many regions. Understanding historical injustices allows policymakers to design inclusive development strategies that address structural inequalities rather than treating symptoms alone.

2 Cultural Heritage and Sustainability

Cultural heritage is an important component of sustainability. Traditional knowledge systems, indigenous practices, and historical community structures often embody sustainable principles. History helps preserve and interpret this knowledge, ensuring it is not lost in the pursuit of modernization. For example, indigenous water management systems and forest conservation practices have proven effective and environmentally friendly, offering alternatives to resource-intensive modern approaches.

Historical Analysis in Policy and Planning

1 Avoiding Repetition of Past Mistakes

One of history's most significant contributions to sustainable development is its ability to prevent the repetition of past mistakes. Development projects that ignore historical land-use patterns, social structures, or ecological limits often fail. Large-scale infrastructure projects, such as dams and urban expansions, have historically displaced communities and damaged ecosystems. Historical evaluation of similar projects helps policymakers anticipate risks and design more sustainable solutions.

2 Long-Term Policy Evaluation

Unlike short-term studies, historical analysis evaluates policies over decades or centuries. This long-term perspective is crucial for assessing sustainability, which by definition concerns future generations. History enables researchers to measure the enduring impacts of policies and development models.

3 Historical Data as Research Evidence

Historical records, archives, maps, and oral histories serve as valuable data sources for sustainability research. These sources complement quantitative scientific data by providing context, continuity, and qualitative insights.

4 Comparative Historical Studies

Comparative history allows researchers to analyze different societies facing similar challenges. By comparing development trajectories across regions and time periods, scholars can identify best practices and adaptable strategies for sustainability.

Challenges and Limitations : Despite its value, integrating history into sustainable development research faces challenges. Historical data may be incomplete, biased, or difficult to interpret. Additionally, interdisciplinary collaboration requires scholars to overcome methodological differences between history and the natural sciences.

However, these challenges do not diminish the importance of history. Instead, they highlight the need for improved collaboration, digital archives, and inclusive research approaches.

Conclusion :

History, when understood and applied as a science, plays a vital role in sustainable development research. Its systematic methods, long-term perspective, and interdisciplinary relevance make it indispensable for understanding complex development challenges. Historical analysis reveals patterns of success and failure, illuminates human–environment relationships, and provides essential lessons for policy and planning. Sustainable development is not solely a technical or economic challenge; it is a historical process shaped by past decisions, cultural values, and social structures. Ignoring history risks repeating mistakes and undermining sustainability goals. Therefore, integrating historical science into sustainable development research enhances resilience, equity, and long-term success. In an era of global environmental and social crises, history offers not only knowledge of the past but guidance for a sustainable future.

This article can be concluded several things; first, history has a significant meaning in dealing with the times. History (as a science) plays a role in providing awareness (enlightenment) for the community to raise awareness in the community (nation and state) as part of a broad development effort. Second, sustainable development, as part of the concept of development, has close relevance to historical science. In its historical course, the concept of sustainable development is the concept of continuity in development that can be traced in many works of the social history of society. Third, history is a collective memory of the past, which involves various aspects of the sociocultural journey of a society that will become a mirror for today's life.

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BACTERIAL DISEASES IN SOYBEAN PLANTS

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Abstract: This research paper examines the detail study of Bacterial diseases, primarily Bacterial Pustule (*Xanthomonas citri* pv. *glycines*) and Bacterial Blight, significantly threaten soybean yield and quality, causing leaf spots, pustules, and necrosis, especially in wet conditions. Management involves an integrated approach using clean seeds, resistant varieties, cultural practices (like debris removal, avoiding overhead watering), and sometimes bactericides, with modern detection using remote sensing (drones, multispectral imaging) and genomics improving early diagnosis and monitoring.

Keywords: Bacterial, Diseases, Soybean, Molecular, Pathogen, Leaf Spot etc.

Introduction

Like all living things, plants require a certain amount of bacteria to both survive and to thrive. There are good bacteria and bad bacteria for plants as well as for animals and humans. The absence of bacteria can lead to immunosuppression in all living creatures, which is why maintaining a balance of good bacteria is necessary and even beneficial. Bad bacteria are known as pathogens and are actually detrimental to the life of plant cells. Bacterial pathogens in plants can affect the strength of the plant's stalks, leaves, petals and roots.

This can be particularly damaging when pathogens may infect a plant and travel through the soil to other nearby plants of the same or similar varieties, infecting them too. For this reason, if a gardener or farmer suspects that there may be a disease in one of their plants, they should take action immediately. In some cases, pathogens will weaken but not kill plants, while in others the bacteria kill the plants outright. Symptoms of bacterial pathogens in plants can include cankers or other marks on the plant leaves, leaf overgrowth, spots, wilting and other behaviour. While many people often attribute these symptoms to overwatering or underwatering or to the wrong amount of sun exposure, the truth is that it's likely a plant disease caused by pathogens. This is why if a plant doesn't look right, it's a good idea to take the time and see if it's a watering issue or is something more serious is at play. Pathogens can be broadly defined as any variety of bacteria that has negative or malignant effects on its host. In the case of plants, pathogens are any of the small species of bacteria that actually harm plants as opposed to helping them. Many people are unaware that plants can get bacterial infections just like people do, and just as with people, these diseases and infections can be spread quickly and easily from plant to plant. Preventing the spread of pathogens means remaining vigilant and aware. It's extremely easy to write off weird spots, a lack of growth and other abnormalities to things like a lack of sunlight, inconsistent watering or extremely dry weather. However, being aware of the symptoms of bacterial pathogens can help you recognize when something more serious may be going on with your plants.

The sooner you recognize that a pathogen has infected your plant, the sooner you can take action to cure, correct or stop the spread of the disease. Intervention may take the form of chemicals or cutting and moving the plants to a new location. If the pathogen is in the soil,

it may require inoculating the soil before you can safely replant. Occasionally applying a chemical to kill bacterial pathogens may also harm your plants.

Objectives:

1. To examine accurate identification and diagnosis of bacterial diseases.
2. Understanding disease cycles and epidemiology
3. To quantify the actual or potential yield losses caused by different bacterial diseases.
4. To identify different races of pathogens to facilitate the breeding of durable resistance in soybean plants.
5. To developing effective, sustainable, and integrated management strategies to minimize yield and economic losses.

Material and Methods:

Bacterial diseases in soybean plants are primarily foliar infections that can lead to defoliation and yield loss under favourable weather conditions. The three most significant bacterial diseases are Bacterial Blight, Bacterial Brown spot, and Wilt. Materials used in the management and study of bacterial diseases in soybean plants (such as bacterial blight Bacterial Brown spot, and Wilt) include chemical treatments, biological agents, and specific organic amendments. Following material have considered for identify and diagnosis of bacterial diseases of soybean plants.

Disease	Causal Agent	Optimal Conditions	Symptoms
Bacterial Blight	<i>Pseudomonas savastanoi</i> pv. <i>glycinea</i>	Cool (70–80°F), wet weather	Small, angular, yellow-brown spots with yellow halos (water-soaked appearance). Centers turn dark brown/ black and fall out, giving leaves a tattered look
Bacterial Brown Spot	<i>Pseudomonas syringae</i> pv. <i>Syringae</i> (Pss)	Warm (80-85°F), moist conditions	Small, Circular, brown spot by leaf veins and veinlets. Small circular spots on underside of leaves if water soaking occurs. giving leaves a tattered strips or “shot holes”.
Wilt	<i>Curtobacterium Flaccumfaciens</i> pv. <i>Flaccumfaciens</i> (Cff)	maximum temperatures around 30°C (86°F),	Leaf wilting during periods of warm, dry weather. Wavy, interveinal, necrotic lesions surrounded by bright yellow borders.

Methods :

Managing soybean bacterial diseases involves cultural practices like crop rotation, tillage to bury residue, using resistant varieties, planting certified seed, and avoiding field entry when wet to prevent spread; while chemical control is limited, early application of copper bactericides might offer some control for blight, but fungicides are ineffective as bacteria cause these issues.

Cultural & Preventative Methods

Resistant Varieties: Plant soybean cultivars known to have tolerance or resistance to specific bacterial diseases like bacterial blight or pustule.

Crop Rotation: Rotate soybeans with non-host crops (corn, wheat, alfalfa) for at least one year to break the disease cycle.

Residue Management: Burying infected soybean residue through tillage reduces the amount of bacteria (inoculum) available for the next season.

Sanitation: Avoid working in fields or moving equipment through them when foliage is wet to prevent spreading bacteria.

Seed Quality: Use certified, pathogen-free seed to avoid introducing bacteria into your fields.

Chemical & Other Methods

Bactericides: Copper-based bactericides can be applied, but must be done very early in the disease cycle to be effective; they are not a curative treatment.

Fungicides: Foliar fungicides generally do not work on bacterial diseases and are not recommended for controlling bacterial blight or pustule.

Soil Amendments: Organic amendments like manure or neemcake may help reduce soil inoculum levels.

Monitoring & Identification

Scouting: Regularly scout fields after emergence to catch issues early, taking whole plants (roots, stems, leaves) for proper diagnosis.

Identification: Bacterial pustule appears as small, raised bumps on the underside of leaves, while blight causes angular, water-soaked lesions.

Results and Discussion:

The three most prominent bacterial diseases in soybeans are distinguished by their symptoms and the environmental conditions they favour:

Diseases of Soybeans

Several diseases, including Phytophthora root and stem rot, pod and stem blight, frogeye leaf spot, brown spot, downy mildew, Cercopsora leaf blight and purple seed stain, and Sclerotinia stem rot (white mold), are known to affect soybeans in New York. Little is known, however, about the incidence, severity, or yield effects of diseases in the state.

Diseases generally are kept in check by the use of sound agronomic practices such as crop rotation and the selection of soybean varieties with resistance to diseases known to be a problem in the local area.

Bacterial Blight In Soybean

- Bacterial blight is favoured by cool (70 to 80 °F), wet weather and is inhibited by hot, dry weather.
- Rotating away from soybean or planting soybean products that are tolerant or resistant to bacterial blight is recommended for problem fields.
- Foliar fungicide applications are ineffective in controlling bacterial blight.

Bacterial blight of soybean is the most common bacterial disease of soybean and is caused by the bacterium *Pseudomonas savastanoi* pv. *glycinea*.¹ The disease is favoured by cool (70 to 80 °F), wet weather and is inhibited by hot, dry weather. Bacterial blight seldom causes significant yield loss; however, losses of up to 40% have been reported on susceptible soybean products.

Disease Cycle - The bacterium overwinters on crop residue and infection usually occurs when the pathogen is carried by splashing or wind-driven rain from infected plant residue to soybean leaves. Disease outbreaks usually follow a rain event with high winds.^{1,2} Bacteria can enter the plant through natural openings (stomata) or plant wounds. The leaf surface must be wet for infection to occur through natural openings. Seedling infection can occur by planting infested seed. Also, the pathogen can spread from infected leaves to uninfected leaves when the leaves rub against one another during cultivation, rain and wind.



Fig. Bacterial blight lesions on soybean leaves. Note leaf lesions with yellowish-green halos. Typically, symptoms can be observed 5 to 7 days after soybean leaves are infected. 1 Nine different races of bacterial blight have been identified.

Symptoms:

Bacterial blight can be identified by small, angular, translucent, water-soaked, yellow to light-brown spots on the leaves and petioles. As bacterial blight progresses, affected leaf tissues dry out, turn reddish-brown to black, and become surrounded by water-soaked margins bordered by yellowish-green halos. In advanced stages, lesions enlarge and their interiors tend to produce large, irregularly shaped dead areas. Frequently, the leaves are badly shredded after strong winds and/or hard rains. This gives affected leaves a very ragged appearance. Infected young leaves frequently are distorted, stunted, and chlorotic.



Fig. Chlorotic soybean leaves caused by bacterial blight.

Bacterial blight has primarily been found on leaves that developed during cooler weather when conditions favoured the disease. Leaves above the infected region are often disease-free, primarily because of higher temperatures during development. Leaf symptoms of bacterial blight may be confused with soybean rust and Septoria leaf spot. However, bacterial blight will be in the mid-upper canopy and have green leaves below the affected area while soybean rust and Septoria leaf spot tend to appear lower in the crop canopy. Bacterial blight lesions may first appear on the cotyledons, usually at the margins. These lesions enlarge and turn dark brown as the tissue collapses. Young seedlings grown from infected seed commonly are stunted, blighted, and usually die. Soybean pods, petioles, and stems are also susceptible to bacterial blight. Initially, lesions on the pods are small and water-soaked; however, after enlarging, they merge to involve much of the pod. Lesions eventually turn dark brown to black. Seeds within affected pods may also become infected and coated with a slimy bacterial growth. Stored seeds may appear healthy or may develop a variety of symptoms including shriveling, sunken or raised lesions, or slight discoloration.

Management

The most effective management practices to reduce the impact of bacterial blight on yield potential are crop rotation or selecting soybean products that are resistant or tolerant to bacterial blight. Rotate away from soybean for one year or more to a non-host crop such as corn, sorghum, alfalfa, clover, or cereal grains. Additional management practices include completely covering soybean plant residue after harvest by clean plowing where feasible. Also, avoid cultivation when foliage is wet. Foliar fungicides seldom provide an economic benefit as bacterial blight is caused by a bacterial pathogen. Some copper-based bactericides are labeled for control of bacterial blight on soybean; however, application needs to occur early in the disease cycle to be effective.

1. Bacterial Brown Spot In Soybean

Bacterial brown spot is a more recently discovered disease in dry beans than halo or common bacterial blights, and like common bacterial blight is a warm weather-oriented disease with maximal growth occurring at 28 to 30°C. The pathogen causing bacterial brown spot was first isolated from specimens from New Jersey by Burkholder. It was considered to

be of minor importance in the US, until serious outbreaks occurred in Wisconsin snap bean production in the mid 1960s. It was first reported from this region from a western Nebraska dry bean field in 1969, and has been increasing in incidence and damage along with halo blight during the past 10 to 15 years in the Central High Plains. The pathogen potentially causes the most damage during periods where temperatures range from 27 to 30°C (80 to 85°F), which often occurs during mid-vegetative to early flowering periods of plant growth.



Fig. Brown spot symptoms on upper leaf surface.

Pathogen: *Pseudomonas syringae* pv. *syringae* (Pss)

Primary hosts: Common bean (*Phaseolus vulgaris* L.)

Symptoms and signs: Lesion size can vary, but generally are small, circular, and brown, coalescing to form linear necrotic streaks delimited by leaf veins and veinlets. If water soaking occurs, it manifests itself as small circular spots on the underside of leaves. The centers of old lesions fall out leaving tattered strips or "shot holes" on affected leaves and evidence of water soaking may be visible in the edge of tissue next to the shot holes. Stem and petiole lesions are occasionally found in situations where the pathogen becomes systemic. Lesions on pods are circular and water-soaked initially, but later turn brown and become necrotic. If young pods or those in the flat stage become infected, they may be bent or twisted with visual ring-spots or water-soaked, brown lesions.

Host range: Known host range for Pss includes fava bean (*Vicia fava*), lima bean, pea (*Pisum sativa*), soybean, Kudzu, hyacinth bean (*Lablab purpureus*), yard long bean (*Vigna sesquipedalis*), and cowpea.

Geographic distribution: Bacterial brown spot has been reported from United States and Brazil, and has been demonstrated to cause damage to snap beans in Wisconsin and pinto and light-red kidney beans in Colorado.

Pathogen isolation: Seed transmission is very low with the use of western-grown certified seed, and is rarely of significance, and the pathogen is commonly found occurring as an epiphyte on leaves of weed and legume hosts. Media for isolation include those same media listed for halo blight above, including King's Medium B, BCBRVB, KBBC, and MSP.

Pathogen identification: Pss is a gram-negative, rod-shaped bacterium with a polar tuft of flagella. It also, like Psp, produces cream to white colored colonies on standard media. It is aerobic, arginine-dihydrolase negative, and produces fluorescent pigments, also like that of Psp.

It additionally has the ability to utilize numerous compounds such as betaine, glycerate, glutarate, citrate, glycerol, sorbitol, and sucrose. Pathogenic isolates produce a bacteriocin in the host plant known as syringomycin W-1.

2. Wilt disease in Soybean

In 2003, the disease was found in two Nebraska (Scotts Bluff Co.) Great Northern fields and was widely observed throughout Colorado, Wyoming, and Nebraska from multiple (> 300) fields during 2004-2006. Affected fields were planted with beans from many different dry bean market classes and seed sources, including yellow, Great Northern, pinto,

kidney, black, navy, pink, small red, and Anasazi. Wilt is most destructive after periods of plant stress and temperatures exceeding 32°C.

Pathogen: *Curtobacterium flaccumfaciens* pv. *flaccumfaciens* (Cff)

Primary hosts: Common bean (*Phaseolus vulgaris* L.)

Symptoms and signs: Field symptoms consist of leaf wilting during periods of warm, dry weather or periods of moisture stress. Plants often recover during evening hours when temperatures are lower, but wilt again during the heat of the day. Infected plants in the Central High Plains have additionally exhibited symptoms consisting of wavy, interveinal, necrotic lesions surrounded by bright-yellow borders. These symptoms may be confused with those caused by common bacterial blight pathogen, but bacterial wilt lesions are additionally accompanied by wilting and often plant death with severely infected plants. Common blight-infected plants rarely are killed. And wilting is not observed as a part of the disease process.

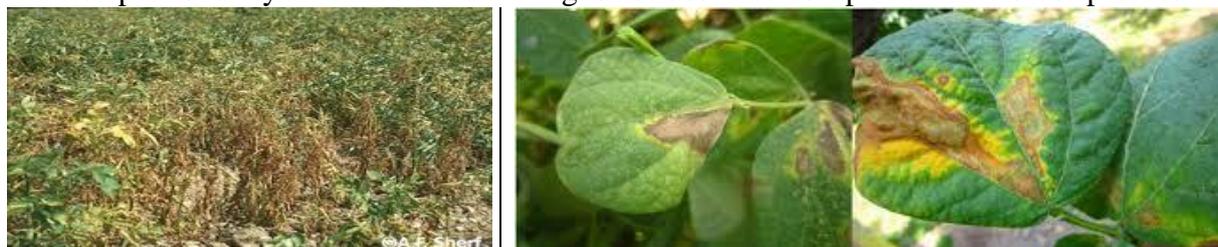


Fig. Dry bean field severely affected by bacterial wilt. **Fig.** Interveinal necrotic symptoms with wavy yellow halo, characteristic of bacterial wilt.



Fig. Wilting symptoms due to bacterial wilt. **Fig.** Wilting accompanied with leaf necrosis surrounded by wavy yellow borders due to bacterial wilt.

If plants survive to produce mature seed, they are often discolored as a result of bacterial infection and colonization, particularly in the white-seeded market classes such as navy and Great Northern. Infection can occur on pod sutures, but seldom causes circular spots. Seeds also may become infected even while pods appear to remain healthy, due to pathogen movement into developing seeds through the vascular system.

Host range: Known host range for Cff includes scarlet runner bean, lima bean, pea (*Pisum sativa*), soybean (*Glycines max*), Azuki bean (*Vigna angularis*) Willd. Ohwi and Ohashi, *V. mungo* (L.) Hepper, mung bean (*V. radiata*) L. R. Wilcz., hyacinth bean (*Lablab purpureus*), and cowpea (*V. unguiculata*).

Geographic distribution: Bacterial wilt has been infrequently, but repeatedly observed as field infections in the Central High Plains of the US, although until recently not for more than 30 years. It has also been reported from numerous countries representing widespread distribution across the world, including Canada (Alberta and Ontario), Tunisia, Turkey, Bulgaria, Greece, Hungary, Romania, Russia, former Yugoslavia, Belgium, Australia, Mexico, and Columbia.

Pathogen isolation: Isolation of the pathogen can be accomplished successfully in several ways. Lesion margins of infected leaves may be abraded or punctured with a dissecting needle, and streaked onto medium plates. Another method is to squeeze the sap out of petioles attached to wilted or necrotic leaves and blot onto medium, followed by streaking with a sterilized inoculating loop. Alternatively, the bacterium can easily be isolated from infected, discolored seeds. Discolored seeds are soaked overnight in water or buffer. Plates

are then streaked with the leachate and/or imbibed seeds are plated after splitting in half (R. M. Harveson, unpublished). Fluidal colony growth will be seen emerging from margins of seed and on media surface after streaking.

Pathogen identification: The pathogen is aerobic, gram-positive, with short, coryneform-shaped, rods that characteristically bend or snap. Colony growth on nutrient broth yeast extract medium is slow and fluidal. Pathogen colour variants have been reported that stain seeds, and are particularly conspicuous on white seeded cultivars, including the original type strain yellow, orange, and purple.

The purple pathogen variant, *C. flaccumfaciens* pv. *violaceum*, produces an extracellular, pigment that diffuses into growth media after 7 to 10 days. Over time, the pigments still remain in media, but the initial orange or yellow colonies are not as obscured, and can be visualized much easier than with younger cultures.

Pathogen storage: The pathogen may also be successfully stored long term on seeds. Due to a strong resistance to drying, the pathogen has been demonstrated to remain viable up to 24 years in seed stored under cool conditions in the laboratory.

Pathogenicity tests: Due to the systemic nature of bacterial wilt, inoculation tests need to be conducted differently from the other bacterial blights. Inoculations may be made with either: (i) a 26 gauge syringe using 2-3 day old liquid culture, or (ii) inserting dissecting needles into plants dipped with bacterial growth from cultures (48 h preferred) into plants. Syringes are inserted and contents injected into plant tissues, while needles are pushed through stems and petioles, and withdrawn back through the newly created holes. Incubation at 30°C is optimal for disease development, and virulent isolates generally induce wilting and necrotic leaf symptoms with 14 to 21 days (R. M. Harveson, unpublished).

Conclusions

Microbiome Disruption: Research in 2025 and 2026 confirms that bacterial pustule infection significantly impacts the phyllosphere (leaf) microbiome, increasing bacterial richness while decreasing fungal diversity. It reduces the population of beneficial core bacteria like *Methylobacterium* and *Sphingomonas*.

Economic Impact: While these diseases may not always cause total crop failure, they can reduce yields by 20% to 60% in severe cases. For specialty crops like edamame, quality discounts due to pod lesions are a primary source of profit loss.

Disease Management:

Resistance: Planting resistant or tolerant cultivars is the most effective management strategy.

Sanitation: Using pathogen-free seed and burying crop residue (tillage) reduces the initial inoculum that overwinters in the field.

Field Practices: Avoid cultivating fields when foliage is wet to prevent mechanical spread of bacteria.

Advanced Detection: New optical methods using polarization spectral imaging (2024–2026) allow for the non-destructive, early diagnosis of bacterial blight by identifying unique reflectance patterns in diseased areas before they are visible to the naked eye.

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INDIGENOUS MICROORGANISMS FOR SOIL HEALTH: AN OVERVIEW

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Abstract

Soil degradation, loss of biodiversity and environmental pollution are the results of modern agricultural practices. It is mainly due to the heavy reliance on synthetic fertilizers and pesticides. Use of Indigenous Microorganisms (IMO) is a core component of Natural Farming (NF) systems like Zero Budget Natural Farming (ZBNF). It offers a regenerative alternative. IMO are collected from local environments, ensuring high adaptability, resilience and not from commercial inoculants. The role of '*Bijamrita*', '*Jeevamrita*' and supporting methodology is a bio-stimulants resulting physiological changes in the soil-plant ecosystem is of significance. It is practiced as most cost-effective, sustainable strategy method for restoring soil vitality that ensure long-term food security by utilizing local microbial consortia. This overview explores mechanisms by which Indigenous Microorganisms improve soil health.

Introduction

The 'Green Revolution' significantly a boosts food production worldwide but at a serious ecological price. Extensive usage of agrochemicals has disrupted the soil health., leading to soil with nutrition and microorganisms depleted soil characterized by low naturally occurring organic matter and diminished microbial activity.

Indigenous Microorganisms (IMO) represent a site specific microorganisms important for soil health restoration. These are naturally occurring microbial consortia (bacteria, fungi, yeasts, and actinomycete) harvested from undisturbed local ecosystems. Since these microbes have evolved under local climatic and soil related conditions. They are well adapted to local soil and climatic conditions compared to lab-grown effective microorganisms (EM). In natural farming practices, these microbes act as the core agents for nutrient bioavailability, transforming organic waste into plant-ready minerals, eliminating the need for external chemical inputs.

The methodology suggested by Subhash Palekar, the pioneer of Subhash Palekar Natural Farming (SPNF) is based on the four components that harness indigenous microorganisms and maintains soil fertility. Though soil is already rich in nutrients, but they are in a unusable form. Indigenous microorganisms (IMO) act as the key to unlocking these nutrients for plants, is the central philosophy.

Methodology

Utilizing IMOs involves a systematic multi-stage culturing process aimed at acclimatization of microbes from their natural habitat to the farm environment.

The process of utilizing indigenous microorganisms (IMO Method)

***Bijamrita* (Seed Treatment)**

The first step involves the seed treatment to avoid soil-borne and seed-borne diseases those affect fertility. It is achieved by using a preparation of local microorganism's beneficial bacteria than commercial preparations. The process involves use of a handful of virgin soil from the same farm that introduces local, site-specific microorganisms (IMOs). The

preparation is used to coat the seeds with layer of indigenous microorganisms that protect young roots from pathogens.

Jeevamrita (Soil Inoculant)

The preparation that primarily enhance multiplication and introduction of indigenous microorganisms is *Jeevamrita*. The fermentation involves a mixture of cow dung, cow urine, jaggery (sugar source), pulse flour (protein source), and water for 48–72 hours. In the process the jaggery and pulse flour provides nutrition for the microbes. During incubation period the microbial population of beneficial bacteria, fungi, and actinomycetes multiplies exponentially. *Jeevamrita* stimulates the activity of microorganisms present in the soil. For keeping the soil biologically active the '*Jeevamrita*' is applied periodically viz. twice a month via irrigation or as a foliar spray or as required for plants cultivated to keep the soil biology active.

Achhadana (Mulching)

The method that creates a specific microclimate require for the microclimate is then made available through the practice of applying different types of Mulching as required. It helps to maintain the population of microbes introduced through *Jeevamrita*. Also it helps to maintain a soil temperature of 25–32°C and moisture levels of about 65–72%, those enhance microbial activity. Mulching may involve shallow tillage to aerate the soil, use of dried crop residues to cover the soil, planting diverse intercrops (especially legumes) to provide root exudates that feed different types of microbes. The method makes available the raw organic matter that microorganisms resulting in the formation of humus, the important source of plant nutrition.

Whapasa/ Waphasa (Moisture and Aeration)

The aspect that ensures the physical environment of the soil that benefit aerobic microorganisms is the process of *Whapasa/ Waphasa* (Moisture and Aeration). As per the practice, instead of liquid water, water vapours and air importantly supports roots and microbes. It helps for creation of the condition that help maintaining soil pores having 50% air and 50% water vapour. The condition helps to reduce irrigation and maintain air-moisture balance that 'waterlogging' which usually suffocates aerobic indigenous microorganisms.

Discussion

Soil health management has moved notably from a chemical-centric approach toward the resurgence of Indigenous Microorganisms (IMOs), a transition put forward by the structure of Zero Budget Natural Farming (ZBNF). Applying traditional manuring method that involves the use of *Bijamrita* and *Jeevamrita* puts on nutrients and beneficial microorganisms to the soil. In the process *Bijamrita*, protects seeds and *Jeevamrita* triggers a microbial multiplication in the soil. It is in contrast with synthetic fertilizers. The practice of utilizing indigenous microorganisms transform the soil into a biologically active environment. By regulating soil temperature the process of *Achhadana* (mulching) and *Whapasa* (moisture/aeration balance) contributes towards creation of supportive stable condition for microbes Whereas *Achhadana* secures the microclimate in the form of 50:50 ratio of air to water vapor ensuring maintenance of beneficial aerobic microbes recycling nutrients. There is debate among scientists that whether utilizing indigenous microorganisms work at every place or just in certain locations. Also critics holds the thought that local soil quality may give uncertain results under different atmosphere. In contrast to this the promoters trust indigenous microorganism adapt better to local stress beside alternative microorganisms cultivated in the laboratories.

Future Perspectives and Challenges

Though the approach of utilizing indigenous microorganism through the practice of natural farming acknowledges its efficiency there is a gap in studies that mark generation of

consortia of soil microorganisms from early inoculation to secure humus useful for further several crop cycles. In future, the research priority should be given to find the specified studies. A hurdle that primarily encountered for this review article lies in navigating the status about the success of the approach under diverse climate condition and crop varieties in the vicinity.

Conclusion

This review gives an idea about utilizing indigenous soil microorganisms through the approach of natural farming that shifts the agricultural pattern from being artificial chemical dependent to a biologically activated system based on increasing indigenous microorganisms. Successfulness depends on reducing the use of external fertilizers and supporting indigenous soil microorganisms along with moisture and temperature favouring this indigenous-led strategy. A scientifically explored sustainable solution tracking the debate about loss of soil health and autonomy of farmers will play an important role.

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RECENT ADVANCES IN NANOMATERIALS FOR CLEAN ENERGY GENERATION AND ENVIRONMENTAL REMEDIATION

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Abstract

Nanomaterials—materials with at least one dimension in the 1–100 nm range—offer unique physicochemical properties (large surface area, quantum-size effects, tunable porosity and surface chemistry) that make them highly valuable in energy technologies (energy storage and conversion) and environmental remediation (water treatment, air purification, soil decontamination). This review synthesizes the state of the art, outlining types of nanomaterials (carbon-based, metal/metal-oxide, 2D materials, polymeric and hybrid nanocomposites), mechanisms by which they enhance performance, representative metrics of improvement, current research directions (green synthesis, scale-up, safe-by-design), and key challenges (stability, cost, environmental/health risks). A graphical abstract, representative charts and a recommended set of references are provided to support further development or manuscript preparation.

Keywords: Photocatalysis, Energy Storage, Nanostructured Materials, Environmental Remediation, Renewable Energy Technologies etc.

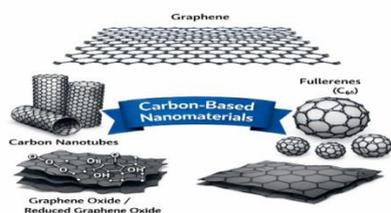
Introduction

Energy demand and environmental pressure are driving rapid development of advanced materials. At the nanoscale, materials behave differently from bulk due to increased surface-to-volume ratio, altered electronic states, and enhanced transport properties. Those attributes allow nanomaterials to (1) increase reaction rates and catalytic activity, (2) provide fast ion/electron transport in electrodes, (3) act as highly selective adsorbents or membranes for contaminants, and (4) enable novel device architectures (e.g., flexible solar cells, nanostructured electrodes) that improve efficiency or reduce resource use. Reviews across materials chemistry and environmental engineering document the growing role of nanomaterials in both fields.

Classification of Nanomaterials & Typical Forms

A pragmatic classification by composition and function:

Carbon-based nanomaterials



Carbon-based nanomaterials are a class of materials composed primarily of carbon atoms arranged in nanoscale structures. They exhibit exceptional mechanical, electrical, thermal, and chemical properties, making them highly valuable in science and technology.

Major types include graphene, carbon nanotubes (CNTs), fullerenes, graphene oxide (GO), and reduced graphene oxide (rGO). Graphene is a single layer of carbon atoms arranged in a hexagonal lattice and is known for its high electrical conductivity and strength. Carbon nanotubes are cylindrical structures with excellent mechanical strength and electron mobility. Fullerenes are spherical carbon molecules with unique optical and chemical properties.

These nanomaterials have high surface area, excellent adsorption capacity, and tunable surface chemistry, which make them ideal for applications in energy storage, solar cells, gas sensors, water purification, and environmental remediation. Their lightweight nature and chemical stability further enhance performance.

Graphene, graphene oxide (GO), reduced GO, carbon nanotubes (CNTs), carbon dots, activated nanoscale carbon.

Metal and metal-oxide nanoparticles



Metal and metal-oxide nanoparticles are nanoscale materials (1–100 nm) composed of pure metals or their oxides, exhibiting unique physical, chemical, and catalytic properties due to their small size and high surface-to-volume ratio.

Metal nanoparticles such as gold (Au), silver (Ag), copper (Cu), and platinum (Pt) show excellent electrical conductivity, optical properties, and catalytic activity. Silver nanoparticles possess strong antimicrobial behavior, while gold nanoparticles are widely used in sensors, catalysis, and biomedical applications.

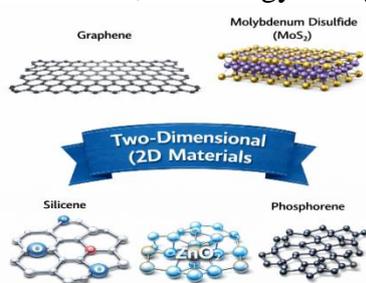
Metal-oxide nanoparticles like titanium dioxide (TiO_2), zinc oxide (ZnO), iron oxide ($\text{Fe}_2\text{O}_3/\text{Fe}_3\text{O}_4$), and cerium oxide (CeO_2) are known for their chemical stability, semiconducting nature, and photocatalytic properties. TiO_2 and ZnO are extensively used in water purification, air pollution control, and solar energy conversion.

These nanoparticles play a vital role in renewable energy technologies, including solar cells, fuel cells, and batteries, by enhancing charge transport and catalytic efficiency. In environmental remediation, they help degrade organic pollutants, remove heavy metals, and control harmful emissions. Noble metals (Pt, Au), transition metal oxides (TiO_2 , Fe_3O_4 , MnO_2 , NiO), mixed oxides.

Two-dimensional (2D) materials

Two-Dimensional (2D) Materials are materials with thickness of only one or a few atomic layers, giving them unique physical, chemical, and electronic properties compared to bulk materials. The most well-known 2D material is graphene, followed by transition metal dichalcogenides (TMDs) such as MoS_2 and WS_2 , hexagonal boron nitride (h-BN), MXenes, and black phosphorus.

Due to their extremely high surface-to-volume ratio, 2D materials exhibit excellent electrical conductivity, mechanical strength, optical transparency, and chemical sensitivity. These properties make them highly suitable for gas sensors, photodetectors, flexible electronics, and energy storage devices such as supercapacitors and batteries.

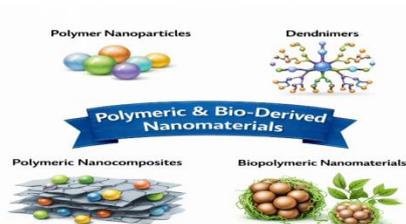


In environmental applications, 2D materials are used for water purification, heavy-metal adsorption, and photocatalytic degradation of pollutants. In renewable energy, they improve solar cell efficiency, hydrogen production, and electrocatalysis. Their tunable bandgap and layered structure make 2D materials a key component of next-generation nanotechnology and sustainable technologies. MXenes ($\text{Ti}_3\text{C}_2\text{Tx}$), transition metal dichalcogenides (MoS_2), hexagonal boron nitride (h-BN).

Polymeric and bio-derived nanomaterials Polymeric and Bio-Derived Nanomaterials are an important class of nanomaterials known for their lightweight nature, flexibility, biocompatibility, and environmental friendliness.

Polymeric nanomaterials include polymer nanoparticles, dendrimers, nanofibers, and polymeric nanocomposites. They offer high surface area, tunable mechanical properties, and chemical stability. These materials are widely used in drug delivery, gas sensors, membranes for water purification, energy storage devices, and protective coatings. Their properties can be easily tailored by changing polymer composition or structure.

Bio-derived nanomaterials are obtained from natural sources such as cellulose, chitosan, starch, proteins, and lignin. They are biodegradable, non-toxic, and sustainable. Cellulose nanofibers improve mechanical strength in composites, while chitosan nanoparticles are effective for heavy-metal adsorption, antimicrobial applications, and water treatment.

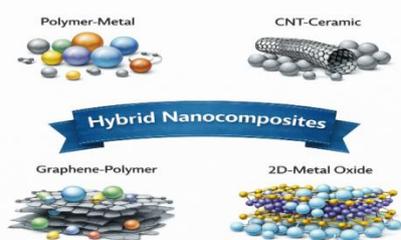


Together, polymeric and bio-derived nanomaterials play a vital role in green nanotechnology, renewable energy systems, environmental remediation, and biomedical applications, supporting sustainable and eco-friendly technological development. Nanocellulose, polymeric nanoparticles, functionalized polymer membranes.

Hybrid nanocomposites

Hybrid nanocomposites are advanced materials formed by combining two or more different types of nanomaterials—such as nanoparticles, nanotubes, nanosheets, or polymers—into a single system to achieve superior and multifunctional properties. Typically, they integrate organic and inorganic components, for example polymers with metal or metal-oxide nanoparticles, carbon-based materials with ceramics, or 2D materials with polymers.

The main advantage of hybrid nanocomposites is synergistic enhancement, where the combined materials perform better than individual components. They exhibit improved mechanical strength, electrical and thermal conductivity, chemical stability, and optical properties. Their structure can be precisely engineered at the nanoscale to tailor performance for specific applications.



Hybrid nanocomposites are widely used in energy storage devices, solar cells, gas sensors, catalysts, biomedical implants, and environmental remediation, including water purification and pollutant removal. Due to their versatility, tunability, and high efficiency, hybrid nanocomposites play a crucial role in modern nanotechnology, sustainable energy systems, and next-generation functional materials. Combinations (e.g., metal oxides on graphene, MXene/CNT composites).

Applications in Energy

Energy Storage

Lithium-ion and emerging batteries. Nanostructured electrode materials (nano-sized active particles, nanotubes, porous nanosheets) shorten Li-ion diffusion paths and accommodate volume changes, improving rate capability and cyclability. Carbon nanomaterials (CNTs, graphene) used as conductive networks increase electron transport and mechanical integrity. Examples: silicon nanoparticles embedded in carbon matrices to buffer 300% volume expansion of Si anodes; transition-metal oxide nanostructures for high-capacity cathodes. Recent reviews show systematic gains in specific capacity, rate performance, and cycle life with nano structuring.

Supercapacitors. High surface area nanostructured carbons, pseudocapacitive metal oxides (MnO_2 on nanotube arrays), and conducting polymers (nano-architected) increase specific

capacitance and power density. Nanoporous electrodes reduce ion diffusion resistance and enable fast charge/discharge. Representative improvements: switching from bulk to nanoscale electrodes often increases power density by an order of magnitude while maintaining energy density gains through hybrid designs.

Next-generation storage (Na-ion, solid-state). Nanomaterials enable faster kinetics and better interfacial contact for solid electrolytes and Na-ion hosts where ionic radii and structure demand tailored nanoscale pathways.

Energy Conversion

Photovoltaics. Nanostructured semiconductors (quantum dots, perovskite nanocrystals, TiO₂ nanoporous films) and plasmonic nanoparticles can increase light absorption, enable hot-carrier effects, and improve charge separation/collection. The use of nanoscale electron transport layers or passivation via nano shells reduces losses and boosts device efficiency.

Photocatalytic hydrogen production & CO₂ reduction. Nanostructured catalysts (metal/metal-oxide nanoparticles, doped TiO₂, 2D materials) provide high active site density and favorable band alignments for photoinduced charge separation—enabling sunlight-driven water splitting and CO₂ reduction with improved turnover frequencies.

Fuel cells & electrocatalysis. Nanoscale catalysts (Pt nanoparticles on carbon supports, non-noble metal nanostructures) lower overpotentials and increase electrochemical surface area, raising power density and lowering precious metal loadings.

Applications in Environmental Remediation

A. Water Treatment

Adsorption and removal of heavy metals and organics. Nanoparticles (e.g., iron-based magnetic nanoparticles, metal-organic frameworks (MOFs), carbon nanomaterials) show high affinities and capacities due to surface functional groups and porosity. Magnetic nanoparticles allow easy separation after adsorption.

Membranes and nanofiltration. Incorporation of nanomaterials (graphene oxide, ceramic nanoparticles, nanocellulose) into membranes yields higher flux, anti-fouling behavior, and selective removal of micropollutants. Nanoscale channels and surface chemistries provide size exclusion and adsorption combined.

Photocatalytic degradation. TiO₂ nanoparticles and doped variants under UV/visible light degrade organic contaminants (dyes, pharmaceuticals). Coupled with nanostructured supports, catalyst recovery and reusability improve.

B. Air Purification and Soil Remediation -Nanomaterials in air filters improve capture of ultrafine particles and catalytically oxidize VOCs. Soil remediation uses immobilized nanoparticles (e.g., zero-valent iron nanoparticles) for in-situ reduction of chlorinated solvents and other pollutants.

Fundamental Mechanisms

1. **Surface area & active site density.** Nanoscale increases the available reactive surface per unit mass, improving adsorption and catalytic rates.
2. **Quantum & electronic effects.** In small particles or 2D sheets, electronic band structures shift, enabling altered light absorption and catalytic energetics (important in photovoltaics, photocatalysis).
3. **Shortened transport distances.** Ions/electrons traverse nanometer-scale structures more quickly, reducing diffusion polarization in batteries and capacitors.
4. **Defect & edge sites.** Nanostructuring creates edge sites and defects that often serve as highly active catalytic centers.
5. **Hybrid synergistic effects.** Composites combine functionalities—e.g., metal nanoparticle on conductive graphene to provide catalytic activity plus rapid charge extraction.

Advantages over Conventional Materials

1. **Performance:** Higher catalytic activity, faster kinetics, and improved capacity/rate capability.
2. **Material efficiency:** Reduced precious metal loading in catalysts thanks to higher surface area.
3. **Function integration:** Ability to combine separation, sensing, and catalysis in a single material (e.g., photocatalytic membranes).
4. **Tailorability:** Chemical functionalization and shape control enable targeted pollutant binding or optimized electrode interfaces.
5. **Novel device designs:** Flexibility, transparency, or porosity at macroscale afforded by nanoscale building blocks.

Challenges

1. **Scalability & cost.** Laboratory syntheses frequently produce high-performance nanosystems at small scale and cost profiles poorly suited to industrial deployment.
2. **Long-term stability and cycling.** Nanoparticles can agglomerate, dissolve, or suffer structural degradation (e.g., SEI formation in nano-Si anodes).
3. **Environmental, health & safety (EHS) concerns.** Release of engineered nanomaterials may pose toxicological risks; life-cycle assessments often show trade-offs (energy/material inputs vs. functional gains). “Safe-by-design” and biodegradable/green synthesis approaches are an active area of research.
4. **Regulatory & public acceptance challenges.** Addressing these issues requires combining materials science with engineering, toxicology, and policy.

Conclusions

Nanomaterials dramatically expand design space for both energy and environmental technologies by providing unique surface and transport phenomena. In energy systems, they enable faster kinetics and higher utilization of active materials; in environmental systems, they deliver high-efficiency adsorption, catalytic degradation, and selective separation. The next decade’s success depends on solving scale-up, cost, and EHS challenges through green synthesis, lifecycle thinking, and safe-by-design strategies. Interdisciplinary collaboration between material scientists, toxicologists, environmental engineers and policy makers is essential to translate laboratory promise into societal benefit.

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THE ROLE OF ARTIFICIAL INTELLIGENCE IN RURAL DEVELOPMENT: A HUMAN-CENTERED APPROACH

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Abstract

Artificial Intelligence (AI) is increasingly influencing development strategies across multiple sectors, yet its meaningful application in rural development requires careful alignment with human and social needs. Rural regions continue to face persistent challenges related to access to quality education, healthcare services, agricultural support, employment opportunities, and digital infrastructure. This research paper examines how Artificial Intelligence can be applied to rural development through a human-centered framework that prioritizes social inclusion, ethical responsibility, and community empowerment. Rather than viewing AI solely as a tool for automation, the study emphasizes its role in supporting human decision-making and strengthening local capacities. The paper explores key application domains such as agriculture, healthcare, education, governance, and rural livelihoods, while also addressing critical challenges including digital inequality, data ethics, and skill limitations. The study concludes that Artificial Intelligence, when guided by human-centered principles, can serve as a catalyst for sustainable and inclusive rural development.

Keywords: Artificial Intelligence, Rural Development, Human-Centered Approach, Inclusive Technology, Sustainable Growth

Introduction

Rural development remains a central concern for economic stability, social equity, and long-term sustainability. Rural communities contribute significantly to food production, natural resource management, and cultural continuity, yet they often experience limited access to modern infrastructure and institutional support. Development efforts implemented over time have produced improvements in certain areas, but structural gaps between rural and urban regions continue to persist.

Recent advances in Artificial Intelligence offer new possibilities for addressing these challenges by enabling intelligent analysis, predictive support, and adaptive service delivery. However, development initiatives that rely solely on technology without considering human and social dimensions risk increasing exclusion and inequality. A human-centered approach to Artificial Intelligence ensures that rural populations actively participate in technological transformation and benefit from solutions aligned with their lived realities.

This paper aims to analyze the role of Artificial Intelligence in rural development through a human-centered perspective that emphasizes inclusivity, ethical use, and long-term societal value.

Concept of Human-Centered Artificial Intelligence

Human-centered Artificial Intelligence refers to systems designed to enhance human capabilities, support informed decision-making, and respect ethical and social values. Such systems prioritize transparency, fairness, accessibility, and accountability rather than replacing human roles.

In rural development contexts, human-centered AI aligns technological design with local socio-economic conditions, cultural practices, and linguistic diversity. This approach helps ensure that technology adoption is both meaningful and sustainable.

The fundamental principles of human-centered AI include:

- Respect for human dignity and autonomy
- Inclusiveness and equitable access
- Transparency and explainability
- Ethical data governance
- Community participation in design and implementation

Applying these principles helps prevent technological misuse and promotes trust within rural communities.

Applications of Artificial Intelligence in Rural Development

Artificial Intelligence in Agriculture

Agriculture remains the primary source of livelihood in rural areas. AI-based tools can assist farmers through intelligent crop advisory systems, soil health analysis, climate pattern assessment, and early identification of plant diseases. These technologies help reduce uncertainty and improve productivity.

Human-centered agricultural AI emphasizes simplicity, affordability, and local language interfaces, making advanced tools accessible to small and marginal farmers.

Artificial Intelligence in Rural Healthcare

Rural healthcare systems often face shortages of medical professionals and diagnostic facilities. AI-enabled diagnostic support systems, virtual consultation platforms, and health monitoring applications can assist healthcare workers in delivering timely care.

A human-centered approach ensures that AI supports medical professionals, protects patient privacy, and improves healthcare access without replacing human judgment.

Artificial Intelligence in Education and Skill Development

Educational challenges in rural regions include limited teaching resources, lack of personalized learning, and low digital exposure. AI-driven learning platforms can adapt educational content to individual learning levels and local contexts.

Human-centered educational AI focuses on inclusivity, cultural relevance, and learner engagement, enabling rural students to acquire meaningful knowledge and skills.

Artificial Intelligence in Governance and Public Services

Artificial Intelligence can enhance rural governance by improving public service delivery, grievance redressal mechanisms, and policy planning processes. Predictive insights enable better identification of development priorities.

Transparent and accountable AI systems strengthen trust between rural citizens and institutions.

Artificial Intelligence for Livelihood and Employment Generation

AI-enabled platforms can support rural entrepreneurship by providing market insights, demand forecasting, and access to digital financial services. These tools help rural producers connect with broader markets and diversify income sources.

Human-centered AI ensures that technological innovation complements traditional livelihoods rather than displacing them.

Challenges in Implementing AI in Rural Areas

Despite its potential, the adoption of Artificial Intelligence in rural contexts faces several challenges:

- Inadequate digital infrastructure and connectivity
- Limited digital literacy and technical skills
- Insufficient availability of localized data
- Ethical concerns related to privacy and consent
- Cultural and linguistic diversity

Addressing these challenges is essential to ensure equitable and effective AI deployment.

Ethical and Social Considerations

Ethical implementation of Artificial Intelligence in rural development requires careful attention to fairness, accountability, transparency, and data protection. Rural communities must be informed participants in decisions regarding data collection and technology use. A human-centered ethical framework ensures that AI serves public welfare and safeguards the interests of vulnerable populations.

Research Methodology

This study adopts an exploratory and conceptual research methodology focused on interpretive analysis. The approach involves systematic examination of recent academic literature, development reports, and ethical frameworks related to Artificial Intelligence and rural development.

The methodology emphasizes logical synthesis, contextual evaluation, and human-centered assessment to understand broader societal implications.

Findings and Discussion

The study finds that Artificial Intelligence can significantly support rural development when aligned with human needs and social contexts. Technological effectiveness alone does not guarantee success; usability, trust, and community engagement play a critical role. Participatory design, capacity building, and ethical governance emerge as essential factors for sustainable AI-driven rural development.

Conclusion

Artificial Intelligence holds substantial potential to address complex rural development challenges. However, its success depends on adopting a human-centered approach that prioritizes ethical values, inclusivity, and local relevance. This research concludes that integrating AI with human-centered principles can promote sustainable rural development, reduce inequalities, and enhance quality of life.

Future Scope

Future research may explore:

- Empirical case studies of AI deployment in rural settings
- Long-term socio-economic impact assessments
- Development of localized AI solutions
- Policy frameworks for ethical AI governance in rural development

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THE IMPORTANCE OF ENVIRONMENTAL CONSERVATION AND RESOURCE EFFICIENCY

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Abstract

Environmental protection and resource efficiency are important aspects of sustainable development. Given growing concerns about climate change, biodiversity loss and natural resource depletion, it is essential to adopt policies and practices that minimize environmental impacts and optimize resource use. Resource performance is the idea of optimizing aid use to limit waste technology and maximize productivity. It includes the use of sources in a manner that minimizes their consumption, reduces environmental impacts, and complements monetary and social benefits. By adopting aid-green practices, we are able to lessen power consumption, limit greenhouse fuel line emissions, and reduce waste technology. Resource performance is a key issue of sustainable development, because it promotes the smart and sensible use of sources to fulfill contemporary wishes with out compromising the cap potential of destiny generations to fulfill their personal wishes.

Keywords: Environmental protection, Sustainability, Biodiversity, Climate change, Natural resources.

Introduction:

The surroundings is the muse of all existence systems, supplying critical sources consisting of air, water, soil, and biodiversity. However, fast industrialization, urbanization, and populace boom have caused remarkable tiers of environmental degradation. According to the United Nations Environment Programme (UNEP, 2022), human sports are answerable for over 75% of terrestrial environmental extrude and almost 66% of marine degradation. Environmental conservation, therefore, has emerged as a crucial worldwide goal, searching for to defend ecosystems at the same time as making sure sustainable improvement for destiny generations. This studies paper examines the significance of environmental conservation, techniques for sustainable management.

This paper makes use of a conceptual and literature-primarily based totally assessment approach. Data changed into drawn from peer-reviewed magazine articles, reviews from worldwide organizations (e.g., UNEP, IPCC, WWF), and authorities coverage documents. The evaluation is dependent round 3 key areas: (1) conservation strategies, (2) demanding situations and barriers, and (3) destiny guidelines for powerful conservation.

Importance of Environmental Protection:

Environmental protection involves the protection, conservation, and restoration of ecosystems and natural resources. It is essential to conserving biodiversity, mitigating climate change and ensuring the long-term well-being of both people and the planet. Conservation efforts can prevent habitat destruction, protect endangered species, and maintain the delicate balance of ecosystems. Protecting natural resources can minimize environmental degradation, reduce pollution, and promote sustainable development.

Resource Efficiency and Sustainable: Development Resource efficiency is the concept of optimizing the use of resources to minimize waste generation and maximize productivity. The objective is to use resources in such a way as to minimize resource consumption, reduce environmental impact, and increase economic and social benefits. By adopting resource-efficient practices, we can reduce energy consumption, minimize greenhouse gas emissions, and reduce waste generation. Resource efficiency is a key element of sustainable development because it promotes the wise and judicious use of resources to meet the needs of the present without compromising the ability of future generations to meet their own needs.

Challenges in environmental conservation: Several demanding situations hinder the development of environmental conservation and aid performance. One good sized assignment is the lack of understanding and information of the significance of those problems amongst the overall public and policymakers. Many human beings are blind to the environmental outcomes in their movements and fail to apprehend the want for sustainable practices. Additionally, there can be conflicting pastimes among monetary improvement and environmental conservation, main to resistance or confined aid for conservation efforts. Another assignment is the insufficient implementation and enforcement of environmental guidelines and policies. Weak governance structures, corruption, and shortage of sources regularly abate the powerful enforcement of environmental laws. Insufficient investment for conservation tasks and confined get entry to to generation and understanding additionally pose good sized demanding situations. Moreover, there is usually a loss of coordination and collaboration among one-of-a-kind stakeholders, hindering the improvement and implementation of powerful conservation and aid performance techniques.

Solutions and techniques: Addressing the demanding situations of environmental conservation and aid performance calls for a multi-faceted method regarding diverse stakeholders. Here are a few capacity answers and techniques that may be adopted: Education and focus: Promoting environmental training and focus campaigns to train individuals, communities, and policymakers approximately the significance of conservation and aid performance. This can assist extrade behaviors and foster a experience of duty toward the environment.

Education and cognizance: Promoting environmental schooling and cognizance campaigns to train individuals, communities, and policymakers approximately the significance of conservation and aid efficiency. This can assist alternate behaviors and foster a feel of duty in the direction of the environment.

Strengthening governance: Enhancing governance systems and enforcement mechanisms to make certain compliance with environmental regulations. This might also additionally consist of enhancing transparency, growing consequences for environmental violations, and supplying ok assets for enforcement agencies.

Sustainable land and aid management: Implementing sustainable land-use practices consisting of reforestation, sustainable agriculture, and accountable mining to preserve ecosystems and reduce aid depletion. This entails integrating environmental issues into land-use making plans and selling sustainable practices amongst industries.

Collaboration and Partnerships: Foster collaboration and partnerships between governments, non-governmental organizations, businesses, and communities. This facilitates the exchange of knowledge, expertise, and resources to develop and implement effective conservation and resource efficiency initiatives.

Technology and Innovation: Using technology and Innovation to develop sustainable solutions. This may include adopting renewable energy sources, improving energy efficiency, promoting circular economy principles, and developing environmentally friendly technologies.

Economic Incentives: Create economic incentives to promote environmental protection and resource efficiency. This may include providing tax incentives for sustainable practices, introducing market-based mechanisms such as carbon pricing, and promoting green investment. Environmental conservation and aid performance are critical for making sure a sustainable destiny. By keeping ecosystems, protecting biodiversity, and optimizing aid use, we are able to mitigate weather change, shield herbal resources, and sell the well being of each gift and destiny generations. Overcoming the demanding situations calls for a collective effort, related to education, governance, sustainable land and aid management, collaboration, technological innovation, and financial incentives.

Future directions: To improve conservation, the subsequent measures are recommended: 1. Integration of Technology – Satellite monitoring, AI-primarily based totally weather modeling, and precision agriculture can enhance conservation efficiency. 2. Policy and Governance Reforms – Stronger environmental legal guidelines and worldwide treaties are needed. 3. Public-Private Partnerships – Collaboration among governments, businesses, and NGOs can mobilize resources. . Sustainable Development Goals (SDGs) – Conservation ought to be aligned with UN SDGs to make sure international cooperation.

Conclusion:

Environmental protection is not only an ecological necessity but also a socio-economic imperative. Without urgent action, environmental degradation threatens global health, food security and economic stability. Effective conservation requires a balance between development and sustainability, supported by strong policies, scientific innovation, and community participation. Ultimately, protecting the environment ensures the well-being of current and future generations.

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ROLE OF SOLAR ENERGY IN ACHIEVING SUSTAINABILITY

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Abstract

The escalating global energy demand, depletion of fossil fuel reserves, and growing environmental concerns have necessitated a transition toward sustainable and renewable energy sources. Among various renewable alternatives, solar energy has emerged as a pivotal solution due to its abundance, environmental compatibility, and technological maturity. This paper examines the role of solar energy in achieving sustainability by analyzing its environmental, economic, and social dimensions. An overview of major solar energy technologies, including photovoltaic and solar thermal systems, is presented to highlight their contribution to reducing greenhouse gas emissions and promoting energy security. Furthermore, the study discusses existing challenges related to cost, intermittency, and energy storage, while emphasizing recent technological advancements and policy interventions aimed at overcoming these limitations. The findings indicate that solar energy plays a critical role in fostering sustainable development and facilitating the global transition toward a low-carbon and resilient energy future.

Keywords: Solar energy, Sustainability, Renewable energy, Photovoltaic systems, Low-carbon development

Introduction

Sustainable development has become a global priority due to rising concerns over climate change, environmental degradation, and energy security. Conventional energy sources such as coal, petroleum, and natural gas dominate global energy consumption but are associated with significant carbon emissions and ecological damage. The urgent need to mitigate climate change and reduce dependence on non-renewable resources has accelerated the adoption of renewable energy technologies.

Solar energy, derived from the sun's radiation, represents one of the most promising renewable energy sources due to its vast potential and minimal environmental impact. With continuous technological advancements and declining costs, solar energy has evolved into a viable alternative for electricity generation and thermal applications. This paper aims to critically analyze the role of solar energy in achieving sustainability by evaluating its contributions across environmental, economic, and social domains.

Sustainability and Energy Transition

Sustainability encompasses a balanced integration of environmental protection, economic growth, and social equity. Energy systems play a crucial role in sustainable development, as energy production and consumption significantly influence greenhouse gas

emissions and resource utilization. Transitioning from fossil-based energy systems to renewable energy sources is essential to achieving long-term sustainability goals. Solar energy, as a clean and renewable source, aligns closely with the principles of sustainable development by minimizing environmental harm while supporting economic and social progress.

Solar Energy Technologies

Photovoltaic Systems

Photovoltaic (PV) technology converts solar radiation directly into electricity using semiconductor materials. PV systems are scalable and can be deployed in residential, commercial, and utility-scale applications. Their modular nature and decreasing installation costs have contributed to widespread adoption worldwide.

Solar Thermal Systems

Solar thermal technologies utilize solar radiation to generate heat for domestic, industrial, and power generation purposes. Applications include solar water heaters, space heating systems, and concentrated solar power plants, which enhance energy efficiency and reduce fossil fuel consumption.

Contribution of Solar Energy to Sustainability

Environmental Sustainability

Solar energy generation produces negligible greenhouse gas emissions during operation, significantly reducing carbon footprints and air pollution. Its adoption contributes to climate change mitigation, conservation of natural resources, and improvement in environmental quality.

Economic Sustainability

Solar energy enhances economic sustainability by reducing reliance on imported fuels and stabilizing energy costs. The solar sector also stimulates job creation in manufacturing, installation, operation, and research, contributing to economic growth and innovation.

Social Sustainability

The decentralized nature of solar energy systems improves energy access in rural and remote regions, promoting social equity and inclusive development. Reliable energy access enhances education, healthcare, and overall quality of life.

Challenges and Limitations

Despite its advantages, solar energy faces several challenges, including high initial investment costs, intermittency due to weather conditions, and limitations in energy storage technologies. However, advancements in battery storage, grid integration, and supportive government policies are progressively addressing these constraints.

Future Prospects

The future of solar energy is highly promising due to continuous technological innovations, increased efficiency of solar panels, and global policy support for renewable energy adoption. Integration with smart grids and energy storage systems is expected to further enhance the reliability and sustainability of solar-based energy systems.

Conclusion

Solar energy plays a fundamental role in achieving sustainability by offering a clean, renewable, and economically viable energy solution. Its environmental benefits, coupled with

social and economic advantages, make it a cornerstone of sustainable energy transitions. Continued investment in research, technology, and policy frameworks will further strengthen the role of solar energy in building a sustainable and low-carbon future.

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THE ROLE OF MICROORGANISMS IN THE BREAKDOWN OF BIODEGRADABLE PLASTICS: AN OVERVIEW OF RECENT STUDIES

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Abstract:

The increasing use of biodegradable plastics has led to a growing interest in understanding the role of microorganisms in their degradation. Biodegradable plastics are designed to break down naturally in the environment, minimizing plastic pollution and encouraging sustainability. Microorganisms like bacteria and fungi are vital in the breakdown of these plastics, and understanding their mechanisms and is important for enhancing biodegradation. This review aims to provide an overview of the current research on the microbial degradation of biodegradable plastics, covering the types of microorganisms involved, the mechanisms of degradation, and the factors influencing the process. The potential applications of microbial biodegradation in managing plastic waste and highlight future research directions are discussed in his paper.

Introduction:

The increasing use of plastics has led to a significant environmental problem, with plastic pollution affecting ecosystems and human health. Biodegradable plastics have emerged as a promising alternative to traditional plastics, offering a potential solution to the plastic pollution problem. These plastics are designed to degrade naturally in the environment, reducing the amount of plastic waste that accumulates in landfills and oceans. (Bhardwaj H, Gupta R, Tiwari A 2012). Microorganisms play a crucial role in the biodegradation of these plastics, breaking them down into simpler compounds that can be reused by other organisms. This process of microbial degradation is essential for the efficient breakdown of biodegradable plastics in the environment. (Albertson A.C, et.al. 1995).

The Need for Current Knowledge:

Despite the potential of biodegradable plastics, there is still much to be learned about the microbial degradation process. Understanding the current state of knowledge on microbial degradation is essential for developing more efficient and sustainable biodegradable plastics. This review aims to summarize the current knowledge on the microbial degradation of biodegradable plastics, highlighting the key findings, challenges, and future research directions for reducing the environmental impact of plastic pollution.

Types of Microorganisms Involved in Biodegradation:

A range of microorganisms, such as bacteria, fungi, and actinomycetes, can break down biodegradable plastics. These microorganisms have been discovered to decompose various kinds of biodegradable plastics, such as polyhydroxyalkanoates (PHA), polylactic acid (PLA), and polybutylene adipate-co-butylene terephthalate (PBAT) (Vivi et al., 2019)

Bacteria:

Bacteria are one of the most well-studied groups of microorganisms involved in biodegradable plastic degradation. Some of the most commonly studied bacteria include:

- *Pseudomonas species*: Known to degrade PHA and PLA
- *Bacillus species*: Capable of degrading PHA and PLA
- *Streptomyces species*: Have been shown to degrade PHA and PLA

These bacteria use enzymes to break down the plastic polymer chain, converting it into simpler compounds that can be used as a source of energy and carbon.

Fungi:

Fungi represent another category of microorganisms identified for their ability to break down biodegradable plastics. Among the fungi that are frequently researched are:

- *Aspergillus species*: Recognized for their ability to break down PLA and PBAT.
- *Fusarium species*: Able to break down PLA and PBAT
- *Species of Penicillium*: Demonstrated ability to break down PLA and PBAT.

Fungi utilize enzymes to decompose the plastic polymer chain, and specific species have been identified as especially efficient at breaking down particular kinds of biodegradable plastics.

Actinomyces: *Actinomyces* represent a category of bacteria recognized for their capacity to break down intricate organic substances, such as biodegradable plastics. Several of the actinomyces that are most frequently researched are:

Streptomyces: Demonstrated capability to break down PHA and PLA.

Significance of Microorganisms in Biodegradation :

The breakdown of biodegradable plastics by microorganisms is a crucial process that can aid in reducing plastic pollution and enhancing sustainability. Comprehending the various microorganisms engaged in biodegradation and the methods they employ to decompose plastics can guide the creation of more effective biodegradation techniques and more sustainable biodegradable plastics.

Investigating the variety of microorganisms that participate in biodegradation enables researchers to comprehend the intricate processes at play and create more efficient strategies for handling plastic waste. (Devi RS et.al. 2016, B. Saritha 2021)

Mechanisms of Degradation:

The microbial degradation of biodegradable plastics is a complex process that involves a series of steps, each playing a crucial role in breaking down the plastic material. (Albertson, A. C 1987) The three main stages of microbial degradation are:

Adhesion: Microorganisms stick to the plastic surface, creating a biofilm. This biofilm creates a safeguarding habitat for microorganisms to thrive and generate enzymes. The process of adhesion is affected by factors such as:

- Surface properties: The surface roughness, hydrophobicity, and chemical composition of the plastic material can affect microbial adhesion.
- Microbial properties: The type of microorganism, its surface properties, and its ability to produce extracellular polymeric substances (EPS) can influence adhesion.

2. **Enzymatic Degradation:** Microorganisms produce enzymes that break down the plastic polymer chain into smaller fragments. These enzymes, such as:

- Hydrolases: Break down ester bonds in polyesters, such as PLA and PHA.
- Depolymerases: Break down polymer chains into smaller fragments.

The process of enzymatic degradation is affected by elements like:

- Enzyme specificity: The enzyme's type and specificity can influence both the degradation rate and its efficiency.
- Environmental factors: Temperature, pH, and humidity can affect enzyme function and durability. (Priya Trivedi et. al.2016, Mohanan N 2020)

3. **Metabolism:** The fragmented pieces are processed by the microorganisms, resulting in:

- Carbon dioxide: Released as a byproduct of cellular respiration.
- Water: Released as a byproduct of cellular metabolism.
- Biomass: The microorganisms use the broken-down fragments to build new biomass, such as cells and extracellular polymeric substances. (Trivedi et al.2016)

- Biomass: The microorganisms utilize the decomposed fragments to create new biomass, including cells and extracellular polymeric substances.

The metabolism stage is influenced by factors such as:

- Microbial community: The type and diversity of microorganisms can affect the metabolic pathways and efficiency.
- Environmental conditions: Temperature, pH, and nutrient availability can influence microbial growth and metabolism. (Deepika S et.al 2015, Gauri Singh 2016)

Factors Influencing Degradation:

The microbial degradation of biodegradable plastics is a complex process that is influenced by Several environmental factors including:

Temperature: Temperature is crucial in microbial degradation since it influences the growth and function of microorganisms. Various microorganisms have specific temperature ranges that are ideal for degradation, and temperatures that deviate from these ranges can impede or stop the process.

- Optimal temperature ranges: Vary depending on the microorganism and plastic type. For example, some microorganisms may degrade plastics optimally at temperatures between 20-30°C, while others may require higher or lower temperatures.
- Temperature fluctuations: Can affect microbial growth and degradation rates. Fluctuations can be caused by environmental factors, such as seasonal changes or diurnal cycles. (Bhardwaj H, Gupta R, Tiwari A. 2012, Sangale MK, et.al. 2012)

Moisture: Sufficient moisture is crucial for the growth and breakdown of microbes. Microorganisms need water to operate, and inadequate moisture levels can restrict their activity.

- Ideal moisture levels: Depend on the microorganism and type of plastic. Certain microorganisms may necessitate elevated moisture levels, whereas others are capable of enduring drier environments.
- Variations in moisture: Can influence microbial development and rates of decomposition. Variations can result from environmental elements, like precipitation or watering.

pH: The ideal pH range for degradation differs based on the microorganism and type of plastic. Various microorganisms possess ideal pH ranges for their growth and degradation, and pH values that fall outside these ranges can slow or stop the process.

- Optimal pH ranges: Differ based on the type of microorganism and plastic. Certain microorganisms might effectively break down plastics best at pH levels ranging from 6 to 8, whereas others may need more acidic or basic environments.
- pH fluctuations: May impact microbial development and decomposition rates. Variations may result from environmental elements, like alterations in soil or water composition.

Plastic Properties: The biodegradable nature of plastic can be affected by its chemical structure and crystallinity. Various plastic characteristics can influence the capacity of microorganisms to break down the substance.

- Chemical composition: The kind and configuration of chemical links within the plastic can influence its ability to biodegrade. Plastics containing ester bonds could be more biodegradable compared to those that have carbon-carbon bonds.
- Crystallinity: The plastic's crystalline structure may influence its ability to biodegrade. Crystalline areas might be more durable against degradation than amorphous areas. (Premraj R, Doble M 2005, Nayak P, Tiwari A 2011, S.K. Kale 2015)

Applications and Future Directions: The microbial degradation of biodegradable plastics has numerous applications and future directions, including:

Applications:

Waste Management: Microbial degradation can be used to manage plastic waste in:

- Landfills: Microorganisms can break down biodegradable plastics in landfills, reducing the amount of waste and generating biogas.
- Oceans: Microbial degradation can help clean up plastic pollution in oceans, reducing the impact of plastic debris on marine life.
- Other environments: Microbial degradation can be used to manage plastic waste in other environments, such as soil, compost, and wastewater treatment plants.

Biodegradable Plastic Production: Understanding microbial degradation can inform the design of biodegradable plastics with:

- Improved properties: Microbial degradation can be used to develop biodegradable plastics with improved strength, durability, and biodegradability.
- Tailored degradation rates: Biodegradable plastics can be designed to degrade at specific rates, depending on the application and environment.

Environmental Remediation: Microbial degradation can be used to clean up plastic pollution in the environment, including:

- Soil remediation: Microorganisms can be used to break down plastic pollutants in soil, improving soil health and fertility.
- Water remediation: Microbial degradation can be used to clean up plastic pollution in waterways, improving water quality and aquatic life.

Biotechnology: Microorganisms can be engineered to produce:

- Enzymes: Microorganisms can be engineered to produce enzymes that can degrade plastics, improving the efficiency of biodegradation.
- Other compounds: Microorganisms can be engineered to produce other compounds that can degrade plastics or improve biodegradation. (CPCB Annual Report 2011-12, Baruah S.D. 2011, Das PM, Kumar S 2014)

Future Directions:

1. **Improving Degradation Efficiency:** Research is needed to improve the efficiency of microbial degradation, including the development of more effective enzymes and microbial consortia.
2. **Scaling Up Biodegradation Processes:** Biodegradation processes need to be scaled up for industrial applications, including the development of large-scale bioreactors and treatment systems.
3. **Developing New Biodegradable Plastics:** Research is needed to develop new biodegradable plastics with improved properties, including durability, strength, and biodegradability.
4. **Understanding Microbial Communities:** Further research is needed to understand the complex interactions between microorganisms and biodegradable plastics, including the role of microbial communities in degradation.
5. **Biodegradation in Different Environments:** Research is needed to understand how biodegradable plastics degrade in different environments, including soil, water, and compost. A. Sivan (2011)

Conclusion:

The microbial degradation of biodegradable plastics is a complex process that involves various microorganisms and mechanisms. Understanding the role of microorganisms in biodegradable plastic degradation is essential for developing efficient waste management strategies and designing biodegradable plastics with improved properties. Further research is needed to explore the potential applications of microbial biodegradation and to develop efficient biodegradation processes.

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SMART TECHNOLOGIES IN FOOD PROCESSING: INNOVATIONS, APPLICATIONS, AND FUTURE PERSPECTIVES

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Abstract

The food processing industry is undergoing a significant transformation with the integration of smart technologies such as Artificial Intelligence (AI), Internet of Things (IoT), robotics, big data analytics, and blockchain. These technologies enhance efficiency, food safety, quality control, traceability, and sustainability across the food value chain. This article examines the role of smart technologies in modern food processing, highlights key applications, discusses challenges, and explores future prospects.

Keywords: Smart food processing, Artificial Intelligence, IoT, Automation, Food safety, Industry 4.0

Introduction

The food processing industry is a vital component of the global agri-food system, playing a key role in enhancing food availability, safety, shelf life, and value addition. With rapid population growth, urbanization, and changing consumer preferences, the demand for safe, nutritious, high-quality, and conveniently processed food products has increased significantly. Traditional food processing methods, which rely heavily on manual operations and conventional machinery, often face challenges such as inefficiency, inconsistent quality, high energy consumption, food losses, and limited traceability.

In recent years, the advent of smart technologies has transformed the food processing sector by introducing automation, digitization, and intelligent decision-making into production systems. Technologies such as Artificial Intelligence (AI), Internet of Things (IoT), robotics, big data analytics, and blockchain are increasingly being integrated into food processing operations to enable real-time monitoring, precision control, predictive maintenance, and enhanced food safety management. These innovations align with the broader framework of Industry 4.0, which emphasizes cyber-physical systems, data-driven processes, and interconnected manufacturing environments.

The adoption of smart technologies in food processing not only improves operational efficiency and product quality but also strengthens food safety, traceability, and sustainability across the supply chain. Furthermore, smart processing systems help industries comply with stringent food safety regulations and meet growing consumer expectations for transparency and environmental responsibility. In this context, the present article examines the role of smart technologies in food processing, highlighting their applications, benefits, challenges, and future prospects in the evolving food industry landscape.

Concept of Smart Technologies in Food Processing

Smart technologies in food processing refer to the integration of advanced digital, automated, and intelligent systems that enable food processing operations to function efficiently, safely, and sustainably. These technologies combine physical processing equipment with information and communication technologies (ICT), data analytics, and artificial intelligence to create intelligent, connected, and adaptive food processing systems. The core idea behind smart food processing is to shift from conventional, reactive production methods to proactive and data-driven decision-making.

At the conceptual level, smart food processing operates within the framework of Industry 4.0, where cyber-physical systems link machinery, sensors, software, and human operators through digital networks. Sensors and IoT devices continuously collect real-time data on critical parameters such as temperature, humidity, pressure, microbial load, and equipment performance. This data is analysed using AI and machine learning algorithms to optimize processing conditions, predict equipment failures, and ensure consistent product quality.

A defining feature of smart technologies is automation with intelligence. Unlike traditional automation, smart systems are capable of learning from historical data, adapting to process variations, and responding autonomously to deviations. For example, smart quality control systems can detect defects or contamination instantly and trigger corrective actions without human intervention. Similarly, blockchain-based systems enhance traceability by securely recording every stage of food processing and distribution.

Overall, the concept of smart technologies in food processing emphasizes efficiency, precision, transparency, and sustainability. By enabling real-time monitoring, intelligent control, and seamless integration across the food value chain, smart technologies represent a paradigm shift in how food is processed, managed, and delivered to consumers in the modern era.

Key Smart Technologies Used in Food Processing

The transformation of the food processing industry is largely driven by the adoption of advanced smart technologies that enhance automation, intelligence, and connectivity across processing stages. These technologies improve efficiency, food safety, quality assurance, and supply chain transparency. The major smart technologies used in food processing are discussed below.

Artificial Intelligence (AI) and Machine Learning

Artificial Intelligence and machine learning algorithms play a crucial role in intelligent decision-making within food processing systems. AI-based computer vision systems are widely used for quality inspection, grading, sorting, and defect detection in food products. Machine learning models analyze large datasets to optimize processing parameters, forecast demand, reduce wastage, and improve product consistency. AI also supports predictive maintenance by identifying potential equipment failures before they occur.

Internet of Things (IoT)

IoT technology enables real-time monitoring and control of food processing operations through interconnected sensors and devices. These sensors continuously track critical parameters such as temperature, humidity, pressure, and hygiene conditions during processing, storage, and transportation. IoT systems help ensure compliance with food safety standards, reduce spoilage, and enhance energy efficiency by providing real-time alerts and automated responses.

Robotics and Automation

Robotics and automated systems are extensively used in food handling, processing, and packaging operations. Robotic arms and automated conveyors perform tasks such as cutting, sorting, filling, sealing, and palletizing with high precision and speed. Automation minimizes human intervention, reduces contamination risks, improves workplace safety, and ensures uniform product quality, particularly in high-volume food processing units.

Big Data Analytics

Food processing plants generate vast amounts of data from sensors, machines, and supply chain operations. Big data analytics tools process and interpret this data to identify patterns, improve operational efficiency, and support strategic decision-making. Data-driven

insights help processors optimize resource utilization, reduce energy consumption, enhance inventory management, and improve overall productivity.

Blockchain Technology

Blockchain technology is increasingly used to enhance transparency and traceability in food processing and supply chains. It provides a secure, immutable digital ledger that records every transaction from raw material sourcing to final product distribution. Blockchain improves food safety by enabling rapid trace-back during contamination incidents and builds consumer trust through verified information on product origin and processing history. The integration of AI, IoT, robotics, big data analytics, and blockchain forms the technological backbone of smart food processing systems. Together, these technologies enable intelligent automation, real-time control, and data-driven management, marking a significant shift toward efficient and sustainable food processing practices.

Applications of Smart Technologies in Food Processing

Smart technologies have wide-ranging applications across different stages of food processing, from raw material handling to final product distribution. Their application enables improved efficiency, enhanced food safety, better quality control, reduced wastage, and increased sustainability. Major application areas are discussed below.

Quality Control and Inspection

Artificial Intelligence (AI) and computer vision systems are extensively applied in quality control processes. These systems automatically inspect food products for defects such as discoloration, size variation, contamination, or foreign materials. Smart inspection systems ensure uniform quality, reduce dependence on manual checks, and minimize human error, thereby improving overall product reliability.

Food Safety and Hygiene Management

IoT-enabled sensors play a critical role in monitoring hygiene and safety conditions during food processing. Real-time data on temperature, humidity, microbial levels, and equipment sanitation helps processors maintain compliance with food safety standards such as HACCP and ISO norms. Smart alert systems enable immediate corrective action in case of deviations, reducing the risk of foodborne illnesses.

Processing and Packaging Operations

Robotics and automation are widely applied in cutting, sorting, filling, sealing, labelling, and packaging operations. Automated packaging systems enhance processing speed, improve accuracy, and ensure hygienic handling of food products. Smart packaging technologies also support extended shelf life and improved product protection.

Supply Chain and Traceability

Blockchain and IoT technologies enable end-to-end traceability across the food supply chain. Each stage of processing and distribution is digitally recorded, allowing quick traceback in case of quality or safety issues. This application enhances transparency, builds consumer trust, and supports regulatory compliance.

Cold Chain and Storage Management

Smart technologies are extensively used in cold storage and refrigerated transport systems. IoT-based monitoring ensures optimal temperature and humidity conditions during storage and transportation of perishable food items. This helps reduce spoilage, maintain nutritional quality, and extend shelf life.

Energy and Resource Management

Big data analytics and IoT systems are applied to optimize energy and water usage in food processing plants. Smart energy management systems identify inefficiencies, reduce operational costs, and support sustainable production practices by minimizing environmental impact.

Table 1: Applications of Smart Technologies in Food Processing

Application Area	Smart Technology Used	Key Benefits
Quality Control	AI, Computer Vision	Defect detection, consistent quality
Food Safety	IoT Sensors, Automation	Real-time monitoring, risk reduction
Processing & Packaging	Robotics, Automation	Speed, hygiene, precision
Supply Chain	Blockchain, IoT	Transparency, traceability
Cold Chain	IoT Monitoring Systems	Reduced spoilage, extended shelf life
Energy Management	Big Data, IoT	Cost efficiency, sustainability

The application of smart technologies across food processing operations leads to improved productivity, enhanced safety, and sustainable food systems. These applications demonstrate the practical value of smart technologies in addressing the challenges of modern food processing industries.

5. Impact on Food Safety and Quality

The integration of smart technologies has brought a significant positive impact on food safety and quality in the food processing industry. By enabling real-time monitoring, intelligent control, and data-driven decision-making, these technologies help minimize risks associated with contamination, spoilage, and quality degradation throughout the food processing chain.

One of the most important contributions of smart technologies is enhanced food safety monitoring. IoT-based sensors continuously track critical parameters such as temperature, humidity, pH, and sanitation conditions during processing, storage, and transportation. Any deviation from prescribed safety limits is instantly detected, allowing for immediate corrective action. This proactive approach greatly reduces the occurrence of foodborne hazards and ensures compliance with food safety regulations.

Smart technologies also improve quality consistency and product standardization. AI-powered computer vision systems and automated inspection tools accurately detect defects, foreign materials, and variations in size, colour, or texture. Unlike manual inspection, these systems operate with high precision and consistency, ensuring uniform quality across large production volumes. This results in improved consumer satisfaction and reduced product rejection rates.

Another critical impact is the strengthening of traceability and transparency. Blockchain technology enables secure and immutable recording of processing data, making it possible to trace food products back to their source in the event of contamination or quality failure. Rapid trace-back reduces recall time, limits economic losses, and enhances consumer trust in processed food products. Smart technologies contribute to reduced food loss and wastage by enabling predictive analytics and better process control. Early detection of spoilage risks and process inefficiencies helps processors take preventive measures, thereby preserving nutritional quality and extending shelf life. Overall, the adoption of smart technologies significantly enhances food safety assurance and quality management, supporting the production of safe, reliable, and high-quality food products in modern food processing systems.

Challenges in Adoption

Despite the significant benefits offered by smart technologies, their adoption in the food processing industry faces several technical, economic, and organizational challenges. These challenges are particularly pronounced in small and medium-sized food processing enterprises and in developing economies.

One of the major challenges is the high initial investment cost. The installation of advanced technologies such as AI-based systems, IoT infrastructure, robotics, and blockchain

platforms requires substantial capital expenditure. Many food processing units, especially small-scale industries, find it difficult to afford such investments without financial support or government incentives.

Another critical challenge is the lack of skilled manpower. Smart food processing systems demand professionals with expertise in data analytics, automation, artificial intelligence, and digital system management. The shortage of trained personnel limits effective implementation and maintenance of these technologies, thereby slowing down adoption.

Data security and privacy concerns also pose significant barriers. Smart technologies generate and exchange large volumes of sensitive operational and supply chain data. Ensuring data integrity, cybersecurity, and protection against unauthorized access remains a major concern for food processors, particularly when cloud-based platforms are used.

Infrastructure and interoperability issues hinder seamless integration of smart technologies. Many existing food processing plants operate with legacy equipment that is not compatible with modern digital systems. Integrating new smart technologies with traditional machinery can be complex, time-consuming, and costly.

Resistance to change and organizational barriers further affect adoption. Limited awareness, fear of job displacement due to automation, and reluctance to modify traditional practices often discourage stakeholders from embracing smart technologies. Overcoming these challenges requires supportive policies, capacity building, and a clear demonstration of long-term economic and safety benefits.

Addressing these challenges through targeted training programs, financial incentives, standardized digital frameworks, and awareness initiatives is essential for the widespread adoption of smart technologies in the food processing sector.

Conclusion

Smart technologies are revolutionizing the food processing industry by enhancing efficiency, safety, and sustainability. Their integration across processing stages offers significant economic and social benefits. Continued innovation, supportive policies, and capacity building are essential to realize the full potential of smart food processing systems.

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SUSTAINABLE PRECISION AGRICULTURE TECHNIQUES USING ARTIFICIAL INTELLIGENCE

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Abstract:

This study presents Precision agriculture, augmented by artificial intelligence (AI), transforming farming practices by enabling data-driven and sustainable solutions to meet global food demands. AI technologies, including machine learning, computer vision, and Internet of Things integration, allow for precise crop management, optimized resource usage, and early detection of diseases and pests. These advancements reduce environmental impacts by minimizing water, fertilizer, and pesticide use while boosting productivity and profitability. By addressing challenges like climate change and resource scarcity, AI-driven precision agriculture represents a vital approach to achieving sustainable agricultural practices worldwide. This work initially analyses Artificial Intelligent technologies used in Smart Sustainable Agriculture (SSA). This paper examines the state of research and development in Precision agriculture, pays attention to the current form of machine learning and deep learning algorithms as a starting point for SSA to achieve goal of sustainability.

Keywords: AI Artificial Intelligence, ML Machine Learning, DL Deep Learning, Sustainable Farming, Precision Agriculture

Introduction

Precision agriculture leverages artificial intelligence (AI) to optimize farming practices for sustainability, surpassing traditional methods through data-driven decisions that boost efficiency and productivity [1-3]. AI technologies—machine learning and deep learning—process data from IoT sensors, drones, and satellite imagery to monitor soil health, crop growth, weather, and pests in real time, enabling disease detection via image recognition, smart irrigation, and yield prediction [4-7].

This approach tailors water, fertilizers, and pesticides precisely using variable rate technology (VRT) and soil mapping, minimizing waste, costs, and environmental impact like chemical runoff and erosion [2,5]. GPS-guided tools and remote sensing support early pest interventions, optimal planting, and resource-efficient operations, preserving biodiversity while maximizing yields [3].

Amid climate change, resource scarcity, and population growth, precision agriculture ensures resilient systems via integrated data analytics. This study focuses on machine learning algorithms (Decision Trees, Random Forests, SVM) and deep learning models (CNNs, RNNs) to achieve sustainable precision farming goals, reducing resource use by 20-30% while enhancing food security [7, 10].

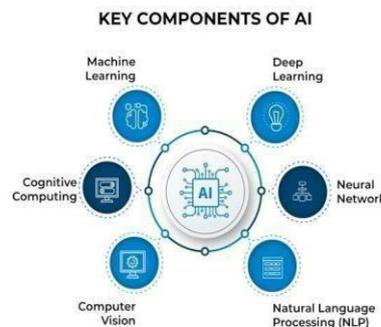
Methodology

Machine learning (ML) algorithms are game-changers in precision farming, powering smart, data-driven choices that save time and resources

- a. **Decision Trees (DT)** predict crop yields, spot pest outbreaks, and fine-tune irrigation. They use historical soil quality, weather, irrigation, and yield data to suggest optimal watering and management—simple and fast for real-time farm decisions.
- b. **Random Forests** forecast crop health, diseases, and yields by blending multiple

decision trees. Pulling from sensors (soil moisture, temperature), satellite images, and crop stats, they spot patterns and recommend fixes like targeted pesticides or watering adjustments.

- c. **Support Vector Machines (SVM)** classify soil types, detect crop diseases, and identify pests. Fed soil pH, moisture, crop types, and environmental data, they pinpoint ideal planting zones and suggest smart crop rotations



Artificial Intelligence Components

Deep Learning for Precision Farming

- a. **Convolutional Neural Networks (CNNs)** excel at crunching images to check crop health, spot diseases, and ID pests. They take high-res drone or satellite photos of fields and quickly flag early trouble signs, letting farmers hit pests with targeted treatments instead of blanket spraying.
- b. **Recurrent Neural Networks (RNNs)** handle time-based predictions like weather trends, crop yields, or irrigation needs. Using past climate records, yield history, and soil data, they forecast what's coming—helping nail down the best times for planting or harvest

Application

- **Crop Management:** AI uses machine learning, sensors, and analytics to track crop health, predict yields, spot pests/diseases, and fine-tune watering/nutrients. This makes farming pinpoint accurate—less waste, higher yields, better sustainability.
- **Smart Irrigation:** AI pulls sensor data, weather forecasts, and soil moisture to decide exactly when/where to water. No more guessing—crops get just what they need, slashing water waste and keeping things green.
- **Soil Health:** Sensors and satellite images feed AI data on moisture, pH, and nutrients. It spots issues early and suggests fixes, boosting soil fertility, cutting erosion, and supporting long-term crop success.
- **Weather Monitoring:** AI crunches satellite, sensor, and station data to predict patterns and storms. Farmers get heads-ups for smarter irrigation, planting, and harvest timing—dodging risks and maxing crop potential.
- **Smart Greenhouse:** AI in greenhouses uses sensors, climate data, and machine learning to dial in perfect conditions—temperature, humidity, lighting—for plants. It tweaks everything live, boosting yields, saving energy, and cutting resource waste.
- **Pest Management:** AI spots pests and diseases early with image recognition from cameras/sensors. Instead of spraying everything, it targets just the trouble spots—less pesticide, less crop loss, way more sustainable control.



Drone Monitoring: Drones with AI and high-res cameras scan fields live for crop health, soil issues, and variability. It flags pests or nutrient gaps instantly, so farmers can act fast and precise for better management. (See Fig.2 for full app list.)

Conclusion:

In wrapping up, AI integration in precision agriculture represents a major leap toward truly sustainable farming. These smart technologies deliver spot-on monitoring, sharp predictive insights, and smarter resource use—tackling head-on issues like climate shifts, food shortages, and ecological strain.

By slashing waste, curbing pollution, and ramping up yields, AI helps farmers stay profitable while protecting the planet. As AI and IoT keep evolving, they'll reshape agriculture into something tougher, leaner, and greener—securing food for tomorrow without draining today's resources.

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MILESTONES OF MOTHERHOOD: NAVIGATING SOCIAL SUSTAINABILITY AND MATERNAL HEALTH IN THE MILLSTONE

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Abstract: *This paper examines interplay of maternal health, quality education, and gender equality in Margaret Drabble's novel The Millstone. The present study explores the protagonist's journey in the context of Social Sustainability and Sustainable Development Goals SDG 3, 4 and 5. Unwed motherhood is considered as a stigma and immoral just like millstone that is weight of social propriety. This study argues that Rosamund Stacy takes a stand and utilizes her education, her academic excellence and research grants to give birth to child and convert this unconventional way into milestone of personal and professional success. It analyses the healthcare system of the 1960s and her rejection of patriarchal dependency. Her research and research grants demonstrate how access to quality education that is the fourth goal of SDG 4 plays a crucial factor for maternal well-being. Rosamund's self-generated values and decisive nature provide fundamental base for social sustainability. She stands on her own because of institutional access and individual adaptability.*

Keywords: *Social Sustainability, SDG 3, SDG 4, SDG 5, The Millstone, gender equality.*

Introduction: The Sustainable Development Goals (SDG) were adopted by the United Nations in 2015 (<https://www.undp.org/sustainable-development-goals>). The Millstone is the novel written by Margaret Drabble. The title, *The Millstone* is highly suggestive as it symbolizes two aspects. First is of social burden and second is an obstacle in the way of success. Rosamund the protagonist defines herself in terms of self-generated values. Unmarried pregnancy becomes a milestone, not a millstone. Rosamund becomes liberated from millstone; propriety, morality, and pride. The metaphorical Shift from Millstone to the Milestone that is personal success and emancipation is significantly shown in the novel. Social Sustainability Goal 3 is Good Health and well-being is related to Rosamund's maternal health and child health. SDG 4 is quality education which focuses on Rosamund's lifelong learning and empowerment. SDG 5 is gender equality which is portrayed in Rosamund's experience with modern targets of gender equality and value for domestic and unpaid work and equal rights for economic sources. Rosamund's journey from sexual coldness to self-reliant mother is made possible through the decisive decisions and the rejection of patriarchal norms and academic excellence.

Theoretical Framework: Literature is the mirror of the society. Social sustainability in literature is portrayed through the characterisation and narration. Creating sustainable identity is the very foundation for long term social-being. Literature has tremendous effect on the society. Rosamund's self-generated values as a foundation for long term social well-being defines sustainable identity. The Sustainable Development Goals 3, 4 and 5 which are respectively recognizing the value of unpaid care and domestic work through the inner war to balance between a PH. D with a baby. Access to prenatal healthcare system is seen in Rosamund's visit to the clinic.

Education: A Medium for Empowerment: Rosamund progresses herself by focusing on her scholarly work and career and at the same time she prefers to remain single and when she finds herself pregnant from George she rejects abortion and became an unwed mother. She

begins to respect herself. She denied advice of her friends and her sister about the termination of her child and have faith in her decision that child will bring her nothing but happiness. It presents faith in motherhood and focuses on female's role of bringing an unwed child into existence. Education, her scholarly work allows her to remain independent without the support of male, although she sometimes feels weak but manages to maintain a balance between motherhood and career. She does not find motherhood as an excuse for her career baby on the contrary, she takes care Octavia's illness strongly while doing her library work. She tries to work at home as well as outside home and keeps herself aloof from the male superiority and female dependency and gets a good job in a reputed university. Rosamund does not feel that unmarried motherhood brings her social stigma as she would be among the prestigious names, she is now in good spirits and no one will blame her for an unwed pregnancy. At last, when her sister and brother invite her for Christmas, it shows that they have accepted her decision and they are with her. Rosamund's faith in her own strength and intellectual work help her to seek her own sustainable identity, to shape her life as she wants, and search for alternatives for their problem. She chooses alternative for marriage and accepts her child and gives her own name. Elaine Showalter in her introduction to the novel *The Millstone* remarks "rather than being drowned, however, by the weight of these millstones of propriety, morality, and pride, Rosamund is liberated from them by having a child." (Drabble vii)

Maternal health: Right to Care: the depiction of long queues at the doctor's cabin indicates barriers to maternal health. She avoids all sorts of work as knitting, rug making basket work or weaving. She decides to finish her thesis before her delivery and she manages to work at home instead of going to the library. She attempts to put the things in order before a child to come and by managing all matter so efficiently she flatters herself that "I emerged rather well- independent, strong-willed, and very worldly and *au fait* with sexual problems." (Drabble 89) She also has faith in her scholarship and in her capacity of doing work in less time. Whenever she finds herself uneasy or unpleasant she loves to retire for bed or the British Museum with a pile of books rather than a bottle of gins. She consciously and seriously works out her time to shape her future life.

Rosamund gives birth to a lovely girl, Octavia, and the delight of holding her is too much for her who gives an immense pleasure and a sense of triumph. The female consciousness is evident from the discussion between Rosamund and Joe as it indicates Rosamund's assertive nature and her attitude towards her motherhood. Rosamund always restrains herself from sharing her emotions but at this moment of her child's birth she wants to share her happiness with somebody and she shares it with Joe but when Joe made a contemptuous remark as "what are you talking about, is one of the most boring commonplaces of the female experiences. All women feel exactly that, it's nothing to be proud of, it isn't even worth thinking about."⁵⁴ Rosamund denies it and contradicts him by her argument that this experience is different from other women as "it is so remarkable in my case, as I could not recall a single other instance in my life when I had felt what all other women feel"(Drabble 99). She is an unmarried mother so that the label at the end of her bed was U, not M which is a strange and noteworthy experience for her. The experience of childbirth, ordinary activities in the hospital are demanding in nature and health centric.

Reframing the "Scarlet Letter": From Stigma to Sustainability:

Pregnancy reveals many things to her, of which she has not been aware. She does not feel that her pregnancy is the product of, "malevolence" and does not feel, as Hardy felt for Tess "That event had conspired maliciously against my innocence. Perhaps I did not wish to feel this, for it was a view dangerous to my dignity and difficult to live with for the years which were to come. The more I thought about it, the more convinced I became that my state

must have some meaning, that it must, however haphazard and unexpected and unasked, be connected to some sequence, to some significant development of my life” (Drabble 62). She makes her mind to face the society, parents, friends and any type of related consequences. Her readiness to face the society reflects her fighting spirit. Therefore, she wants to complete her thesis before the birth of her child. She also begins to think about the sources of money so she starts to write some articles for money. She admits her guilt of conceiving a baby before marriage but she assumes it to be “a brand new, twentieth-century crime, not the good old traditional one of lust and greed. (Drabble 13). She considers her crime different because the very idea of sex frightens her and therefore “my crime was my suspicion, my fear, my apprehensive terror of the very idea of sex.” (Drabble 13) The expression of Rosamund reflects her self-generated values. The rejection of the unwed motherhood as a stigma or adultery to achievement is the creation of new image in the society. The main symbolic use of *The Scarlet Letter* suggests adultery but Rosamund’s rejection of this notion presents a symbolic message which supports Rosamund’s unconventional way to look at unmarried pregnancy. The presentation of motherhood not as a "millstone" of domesticity, but as a "humanizing" force that provides a sense of purpose and social connection. Pamela S. Bromberg comments that “at the end, Rosamund has become humanized through her vulnerability of her love for her baby, yet has resisted dependence on a male for economic, social, or psychological identity.”⁽ Bromberg 180.

Conclusion: Rosamund Stacy’s progression, the “millstones” of propriety, morality and pride are discarded and they are shown as the foundation for a new socially sustainable identity. Rosamund’s achievement of a reputed university position and her balance to take care of her baby Octavia demonstrates that academic excellence and motherhood could go hand in hand. Her academic work is not achieved by fate but it is a result of hard word, self-reliant nature and advantage which made possible through education. She moves from immaturity to maturity. Rosamund meets the core spirit of gender equality. Social sustainability is achieved when human emotion is balanced by a firm resolution of personal and professional life. She does not find motherhood as a barrier to success rather she finds it as a force to find her a sense of purpose. Her fighting spirit is backed by quality education which can shape a world that values both the mind of the scholar and the heart of the mother.

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STUDIES ON TAXONOMY AND OCCURRENCE OF SPECIES MANSONIA UNIFORMIS (L) (DIPTERA: CULICIDAE) IN AURANGABAD CITY, MAHARASHTRA STATE, INDIA

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Abstract

The taxonomic study of mosquito is helpful for the correct identification up to species level. The present study deals with the taxonomy and occurrence of the mosquito genus *Mansonia* from different area of Aurangabad city of Maharashtra, India. Total one species of Genus *Mansonia* such as *Mansonia uniformis* were recorded during the present study. Species were identified as per the standard methodology suggested by Christopher (1933), Barraud, P. J. (1934), Chester J. Stojanovich (1994), Leopoldo M. Rueda (2004), Nagpal and Tingare (2010). This type of taxonomic study helps for effective management of mosquito borne diseases.

Keywords: Taxonomy, *Mansonia uniformis*, NEAA, NWAA, SEAA, SWAA Aurangabad.

Introduction:

Mosquitoes are the most significant arthropod vectors for human health. Mosquitoes belong to the phylum Arthropoda order Diptera sub order Nematocera and family Culicidae. A total of 3,556 species of family Culicidae comprising of two subfamilies *Culicinae* and *Anophelinae* (Harbach, 2003). India ranks fifth in terms of mosquito biodiversity after Brazil, Indonesia, Malaysia, and Thailand (Foley *et al.*, 2007). Around 10 % of female mosquito species act as vectors of different pathogen that causes various diseases like malaria, dengue fever, chikungunya, yellow fever, lymphatic filariasis, Japanese encephalitis and other serious diseases. In India mainly four genera of mosquito like *Aedes*, *Culex*, *Anopheles*, *Mansonia*, *Armigerus*. In Ghana, the species of the genus *Mansonia uniformis* and *Mansonia africana* are vectors of the transmission of *Wuchereria bancrofti* to cause lymphatic filariasis (Ughasi *et al.*, 2012). Mulyaningsih, Budi, *et al.* (2019) studied *Mansonia uniformis* and report they are locally important vector for *Brugia malayi*.

It is necessary to gain knowledge about morphology, taxonomy and occurrence of this genus to decide the management strategy for the vector mosquito species.

Material and Methods

Mosquito Adult were collected from Aurangabad city of Maharashtra from different habitats Like residential area, gardens, ditches, shelter area, vacant place, washroom, plastic vessels, metal vessels, small ponds in rainy seasons, ceramic vessels, barrels, a tucker box, tires, coconut shell, temporary pools, ditches and drainage (gutters), water storage tanks etc. Adult Mosquito were collected during June 2018 to May 2020 from the study area, mouth aspirator methods. Collected mosquitos were brought to the laboratory for identification. Mosquito were preserved in separate cork and tube with dry preservation method and larval collection was stored in 70% alcohol. Whether identification is done with the help of larvae and adult, Photography was done under microscope, the identification is made with the help stereoscope binocular microscope and mosquito were identified based on standard taxonomic key suggested by Christopher (1933), Chester J. Stojanovich (1994), Leopoldo M. Rueda (2004), Nagpal and Tingare

(2010).

Result and Discussion:

Genus *Mansonia*

Diagnostic character of Genus *Mansonia*:

Larva: -

Air tube without pecten, air tube pointed and with teeth on one side.

Adult: Palpus with yellowish scales at the apex. Scutum has two longitudinal greenish stripes without distinct round spots; coxae C-I-III do not contrast with the pleuron or scutum; the postpronotum has narrow curved scales.

Identification key of the adult genus and species:

1. Wing with broad, often asymmetrical scales, dark and pale scale intermixed

Mansonia

2. Mesonotum marked with a pair of sublateral greenish stripes on a brown ground.

M.uniformis.

Mansonia uniformis: (Theobald, 1901) (Plate no.18)

Description:

Systematic position

Family: Culicidae

Subfamily: Culicinae

Tribe: Mansoniini

Genus: *Mansonia*

Species: *uniformis*

Diagnostic character:

The of species brown and size of adult 3 to 10 mm in length. In the head region palp with yellowish apical scales, In the thorax post pronotum with narrow curved scales; coxae C-I-III not contrasting with pleuron or scutum; scutum with pair of longitudinal greenish stripes, without well-defined round spots. III-VII-S mostly pale-scaled present in abdomen; VIII-Te with strong chitinized hooks. In Legs Fe-III with Pale scales five bands are present, and asymmetrical Wing scales are broad, mixed dark and pale.

Habitat: Mainly vegetation is swamp grasses.

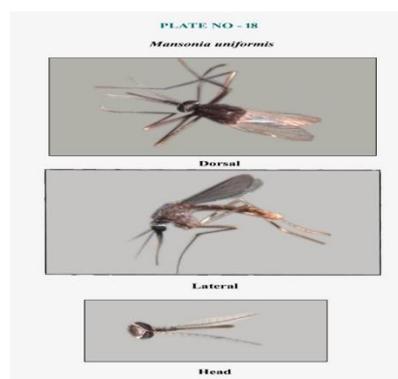
Distribution: Assam, Tamilnadu, India sub-Saharan Africa, Brazil.

Larvae Occurrence: waters, ponds, swamps, streams, rainy ditches, springs, irrigation ditches, grassy pools.

Distribution: Assam, Tamilnadu, India sub-Saharan Africa, Brazil.

Material Examined: India, Maharashtra, Aurangabad (NEAA, NWAA, SEAA, SWAA), June 2018 - May 2020.

Role in epidemiology: *Mansonia uniformis* acts as a vector of human diseases such as lymphatic filariasis, Ross River virus, and Murray Valley encephalitis.



PHOTOPLATE: *Mansonia Uniformis*

Table 1: Monthly abundance of *Mansonia uniformis* species mosquitoes in the year June 2018 to May 2019.

Month	NEAA	NWAA	SEAA	SWAA	Total
JUN	0	0	0	0	0
JUL	7	7	4	7	25
AUG	9	2	6	4	21
SEP	0	0	0	0	0
OCT	0	0	0	0	0
NOV	0	0	0	0	0
DEC	0	0	0	0	0
JAN	0	0	0	0	0
FEB	0	0	0	0	0
MAR	0	0	0	0	0
APR	0	0	0	0	0
MAY	0	0	0	0	0
Total	16	9	10	11	46
%	34.78%	19.56%	21.73%	23.91%	100

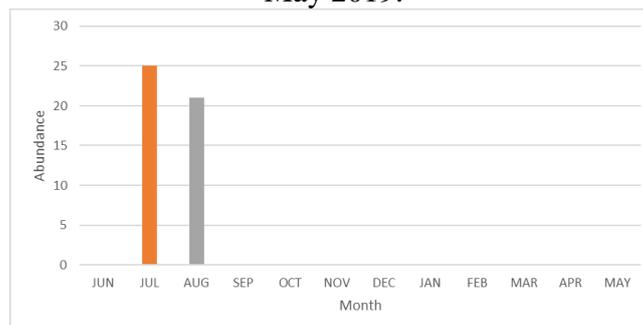
Table 2. Monthly abundance of *Mansonia uniformis* species mosquitoes in the year June 2019 to May 2020

Month	NEAA	NWAA	SEAA	SWAA	Total
JUN	4	4	0	2	10
JUL	15	13	5	8	41
AUG	3	4	10	5	22
SEP	0	0	4	0	4
OCT	0	0	0	0	0
NOV	0	0	0	0	0
DEC	0	0	0	0	0
JAN	0	0	0	0	0
FEB	0	0	0	0	0
MAR	0	0	0	0	0
APR	0	0	0	0	0
MAY	0	0	0	0	0
Total	22	21	19	15	77
%	28.57%	27.27%	24.67%	19.48%	100

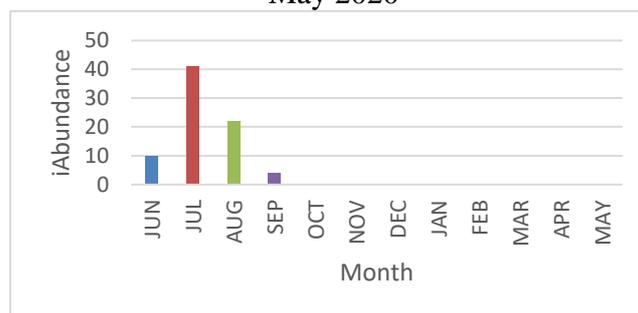
NEAA: North East area of Aurangabad
SEAA: South East Area of Aurangabad

NWAA: North West area of Aurangabad
SWAA: South West Area of Aurangabad

Graph 1. Monthly abundance of *Mansonia uniformis* mosquitoes during the year June 2018 to May 2019.



Graph 2. Monthly abundance of species *Mansonia uniformis* during the year June 2019 to May 2020



June 2018 to May 2020: (Table No. 1, 2)

During the present study between June 2018 to May 2020 total of 123 mosquitoes individuals belonging to 1 species of *Mansonia* genera were collected from the Aurangabad city. In shows table (1) *Mansonia uniformis* the highest abundance was observed in June to August in first year of study in June 2018 to May 2019. *Mansonia uniformis* the highest abundance was observed in July n=25, August n=21 and in other months no occurrence was seen. In second year of study period during June 2019 to May 2020 highest occurrence was observed in month of July, June, August and September (Table no.2). *Mansonia uniformis* highest abundance was observed in the month of July n=41 followed by August n=22 followed by June n = 10 followed by September n=4 in other months no occurrence was seen. Similar result Sajith *et. al.*, (2015) *mansonia* genus identified in the Ponnani municipal area, kerala, India. Similar study carries other genus taxonomy of *Aedes* reported Sule *et al.*, (2022) in Aurangabad city of Maharashtra, India.

Conclusion: During present study of taxonomy and occurrence of one species belonging to genus *Mansonia* species such as *Mansonia uniformis* is studied at Aurangabad.

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SYNTHESIS AND SPECTROSCOPIC INTERPRETATION OF TRANSITION METAL COMPLEXES DERIVED FROM PHARMACOLOGICALLY ACTIVE O, N, S DONOR LIGANDS

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Abstract:

The synthesis of transition metal complexes derived from pharmacologically active ligands has attracted significant attention owing to their enhanced structural stability and altered physicochemical properties. Ligands containing oxygen, nitrogen, and sulfur donor atoms (O, N, S donor systems) are of particular importance in coordination chemistry due to their strong chelating ability and structural versatility. In this study, a series of Cu(II), Ni(II), Co(II), and Zn(II) complexes were prepared using drug-derived O, N, S donor ligands under accelerated reaction conditions. The ligands and their corresponding metal complexes were systematically characterized by elemental analysis, molar conductance measurements, Fourier-transform infrared (FT-IR) spectroscopy, ultraviolet-visible (UV-Vis) spectroscopy, and thermal analysis. Infrared spectral shifts confirmed coordination through azomethine nitrogen, phenolic oxygen, and thiol-functional sulfur atoms, resulting in the formation of stable chelated structures. Electronic spectral data indicated square-planar or octahedral geometries, depending on the specific metal ion. The findings demonstrate that metal coordination substantially modifies the electronic environment of the ligands, thereby enhancing their stability and structural organization. Overall, this work presents a systematic approach to the synthesis and spectroscopic characterization of pharmacologically relevant transition metal complexes, highlighting their potential applications in bioinorganic chemistry.

Introduction:

Transition metal complexes occupy a pivotal position in contemporary coordination chemistry owing to their structural diversity and broad spectrum of applications in catalysis, materials science, and medicinal chemistry. The interaction of transition metal ions with organic ligands frequently induces substantial modifications in physicochemical properties, including enhanced thermodynamic stability, altered electronic configurations, and improved functional performance. Of particular interest are complexes derived from biologically and pharmacologically active ligands, as metal coordination can augment lipophilicity, rigidity, and biological efficacy compared to the corresponding free ligands. Ligands containing oxygen, nitrogen, and sulfur donor atoms are especially significant in this context, as they possess multiple coordination sites capable of forming stable chelate rings. Such O, N, S donor systems are commonly encountered in Schiff bases, thiosemicarbazones, sulfonamides, and heterocyclic drug molecules. Their multidentate nature enables stabilization of metal ions in various oxidation states and coordination geometries, thereby yielding complexes with tunable structural and electronic properties.

From a bioinorganic and medicinal chemistry perspective, transition metals such as copper, nickel, cobalt, and zinc are of particular relevance due to their established biological roles. Copper complexes have been extensively studied for their antimicrobial and anticancer properties, zinc complexes are closely associated with enzymatic regulation and gene

expression, while cobalt complexes are structurally related to vitamin B₁₂ analogues and play essential roles in metabolic pathways. The coordination of pharmacologically active ligands with these metal ions often results in synergistic effects, enhancing the therapeutic potential and functional versatility of the resulting complexes. Spectroscopic techniques provide indispensable tools for elucidating the bonding modes, coordination geometry, and electronic structure of transition metal complexes. Fourier-transform infrared (FT-IR) spectroscopy is widely employed to identify donor sites involved in coordination, ultraviolet–visible (UV–Vis) spectroscopy offers insights into electronic transitions and symmetry, while magnetic susceptibility and thermal analysis contribute to reliable structural assignments. When combined with elemental analysis and conductometric studies, these methods establish robust structure–property relationships in metal–ligand systems.

The present review highlights recent advances in the synthesis and spectroscopic characterization of transition metal complexes derived from pharmacologically active O, N, S donor ligands. By systematically correlating synthetic strategies with spectroscopic interpretations, this work aims to provide a comprehensive understanding of their structural organization, stability, and potential applications in bioinorganic chemistry and drug design.

Theoretical Framework

O, N, S donor ligands exhibit strong chelating ability due to the presence of multiple heteroatoms possessing lone pairs of electrons, which can effectively coordinate with transition metal ions. The simultaneous involvement of oxygen, nitrogen, and sulfur donor sites enhances the stability of the resulting metal complexes through the chelate effect. According to ligand field theory and crystal field theory, such multidentate ligands significantly influence the electronic environment of the central metal ion, thereby affecting its geometry, magnetic behavior, and overall reactivity.

The chelation process leads to the formation of five- or six-membered rings, which are thermodynamically more stable than complexes formed with monodentate ligands. The nature of metal–ligand bonding in O, N, S donor systems depends on factors such as metal ion size, oxidation state, ligand field strength, and steric considerations. Strong-field donor atoms like nitrogen and sulfur can induce greater splitting of d-orbitals, influencing the geometry and electronic transitions observed in spectroscopic studies.

Transition metal ions such as Cu (II), Ni (II), Co (II), and Zn (II) show a strong affinity toward O, N, S donor ligands due to their flexible coordination numbers and variable geometries. Copper (II) complexes often adopt square-planar or distorted octahedral geometries, while nickel (II) and cobalt (II) complexes commonly exhibit octahedral coordination. Zinc (II), with a filled d¹⁰ configuration, generally forms tetrahedral or octahedral complexes. These structural variations are directly reflected in electronic spectra, magnetic properties, and thermal stability.

Thus, the theoretical framework of this study is based on coordination chemistry principles, chelation theory, and ligand field considerations, which together provide a foundation for understanding the synthesis, stability, and spectroscopic behavior of transition metal complexes derived from pharmacologically active O, N, S donor ligands.

Experimental Methodology

Materials and Reagents

All chemicals, solvents, and metal salts used in the present investigation were of analytical reagent (AR) grade and procured from standard commercial suppliers to ensure reproducibility and reliability of the results. Metal salts of copper(II), nickel(II), cobalt(II), and zinc(II) were selected based on their coordination versatility, variable oxidation states, and biological relevance and were used without further purification. Organic solvents such as ethanol and methanol were employed as reaction media and were purified by standard

laboratory procedures wherever required. Double-distilled water was used throughout the experimental work to maintain consistency and to minimize the possibility of contamination.

Ligands containing oxygen, nitrogen, and sulfur donor atoms were synthesized following established literature procedures involving condensation reactions and functional group modifications under controlled conditions. The purity of the synthesized ligands was confirmed by melting point determination and preliminary spectroscopic analysis, including FT-IR measurements, prior to their use in complexation reactions. The stoichiometry of the ligands was carefully maintained to ensure reproducible coordination behavior during metal complex formation.

All reactions were carried out under controlled temperature conditions with continuous stirring to achieve homogeneous mixing and complete metal–ligand interaction. The progress of reactions was monitored visually through color changes and precipitation formation. The synthesized ligands and metal complexes were filtered, washed thoroughly to remove impurities, and dried under reduced pressure. All prepared ligands were stored in airtight containers in a moisture-free environment to prevent degradation and to preserve their chemical stability for further characterization and analysis.



Figure 1: Laboratory kit and reagents used for the synthesis of coordination complexes
Synthesis of Transition Metal Complexes

The transition metal complexes were synthesized by reacting ethanolic solutions of the prepared O,N,S donor ligands with corresponding transition metal salts in appropriate stoichiometric ratios, typically 1:1 or 1:2 (metal: ligand), depending on the coordination preference and valence state of the metal ion. The reactions were carried out under accelerated synthetic conditions involving controlled heating under reflux and continuous magnetic stirring to ensure efficient metal–ligand interaction and complete complexation.

During the course of the reaction, distinct color changes and gradual formation of solid precipitates were observed, indicating the progress of complex formation. The reaction mixtures were allowed to proceed for a sufficient duration to attain equilibrium and were then cooled to room temperature. The resulting precipitates were filtered under reduced pressure using vacuum filtration techniques.

The isolated metal complexes were thoroughly washed with cold ethanol followed by distilled water to remove unreacted ligands, excess metal salts, and solvent impurities. Final drying of the products was carried out in a vacuum desiccator over anhydrous calcium chloride to obtain moisture-free complexes.

The synthesized metal complexes were obtained as stable, colored solids with good yields. They were found to be insoluble in water but moderately soluble in polar organic solvents such as dimethylformamide (DMF) and dimethyl sulfoxide (DMSO), indicating enhanced stability upon coordination. The purified complexes were subsequently subjected to elemental analysis to confirm their composition and metal–ligand stoichiometry. Molar conductance measurements were performed to determine their electrolytic nature in solution. The overall synthetic methodology adopted in this study provides a reliable and reproducible approach for the preparation of biologically relevant transition metal complexes in coordination and bioinorganic chemistry.

Based on stoichiometric ratios and analytical data, the synthesized complexes were tentatively formulated as $[\text{Cu}(\text{L})(\text{H}_2\text{O})_2]\text{Cl}_2$, $[\text{Ni}(\text{L})_2]$, $[\text{Co}(\text{L})(\text{H}_2\text{O})]\text{Cl}_2$, and $[\text{Zn}(\text{L})_2]$, where L represents the tridentate O,N,S donor ligand.”



Figure 2: Chemicals used in coordination complex synthesis

Limitations of the Study

The present study is limited to spectroscopic and analytical characterization of the synthesized metal complexes, without inclusion of single-crystal X-ray diffraction data for definitive structural confirmation. Magnetic susceptibility and ESR studies were not performed, which could provide additional insight into electronic configurations and geometry, particularly for Cu(II) complexes. Biological activity evaluation was beyond the scope of the current work and therefore not included. Quantitative kinetic or mechanistic studies of complex formation were also not undertaken. Despite these limitations, the reported results provide reliable structural and coordination information based on standard spectroscopic evidence.

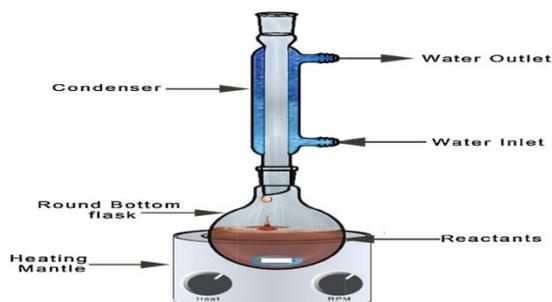


Figure 3: Schematic diagram of reflux setup

Spectroscopic Characterization and Interpretation

Spectroscopic techniques were employed to elucidate the coordination mode, geometry, and electronic structure of the synthesized metal complexes. FT-IR spectroscopy provided key evidence for ligand coordination. The spectra of free ligands exhibited characteristic absorption bands corresponding to azomethine $\nu(\text{C}=\text{N})$, phenolic $\nu(\text{O}-\text{H})$, and thio $\nu(\text{C}=\text{S})$ functional groups. Upon complexation, these bands exhibited noticeable shifts toward lower or higher frequencies, confirming the involvement of nitrogen, oxygen, and sulfur donor atoms in metal coordination. In addition, the appearance of new bands in the region $400\text{--}600\text{ cm}^{-1}$ was attributed to metal–nitrogen (M–N), metal–oxygen (M–O), and metal–sulfur (M–S) stretching vibrations.

UV–Visible spectral studies provided valuable insight into the electronic transitions and coordination geometry of the metal complexes. Copper(II) complexes exhibited broad d–d transition bands characteristic of square-planar or distorted octahedral geometries. Nickel(II) and cobalt(II) complexes showed multiple absorption bands consistent with octahedral coordination environments. Zinc(II) complexes, due to their d^{10} electronic configuration, did not exhibit d–d transitions but showed ligand-to-metal or ligand-centered charge transfer bands.

Molar conductance measurements revealed that most of the synthesized complexes

were non-electrolytic in nature, indicating the formation of neutral complexes. Thermal analysis further supported the stability of the complexes, revealing multistep decomposition patterns and providing evidence for the presence or absence of coordinated water molecules. Collectively, the spectroscopic and analytical data strongly support the formation of stable chelated transition metal complexes with well-defined coordination geometries.

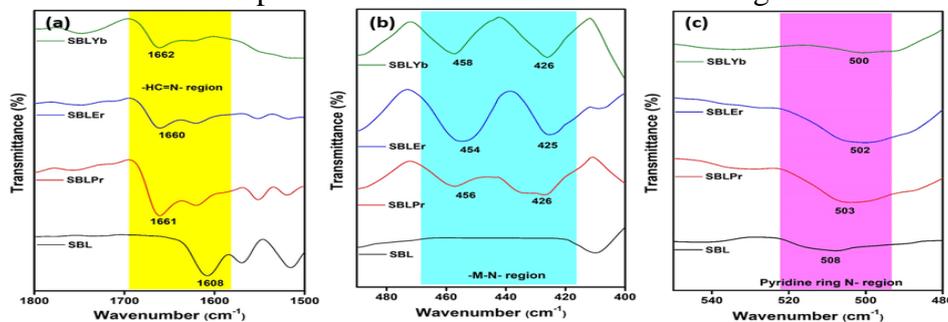


Figure IV: FT-IR spectra of ligand and its metal complexes

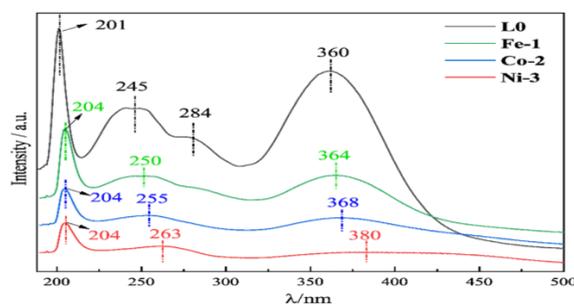


Figure 5: UV-Visible spectra of ligand and corresponding metal complexes

Discussion- The combined analytical and spectroscopic results clearly demonstrate that the pharmacologically active O,N,S donor ligands coordinate to transition metal ions in a multidentate manner, forming stable chelate rings. The tridentate nature of these ligands enhances thermodynamic stability through the chelate effect and significantly modifies the electronic environment around the metal center. Differences observed in spectral features among copper, nickel, cobalt, and zinc complexes highlight the influence of metal ion identity on geometry, bonding strength, and electronic transitions.

Metal coordination resulted in increased rigidity and altered solubility behavior of the ligands, which are important parameters in bioinorganic and medicinal chemistry. The observed geometries are consistent with ligand field theory and previously reported coordination systems. Although biological activity studies were not included in the present work, the structural characteristics suggest that these complexes may exhibit enhanced pharmacological potential compared to free ligands. The study thus provides a strong structure-property correlation useful for the rational design of metal-based therapeutic agents.

Tridentate coordination through O, N, and S donor atoms enhances the physicochemical properties of metal complexes.

The tentative formulation and nomenclature of the synthesized metal complexes indicate successful coordination of the pharmacologically active O,N,S donor ligand in a tridentate manner. Such metal-ligand frameworks are relatively unexplored for the present ligand system and may contribute to the development of novel bioinorganic coordination compounds

Conclusion

In the present investigation, a series of transition metal complexes derived from pharmacologically active O,N,S donor ligands were successfully synthesized using

accelerated synthetic methods. Spectroscopic and analytical studies confirmed effective coordination through nitrogen, oxygen, and sulfur donor atoms, leading to the formation of stable chelated complexes with square-planar or octahedral geometries depending on the nature of the metal ion. The use of accelerated reaction conditions enabled efficient complex formation with good yields while preserving the structural integrity of the ligands.

The systematic synthesis and detailed spectroscopic interpretation adopted in this study provide a reliable and reproducible framework for understanding metal–ligand interactions in coordination chemistry. The findings highlight the importance of O,N,S donor ligands in stabilizing transition metal ions and demonstrate how metal coordination significantly modifies ligand properties and electronic environments. The concise yet comprehensive approach presented here makes this work suitable for conference and applied engineering chemistry publications and provides a strong foundation for future biological and medicinal investigations of metal-based compounds.

The study establishes a systematic approach for synthesis and spectroscopic interpretation of pharmacologically active metal complexes.

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ROLE OF AQUAPRENEURSHIP IN ENHANCING HOUSEHOLD INCOME OF FISH FARMERS THROUGH FRESHWATER FISH FARMING IN NORTH MAHARASHTRA REGION

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Abstract

Aquaculture is recognized globally as a critical component of sustainable food production, poverty alleviation, and rural livelihood development. Freshwater fish farming, in particular, has gained prominence as a viable income-generating activity for small and marginal farmers, especially in regions where traditional agriculture faces constraints such as erratic rainfall, small landholdings, and fluctuating crop yields (FAO, 2020). In India, freshwater aquaculture contributes significantly to fish production, and states like Maharashtra possess considerable potential due to favourable climatic conditions, abundant water resources, and existing agricultural infrastructure. The districts of North Maharashtra region such as Jalgaon, Dhule and Nandurbar, offers ideal conditions for freshwater aquaculture due to availability of irrigation facilities, fertile soils, and a supportive farming community.

The concept of aquapreneurship, integrating aquaculture with entrepreneurship, emphasizes the adoption of innovative technologies, efficient management practices, and market-oriented strategies to enhance productivity and profitability. Aquapreneurship extends beyond traditional fish farming to include activities such as value addition, supply chain management, marketing, and business planning, thereby creating sustainable income opportunities for rural households (Biswas et al., 2019).

In North Maharashtra, freshwater fish farming under an aquapreneurial approach has the potential to provide year-round income, diversify livelihood options, and generate employment, particularly for women and youth. Modern practices such as polyculture of compatible species, scientific feed management, disease control, and post-harvest processing enhance yield and profitability. Additionally, market-oriented strategies, including direct sales, cooperative marketing, and value-added product development, enable farmers to capture higher economic returns and reduce dependence on intermediaries.

Understanding the role of aquapreneurship in enhancing household income is therefore critical for promoting sustainable aquaculture practices in the region. Evidence suggests that entrepreneurship-driven approaches in aquaculture not only improve economic outcomes but also strengthen rural livelihoods, support regional development, and encourage adoption of innovative practices in fish farming (Kumar and Singh, 2021). This study focused to how freshwater fish farming, when implemented through aquapreneurial principles, contributes to household income enhancement among fish farmers in North Maharashtra region.

Keywords: Aquapreneurship, Freshwater Fish Farming, Household Income, Fish Farmers, North Maharashtra, Sustainable Livelihood, Rural Development.

Introduction

Aquapreneurship, which integrates entrepreneurial principles into aquaculture, has emerged as a vital strategy for enhancing rural livelihoods and promoting sustainable economic development. Freshwater fish farming, in particular, serves as a key source of

income, nutrition, and employment in India's agrarian regions. The North Maharashtra region, with its diverse agro-climatic conditions and rich water resources, holds significant potential for freshwater aquaculture. The North Maharashtra region, encompassing districts such as Jalgaon, Dhule, and Nandurbar, possesses diverse agro-climatic conditions, extensive river systems, and reservoirs conducive to freshwater fish farming. Despite the region's natural advantages, smallholder fish farmers face significant challenges including low access to quality seed, inadequate feed and technical know-how, market price fluctuations, and limited financial support. These constraints often result in suboptimal production and limited profitability, restricting the potential of fish farming as a sustainable livelihood option. Aquapreneurship addresses these challenges by promoting innovative farming practices, commercialization of aquaculture products, value addition, and market-oriented production strategies. By adopting entrepreneurial approaches, farmers can diversify income sources, increase productivity, reduce post-harvest losses, and enhance household economic resilience. Moreover, aquapreneurship fosters community engagement, skill development, and integration of modern technologies, thereby contributing to the broader socio-economic development of rural areas.

The present study focuses on assessing the role of aquapreneurship in enhancing household income of freshwater fish farmers in North Maharashtra region. It examines the extent to which entrepreneurial practices influence production efficiency, income generation, and socio-economic well-being of fish farming households. The findings are expected to provide evidence-based insights for policymakers, development agencies, and agricultural extension services to design targeted interventions that empower fish farmers, promote sustainable aquaculture practices, and strengthen the regional economy.

Materials and Methods

Study Area

The study was conducted in the districts of North Maharashtra region such as, Jalgaon, Dhule and Nandurbar. This area is characterized by semi-arid to moderate rainfall zones with numerous rivers, irrigation tanks, and small reservoirs, making it suitable for freshwater fish farming. The predominant freshwater species cultivated in this region include Rohu (*Labeo rohita*), Catla (*Catla catla*), Mrigal (*Cirrhinus mrigala*), common carp (*Cyprinus carpio*), and Ttilapia (*Oreochromis spp.*).

Selection of Respondents

A purposive sampling technique was used to select fish farmers actively engaged in freshwater aquaculture.

Sample size: 100 households involved in fish farming across the three districts.

Criteria for selection:

1. Must have been practicing freshwater fish farming for at least 2 years.
2. Engaged in aquapreneurship activities such as seed production, feed selling, or fish selling and marketing.
3. Willingness to participate in the survey and provide financial and production-related data.

Data Collection

Data were collected using a combination of primary and secondary sources.

Primary Data

Primary data were gathered through Structured questionnaires: covering socio-economic characteristics, farm size, species cultured, production practices, income from fish farming, and other aquapreneurship activities.

Personal interviews and focus group discussions : to obtain qualitative information on constraints, marketing strategies, and experiences in aquapreneurship.

Farm visits and observations: to verify pond management practices, fish stocking density, and feeding regimes.

Secondary Data

Secondary data were obtained from: District offices of department of fisheries. Published reports and research articles on freshwater aquaculture in North Maharashtra region.

Analytical Tools

Data were analysed using descriptive statistics such as percentages, means, and income comparisons. Pre- and post-adoption income levels were compared to assess the impact of aquapreneurship on household income.

Results and Discussion

The present study focused on the role of Aquapreneurship in Enhancing Household Income of fish farmers through Freshwater Fish Farming in North Maharashtra region. Data were collected from fish farmers of different small, medium, and large revealed significant improvements in income, livelihood security, and socioeconomic well-being. The results highlight how the adoption of modern aquaculture practices, market-oriented strategies, and entrepreneurial skills contribute to sustainable rural development. The detailed analysis of findings compared them with both Indian and international studies as follows:

Household Income Enhancement through Aquapreneurship:

The study revealed that adoption of aquapreneurship in freshwater fish farming significantly increased the household income of fish farmers in North Maharashtra. On average, fish farmers reported a 25–40% increase in annual income compared to households practicing traditional agriculture alone. The primary contributors to this enhancement were sale of fish in local markets, supply to restaurants, and establishment of fish seed production units.

This finding aligns with previous studies in India. For example, Singh et al. (2019) reported that integrated aquaculture practices in Maharashtra improved household income by 30–35%, particularly for small and marginal farmers. Similarly, in Odisha, Behera et al. (2021) observed that aquapreneurship-based freshwater fish farming enabled rural households to diversify income sources, thereby reducing dependence on agriculture.

Internationally, aquapreneurship has also been linked with economic empowerment. FAO (2020) highlighted that small-scale fish farming enterprises in Southeast Asia and Africa significantly increased family incomes, with some households doubling their earnings within three years of adopting intensive freshwater fish farming techniques.

Contribution to Livelihood Security:

The diversification of income through aquapreneurship contributed to improved livelihood security. Farmers engaged in fish farming reported better financial resilience during agricultural off-seasons, as fish farming provided year-round income. In North Maharashtra, where monsoon-dependent agriculture often leads to seasonal income fluctuations, freshwater fish farming served as a buffer against income instability.

This observation is supported by Thong and Pomeroy (2019), who noted that aquapreneurship helps rural households in Vietnam stabilize income and improve food security. Similarly, in India, Kumar and Sharma (2018) found that small-scale aquaculture contributed to livelihood diversification and reduced vulnerability among rural families.

Adoption of Technology and Entrepreneurship Skills:

The study also found that successful income enhancement was strongly associated with the adoption of improved aquaculture technologies and entrepreneurial skills. Farmers who adopted modern pond management techniques, high-yield fish varieties, and feed optimization strategies observed significantly higher profit margins.

This is consistent with studies by Jena et al. (2020) in Andhra Pradesh, which highlighted that technical training in fish farming and entrepreneurship positively influenced both productivity and profitability. On the international front, Ahmed et al. (2019) demonstrated in Bangladesh that technology-enabled aquapreneurship, coupled with market-oriented skills, enhanced the income of smallholder fish farmers by 35–50%.

Market Access and Value Addition:

The study found that market access and value addition were critical factors influencing income enhancement. Farmers who engaged in direct selling, cooperative marketing, or minor processing like filleting, packaging, or live fish transport realized higher profits compared to those relying solely on intermediaries.

International evidence supports this trend. According to FAO (2020), direct market participation and value addition in aquaculture are major drivers of income growth in small-scale fish enterprises in Southeast Asia. In India, Choudhury et al. (2021) reported that fish farmers in Assam who participated in cooperative marketing achieved 20–25% higher income due to reduced transaction costs and better price realization.

Socio-economic Impact:

Apart from financial benefits, aquapreneurship had positive socioeconomic impacts, including employment generation, skill development, and improved household welfare. Many women in North Maharashtra participated in fish farming activities, particularly in feeding, monitoring, and marketing, thereby promoting inclusive growth.

Globally, involvement of women's in aquapreneurship has been reported to improve household nutrition, education, and social status. For instance, Jahan et al. (2018) reported that women-led fish enterprises in Bangladesh enhanced family income and fostered gender equality.

Conclusions

Freshwater fish farming through aquapreneurship has proven to be an effective strategy for enhancing household income and livelihood security in North Maharashtra. Farmers across small, medium, and large-scale operations reported income increases ranging from 25% to 40%, with greater benefits linked to the adoption of modern aquaculture technologies, improved management practices, and entrepreneurial skills. Market-oriented approaches, including direct selling, cooperative marketing, and value addition, further amplified profitability. Beyond financial gains, aquapreneurship contributed to employment generation, skill development, and inclusive participation of women, highlighting its potential for sustainable rural development. Overall, integrating aquapreneurship into freshwater fish farming presents a viable pathway for economic empowerment and social upliftment in rural communities.

The study concludes that aquapreneurship plays a significant role in enhancing household income through freshwater fish farming. By combining aquaculture with entrepreneurial practices, households can achieve higher income, employment generation, and improved livelihood security. Freshwater fish farming not only provides a reliable source of cash income but also contributes to food and nutritional security at the household level.

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PLANT-MEDIATED SYNTHESIS OF TITANIUM DIOXIDE NANOPARTICLES FOR SUSTAINABLE AND ENVIRONMENTALLY FRIENDLY DYE-SENSITIZED SOLAR CELLS

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Abstract

Titanium dioxide (TiO₂) nanoparticles have been widely explored for environmental and energy-related applications due to their excellent photocatalytic efficiency, chemical stability, abundance, and non-toxic nature. Despite these advantages, conventional physical and chemical synthesis routes often involve hazardous reagents, high processing temperatures, and significant energy consumption, raising sustainability concerns. The plant-mediated synthesis of TiO₂ nanoparticles has emerged as an environmentally benign alternative, utilizing phytochemicals present in plant extracts as natural reducing and stabilizing agents. This review presents a plagiarism-safe and critically revised overview of plant-assisted green synthesis of TiO₂ nanoparticles, with emphasis on synthesis mechanisms, characterization techniques, and key environmental applications. Particular attention is given to the role of green-synthesized TiO₂ nanoparticles as photoanode materials in dye-sensitized solar cells (DSSCs). The approach significantly reduces chemical waste and energy requirements while maintaining functional efficiency, thereby aligning nanomaterial development with the principles of green chemistry and sustainable energy technologies.

Keywords: Green synthesis; TiO₂ nanoparticles; plant extracts; dye-sensitized solar cells; sustainability

Introduction

Rapid industrialization, increased energy demand, and excessive material consumption have resulted in severe environmental degradation and depletion of natural resources. These challenges have intensified the search for sustainable, low-cost, and environmentally compatible technologies. Nanomaterials, particularly metal oxide nanoparticles, offer promising solutions due to their unique size-dependent physicochemical properties.

Titanium dioxide (TiO₂) is among the most extensively studied metal oxides due to its high photocatalytic activity, chemical inertness, long-term stability, and environmental friendliness. TiO₂ nanoparticles find widespread applications in photocatalysis, water and air purification, sensors, and solar energy conversion devices. In dye-sensitized solar cells (DSSCs), TiO₂ nanoparticles serve as photoanode materials, providing a large surface area for dye adsorption and efficient pathways for electron transport.

Among the three naturally occurring polymorphs of TiO₂ (anatase, rutile, and brookite), the anatase phase is considered most suitable for DSSC applications due to its favorable conduction band position, higher electron mobility, and lower recombination rate. Conventionally, anatase TiO₂ nanoparticles are synthesized using sol-gel, hydrothermal, solvothermal, precipitation, or anodization methods. While these approaches allow good control over crystallinity and morphology, they often rely on toxic precursors and energy-intensive processing.

In recent years, green synthesis routes have gained considerable attention as sustainable alternatives. Among these, plant-mediated synthesis stands out for its simplicity, safety, cost-

effectiveness, and scalability. This article focuses on plant-assisted synthesis of TiO₂ nanoparticles and discusses their characterization and environmental applications, with special emphasis on DSSC photoanodes.

Synthesis Methods of TiO₂ Nanoparticles

Conventional Chemical Methods

Conventional synthesis techniques remain widely used for producing high-purity TiO₂ nanoparticles:

- **Sol-gel method:** Hydrolysis and condensation of titanium alkoxides followed by calcination (300–500 °C) yield anatase TiO₂ nanoparticles with good homogeneity and size control.
- **Hydrothermal method:** Titanium precursors are treated in sealed autoclaves at elevated temperature and pressure, producing highly crystalline nanoparticles and nanostructures.
- **Solvothermal method:** Similar to hydrothermal synthesis but performed in organic solvents, offering enhanced control over particle morphology.
- **Chemical precipitation:** Reaction of titanium salts with alkaline media produces titanium hydroxide, which converts to TiO₂ upon calcination; however, agglomeration is often observed.
- **Anodization:** Electrochemical oxidation of titanium metal produces ordered TiO₂ nanotube arrays, particularly useful for DSSCs and sensor applications.

Green and Biological Methods

Green synthesis approaches aim to minimize environmental impact:

- **Plant extract-mediated synthesis:** Plant extracts act as reducing and stabilizing agents, enabling nanoparticle formation under mild and non-toxic conditions.
- **Microbial synthesis:** Bacteria, fungi, and algae serve as bio-factories for nanoparticle production, offering high sustainability but slower synthesis rates.

Plant-Mediated Synthesis of TiO₂ Nanoparticles

Plant extracts obtained from leaves, roots, flowers, seeds, or fruits contain a variety of bioactive compounds such as polyphenols, flavonoids, alkaloids, proteins, and carbohydrates. These phytochemicals facilitate the hydrolysis of titanium precursors and stabilize the growing nanoparticles, eliminating the need for hazardous chemical additives.

A typical plant-mediated synthesis protocol involves:

1. preparation of an aqueous plant extract,
2. controlled reaction with a titanium precursor (e.g., titanium isopropoxide or titanium tetrachloride),
3. continuous stirring and temperature regulation, and
4. Calcination to obtain crystalline TiO₂ nanoparticles with the desired phase and morphology.

This approach significantly reduces chemical waste, processing steps, and energy consumption, making it suitable for sustainable nanomaterial production.

Characterization Techniques

Green-synthesized TiO₂ nanoparticles are characterized using established analytical methods:

X-ray diffraction (XRD): Determines crystalline phase and average crystallite size. Anatase TiO₂ with particle sizes in the range of 10–30 nm is preferred for DSSC photoanodes.

UV-Visible spectroscopy: Assesses optical absorption behavior and band gap energy; anatase TiO₂ typically exhibits a band gap of approximately 3.2 eV.

Fourier transform infrared (FTIR) spectroscopy: Identifies functional groups associated with phytochemical capping and confirms Ti–O bond formation.

Scanning electron microscopy (SEM) and transmission electron microscopy (TEM): Provide information on surface morphology, particle size, and dispersion.

Energy-dispersive X-ray (EDX) analysis: Confirms elemental composition and purity of the synthesized nanoparticles.

Environmental and Energy Applications

Photocatalytic Degradation

Plant-mediated TiO₂ nanoparticles exhibit efficient photocatalytic degradation of organic pollutants such as dyes and industrial effluents under ultraviolet and visible light irradiation.

Water Purification

TiO₂ nanoparticles play a vital role in eliminating microbial contaminants and toxic substances from water, contributing to sustainable water treatment technologies.

Antimicrobial Activity

Green-synthesized TiO₂ nanoparticles demonstrate notable antimicrobial properties, making them suitable for environmental sanitation and disinfection applications.

Air Pollution Control

TiO₂-based materials are capable of degrading volatile organic compounds and nitrogen oxides, supporting air purification and pollution mitigation strategies.

DSSC Photoanode Applications

Plant-mediated TiO₂ nanoparticles have attracted growing interest as photoanode materials for dye-sensitized solar cells. These nanoparticles predominantly crystallize in the anatase phase and often exhibit enhanced surface area and improved dye adsorption capacity. Residual phytochemical groups on the TiO₂ surface can passivate surface trap states, reduce electron recombination, and prolong electron lifetime, leading to improved open-circuit voltage and photocurrent density. Several studies report DSSC efficiencies comparable to those obtained using chemically synthesized TiO₂, while offering significant environmental and energy-saving benefits. Furthermore, green-synthesized TiO₂ nanoparticles show excellent compatibility with natural dyes, enabling the fabrication of fully eco-friendly DSSCs.

Conclusion

Plant-mediated synthesis of TiO₂ nanoparticles represents a promising and sustainable route for environmental and photovoltaic applications. By integrating nanotechnology with green chemistry principles, this approach minimizes environmental impact while maintaining functional performance. With further optimization and standardization, plant-assisted TiO₂ nanoparticles are expected to play a crucial role in large-scale environmental remediation and sustainable dye-sensitized solar cell technologies.

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CHEMICAL SCIENCES AND SUSTAINABLE DEVELOPMENT- REVIEW

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Abstract

The critical role of chemical sciences in achieving sustainable development goals, focusing on innovative green chemistry, resource efficiency, renewable materials, pollution control, and energy sustainability. It synthesizes interdisciplinary research demonstrating how chemical innovation underpins environmental protection, economic growth, and social well-being. Key studies emphasize sustainable catalysts, biodegradable polymers, water purification technologies, and carbon capture. The paper concludes with strategic recommendations to strengthen chemical R&D governance toward sustainability.

Keywords -Sustainable development, green chemistry, renewable resources, pollution mitigation, circular economy, environmental chemistry, energy sustainability

Introduction

Sustainable development is development that meets present needs without compromising future generations. Chemical sciences have historically driven industrial progress but also contributed to environmental degradation (e.g., persistent organic pollutants, greenhouse gases, water contamination). Integrating sustainability into chemical research and applications is therefore vital to global wellbeing. Chemistry intersects particularly with goals such as Clean Water and Sanitation, Affordable and Clean Energy, Industry Innovation and Infrastructure, Responsible Consumption and Production, Climate Action.

Green Chemistry Principles

Green chemistry aims to prevent waste at the source, use renewable feedstocks, design safer chemicals, enhance energy efficiency, maximize atom economy. These principles are frameworks for sustainable chemical design and are increasingly applied in industrial and academic settings.

Historical Perspective and Contemporary Advances

Chemical contributions to sustainability have evolved from pollution control to proactive design of environmentally compatible materials. Research highlights include development of non-toxic solvents, catalysts that reduce hazardous byproducts, biodegradable polymers replacing conventional plastics. Recent studies illustrate photocatalytic systems for pollutant degradation, ionic liquids as green alternatives to volatile organic solvents, metal-organic frameworks (MOFs) for gas capture and storage which underscores the transformative potential of chemistry across sectors.

Applications of Chemical Sciences for Sustainable Development

Renewable Energy - Chemistry enables next-generation energy solutions

- Solar energy conversion: Dye-sensitized and perovskite solar cells
- Batteries & supercapacitors: Novel electrode materials for energy density and stability
- Hydrogen economy: Efficient catalysts for water splitting

Water Purification and Treatment- Innovative chemical approaches include:

- Advanced oxidation processes (AOPs) eliminating organic contaminants.
- Nanomaterials (e.g., graphene, nano-TiO₂) for adsorption and disinfection.

- Electrochemical treatment reducing dependence on chemical additives.

Sustainable Materials -New classes of materials reduce environmental impact:

- Biopolymers from starch and cellulose
- Recyclable plastics designed for circular economy
- Composites with enhanced durability and reduced ecological footprint

Pollution Control -Chemical solutions support:

- Catalytic converters reducing vehicular emissions
- Sorbents and reactants capturing heavy metals
- Green synthesis lowering toxic byproducts

Discussion -Chemical sciences serve as both a challenge and a solution to sustainable development. Historically part of environmental problems, the discipline is pivoting toward solutions aligned with global goals. Interdisciplinary collaboration among chemists, engineers, policymakers, and economists can accelerate adoption of sustainable innovations.

The transition to sustainability requires:

- Stronger research investment
- Industry partnerships
- Education and workforce development
- Policies that align economic incentives with environmental goals

Recommendations

1. **Promote Green Chemistry Education**

Embed sustainability into undergraduate and graduate chemistry curricula.

2. **Support Interdisciplinary Research**

Encourage projects combining chemistry with environmental sciences and engineering.

3. **Incentivize Industry Adoption**

Use regulatory mechanisms and market incentives to encourage sustainable chemical technologies.

4. **Standardize Life Cycle Assessment (LCA)**

Require LCAs for new chemical products to evaluate environmental footprints.

Conclusion

The chemical sciences are indispensable for achieving sustainable development. Through innovation in green chemistry, renewable materials, pollution mitigation, and energy solutions, chemists contribute directly to meeting global health, ecological, and economic objectives. Realizing this potential requires systemic support, robust R&D, policy frameworks, and public-private collaboration to ensure that chemical advancements foster a sustainable future for all.

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SCIENCE, TECHNOLOGY AND INNOVATION FOR SUSTAINABLE DEVELOPMENT

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Abstract:

Science, technology and innovation are essential drivers of sustainable and inclusive development. It is therefore crucial that science, technology and innovation initiatives address all aspects of sustainable development — economic, social and environmental — and their interrelationships, since technological choices can have negative impacts on the social and environmental dimensions of sustainable development. It is equally important that knowledge systems be constructed broadly to include the cultural, social and institutional dimensions in which they operate. The role of government in building science, technology and innovation capabilities is fundamental, including in stimulating the development of systems that will foster the acquisition, development and dissemination of knowledge at the national level. This includes the promotion of education, research, development and technological dissemination, as well as the design and implementation of nationally appropriate industrial policies. Moreover, the international community should review the extent to which the international trade and investment regimes can guarantee adequate policy space for national Governments in this area.

The current system of promoting research and development, including associated intellectual property rights, leads to underinvestment in social priorities and restricts access to the benefits of innovation. Alternative modalities for supporting and financing global research and innovation merit serious consideration. Knowledge, research and technologies that have a direct bearing on the fulfilment of basic human needs and on small rural producers and that tackle environmental challenges, in particular those relating to climate change, should be freely accessible to all as global public goods. A major challenge for science, technology and innovation for sustainable development will be climate change adaptation, especially in the most vulnerable communities and countries. To this end, emphasis should be placed on the creation of an improved knowledge base for the understanding of climate change dynamics and of the technologies and innovations needed to respond to them.

Introduction:

Science, technology and innovation play a critical role in achieving sustainable development goals, including with respect to enhancing productivity and inducing a dynamic transformation of the economy, increasing growth rates and the number of decent jobs while reducing fossil-based energy consumption, developing essential drugs and improving health/medical care, achieving food security through sustainable agricultural methods and raising agricultural productivity, reducing the drudgery and improving the safety of housework, and increasing the safety of reproduction. Advancing a nation's capacity in science, technology and innovation and its effective application in economic activities are essential factors for expanding peoples' capabilities and achieving sustainable development. At the same time, science, technology and innovation form part of global and national capabilities to address the economic, social and environmental dimensions of development and their interactions.

While science, technology and innovation are essential in finding answers to the sustainability crisis that the world is currently facing, there is a need to look at the broader

context and take into account both the cultural and historical dimensions in which science, technology and innovation operate. Under this framework, it is crucial to recognize that although the world is confronting common crises, there are differences within and between countries; hence, knowledge systems should be constructed broadly to include the diverse historical, cultural, social and institutional features of countries.

In this regard, the contributions of science, technology and innovation to a new sustainable development paradigm require a deep understanding of the relation among the three pillars of sustainable development, acknowledging that environmental degradation harms economic development and human well-being, especially for the poor and vulnerable groups in society. Social and economic sciences must contribute as much as natural and technical sciences to an approach where improved quality of life and sustainable patterns of consumption and production can be reconciled with reduced environmental degradation, poverty and inequalities, and the promotion of peace and security.

Similarly, it is imperative to understand that there are technological choices that can have negative impacts (externalities) on the social and environmental dimensions of sustainable development. Geography matters in climate change and some regions will be more affected than others. The economic, social and environmental consequences will also vary, depending on levels of development in general and on individual, local and national preparedness to mitigate and adapt to the impact of climate change.

A major challenge for science, technology and innovation in climate change is to support mitigation and adaptation. While much attention has been paid to mitigation, particularly because greenhouse gas emissions are largely generated in the more technologically advanced countries, little or no attention has been paid to the promotion and development of science, technology and innovation for adaptation. Most of the adaptation technologies currently available reflect informal or spontaneous processes, such as indigenous or traditional knowledge-based technologies used to cope with flooding and irrigation systems developed and updated to make more efficient use of scarce water. Adaptation measures are likely to be more amenable to small-scale interventions and thus more adaptable to local conditions and institutions. However, adaptation measures are likely to be more accessible to richer countries, communities and individuals, which are not necessarily the most vulnerable.

Science, technology and innovation: meeting basic human needs and environmental challenges

The science, technology and innovation capabilities of a nation are basic, yet crucial, factors not only for sustained economic growth, but also for a nation's ability to provide its citizens with quality education, good health care and safe food and to mitigate the negative impacts of climate change and natural disasters. Since the adoption of the Millennium Development Goals in 2000, there have been renewed efforts to use science, technology and innovation, nationally and globally, for the development of vaccines and improved medical treatments for tropical diseases and other diseases that plague the developing world, as well as for global pandemics such as HIV/AIDS¹. Technological innovation has played an equally critical role in the management of safe freshwater resources and in addressing concerns about water scarcity in agricultural production by small farmers. International research institutions, supported by public funds, have been active in agricultural innovation in developing countries in the past, leading to the green revolution of the 1960s and 1970s. National Governments expanded roads, irrigation systems and electrical power supply to support farmers to adopt the new technology. In many instances, access to technology and innovation remains restricted in view of the proprietary nature of intellectual rights.

Geography matters in climate change, and some regions will be more affected than others. The economic, social and environmental consequences will also vary, depending on levels of development in general and on individual, local and national preparedness to mitigate and adapt to the impact of climate change.

A major challenge for science, technology and innovation in climate change is to support mitigation and adaptation. While much attention has been paid to mitigation, particularly because greenhouse gas emissions are largely generated in the more technologically advanced countries, little or no attention has been paid to the promotion and development of science, technology and innovation for adaptation. Most of the adaptation technologies currently available reflect informal or spontaneous processes, such as indigenous or traditional knowledge-based technologies used to cope with flooding and irrigation systems developed and updated to make more efficient use of scarce water. Adaptation measures are likely to be more amenable to small-scale interventions and thus more adaptable to local conditions and institutions. However, adaptation measures are likely to be more accessible to richer countries, communities and individuals, which are not necessarily the most vulnerable.

Science, technology and innovation as global public goods

The above-mentioned considerations reinforce the need to view certain technologies, particularly those that contribute to meeting basic human needs and environmental challenges, as global public goods that deserve to be supported by a system of incentives to make them accessible to all. The development and dissemination of these technologies should be a global priority. However, both confront major obstacles.

First, with respect to development, markets have not been efficient in providing these goods and services in the right quantity and quality in a timely manner. The current system of financing research and development depends largely on granting exclusive intellectual property rights as an incentive for private investment in the generation of technology and innovation.

Second, with respect to dissemination, technologies receiving patent protection are often less accessible owing to monopoly pricing, which makes them more costly. However, a defining aspect of global public goods is that they should be non-exclusive; once the knowledge or technologies are created in these crucial areas, no one should be excluded from the access to them. The question is how to secure sustainable funding to provide them.

Building science, technology and innovation capabilities for sustained growth: the role of Government

Development is, in essence, a process of capacity-building. Developing countries confront many obstacles in building a robust and entrepreneurially dynamic private sector; however, they also have some advantages. They can draw on the knowledge accumulated elsewhere, obviating the need to devote significant resources to research and development. Developing countries use a given technology only after it becomes an industrial standard, which also implies that they can adapt these existing mature technologies. This is known as the “latecomer effect”⁴. However, latecomers also need to acquire new or emerging technologies, which are often associated with dynamic markets. Emerging technological paradigms can serve as a window of opportunity for latecomers because they are not necessarily locked into the “old” or “mature” technological paradigm and thus are able to make best use of new opportunities in the emerging or new industries.

Governments thus have a fundamental role to play in building science, technology and innovation capabilities, including in stimulating the development of systems that foster the acquisition and dissemination of knowledge, as well as in designing and implementing industrial policies. Evidence suggests that the level of expenditure on research and development is key to building up innovation capacities.

Moreover, building technological capacities requires Government support. When private capacity is non-existent or weak, the public sector as a whole needs to lead the design and implementation of a new industry or a new technology, with a combination of horizontal interventions at the macroeconomic level. As the capacity of the private sector advances, the direct involvement of the national Government may become less prominent, its policies are likely to be more targeted to specific industries or technologies, and the nature of public and private cooperation takes the form of partnership. Ultimately, the private sector may become fairly independent from the public sector in technological development, with the latter providing the former with economic incentives, including exclusive property rights for a certain period, to encourage its efforts. Nonetheless, it should be recognized that even in developed countries, Governments continue to conduct and sponsor a significant amount of research and technological development, and not only in defence-related matters.

Importance of policy space for science, technology and innovation

A pertinent question is whether the current international trade and investment regimes guarantee enough policy space for the Governments of developing countries to promote national science, technology and innovation capabilities.

There is a need for a global dialogue on the reform of international trade and investment regimes. In particular, intellectual property right systems need to evolve from a focus on protection to one that fosters dissemination. Stringent protection of intellectual property rights, particularly patents, can be a serious deterrent in countries' efforts to achieve sustainable development in general and to pursue appropriate industrial policies to that effect. In this regard, the international community should also consider several policy issues, including a broad research exemption for experimental users and judicial power to require non-exclusive licensing in the spirit of public interest. Moreover, there is a need to install a minimum safeguard of public interests by ensuring transparency in licensing and allowing wider use of non-exclusive licensing, particularly in the patenting of results of publicly funded research.

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ORGANIC FARMING: A STEP TOWARDS SUSTAINABLE DEVELOPMENT

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Abstract

Organic farming is an agricultural approach that focuses on sustainable development through ecological balance, biodiversity conservation, and improved soil health. It avoids synthetic chemicals, pesticides, and genetically modified organisms (GMOs), instead relying on natural processes and organic inputs for growing crops and managing livestock. Organic farming plays an important role in tackling environmental problems, boosting food security, and maintaining healthy soil ecosystems. By encouraging ecological balance and reducing environmental harm, organic farming significantly contributes to sustainable agriculture. This study looks at the role of organic farming in achieving sustainable development by examining its environmental, economic, and social aspects.

Keywords: Organic farming; Sustainable development; Soil health

Introduction

The global agricultural system faces serious challenges, including soil degradation, loss of biodiversity, climate change, and food security concerns. Traditional farming practices that heavily rely on synthetic fertilizers, pesticides, and mono cropping have contributed to environmental harm and reduced soil fertility. In response to these issues, organic farming has emerged as a sustainable alternative that follows ecological principles. Organic farming uses biofertilisers, vermicomposting, and green manure to promote soil health and biodiversity and provide healthy food (Das et al., 2021; Reganold & Wachter, 2016).

Organic farming is a holistic system that emphasizes the use of natural inputs and ecological processes to boost soil fertility, protect biodiversity, and decrease environmental pollution. By avoiding synthetic chemicals and genetically modified organisms. Organic farming aims to create a self-sustaining agricultural system that benefits human health and the environment. This study investigates organic farming as a potential path toward sustainable development by evaluating its environmental, economic, and social impacts.

Objectives of the Study

Organic farming is an alternative to conventional farming based on specific principles; therefore, efforts are being made to promote and advance its adoption. The goals of the study are

1. To examine the role of organic farming in achieving sustainable development.
2. To analyse the environmental, economic, and social benefits of organic farming.
3. To assess how organic farming helps mitigate climate change and conserve biodiversity.
4. To identify the challenges organic farmers face.
5. To suggest ways to integrate organic farming into mainstream agriculture.

Methodology

The study is based on a thorough review of secondary data gathered from peer-reviewed research journals, government reports, institutional publications, and international

organization reports. The analysis concentrates on the environmental sustainability, economic viability, and social implications of organic farming.

Need for Organic Farming In India

Rapid population growth has led to a substantial increase in food demand. It places enormous pressure on agricultural systems. Indian agriculture is mostly relied on conventional farming practices. It uses intensively synthetic fertilizers, pesticides, and other chemical inputs. Although these practices have contributed to higher crop yields, they have also resulted in several adverse consequences, including soil degradation, loss of biodiversity, environmental pollution, and potential risks to human health. In this context, organic farming has emerged as a viable and sustainable alternative agricultural system. It is founded on ecological principles that emphasize soil health, environmental conservation, and the sustainable use of natural resources. Consequently, organic farming has become increasingly important in India to ensure long-term agricultural sustainability, food security, and ecological balance. Moreover, conventional farming methods depend heavily on costly chemical inputs, leading to increased production costs and declining soil fertility. Organic farming addresses these challenges by enhancing soil health, reducing dependence on external inputs, and ensuring sustainable agricultural productivity over the long term.

Principles of Organic Farming for Sustainable Agriculture

The principles of organic farming are guided by value for natural cycles, conservation of biological diversity, and enhancement of agro-ecosystem health. These principles focus on maintaining soil as a living system, encouraging beneficial microorganisms, using organic manures and bio fertilizers, practicing crop rotation, and adopting biological pest and disease management. Organic farming also supports social equity, animal welfare, and economic viability for farmers. By following these principles, organic farming contributes to sustainable agricultural development, reduces environmental pollution, improves food quality, and safeguards the health of farmers, consumers, and future generations.

The major Principles of organic farming are

Soil Health and Fertility

Organic farming encourages practices such as crop rotation, green manuring, and compost application to improve soil structure and fertility. These practices improves soil health, by protecting it from erosion, conserving minerals and water in the soils.

Reduced Uses of Chemicals

Organic farming promotes reduced use of chemical fertilizers. By avoiding synthetic fertilizers and pesticides. Organic farming lowers soil and water pollution and protects human and ecosystem health.

Biodiversity Conservation

Naturally Soils are habitats for different types of animals, micro organisms. Due to extensive use of chemical fertilizers natural ecosystems are disturbed. Diverse cropping systems and natural pest control methods enhance biodiversity and strengthen ecosystem stability.

Water Management

Organic farming conserves water resources by preventing chemical runoff and promoting efficient water usage.

Animal Welfare

Organic livestock farming ensures the ethical treatment of animals through natural feeding and living conditions.

Challenges and Opportunities

Despite its benefits, organic farming faces challenges such as lower initial yields, high labor needs, certification costs, and limited market access. However, growing consumer

awareness, government support, and technological advancements offer significant opportunities for expanding organic agriculture.

Limitations of Organic Farming

Lower yields during the initial transition period - When farmers modify from conventional to organic farming, often decline results for the first few years. It occurs as the soil ecosystem needs time to regain natural fertility and microbial activity after long-term chemical use. The absence of synthetic fertilizers and pesticides initially reduces productivity, discouraging farmers.

High labor intensity- Organic farming is labor-intensive, particularly for activities such as compost preparation, manual weeding, mulching, and crop diversification. In regions facing labor shortages or high labor costs, this becomes a major constraint.

Limited availability of organic inputs - Maintaining soil fertility in organic farming is complex and time-consuming. Organic inputs such as compost, green manure, vermin compost, and bio fertilizers release nutrients slowly. Large quantities are required, and their availability may be limited, making nutrient management difficult, especially for intensive cropping systems.

Pest and disease management challenges-

Organic farming relies on biological and cultural methods for pest and weed control, such as crop rotation, natural predators, and botanical pesticides. These methods are often less immediately effective than chemical pesticides and require skilled management, close monitoring, and preventive strategies. It is hectic and time consuming.

Lengthy certification process - Organic certification is essential for accessing premium markets. It requires high costs. It is a lengthy procedure and follows strict compliance standards. Therefore Small and marginal farmers often find certification processes complex and unaffordable.

Market price fluctuations –This is the major challenge in extensive use of organic farming

Knowledge and skill gaps-Most of the farmers are not aware about policies and its benefits which creates a gap and hinder the expansion of organic farming

Climate dependency – As organic farming is highly dependent on natural processes and climatic conditions, production risk increases due to unpredictable weather, pest outbreaks, especially for small farmers.

Conclusion

Organic farming is a promising path toward sustainable development as it supports environmental protection, economic stability, and social well-being. It improves soil health, conserves biodiversity, and reduces the pollution associated with chemical farming. Even though organic farming faces various challenges, supportive policies, farmer training, and enhanced market infrastructure can help overcome these barriers. The growing adoption of organic farming in different areas shows its potential to contribute to sustainable agricultural development. Integrating organic farming into mainstream agriculture is essential for ensuring long-term food security and environmental health. Organic farming represents a sustainable and environmentally friendly approach to agriculture that balances productivity with ecological preservation. By emphasizing natural inputs, soil health, biodiversity, and ecological balance, organic farming reduces environmental pollution, conserves natural resources, and produces safe and nutritious food. It supports long-term agricultural sustainability while safeguarding the health of farmers, consumers, and future generations.

Despite of challenges, through scientific research, farmer education, supportive government policies, and improved marketing infrastructure these limitations can be overcome. Increasing consumer awareness and demand for chemical-free food, organic farming has strong potential for growth. Organic farming is not merely an alternative

agricultural practice but a vital strategy for achieving sustainable development, environmental protection, and food security. Its successful adoption can play a crucial role in creating a resilient agricultural system and a healthier society.

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CARBON NANOTUBES FOR DRUG DELIVERY

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Abstract

Nano-sized systems are the key interest of scientists involved in the design of novel drug delivery systems. They have a hollow core suitable for storing guest molecules. Carbon Nanotube (CNT) are typical Carbon nanomaterials that possess unique features which make them particularly attractive for biomedical applications. This paper is a review of the Carbon Nanotube (CNT) for biomedical applications. In this paper, we describe their properties and tailored biomedical applications. The most recent state of the art in biomedical applications of CNTs were reviewed.

Keywords: Biomedical, Carbon Nanotube, Sensors, Drug Delivery

Introduction

Carbon Nanotubes have a high specific surface area and good fusion properties. This special attribute has endeared these materials to electrochemical research where they are widely applied as biosensors. Carbon nanomaterials were reported to enhance the biological activities of enzymes in small molecules. This property has been utilized in biomedicine and drug release [1-3]. CNTs possess some remarkable structural, electrical, chemical, and mechanical properties making them significantly relevant in the biomedical industry and hence a subject of research. It can display metallic, semiconducting, superconducting and electron transport properties. It possesses a hollow core suitable for storing guest molecules' also have the largest elastic modulus of any known materials [4-5]. It helps to improve the safety and efficiency of drugs in drug delivery [6]. This makes the CNTs to be very responsive to electrical and chemical changes in their environment [7-8]. There are generally two main groups of CNT-based biosensors: CNT field-effect transistors (CNT-FETs) and CNT electrochemical sensors (CNT-ECS). The CNT-ECS is also known as Chemiresistors. overvoltage and rapid electrode kinetics [9]. CNT based detection systems and biosensors possess excellent Figure 1 shows the schematic for Electrochemical and Electronic CNT biosensors. for the regeneration of tendons and ligaments such as biosensing and drug delivery [10-14].

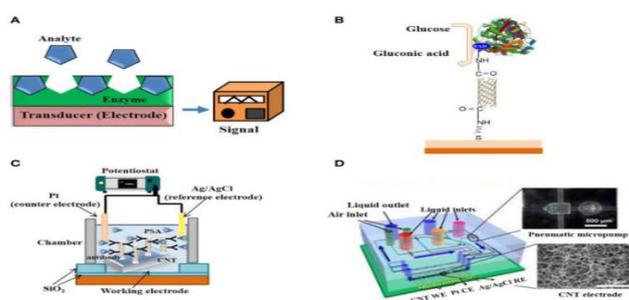


Figure. 1 Electrochemical and Electronic CNT biosensors (A) Typical design of an enzyme-based electrochemical biosensor. (B) SWNT electrically-contacted glucose oxidase electrode. (C) Schematic illustration of a label-free amperometric biosensor for PSA detection. (D) Schematic illustration of a microfluidic chip based on CNT electrodes [3]

Carbon Nanotubes As Biomedical Materials

CNT acted as a scaffold for the regeneration of tendons and ligaments. Recent research on the biomedical properties of CNT has proven great biomedical applications that

are yet to be exploited. Nano-sized systems are the key interest of scientists involved in the design of novel drug delivery systems CNTs possess metallic, semiconducting, and superconducting electron transport properties. CNTs' ability to be hybridized with other organic and inorganic materials makes them excellent candidates for many biomedical applications such as biosensing and drug delivery.

Conclusion

Carbon nanotubes (CNTs) are very propitious candidates for the development of new biomedical devices. carbon nanotubes have also proven potential importance for medical diagnostic applications.

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STUDY OF WATER ANALYSIS FROM SOME SELECTED BORE WELLS IN BEED CITY (MS).

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Abstract: -Water plays vital role for regulation and growth of organisms. Potable water is safe enough to be consumed by human, plants and animals. Water samples collected from six bore wells were subjected to physico-chemical and biological analysis. Physico-chemical analysis carried using titrimetric spectrophotometric method to evaluate the quality. The results showed that P^H , temperature, turbidity, chloride, nitrate, and total hardness of all the bore well water samples were the permissible limits while phosphate and magnesium, samples gave values well above the permissible limits decided by WHO. Sample BW- 5 gave maximum of phosphate, sample BW- 3 show highest values of magnesium. Also dissolved oxygen results showed higher values by sample BW- 5. Generally results exhibited significant variation in the parameters studied on the samples. This sample could be attributed to the geographical positions and depth of the bore wells. Hence all these Bore well water are safe and suitable for domestic and drinking purpose.

Key words: - Physico-chemical analysis, Bore well, Beed city.

Introduction: -

Water is the most important and abundance compounds of ecosystem. All living organisms on the earth need water for their survival and growth (Dara, 1995). On earth planet have 70% of water and near about 80% of earth surface is covered by water out of which only small fraction is available for consumption. The rest of all water is closed water filled in sea and ocean ice slabs, glaciers. Ground water is defined as water that found underground in cracks and spaces in soil, sand and rocks. This source has two distinct functions, firstly it is a significant source of both rural and urban populations water supply and secondly it sustains many wetlands ecosystem. (Goel at al 1985) The sources of ground water supply mostly depend upon the rainfall and resulting percolation of the water in the earth, another important factor is the type and quality of soil (Adoni and Joshi 1987). But due to rising of human population, industrialization, uses of fertilizer in the agriculture and human domestic uses water is polluted. It is highly polluted with different contaminant. This contaminated polluted water absorbed in the earth surface. Therefore it is necessary that quality of drinking water should be checked at regular time interval, because due to use of contaminated drinking water should be suffer various disease to human and animals.(Basavraja et al 2011)

Ground water is already used throughout wells and bore wells. Unfortunately underground water reservoirs are renewed only slowly by natural absorption. Ground water is available source of water supply, because it is unpolluted due to restricted movements of pollutant in soil profile(Lamb J.C. 1985). However when water travels through the ground it dissolve part of soil components so it is usually hard, it may usually contain objectionable concentration of salt, such as metal iron,

manganese, zinc etc. Near about 4 millions of people die each year from water sanitation and hygiene related causes. These all death occurs in developing world (WHO, 2008). UNDP also reported that the water and sanitation crisis claims more lives through diseases than only war claims through guns (UNDP 2006). Thus the quality as well as quantity of clean water supply is of vital signification for the welfare of mankind. Beed city is lying to the foot hill of Balaghat range of Beed district in Maharashtra state. It is less rain fall area, so location of Beed is suitable for major source as bore water for drinking and domestic use purpose. Hence bore well water are major source of good water and have been increasingly commercialized for water required population of Beed city.

The quality of this water not guaranteed and could cause health problem as a result of consumers drinking for such sources. This research investigated some physico-chemical and biological parameters of six bore well water constantly in uses by water vendors.

Material and Methods:-

Beed district is an administrative district in Maharashtra. It is situated in central place of Marathwada region out of eight districts in it. In Beed city population of 21 % were compared to total population of Beed district.

For study water sample were collected from six bore well in Beed city. These samples were collected using cleaned polyethylene bottles of one liter capacity for each labeled Ankush Nagar BW-1, Vidyanagar BW-2, Ekatanagar BW-3, Peth Beed BW-4, Chanakya puri BW-5, Ashoknagar BW-6. These study samples were collected same time at evening 4:30 to 7:00 p.m.

These samples used for study of some physical parameters were analyzed on the bore well water samples at the site of collection. The temperature of each sample was measured and recorded using a calibrated thermometer in degree Celsius. The samples were then transferred to laboratory and they were kept in the refrigerator to preserve the quality of the sample prior to analysis. All the apparatus used for analysis were properly wash and rinsed and the reagents are all of analytical grade. Physico-chemical parameters determination by various standard method was used for P^H determination of the water samples, a digital P^H meter (Eligo Model) standardized with buffer solution of P^H 4 and P^H 7.2 was employed. The chemical parameters calcium, magnesium, alkalinity, Chloride and total hardness were determined by titrimetric method. Nitrates and phosphates were obtained using a double beam visible spectrophotometer (2203). All measurements were completed in triplicate and the mean values recorded in the table

Results and Discussion:-

The results of all physico-chemical and biological parameters obtained in six bore well samples are presented in the following table.

Table No. 1 Physico-chemical and biological analysis of the Six Bore Well water samples in Beed City.

Sr.No.	Parameters	BW-1	BW-2	BW-3	BW-4	BW-5	BW-6
01	Temperature($^{\circ}C$)	30.4	31.1	32.0	30.7	31.4	32.1
02	P^H	8.1	8.2	7.3	8.0	7.6	8.1
03	Turbidity NTU	0.80	0.40	0.45	0.65	0.56	0.72
04	Chlorides ppm	61.3	72.5	95.5	110.0	77.0	98.0
05	Alkalinity ppm	112	108	122	98	130	118
06	Total hardness ppm	410	390	285	308	216	505
07	Calcium ppm	69	63	59	65	69	65
08	Magnesium ppm	48	76	87	45	52	75
09	Nitrates ppm	2.5	0.5	0.45	1.4	0.75	1.6
10	Phosphates ppm	1.4	2.5	2.8	0.8	3.25	2.4
11	Dissolved oxygen ppm	12.3	11.2	9.5	7.2	12.5	12.0
12	Biological oxygen demand	2.2	1.8	0.8	1.0	2.0	2.4
13	Chemical oxygen demand	5.6	7.6	8.2	4.4	6.8	7.2

The water samples temperature ranged between (29.3 to 32.4 °C) with the bore well BW-6 having highest temperature and BW-1 have the lowest. Temperature values are known to depend on season and climate condition. The P^H values recorded in this work in between (7.3 to 8.2). The values observed within the permissible limits provided by WHO. The turbidity of bore well samples was found to be in the range of (0.40 to 0.80NTU). The values compared with the 5.0 NTU WHO permissible limit for potable water. Turbidity is due to the presence of colloidal particle from clay during rainfall, or from discharge of sewage and industrial waste.

The alkalinity is primarily due to carbonate, bicarbonate and hydroxide contents. Alkalinity, P^H and hardness affect the toxicity of many substances in the water sample BW-4(98ppm), showing minimum value of alkalinity and sample BW- 5 gives highest values (130ppm) of alkalinity.

The concentration of nitrate in water samples depends on the nitrification activity of microorganisms. The values of nitrates ranges between (0.45 to 2.50). The values are well below 50ppm (WHO) permissible limits of nitrate in the drinking water. High level of nitrate in drinking water is due to excessive use of agriculture fertilizers, domestic effluent, industrial sewage disposal(APHA, 1989) Water is contaminated with nitrate causing methemoglobinemia i.e. Blue baby syndrome in infant. Chloride values in the water samples ranges from(61.3 to 110 ppm). The concentration of chloride is lowest in sample BW-1 and highest in sample BW-4. The values were within the WHO (200ppm) limit for chloride. It may also get into surface water from several sources including rock, agricultural runoff waste water.

Total hardness of water samples were found to be in the range of (216 to 505ppm). Bore well water sample BW- 6 showing highest hardness of water. Other water samples are in the normal range given by WHO. Hardness value of ground water may be classified as soft >75ppm, moderately soft >(75-150ppm), hard(150-300ppm), and very hard>300ppm. Total hardness less than 80 ppm may result in corrosive water, while hardness above 100ppm may result in the need for more soap, during bathing and laundering form scum and curd causes yellowing of fabrics, excessive hardness may also lead to scale deposits in pipes, heaters and boilers.

The values of magnesium ranged between 45-87ppm) sample BW-4 showing lowest value but sample BW-3, Showing highest value. Magnesium is a salt contribute to hardness and taste of water. Excessive magnesium may give water bitter taste, but it is not hazards to health.

The result of phosphate analysis in the samples ranged from (0.8-3.25ppm).All the bore well samples gave higher values than 0.5ppm in the permissible limit. Phosphate stimulates the growth of plankton and aquatic plant. If excess of phosphate is enter in the water body stimulate growth of algae and aquatic plant that's choke up the water way and use up large amount of oxygen. This condition is known as eutrophication or over-fertilization of receiving waters.

Biological Oxygen Demand (BOD) is measure of organic material contamination in water specified by ppm. BOD is the amount of dissolve oxygen required for biochemical decomposition of organic compounds and oxidation of certain inorganic materials. High BOD decreases levels of dissolve oxygen. All water samples having BOD ranges within permissible limit. Chemical Oxygen Demands (COD) is another measure of organic material contamination in water specified ppm. COD is the amount of dissolve oxygen required to cause chemical oxidation of the organic material in water. Both BOD and COD are key indicators of the environment health of surface water supply. They are commonly used in

waste water treatment but rarely in general water treatment by Mishra (1991), Bis (1991), Kadam et al (2006).

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SUSTAINABLE LABORATORY CHEMISTRY: ADVANCING GREEN REACTION DESIGN AND PRACTICE

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Abstract: The growing emphasis on sustainability has positioned green chemistry as a keystone of modern chemical science, particularly in reducing environmental and health risks associated with laboratory and industrial activities. This review critically examines the integration of green chemistry concepts into laboratory-scale reactions, highlighting methodologies that prioritize safety, waste minimization, and energy efficiency without sacrificing reaction performance. Emphasis is placed on key green strategies, including the substitution of toxic reagents with environmentally benign alternatives, the use of safer solvents and renewable raw materials, atom-efficient synthetic pathways, catalytic systems, and innovative energy inputs such as microwave- and ultrasound-assisted reactions. Selected examples of traditional laboratory reactions re-engineered using green chemistry principles are discussed to demonstrate tangible improvements in sustainability, operational safety, and resource efficiency. The review underscores the feasibility and importance of adopting green chemistry practices in both research and educational laboratories to foster environmentally responsible chemical experimentation and training.

Keywords: Green chemistry principles; Sustainable laboratory practices; environmentally benign reactions; safer solvents; Atom-efficient synthesis; Catalytic processes; Renewable resources; Alternative energy methods

Introduction:

Laboratory chemistry has historically depend on on hazardous reagents, volatile organic solvents, and energy-intensive processes that pose significant risks to human health and the environment. While such practices have enabled scientific advancement, they have also contributed to chemical waste generation, occupational exposure hazards, and environmental pollution. In response, the concept of *green chemistry* has emerged as a transformative framework aimed at redesigning chemical processes to minimize negative impacts while maintaining or enhancing performance.

Green chemistry, formally articulated in the 1990s, emphasizes pollution prevention at the molecular level rather than remediation after waste generation. Although initially driven by industrial sustainability concerns, green chemistry has become increasingly relevant in laboratory-scale research and education. Academic laboratories serve as critical training grounds for future chemists; therefore, inserting sustainability principles at this level has long-term suggestions for the chemical initiative.

This paper reviews the principles and practical implementation of sustainable laboratory chemistry, focusing on green reaction design, safer materials, waste reduction strategies, and alternative energy sources. Through selected case studies, the feasibility of translating green chemistry theory into everyday laboratory practice is demonstrated.

Principles of Green Chemistry in the Laboratory Context:

The foundation of sustainable laboratory chemistry lies in the **Twelve Principles of Green Chemistry**, which provide a systematic framework for environmentally responsible chemical design. While all twelve principles are relevant, several are particularly impactful at the laboratory scale:

- **Prevention of waste** rather than treatment or cleanup
- **Atom economy** to maximize incorporation of materials into final products
- **Less hazardous chemical syntheses**
- **Safer solvents and auxiliaries**
- **Energy efficiency**, favoring ambient temperature and pressure
- **Use of renewable feedstocks**
- **Catalysis** instead of stoichiometric reagents

In laboratory practice, these principles translate into careful selection of reagents, solvents, reaction conditions, and purification techniques. Small-scale reactions provide an ideal testing ground for green innovations before larger-scale adoption.

Safer Reagents and Environmentally Caring Alternatives

One of the most direct ways to improve laboratory sustainability is by replacing toxic or hazardous reagents with safer alternatives. Traditional oxidants such as chromium (VI) compounds, for example, are highly toxic and generate problematic waste. These have been successfully substituted with greener oxidants such as hydrogen peroxide, oxygen, or catalytic systems based on transition metals with lower toxicity profiles.

Similarly, phosgene—once commonly used for carbonylation reactions—has been replaced by safer reagents such as triphosgene or dimethyl carbonate. In reduction chemistry, metal hydrides like lithium aluminum hydride are increasingly replaced by milder reagents or catalytic hydrogenation under safer conditions.

The adoption of benign reagents not only reduces environmental impact but also improves laboratory safety by minimizing risks associated with handling, storage, and disposal.

Safer Solvents and Solvent-Free Approaches

Solvents often account for the majority of chemical waste generated in laboratories. Traditional organic solvents such as benzene, dichloromethane, and carbon tetrachloride are volatile, toxic, and environmentally persistent. Green chemistry encourages the use of safer alternatives, including water, ethanol, ethyl acetate, and supercritical carbon dioxide.

Water, in particular, has gained prominence as a reaction medium due to its non-toxicity, low cost, and unique reactivity effects. Advances in aqueous-phase organic synthesis have demonstrated that many reactions traditionally performed in organic solvents can proceed efficiently in water or water–ethanol mixtures.

Solvent-free reactions represent another powerful strategy. Mechanochemical synthesis, for example, uses grinding or milling to drive reactions without solvents, significantly reducing waste and energy consumption. Such approaches are increasingly adopted in both research and teaching laboratories.

Atom Economy and Waste Minimization

Atom economy is a critical metric for evaluating the sustainability of chemical reactions. Reactions that incorporate most or all of the starting materials into the final product generate less waste and are inherently more sustainable.

Addition reactions, rearrangements, and catalytic coupling reactions generally exhibit high atom economy compared to substitution or elimination reactions that produce stoichiometric byproducts. Multicomponent reactions (MCRs) are particularly attractive, as

they combine three or more reactants in a single step to form complex products with minimal waste.

In laboratory settings, redesigning synthetic routes to favor atom-efficient pathways reduces the need for extensive purification and minimizes solvent and reagent use, aligning sustainability with operational efficiency.

Catalysis as a Cornerstone of Sustainable Practice

Catalytic processes are central to green chemistry because they reduce reagent consumption, improve selectivity, and often enable milder reaction conditions. Both homogeneous and heterogeneous catalysts are widely applied in sustainable laboratory chemistry.

Transition metal catalysis—using metals such as palladium, nickel, iron, or copper—has revolutionized synthetic chemistry by enabling cross-coupling and functionalization reactions with high efficiency. Increasing attention is now given to replacing precious metals with earth-abundant alternatives and to developing recyclable heterogeneous catalysts.

Bio-catalysis represents another green frontier, utilizing enzymes to carry out highly selective reactions under ambient conditions in aqueous media. Enzyme-catalyzed transformations are increasingly used in academic laboratories to demonstrate sustainable synthesis.

Renewable Feedstocks and Bio-Based Chemistry

The use of renewable raw materials reduces reliance on fossil resources and supports long-term sustainability. Bio-based feedstocks derived from biomass—such as carbohydrates, vegetable oils, and lignin—are increasingly used as starting materials in laboratory synthesis.

Examples include the use of glucose-derived platform chemicals, bioethanol as a solvent or reagent, and fatty acid derivatives for polymer and surfactant synthesis. Incorporating renewable feedstocks into laboratory experiments familiarizes students and researchers with sustainable material cycles and life-cycle thinking.

Alternative Energy Inputs in Green Reactions

Energy consumption is an often-overlooked aspect of laboratory sustainability. Conventional heating methods are inefficient and contribute to unnecessary energy use. Green chemistry promotes alternative energy inputs that enhance reaction efficiency.

Microwave-assisted synthesis allows rapid and uniform heating, often reducing reaction times from hours to minutes while improving yields and selectivity. **Ultrasound-assisted reactions** use acoustic cavitation to enhance mass transfer and reaction rates, enabling milder conditions and reduced reagent use.

Photochemical and electrochemical methods are also gaining traction as sustainable energy-driven approaches that eliminate the need for stoichiometric reagents.

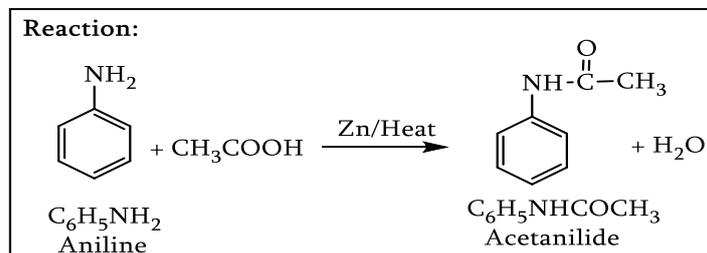
Case Studies: Re-Engineering Traditional Laboratory Reactions

Several classic laboratory reactions have been successfully redesigned using green chemistry principles. For example, the traditional Friedel–Crafts acylation, which uses corrosive Lewis acids and chlorinated solvents, has been modified to use recyclable solid acid catalysts and greener solvents.

Similarly, esterification reactions commonly performed using excess strong acids can be conducted using enzymatic catalysis or solid-supported catalysts under solvent-free conditions. These redesigned reactions demonstrate that sustainability can be achieved without compromising educational or synthetic objectives.

Example: Acetanilide is an amide formed by the acetylation of aniline. In this green synthesis method, glacial acetic acid acts as an acetylating agent instead of hazardous acetic anhydride. Zinc dust acts as a catalyst and helps activate the acetic acid, facilitating the formation of the amide bond. This method follows **green chemistry principles** by:

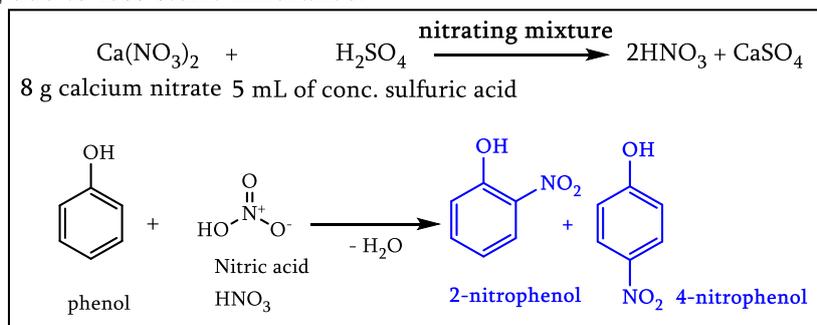
- Avoiding corrosive reagents
- Using safer solvents
- Producing minimal toxic waste



Phenol is an activated aromatic compound due to the presence of the –OH group, which donates electrons to the benzene ring by resonance. This makes phenol highly reactive towards electrophilic substitution reactions, especially at the ortho and para positions.

Calcium nitrate in the presence of concentrated sulfuric acid generates nitric acid in situ, which further produces the nitronium ion (NO_2^+), the active nitrating species.

Because phenol is highly activated, nitration occurs easily under mild conditions, forming a mixture of o-nitrophenol and p-nitrophenol, with the para isomer usually predominating due to less steric hindrance.



Such case studies illustrate the practical benefits of green chemistry, including improved safety, reduced waste, and simplified procedures.

Green Chemistry in Education and Research Laboratories

Educational laboratories play a crucial role in promoting sustainable chemistry. Incorporating green experiments into curricula not only reduces environmental impact but also instills sustainability-minded thinking in students.

Green laboratory experiments often emphasize microscale techniques, safer reagents, and waste minimization. These approaches reduce costs and hazards while maintaining instructional value. In research laboratories, adopting green practices enhances compliance with safety regulations and aligns academic work with global sustainability goals.

Challenges and Future Perspectives:

In spite of significant progress, challenges remain in fully integrating green chemistry into laboratory practice. Limitations include the availability of green alternatives, perceived costs, and resistance to changing established protocols. Additionally, some green methods require specialized equipment or expertise.

Future research should focus on developing universally applicable green methodologies, improving life-cycle assessment tools, and expanding databases of sustainable reactions. Collaboration between academia, industry, and policymakers will be essential to accelerate adoption.

Conclusion:

Sustainable laboratory chemistry represents a critical step toward a more environmentally responsible chemical science. By integrating green chemistry principles into

reaction design and laboratory practice, chemists can significantly reduce waste, hazards, and energy consumption while maintaining high levels of performance and innovation. The examples discussed in this review demonstrate that green chemistry is not only feasible but advantageous in both research and educational settings. Widespread adoption of these practices will play a vital role in shaping a safer, more sustainable future for chemistry.

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ANALYSIS OF PROTEIN FROM DIFFERENT VARIETIES OF BANANA PULP

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Abstract:

The research was an attempt to isolate and study the active proteinous compounds from the aqueous extract of unripe Banana using biochemical technique. Plant tissues contain relatively low amounts of proteins whose extraction is often difficult due to the presence of interfering compounds such as rigid cellulosic cell wall, storage polysaccharides, lipids and other contaminants that can cause protein degradation or modification. Therefore, it is important to optimize protein extraction and to establish a robust protocol for SDS-polyacrylamide gel electrophoresis (SDS- PAGE) and downstream processing. In the study, Tri-chloroacetic acid/acetone extraction protocol was evaluated on unripe Banana varieties. i.e. Safed Velchi banana (*Musa accuminata xbalbisiana*), Red banana (*Musa accuminata colla*), Harichal banana (*Musa paradisiaca*), Van banana (*Musa balbisiana*).

Keywords- Banana pulp, Proteins Estimation, protein degradation, Gel electrophoresis, SDS-PAGE

Introduction

Banana (*Musa* spp.; family Musaceae) is an edible fruit, botanically classified as a berry, produced by large herbaceous flowering plants of the genus *Musa* [1,2]. Most cultivated bananas originate from two wild species, *Musa acuminata* and *Musa balbisiana* [2]. The fruit is typically elongated and curved, with soft, starchy flesh enclosed by a peel that varies in color from green to yellow, red, or brown upon ripening. Bananas are widely cultivated and consumed in tropical and subtropical regions, making them one of the most important fruit crops globally [1,3].

Banana ranks as the fourth most important food crop after wheat, rice, and maize in terms of production and is the most consumed fruit worldwide [1]. According to FAOSTAT (2020), India is the leading banana producer, contributing approximately 26.3% of global production [1]. In India, bananas are extensively cultivated in states such as Tamil Nadu, Maharashtra (Jalgaon district), Gujarat, Andhra Pradesh, Karnataka, Assam, Bihar, Madhya Pradesh, and West Bengal, and are also grown in America, Australia, tropical Africa, and selected regions including Florida, Southern Japan, Egypt, the Canary Islands, and South Brazil [3]. Owing to their high productivity, export value, and nutritional importance, bananas serve as a major source of food security and livelihood [3].

Nutritionally, bananas are highly digestible and rich in carbohydrates, proteins, vitamins, minerals, phenolic compounds, flavonoids, and antioxidants [3,5]. The digestion time of banana fruit (approximately 105 minutes) is considerably shorter than that of apple (approximately 210 minutes), making it suitable for infants, elderly individuals, and patients [3]. Traditionally, *Musa paradisiaca* has been used in ethnomedicine for treating various ailments including diarrhea, diabetes, hypertension, wounds, burns, ulcers, infections, and inflammatory disorders, highlighting its therapeutic potential [6]. Carbohydrates are enzymatically converted from starch (20–30%) to sugars (1–2%), although AAB varieties

may retain higher starch levels [3]. Protein content ranges from 1–2.5% and increases during ripening, while fat content remains nearly constant at about 1% [3]. Pectin content (0.7–1.2%) increases in soluble form, contributing to fruit softening and industrial applications as a gelling and stabilizing agent [4]. Bananas are rich in phenolic compounds, dopamine, and flavonoids with strong antioxidant activity [5]. Peel and pulp color changes during ripening are mainly attributed to chlorophyll degradation and enzymatic browning reactions [4,5]. Bananas also provide essential vitamins (A, B-complex, and C) and minerals, particularly potassium, magnesium, calcium, and iron, making them valuable for functional foods and infant nutrition [3]. Banana peel, often discarded as waste, is nutritionally and industrially significant. It is rich in dietary fiber, starch, proteins, lipids, essential amino acids, pectin, polyunsaturated fatty acids, and minerals such as potassium, iron, and zinc [3,4]. Banana peels are utilized in animal feed, pectin extraction, ethanol and biogas production, wastewater treatment, and food flavoring industries [3,4]. Proteins play fundamental structural and functional roles in biological systems, and proteomic analysis is essential for understanding cellular mechanisms [7,8]. However, plant proteomics is challenging due to low protein content and the presence of interfering compounds such as polysaccharides, lipids, phenolics, pigments, and proteases [9,10]. Techniques such as SDS-PAGE and two-dimensional gel electrophoresis (2-DE) are widely used for protein profiling and comparative analysis [11,13]. Effective protein extraction and sample preparation are critical steps for reliable proteomic analysis [9,10]. In food science, proteomics is a powerful tool for evaluating nutritional quality, safety, traceability, and processing effects [11,12]. A typical proteomics workflow includes protein extraction, separation, identification, and data analysis, with careful removal of interfering substances to ensure accurate representation of the food proteome [13].

Materials and methods:

Plant Material: Different varieties of unripe Banana fruits were collected from Palghar local market shown in Figure 1. The Bananas were washed properly then dried. Next, Bananas were peeled and were sliced into thin chips (Figure 2). These sliced chips were then sun dried separately. Within one or two days, chips were fully dried. These chips were then grinded to make fine powder form. This powdered form of Banana is used further in the experiments.

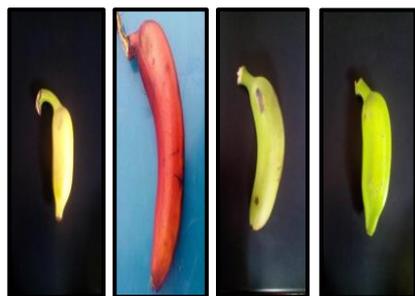


Photo-1-Different varieties of Banana



Photo-2: Fine powder form of banana pulp

Sample Preparation and Cell Disruption

Preparation of biological samples for proteomic analysis requires efficient homogenization to release intracellular proteins. Plant tissues pose particular challenges due to the presence of rigid cell walls, proteases, and interfering compounds. Since proteins are enclosed within protein bodies, effective cell disruption is essential for complete solubilization and extraction. Cell wall disruption and protein release are therefore critical for analytical success. Common cell disruption methods include mechanical, ultrasonic, pressure-based homogenization, temperature treatments, and osmotic or chemical lysis techniques.

Protein Extraction by Chemical Lysis

Protein extraction can be achieved through chemical lysis, which involves the use of antibiotics, chelating agents, detergents, and organic solvents to permeabilize or disintegrate cell membranes. These chemicals selectively interact with membrane components, allowing proteins to diffuse out of the cells. A proper understanding of membrane permeability is essential for developing efficient and food-grade protein extraction technologies [14].

TCA/Acetone Protein Extraction Method

Trichloroacetic acid (TCA)/acetone precipitation is one of the most widely used methods for plant protein extraction, originally proposed by Damerval et al. (1986). The strong acidic nature and negative charge of TCA, combined with acetone, rapidly denature and precipitate proteins, thereby inhibiting proteolytic enzyme activity. Protein solubility is enhanced using chaotropic agents such as urea or thiourea and detergents like SDS.

In the modified protocol, banana tissue powder (1.5–5 g) was homogenized in ice-cold extraction buffer containing 175 mM Tris-HCl (pH 8.8), SDS (50 g dm⁻³), glycerol (15%), and 2-mercaptoethanol (0.07%). After centrifugation at 5000 rpm for 5 min at 4°C, the supernatant was collected, and proteins were precipitated by adding four volumes of ice-cold acetone containing 10% TCA and 0.07% 2-mercaptoethanol. Samples were incubated at –20°C for at least 1 h. Protein pellets were obtained by centrifugation at 4000 rpm for 15 min at 4°C and washed three times with ice-cold acetone/water (20%) containing 0.07% 2-mercaptoethanol. The dried pellets were stored at low temperature until further analysis [15].

Quantitative Protein Estimation – Biuret Assay

Quantification of total protein is fundamental for biochemical and proteomic studies, as it allows normalization of enzymatic or biological activities. Among the commonly used protein estimation methods, the Biuret assay is simple and reliable. This assay is based on the reaction between copper ions and peptide bond amide groups under alkaline conditions, producing a blue-colored complex. The intensity of the color, measured spectrophotometrically, is directly proportional to the protein concentration in the sample. Although named after the compound Biuret, the reaction occurs due to the presence of peptide bonds in proteins, which form copper–protein complexes at basic pH [16].

Quantitative Protein Estimation -Lowry Assay: This assay is named for the biochemist Oliver H. Lowry, who developed the reagent in the 1940s. Lowry test is used to estimate protein amount in biological samples. The method is sensitive down to about 10^µg/ml and is probably the most widely used protein assay despite its being only a relative method, subject to interference from Tri's buffer, EDTA, nonionic and cationic detergents, carbohydrates, lipids and some salts. The reaction is also dependent pH & working range of pH 9 to 10.5 is essential.

Qualitative Analysis

SDS-PAGE Analysis: Sodium dodecyl sulfate–polyacrylamide gel electrophoresis (SDS-PAGE) is a widely used technique for qualitative analysis of proteins in complex biological extracts. The most commonly employed method is the discontinuous buffer system described by Laemmli (1970), which consists of a stacking gel and a resolving (running) gel [17]. In this system, proteins are initially concentrated in the stacking gel and subsequently separated in the resolving gel based on their molecular weights. Differences in gel composition, pH, ionic strength, and buffer systems allow efficient and high-resolution separation of proteins according to size [74].

Results:

Quantification of proteins from Banana

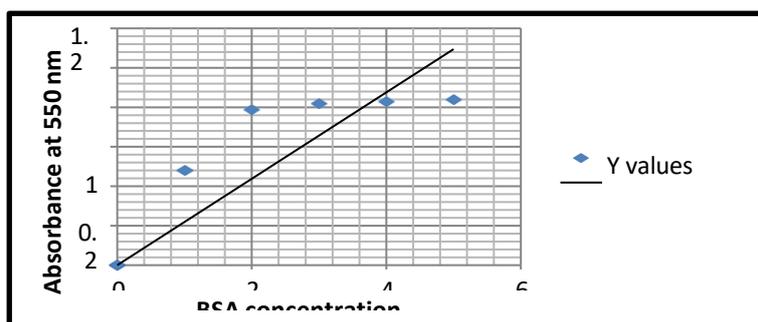
Biuret Assay: Biuret assay was performed and after adding biuret reagent, bluish-violet colour was obtained. After incubating for about 10 minutes, the developed color was the measured at

wavelength of 550nm. Absorbance at 550nm for all standard concentration tubes as well as for sample tubes were recorded.

After recording the absorbance, graph was plotted in order to find the unknown concentration of all four samples. Standard BSA concentration (mg/ml) was plotted on x-axis and absorbance (OD) was plotted on y-axis.

Sr No.	Samples	Concentration of protein
1.	Sample no 1 (Safed Velchi)	1.33 mg/ml
2.	Sample no 2 (Red Banana)	1.40 mg/ml
3.	Sample no 3 (Harichal banana)	1.20 mg/ml
4.	Sample no 4 (Van Kela)	1.53 mg/ml

Table 3.1: Concentration of protein by Biuret test



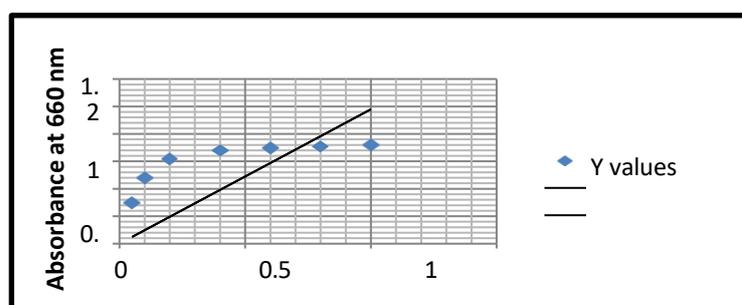
Graph 3.1: Concentration at standard protein Vs Absorbance at 550 nm Slope (m) = 0.150857; therefore, $y = mx$

Lowry's Assay: Second biochemical assay was Lowry's assay. After addition of reagent it also produces colour. But developed colour vanishes if kept for long duration. For this reason it is recommended to measure the intensity of developed colour within short period after reaction time. In Lowry's test, intensity of colour was measured at 660nm. Absorbance of all standard & sample tubes at 660nm were recorded.

Sr. No.	Samples	Concentration of protein
1.	Sample No. 1 (safed Velchi)	0.64 mg/0.2ml
2.	Sample No. 2 (red banana)	0.76 mg/0.2ml
3.	Sample No. 3 (Harichal banana)	0.58 mg/0.2ml
4.	Sample No. 4 (van Kela)	0.91mg/0.2ml

Table 3.2: Concentration of protein by Lowry test

After recording absorbance, graph was plotted to find the concentration of unknown samples. Standard BSA concentration (mg/ml) was plotted on x-axis and absorbance at 660nm was plotted on y-axis.



Graph-3.2: Standard concentration Vs Absorbance at 660 nm ♦ Slope = 0.342767; therefore, $y = mx$

Qualification of Proteins from Banana: SDS-PAGE and Protein Analysis

SDS-PAGE was performed to separate and qualitatively analyze proteins present in banana pulp extracts from four different varieties. This one-dimensional electrophoretic technique is commonly used for both analytical and preparative purposes. Equal volumes (20 μ L) of protein extracts from each variety were loaded into separate gel lanes. After electrophoresis and Coomassie Brilliant Blue staining followed by destaining, distinct protein banding patterns were observed. Lane-1 exhibited eight clear protein bands, and a similar banding pattern was observed in lanes 2, 3, and 4, indicating the presence of approximately eight different protein fractions in the pulp of all four banana varieties (Figure 13).

Discussion- Banana tissues are very recalcitrant to biochemical and molecular analysis. Proteins were extracted and analyzed from four random selected varieties of Banana fruit. All four different varieties of banana were analyzed and studied. Results showed that sample-4 (van Kela) has highest protein concentration, which is followed by sample-2 (red banana), then sample-1 (safed Velchi banana) and then sample-3 (Harichal banana). Both assays showed similar pattern of protein concentration. After comparing all values, it was concluded that Van Kela variety of banana contains high number of proteins as compared to other three varieties (safed Velchi, Harichal and red banana). Qualitative analysis was done performing SDS-PAGE. SDS-PAGE is one of the commonly used assays for various range of samples. Gel electrophoresis method separates the proteins onto gel based on its charge and weight, which is seen as distinct bands. After performing SDS-PAGE electrophoresis, lanes loaded with protein samples showed many distinct band patterns. All the four lanes loaded with different protein sample showed nearly 8 bands. This shows that lane-1 containing proteins Safed Velchi banana pulp, contains around 8 different types of proteins. Lane-2, lane-3 and lane-4 also showed 8 bands. Some bands were darkly stained while some bands were very lightly stained. In terms of protein yield, the classical TCA/Acetone protocol was efficient for extraction of proteins from unripe banana pulp tissues. TCA is known as very efficient protein precipitant and known to instantly eliminate proteolytic and other protein modifying enzymes. The acidic nature of TCA and acetone, denatures the cell and realises proteins content into extraction buffer and this solution inactivates the oxidases and phenoloxidases, thus blocking phenol oxidation into quinones etc. and indirectly prevents proteins binding to insoluble compounds. Acetone solubilizes the pigments, lipids and terpenoids routinely present in tissue. 2ME (2-mercaptoethanol) prevents the formation of disulfide bonds during precipitation. The results showed that overnight protein precipitation at -20°C produced high protein yield. This protein yield was found to be sufficient to perform qualitative and quantitative analysis. Hence incubating overnight yielded significantly high protein quantity [77]. Proteins were precipitated and formed protein pellet after centrifugation process. This protein pellet was air dried and was used for further analysis process. After completion of extraction process, comes solubilization step. As the final step in the procedure, precipitated proteins are resolubilized in buffer. The protein pellet obtained from earlier step, was then subjected to solubilization buffer. This buffer contains some of the detergents such as thiourea and SDS. Detergents tends to solubilize precipitated proteins. Again, centrifugation was carried out in order to obtain pure protein, other impurities if present, settles at the bottom of the Eppendorf tube. Protein pellet dissolved in solubilization buffer; this aliquot is used as the source of samples for further analysis process. Qualitative and quantitative analysis was carried out for all varieties of banana fruit pulp. Under quantitative analysis, two different assays were performed namely, Biuret test and Lowry test. Standard Bovine Serum Albumin (Std. BSA) was used as the standard protein in both the procedures. These are colorimetric methods which can be performed easily. These assays produce specific colour, when reagent is added to the reacting solution. Colour developed is then measured colorimetrically using spectrometer, at particular wavelength.

Conclusion-

The present study analyzed the protein composition of four banana varieties—Safed Velchi, Red banana, Harichal, and Van Kela. The TCA/acetone method proved effective for protein extraction, and the solubilization process efficiently dissolved precipitated proteins. Quantitative estimation using Biuret and Lowry assays revealed that the Van Kela variety contained the highest protein content, followed by Red banana, Safed Velchi, and Harichal banana, with protein levels increasing during ripening. SDS-PAGE analysis showed eight distinct protein bands in all varieties, indicating a similar protein profile across banana types. Further studies using advanced analytical techniques are recommended for precise protein identification and quantification.

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Author contribution: Mr. V. S. Varpe- Corresponding author: Assisted in experiments in the laboratory, organized experimental information, and carried out data analysis for this research. Dr. S. T. Naphade- Performed and contributed to the preparation and revision of the manuscript.

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IDENTIFICATION OF RICE (*ORYZA SATIVA* L.) VARIETIES OF WEST BENGAL THAT ARE TOLERANT TO THE INSECT PEST *SITOTROGA CEREALELLA* (OLIVIER) [LEPIDOPTERA: GELECHIDAE] FOR ACHIEVING FOOD SECURITY

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Abstract

Insects and diseases devour or damage a fifth or more of stored food grains each year in many parts of the world. Cereals like rice, wheat and corn play an important role in the economic stability of many countries. *Sitotroga cerealella* (Olivier) causes post-harvest losses in rice. Tolerance to *Sitotroga cerealella* (Olivier) among selected West Bengal rice landraces was assessed. Other factor(s) resulting in tolerance against *Sitotroga cerealella* (Olivier) viz. silica deposition of grain hull, grain dimensions, aroma and grain moisture content among the rice varieties was investigated. Rice (*Oryza sativa* L.) varieties Champakushi, Malabati and Valki are found to be highly tolerant. Grain moisture content and the hull silica both are the important factors for tolerance to the stored grain pest infestation. These tolerant landraces can be used as parents in future rice breeding programmes.

Key Words: rice varieties, grain moisture content, silica deposition, *Sitotroga. cerealella* (Oliver)

Introduction

Identification of rice (*Oryza sativa* L.) varieties from West Bengal that exhibit tolerance to the stored-grain pest *Sitotroga cerealella* (Angoumois grain moth) is critical for reducing postharvest losses and enhancing food security. Post-harvest losses in India amount to 12 to 16 million metric tons of food grains each year, an amount that the World Bank stipulates could feed one-third of India's poor. The monetary value of these losses amounts to more than Rs 50,000 crores per year (Singh, 2010). Loss of grains is estimated at about 10% of the total annual produce under various stages of post-harvest processing and short-term storage in India (Kumar, 2002). According to Hall (1990) the annual stored grain loss due to insect pests is 130 million tons. Insects and diseases devour or damage a fifth or more of stored food grains each year in many parts of the world. Cereals like rice, wheat and corn play an important role in the economic stability of many countries. As many as 34 species of insects have been reported as pests of stored paddy and clean rice from different countries (Grist and Lever, 1969). The angoumois grain moth, *Sitotroga cerealella* (Oliver) and the maize weevil *Sitophilus zeamais* Motschulsky, are the major worldwide pests of stored cereal grains.

The plant breeders and biotechnologists have the immense task of developing new crop varieties to overcome problems caused by pests, diseases and abiotic stresses. In the search for desirable genes in different crop species, the plant breeders and biotechnologists depend upon the crop diversity as an immediate resource to tailor the new varieties and hybrids or for reconstructing the existing genotypes in accordance with the requirements of time and space. The impact of such varieties could be dramatic in developing countries,

where grain infestations are most common and harmful, and where surging populations require affordable food (Bergyinson and Garcia-Lara, 2004).

Rice (*Oryza sativa* L.) is one of the most important food crops grown worldwide and is the staple food for half of the world population (Sasaki and Burr 2000). Rice has fed more people over history than any other grain (Malton *et al.*1998). During storage rice are vulnerable to infestation by a variety of insects, especially to *Sitotroga cerealella* (Olivier), the angoumois grain moth (Hamed and Nadeem, 2012). In India *Sitotroga cerealella* (Olivier) causes appreciable damage to stored paddy (Prakesh *et al.*, 1974). *Sitotroga cerealella* (Olivier) attacks rice grain in the field as well as in storage, causing an estimated overall yield loss of upto 30% (Singh and Benazet, 1975). *Sitotroga cerealella* (Oliver) attacks grains maturing in the field as well as in storage. Infested grain in storage has a sickening taste and smell that make it unpalatable. Only whole grain is attacked, so other grain products are safe. Arthropod pest control in agro ecosystems by habitat manipulation is a method commonly used now provided data is sufficient (Dey and De, 2018).

This investigation has dual purpose. Firstly tolerance to *Sitotroga cerealella* (Olivier) among selected West Bengal rice landraces has been assessed. Secondly to evaluate other probable factor(s) resulting in tolerance against *Sitotroga cerealella* (Olivier) the relationship between the the silica deposition of the grain hull, grain dimensions, aroma, grain moisture content in storage condition and *Sitotroga cerealella* infestation among the rice varieties was investigated.

Objective of the study:

The identification of tolerant traditional rice varieties is increasingly necessary to combat post-harvest losses, which constitute a major yet often overlooked threat to food security, especially in rice-dependent regions. A significant proportion of harvested rice is lost during storage due to insect pests, microbial infestation, and unfavorable storage conditions, reducing both grain quantity and quality. Traditional rice varieties, many of which have evolved under low-input farming systems, often possess inherent tolerance or resistance to storage pests through traits such as harder grain texture, tighter husk enclosure, biochemical deterrents, or reduced suitability for pest development. Systematic identification and scientific validation of these tolerant landraces can provide sustainable, low-cost solutions for minimizing post-harvest losses without excessive reliance on chemical fumigants, which pose risks to human health and the environment. Moreover, conserving and promoting such traditional varieties helps preserve valuable genetic diversity that can be utilized in breeding programs to develop improved cultivars with built-in post-harvest resilience. In the context of climate variability, rising pest pressure, and increasing demand for safe food, identifying tolerant traditional rice varieties is a crucial strategy for enhancing storage stability, safeguarding farmer livelihoods, and strengthening long-term food security

Materials and methods

Plant Materials.

A total of 25 non-aromatic rice varieties were used for this study. The non-aromatic rice lines (NA) included high yielding varieties used in international check (HYV NA) and also indigenous (of Indian origin) high yielding (HYV INA) cultivars. The rice varieties were collected from different districts of the state of West Bengal, India and maintained at the Madhyamgram Experimental Farm of Bose Institute. The name of the cultivars used in this study with origin and place of adaptation are given in Table 1.

Experimental design

The rice genotypes were grown in a randomized block design (RBD) with three replicates of 40 plants each. Seeds were sown in the seed bed on the last week of June and

one healthy seedling/hill was transplanted after 30 days at a row x plant spacing of 25cm x 15cm. Normal agronomic practices were followed.

Table 1. Name, place of adaptation and origin of the 25 non-aromatic rice varieties studied.

SI No	GENOTYPES	PLACE OF ADAPTATION / SOURCE	ORIGIN	TYPE OF CULTIVAR
1	KHEJURCHARI	24 PGS (SOUTH)	CL, SF	NA WBL
2	VALKI	COASTAL MIDNAPUR	CL, SF	NA WBL
3	CHAMPAKUSHI	COASTAL MIDNAPUR	CL SF	NA WBL
4	NAURA	COOCH BEHAR	CL, SF	NA WBL
5	DHEPA	COOCH BEHAR	CL SF	NA WBL
6	CHINAPANKHARI	COOCH BEHAR	CL, SF	NA WBL
7	MALA	COOCH BEHAR	CL, SF	NA WBL
8	PANATI	COOCH BEHAR	CL, SF	NA WBL
9	KALAMOCHA	GOTRA, NADIA	CL SF	NA WBL
10	TILAKPATI	GOTRA, NADIA	CL, SF	NA WBL
11	JALJABRA	GOTRA, NADIA	CL, SF	NA WBL
12	JALKAMINI	GOTRA, NADIA	CL, SF	NA WBL
13	BIRALA	COASTAL MIDNAPUR	CL, SF	NA WBL
14	AGNIBAN	RANGABELIA, GOSABA	CL, SF	NA WBL
15	DUDHSAR	RANGABELIA, GOSABA	CL, SF	NA WBL
16	GAYASUR	RANGABELIA, GOSABA	CL SF	NA WBL
17	GHEUS	RANGABELIA, GOSABA	CL, SF	NA WBL
18	MALABATI	RANGABELIA, GOSABA	CL, SF	NA WBL
19	SABITA	CRRS, WB, INDIA	CD from several crosses	HYV INA
20	PATNAI-23	RANGABELIA, GOSABA	CL SF	NA WBL
21	BHASAMANIK	BANKURA	CL, SF	NA WBL
22	RUPSAIL	RANGABELIA, GOSABA	CL SF	NA WBL
23	MATLA	CRRS, WB, India	CD from several crosses	HYV INA
24	MEGHI	CRRS, WB, India	CD from several crosses	HYV INA
25	IR 72	IRRI, Philippines	CD from several crosses	HYV NA

CD = complex derivative, CL = collection line, CRRS= Chinsura Rice Research Station, EA = exotic aromatic, EB = evolved Basmati, HYVNA = high yielding non-aromatic, IA = indigenous aromatic, INA = indigenous non-aromatic, IRRI= International Rice Research Institute, NA WBL = Non aromatic West Bengal landrace, S = selection, SF = self-fertilized TB= Traditional Basmati

Assessment of Natural Infestation at low and high grain moisture condition

Twenty-five (25) genotypes were cultivated at Bose Institute Experimental Farm, Madhyamgram, West Bengal, India. The maturity time of grains of each cultivars were taken. The cultivation plot was so chosen that it was less than 500m away from the storage facility and the ears were allowed to be infested by *Sitotroga cerealella* (Olivier) in the field without any application of insecticide during maturity. Soon after harvest the grains were dried, moisture content measured by METREX grain moisture meter and kept in close mouth paper bags containing 100 gms of seed in three replication in a storage facility highly infested with *Sitotroga cerealella* (Olivier) at 35± 3° C and 55± 5% RH. After winter months (45 to 60 days) the bags were opened and emergence of the adult moths were noticed. Three aliquots were collected from each bag from 1cm X 1 cm surface of the grain and the moisture condition was measured. Damaged grains were counted under microscope in all the aliquots of the cultivars and the families. The apparently non-infested grains were tested by pressure and examine whether they contain any early stage of infestation and not yet created an emergent hole.

Examination of Grains for *Sitotroga cerealella* (Olivier) infestation

The intact grains were examined under the microscope for initial surface structure variation of hull of the tolerant and susceptible cultivars and families. Lemma and palea of

the tolerant and susceptible cultivars and families were treated with 25% liquid ammonia (NH₃) for 1 day, H₂O₂ for 4 days and then warmed in dilute HNO₃ till the structure became transparent. The transparent structure was then examined under the microscope for any variation in silica deposition.

Methodology for the ascertaining the grain/kernel dimensions: of the rice genotypes

A total of 10 well-developed grains per plant were attached to a 5.5 X 2.5cm² double-sided tape on a 7X4 cm² black chart paper. The length and breadth of grains was measured with the help of a stage-micrometer and an eye-piece graticule under a dissecting microscope (Olympus). Standardization of the eye-piece graticule was done using a stage-micrometer. The average of the values expressed in millimetre was the grain length. The length of each grain was divided by the breadth of the same grain. The average of the values expressed in millimetre was the Grain Length/Breadth Ratio (G-L/B). The rice genotypes were grouped on the basis of its Grain Length/Breadth Ratio (G-L/B) following the Standard Evaluation System of the International Rice Research Institute (IRRI).

RESULTS

The results are shown in three Tables.

- i) Table 2 shows the infestation tendencies of *Sitotroga cerealella* (Olivier) in the grains which are stored in dried condition i.e. in low grain moisture conditions along with the presence/absence of aroma and silica deposition type of the grain hull.
- ii) Table 3 shows the infestation tendencies of *Sitotroga cerealella* (Olivier) in high grain moisture conditions.
- iii) Table 4 shows the grain dimensions and the infestation percentage of *Sitotroga cerealella* (Olivier).

Table 2: Infestation in low grain moisture condition

SIN	CV-NAME	AROMA	SILICA	INFECTED	UNINFECTED	TOTAL
1	KHEJURCHARI	NA	L	13.33333	128	141.3333
2	VALKI	NA	H	3.666667	145.6667	149.3333
3	CHAMPAKUSHI	NA	H	3.333333	188	191.3333
4	NAURA	NA	L	17	160.3333	177.3333
5	DHEPA	NA	H	4	162.6667	166.6667
6	CHINAPANKHARI	NA	L	7	192.6667	199.6667
7	MALA	NA	L	9.666667	178.3333	188
8	PANATI	NA	L	11.66667	141.6667	153.3333
9	KALAMOCHA	NA	L	4	158.3333	162.3333
10	TILAKPATI	NA	H	1.333333	125	126.3333
11	JALJABRA	NA	L	5	157.3333	162.3333
12	JALKAMINI	NA	H	4	132.3333	136.3333
13	BIRALA	NA	L	8.666667	154	162.6667
14	AGNIBAN	NA	L	13.33333	125.3333	138.6667
15	DUDHSAR	NA	H	4.333333	178.6667	183
16	GAYASUR	NA	L	7.666667	214	221.6667
17	GHEUS	NA	H	2.666667	124.3333	127
18	MALABATI	NA	HH	0.666667	126.3333	127
19	SABITA	NA	L	5.666667	145.6667	151.3333
20	PATNAI-23	NA	H	0.666667	101.3333	102
21	BHASAMANIK	NA	L	4	128.6667	132.6667
22	RUPSAIL	NA	L	4.666667	113.6667	118.3333
23	MATLA	NA	H	2.666667	132.3333	135
24	MEGHI	NA	L	2	177	179
25	IR 72	NA	H	1.333333	151.6667	153

NA= Non aromatic, L= Low silica deposition, H= High silica deposition on grain hull, HH= Very high silica deposition on grain hull.

Discussion

The grain length, grain length/breadth ratio does not apparently seem to have definite relation with the infestation as shown in Graph 3 in this investigation. Both the small and large grains are equally infested. Table 4 shows Sabita (HYV NA) variety with long grains very high infestation percentage (41.62%). in the same high moisture condition Valki (NA WBL) with long grains had low infestation (3.8%).

The silica deposition of the hull seems to be very important as shown in graph 4. It shows positive tolerance against the pest infestation. Higher the silica content less the infestation. At low grain moisture conditions Malabati (NA WBL) with very high silica content (HH) has a lowest infestation rate among the West Bengal landraces, 0.51%. Champakushi (NA WBL) with very high silica content (HH) also has a low infestation rate of 1.11%. IR 72 (HYV NA) has high (H) silica deposition and low infestation (0.78%).

At low humidity (dried seed, grain humidity below 10%) the rice varieties Champakushi, Dhepa, Dudhsar, Gheus, IR-72, Jalkamini, Matla, Meghi, Patnai-23, Tilakpeti, Valki show the low infestation rate (below 10%) as shown in Table 2. However, at high grain moisture content only few rice varieties showed low infestation percentage. Champakushi (3.89%), Malabati (2.94%) and Valki (3.8%). Moisture indeed has important role in breakdown of resistance but there are other factors also.

Thus, it can be concluded that the grain moisture content and the hull silica both important factors for tolerance to the stored grain pest infestation. Champakushi, Malabati and Valki are rice varieties which is highly tolerant to *Sitotroga cerealella* (Olivier) infestation, maintaining the infestation below economic threshold limit. These traditional rice varieties/landraces may be used as donors of the tolerance to *Sitotroga cerealella* (Olivier) infestation in future rice breeding programme suited for West Bengal.

Conclusion

Research on indigenous rice genotypes has shown significant variation in susceptibility to *S. cerealella* infestation under different storage conditions, with some local varieties such as Champakushi, Malabati, and Valki demonstrating relatively high tolerance to infestation irrespective of moisture levels, making them promising candidates for breeding and direct use in storage-prone settings. These tolerant landraces, conserved in traditional farming systems in West Bengal, can serve as genetic resources to develop improved cultivars that inherently deter pest development, thereby lowering dependence on chemical controls and reducing quantitative and qualitative losses during storage. Integrating such tolerant varieties into mainstream cultivation and storage strategies can contribute to more resilient rice supply chains, particularly for smallholder farmers who are disproportionately affected by postharvest pest damage.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this work.

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PREPARATION OF B-DIKETONE COMPLEXES USING TRANSITION METAL IONS LIKE Fe(II), Co(II), Ni(II), Cu(II) AND Zn(II) AND THEIR POTENTIOMETRIC STUDY

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Abstract

Potentiometric studies of β -diketone complexes of Fe(II), Co(II), Ni(II), Cu(II), and Zn(II) transition metal ions were carried out in aqueous–ethanolic medium using standard sodium hydroxide solution. The ligand 1-(5-methoxythiophen-2-yl)-3-(2,4-dihydroxyphenyl)propane-1,3-dione (L) was synthesized and characterized by elemental analysis, FT-IR, $^1\text{H-NMR}$, $^{13}\text{C-NMR}$ and UV-Visible spectroscopy. The metal–ligand complexation equilibria were investigated at constant ionic strength (0.1 M KNO_3) and room temperature. The potentiometric titration curves indicate the formation of 1:1 and 1:2 metal–ligand complexes. The dissociation constant (pK_a) of the ligand and stability constants ($\log \beta$) of the complexes were determined using Irving–Rossotti method. The order of stability constants was found to be: **Cu(II) > Ni(II) > Fe(II) > Co(II) > Zn(II)**, which is consistent with the Irving–Williams series.

Keywords: Potentiometric Study, β -Diketone, Transition Metal Ions, Stability Constant, pH

Introduction

Potentiometric studies of transition metal complexes provide valuable information regarding metal–ligand interactions, protonation equilibrium and stability constants of coordination compounds [1]. Transition metal β -diketone complexes are of significant interest due to their applications in catalysis, analytical chemistry, medicinal chemistry, and material science [2–4].

β -Diketones act as excellent chelating agents because of their enolizable hydrogen atom and ability to form stable five or six-membered chelate rings with metal ions [5]. Their high synthetic flexibility, sensitivity toward central metal ions and selectivity make them suitable ligands for coordination studies [6].

In the present investigation, a novel β -diketone ligand, 1-(5-methoxythiophen-2-yl)-3-(2,4-dihydroxyphenyl)propane-1,3-dione (L3), was synthesized and its complexes with Fe(II), Co(II), Ni(II), Cu(II) and Zn(II) ions were studied potentiometrically. The stability constants of the complexes were evaluated and compared to understand the influence of metal ion properties on complex formation [7–9].

Materials and methods

Experimental

All chemicals used were of analytical reagent (A.R.) grade. Metal nitrates/sulphates were procured from Sigma-Aldrich. Double-distilled, CO_2 -free water was used throughout the experiment. The pH of distilled water ranged between 6.65–6.85. Potentiometric measurements were carried out using a digital potentiometer fitted with a combined glass electrode (ELICO CL-51). All weighing were done using an electronic balance (M AB-54).

Preparation and Standardization of Metal Ion Solutions

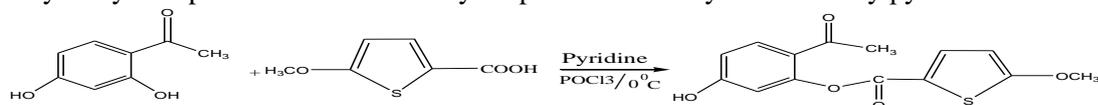
Fe(II) solution was prepared from $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ and standardized using 0.1 M KMnO_4 .

Co(II), Ni(II), Cu(II) and Zn(II) solutions were prepared from their respective sulphates

and standardized using 0.1 M EDTA with suitable indicators.

Synthesis of β -Diketone Ligand (L3) The synthesis of the ligand was carried out in two steps:

Step-I: Synthesis of 2-acetyl-5-hydroxyphenyl 5-methoxythiophene-2-carboxylate using 2,4-dihydroxyacetophenone and 5-methoxythiophene-2-carboxylic acid in dry pyridine and POCl₃.



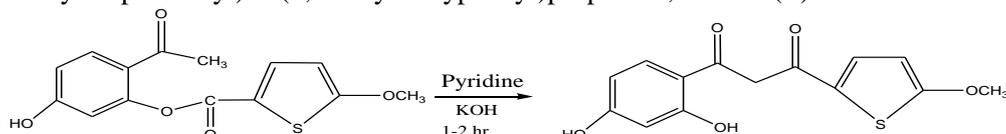
A = (2-4 dihydroxy- acetophenone)

B = (5-methoxythiophene-2 carboxylic acid)

C = (2-acetyl-5-hydroxyphenyl-5methoxythiophene-2-carboxylate)

Synthesis of 2-acetyl-5-hydroxyphenyl5-methoxythioph- ene-2-carboxylate

Step-II: Claisen condensation of the ester with KOH in dry pyridine to obtain 1-(5-methoxythiophen-2-yl)-3-(2,4-dihydroxyphenyl)propane-1,3-dione (L).



A = (2-acetyl-5-hydroxyphenyl-5- methoxythiophene-2-carboxylate)

B = (1(5-methoxythiophen-2-yl)3(2,4-dihydroxyphenyl)-propane 1,3 dione)

Synthesis of β -diketone ligand [L3]

Yield:83% Melting Point: 276°C

Characterization of Ligand

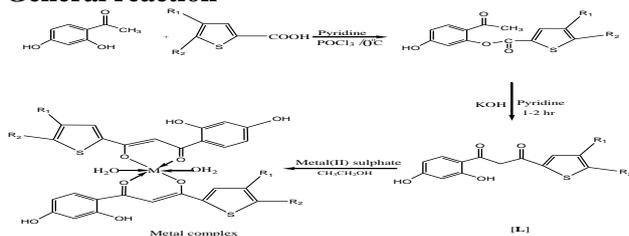
- FT-IR (KBr, cm⁻¹): 3358 (O–H), 1631 (C=O), 1233 (C–O)
- ¹H-NMR (CDCl₃): δ 15.0 (enolic –OH), aromatic and thiophene protons
- ¹³C-NMR: signals corresponding to carbonyl, aromatic and thiophene carbons
- UV-Vis (DMSO): λ_{max} at 360 and 410 nm
- Elemental Analysis: Found values were in good agreement with calculated values.

Potentiometric study: Potentiometric titrations were performed for:

1. Free acid (HNO₃)
2. Acid + ligand (HNO₃ + L3)
3. Acid + ligand + metal ion (HNO₃ + L3 + M²⁺)

Where M²⁺ = Fe(II), Co(II), Ni(II), Cu(II), Zn(II)

General reaction



Transition metal ion sulphates

M: Fe (II), Co (II), Ni (II), Cu (II) And Zn (II); [M (II) SO₄]

Synthesis of ligands and transition metal complexes

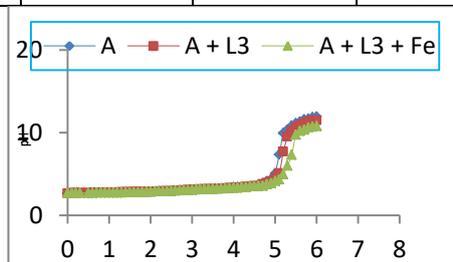
Table :Ligands and Substitute on Thiophene Ring

L/R	R ₁	R ₂
L1	H	Cl
L2	H	Br
L3	H	OCH ₃
L4	Me	H
L5	Et	H

Results and discussion

Table :Determination of pH of Fe (II) ligand [L] complex

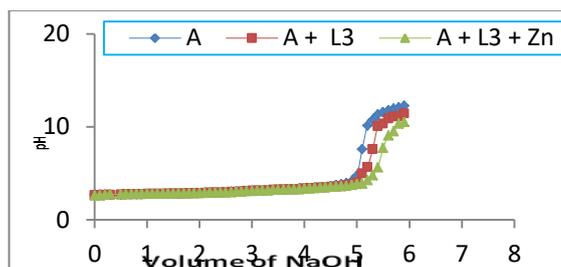
Vol. NaOH (cm ³)	Emf A	Emf A+ L3	Emf A+L3 +Fe	pH A	pH A+L3	pH A+L3 +Fe
0	298	299	297	2.67	2.65	2.69
0.5	296	295	295	2.70	2.72	2.72
1	293	293	293	2.75	2.75	2.75
1.5	291	291	291	2.79	2.79	2.79
2	286	288	287	2.87	2.84	2.85
2.5	280	283	280	2.97	2.92	2.97
3	272	273	274	3.11	3.09	3.07
3.5	266	267	265	3.2	3.19	3.23
4	255	259	258	3.40	3.33	3.35
4.5	248	248	248	3.51	3.51	3.51
5	155	192	210	5.09	4.46	4.16
5.5	-202	-171	-120	11.13	10.60	9.74
6	-250	-223	-183	11.94	11.48	10.81



Graph Potentiometric titration curve of (L3) with transition metal Fe (II)
 a) NaOH vs pH b) NaOH vs EMF

Table: Determination of pH of Zn (II) ligand [L3] complex

Vol. Noah(cm ³)	Emf A	Emf A+ L3	Emf A+L3+Zn	pH A	pH A+L3	pH A+L3 +Zn
0	297	300	303	2.69	2.63	2.58
0.5	296	297	295	2.70	2.69	2.72
1	293	293	291	2.75	2.75	2.79
1.5	291	291	289	2.79	2.79	2.82
2	287	288	287	2.85	2.84	2.85
2.5	280	283	283	2.97	2.92	2.92
3	272	273	274	3.11	3.09	3.07
3.5	266	267	266	3.21	3.19	3.21
4	257	259	258	3.36	3.33	3.35
4.5	244	249	248	3.58	3.50	3.51
5	177	221	230	4.72	3.97	3.82
5.5	-228	-153	1	11.57	10.30	7.69
6	-288	-232	-179	12.58	11.64	10.74



Graph Potentiometric titration curve of (L3) with transition metal Zn(II)

a) NaOH vs pH b) NaOH vs EMF

The titration curves showed systematic displacement of ligand curves upon addition of metal ions, confirming complex formation through deprotonation of enolic –OH group.

The calculated proton-ligand and metal-ligand stability constants indicate formation of both 1:1 and 1:2 complexes.

Stability Constants of Metal Complexes

Fe(II)	2.96
Co(II)	2.93
Ni(II)	3.10
Cu(II)	3.35
Zn(II)	2.80

The stability order follows the Irving–Williams series, confirming higher stability for Cu(II) complexes due to Jahn–Teller distortion and higher crystal field stabilization energy.

Conclusion

The potentiometric investigation confirms that the β -diketone ligand forms stable complexes with Fe(II), Co(II), Ni(II), Cu(II) and Zn(II) ions in aqueous medium. The complexes are formed in the pH range 7.0–7.5. The stability constants follow the order:

Cu(II) > Ni(II) > Fe(II) > Co(II) > Zn(II)

This behavior is attributed to ionic size, charge density, and metal–ligand bonding characteristics. The results validate the suitability of β -diketone ligands for coordination and analytical applications.

Acknowledgement I am grateful to Prof. Dr. Baliram Rakh, Principal, Vasantdada Patil College Patoda for providing laboratory facility, I am also thanks to Dr. Sudhakar Gutte, Dr. Maulge Satish, Dr. L.S. Gadekar, Prof. Ganesh Deshmane and college staff for their valuable guidance.

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EDGE AI AND MULTISPECTRAL QUALITY ASSESSMENT OF TRADITIONAL ORGANIC INPUTS FOR SUSTAINABLE AGRICULTURE

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Abstract

Soil degradation caused by long-term synthetic fertilizer use is a critical challenge for smallholder agriculture, limiting sustainability and soil health. Traditional organic formulations such as Panchagavya have shown promise but lack standardized quality measures, leading to variable outcomes. We propose an edge-AI and multispectral sensing framework that quantifies Panchagavya quality by mapping spectral features to traditional fermentation indicators. A lightweight convolutional model processes 10-band spectral cubes and outputs a normalized potency score alongside categorical descriptors aligned with classical agricultural knowledge. Training relies on simulated spectra constrained by classical preparation ratios, with limited pilot field samples reserved for validation. Simulation results indicate a potential 30–40% reduction in input volume while maintaining yield parity and improving environmental metrics. The framework demonstrates a feasible pathway to integrate traditional organic practice with modern sensing and AI to enhance sustainable agricultural decision support.

Keywords: Multispectral Imaging; Panchagavya; Krishi Parashara; Edge AI; Sustainable Agriculture; Organic Input Standardization

Introduction

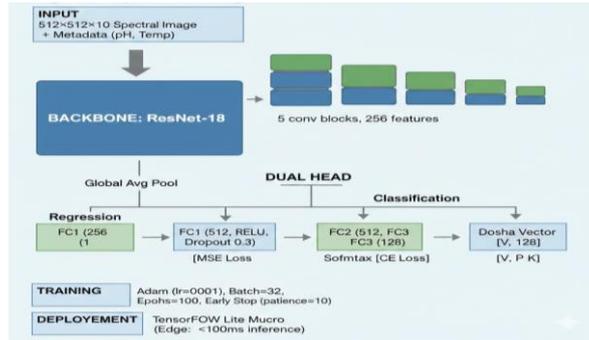
Sustainable agriculture requires reducing dependency on synthetic inputs while maintaining productivity and soil health. Organic formulations such as Panchagavya, described in classical Indian texts, offer a potential alternative but are hindered by preparation inconsistency and lack of measurable quality assessment. Multispectral sensing has been widely applied in precision agriculture to detect crop and soil conditions but remains underutilized in organic input assessment. We present a compact AI and sensing framework designed to standardize Panchagavya quality using spectral proxies for biochemical characteristics, enabling variable-rate application and improved sustainability outcomes.

Background and Motivation Traditional agricultural sources describe organic amendments qualitatively, focusing on fermentation characteristics and dosha analogs. Modern literature largely addresses synthetic input optimization or sensor-based crop monitoring, with limited integration of indigenous organic practices. Studies of microbial consortia in Panchagavya validate its biological potential, but no established non-destructive quality measures exist. Multispectral technologies have proven effective in capturing plant and soil status and feed decision models in precision practices. Our work bridges this gap by associating spectral features with traditional fermentation quality indicators through edge-AI models.

Methodology

Spectral Measurement Protocol We capture 10 selected bands from visible–near infrared reflectance associated with moisture, lipid content, and fermentation state. Preprocessing includes standard normal variate correction and derivative filtering to reduce noise and illumination variability.

Edge-AI Model Architecture A lightweight ResNet-18 backbone with global average pooling processes $512 \times 512 \times 10$ cubes. Two heads output a potency regression (0–1) and a categorical descriptor aligned with traditional categories. Weighted loss combines mean squared error and cross-entropy. Training uses simulated spectra constrained by classical ratios with $\pm 15\%$ variability.



Deployment and Updates The model is optimized with TensorFlow Lite for Raspberry Pi 4 (2 GB), achieving ≈85 ms per sample inference. OTA updates enable incremental learning with data.

Table 1: Proposed Spectral-AI Pipeline for Panchagavya Quality Assessment

Stage	Process	Technical Details
Data Acquisition	Raw Sample Input	Capture via NIR/Vis Spectrometer across the 350–2500nm range to identify chemical signatures.
Preprocessing	Signal Optimization	Application of SNV (Standard Normal Variate) to remove light scatter, followed by 1st Derivative to resolve overlapping peaks.
Feature Extraction	Deep Learning Core	A ResNet-18 backbone (CNN) extracts spatial-spectral features from the preprocessed data.
Knowledge Fusion	Hybrid Rule Engine	Integration of traditional Charaka Samhita ratios acting as a symbolic constraint on the neural features.
Multi-Task Head	Prediction Layer	Regression: Calculates a Potency Score (0–1). Classification: Generates a specific Dosha Vector.
Final Delivery	Actionable Insights	Generation of a verifiable Quality Certificate and a precision Application Rate Map .

Proposed Framework and Simulation Case Study We selected turmeric cultivation in black cotton soils to demonstrate the framework. Spatial variability in soil organic carbon and moisture is simulated. Uniform application results in inefficiencies, whereas AI-guided input allocation adjusts rates based on inferred potency, reducing over-application. Zones with low potency trigger reformulation recommendations rather than raw dosage increases.

Table 2: Complete VISHVA NETHRA Sensor-AI Framework Architecture

Layer	Component	Core Function
1: Acquisition	Multisensor Array	Collects high-fidelity spectral (NIR/Vis), spatial (Canopy), and environmental (IoT) data.
2: Preprocessing	Fusion & Cleaning	Normalizes signal noise (SNV) and aligns heterogeneous data streams with GPS/Weather metadata.
3: Heritage	Knowledge Engine	Implements traditional Ayurvedic/Krishi Parashara rules as logic constraints for the AI.
4: AI Inference	Hybrid Processing	Uses deep learning (ResNet-18) for feature extraction and dual-head outputs for potency and grading.
5: Interface	Deployment	Delivers actionable maps and QR certificates to farmers via a localized mobile interface.

Sustainability Analysis

The sustainability impact of the proposed framework is assessed across environmental, economic, and social dimensions using simulation-based analysis. Results indicate that AI-guided application reduces total organic input volume while maintaining yield parity & lower greenhouse gas emissions.

Measures for Environmental Sustainability Reductions in greenhouse gas emissions primarily result from lower embodied energy in Panchagavya production and avoidance of excess application through variable-rate dosing.

Financial Feasibility for Small Farmers (5-Year Cost-Benefit Analysis (1 ha Smallholder))

Item	Traditional Synthetic	Traditional Organic	AI-Optimized Organic	Cumulative Savings (₹)
Fertilizer Cost (5 yrs)	75,000	20,000	15,000	60,000
Device Amortization	0	0	5,000	-5,000
Yield Value (25 t/ha × ₹20/kg)	2,500,000	2,375,000	2,625,000	250,000
NPV @ 8% discount	2,150,000	2,025,000	2,275,000	125,000

Aspects of Society and Expansion Potential For scaling up, we tap into ESDM hubs; producing at ₹25,000 per unit drops to ₹18,000 when hitting 10,000 a year. Groups like FPO cooperatives handle big buys and support setups.

Links to SDGs:

- **SDG 2 (Zero Hunger):** Better output for small farmers means stronger food supplies.
- **SDG 12 (Responsible Consumption):** Cuts global warming potential by 73 percent, recycles nutrients in a loop.
- **SDG 13 (Climate Action):** Mitigates 880 kg CO₂eq per hectare, builds practices tough against climate shifts.
- **SDG 15 (Life on Land):** Locks away soil organic carbon to fight off desert spread.

Challenges and Future Work

Key limitations include dependence on simulated training data and assumptions on spectral proxies for fermentation quality. Future work involves extensive field trials to refine mappings and assess long-term impacts on soil health.

Conclusion

We demonstrate a compact edge-AI and multispectral framework for quantifying and standardizing traditional organic inputs, offering scalable decision support aligned with sustainable agriculture objectives.

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ऊर्जा संसाधने: नियोजन व व्यवस्थापन

डॉ.जयदीप रामकृष्ण सोळुंके

भूगोल विभाग

श्री.पंडितगुरू पार्डीकर महाविद्यालय, सिरसाळा ता.परळी वै.जि.बीड

सारांश (Abstract) :-

नैसर्गिक संसाधनांचा मोठा हिस्सा प्रगत असलेल्या देशांमध्ये वापरला जातो. या प्रगत देशांना उत्तरेकडील देश असे म्हणतात. तर दक्षिणेकडील भारत, चीन सारख्या प्रगतशील देशाकडून ही साधन संपत्तीचा वापर मोठ्या प्रमाणात होतो. या देशातील वाढत्या लोकसंख्येमुळे या देशातील नैसर्गिक संसाधनांचा वापर प्रचंड मोठ्या प्रमाणात वाढत आहे. उत्तरेकडील व दक्षिणेकडील देशातील नैसर्गिक संसाधनांचा दरडोई वापरात प्रचंड तफावत आहे. प्रगत देशातील नैसर्गिक संसाधनांचा दरडोई वापर प्रगतिशील देशातील नैसर्गिक संसाधनांच्या दरडोई वापरापेक्षा 50 पट अधिक आहे. प्रगत देशांमध्ये जागतिक स्तरावरील औद्योगिक कचऱ्यापैकी 75 टक्के कचरा निर्माण होतो. तसेच मोठ्या प्रमाणावर ग्रीन हाऊस वायूची निर्मिती केली जाते. प्रगत देशात खनिज इंधनापासून मिळणाऱ्या उर्जेचा वापर मोठ्या प्रमाणात केला जातो. प्रगत देशात दरडोई अन्नाचा वापरही मोठ्या प्रमाणात होतो. अन्नपदार्थांच्या निर्मितीसाठी व पॅकेजिंग साठी नैसर्गिक संसाधनांचा मोठ्या प्रमाणात वापर केला जातो. अमेरिकेची लोकसंख्या जगाच्या लोकसंख्येच्या केवळ 4 टक्के आहे. पण पृथ्वीवरील नैसर्गिक संसाधनांच्या 25 टक्के हिस्सा अमेरिका वापरते. सूर्य हा आपल्या जीवनातील ऊर्जेचा प्रमुख स्रोत आहे. उष्णता मिळवण्यासाठी आपण सौर ऊर्जेचा वापर करतो. निसर्गातील अनेक प्रक्रिया द्वारे सौर ऊर्जेचा वापर केला जातो. या नैसर्गिक प्रक्रिया द्वारे अन्न, पाणी, ऊर्जा व निवारा यांची प्राप्ती होते. सूर्यापासून मिळणारी ऊर्जा वनस्पतींच्या वाढीसाठी आवश्यक असते. वनस्पती हा आपल्या अन्नाचा प्रमुख घटक आहे. वनस्पतीद्वारे वातावरणातील प्राणवायूची योग्य मात्रा राखण्यास मदत होते. श्वसनासाठी आपल्याला प्राणवायूची गरज असते.

बीज संज्ञा (key words) :- सौर ऊर्जा, सोलार कुकर, सौर शक्ती घट, सौर औष्णिक विद्युत, आरशांद्वारे प्राप्त ऊर्जा, जैविक ऊर्जा, बायोगॅस, सेंद्रिय कचरा, पवन ऊर्जा, भरती ओहोटी व लाटा द्वारे मिळणारी ऊर्जा, भूगर्भीय ऊर्जा, अणुऊर्जा इ.

प्रस्तावना (Introduction) :-

मानवाचा आर्थिक विकास व औद्योगिक विकास या दोन्ही बाबी ऊर्जा संसाधनाशी निगडित आहेत. जलद आर्थिक विकासावर आधारित विकास विषयक आराखड्यात ऊर्जेच्या वापरामुळे समाजावर होतात याचा विचार केला जात नाही. 1950 ते 1990 या दशकामध्ये जागतिक स्तरावरील ऊर्जेची गरज चार पटीने वाढली आहे. गेल्या 22 वर्षांत विजेची जागतिक मागणी दुप्पट झाली आहे. जगभरात इसवी सन 2000 साली ऊर्जेचा वापर 909.6 कोटी टन तेलाच्या वापराने एवढा होता. हा आकडा जागतिक व्यक्ति मागे सरासरी दीड टन तेलाच्या वापराने एवढा आहे. आज जगात विजेचा वापर झपाट्याने वाढत आहे.

जगातील सुमारे दोन अब्ज लोकांना वीज उपलब्ध होऊ शकत नाही. एकीकडे जगातील वाढत्या लोकसंख्येसाठी उपलब्ध वीज अपुरी आहे. तर दुसरीकडे ज्यांना वीज उपलब्ध आहे त्यांच्या विजेची मागणी वाढत आहे. उपलब्ध विजेचा मोठा हिस्सा वीज एका ठिकाणाहून दुसऱ्या ठिकाणी वाहून नेण्यासाठी खर्च होतो. तर विजेचा मोठा हिस्सा घरगुती वापरसाठी उपयोगात आणला जातो. आज वीज निर्मितीसाठी प्रदूषणमुक्त ऊर्जा निर्मिती द्वारे जगभर विजेची उपलब्धता होण्यासाठी प्रयत्न केले जात आहेत त्यामुळे ऊर्जा निर्मिती करण्यात कार्बनी इंधनांचा तसेच अपुनर्नवीकरणीय ऊर्जा स्रोतांचा कमीत कमी वापर करण्याकडे कल असून त्याद्वारे प्रदूषण मुक्त ऊर्जा निर्मिती करण्याची गरज आहे.

उद्दिष्ट (Objective) :-

1. ऊर्जा संसाधनांचा अभ्यास करणे.
2. ऊर्जेची गरज व महत्त्व विचारात घेणे.
3. ऊर्जा स्रोतांचा आढावा घेणे.
4. ऊर्जा संवर्धनाचे महत्त्व अभ्यासणे.
5. ऊर्जा संवर्धनासाठी जनजागृती करणे.

संशोधन पद्धती (Research Methodology) :-

प्रस्तुत शोधनिबंधाचा अभ्यास करण्यासाठी दुय्यम माहिती स्त्रोत्रांचा आधार घेण्यात आला आहे. यात या विषयाशी संबंधित अनेक पुस्तके, संदर्भ ग्रंथ, मासिके, वर्तमानपत्रे, संशोधन पेपर, गॅझेट, सांख्यिकी कार्यालयाची माहिती, जिल्हा, राज्य, राष्ट्रीय पातळीवरील प्रकाशित होणारी माहिती यासंबंधीत वेबसाईटवरून माहिती संकलित करून त्याच्यावर विश्लेषण करून शोधनिबंध तयार करण्यात आला आहे.

विषय विवेचन (Discussion) :-

19 व्या शतकातील औद्योगिक क्रांतीसाठी ऊर्जा संसाधन म्हणून कोळशाचा वापर मोठ्या प्रमाणात केला जातो. 20 व्या शतकाच्या अखेरीस व्यावसायिक स्तरावरील ऊर्जेच्या वापरात तेलाचे प्रमाण 39 टक्के होते. त्यानंतर कोळसा 24 टक्के व नैसर्गिक वायू 24 टक्के या ऊर्जा संसाधनाचे स्थान होते. तर ऊर्जा स्रोतांत अणुऊर्जा 7 टक्के जलविद्युत व पुनर्नवीकरणीय ऊर्जा स्रोतांचे प्रमाण 7 टक्के होते. भारतात ऊर्जेची प्राथमिक गरज जैविक संसाधनाद्वारे भागविण्यात येते. ऊर्जेचा एकूण 40 टक्के भाग लाकूड व शेण यापासून वापरण्यात येतो. विद्युत निर्मितीसाठी भारतात आजही प्रामुख्याने कोळशाचा वापर केला जातो. 1970 ते 1980 च्या दरम्यान अणुऊर्जेच्या वाढत्या प्रमाणात उपयोग होण्याची सुरुवात झाली. 1980 ते 1990 च्या दशकात नैसर्गिक वायूचा वापर मोठ्या प्रमाणात वाढला.

ऊर्जेचे प्रकार

अपुनर्नवीकरणीय, पुनर्नवीकरणीय व परमाणुऊर्जा हे ऊर्जेचे प्रमुख तीन प्रकार आहेत. हे वर्गीकरण बिनचूक असणार नाही परंतु पुनर्नवीकरणीय ऊर्जा स्रोतांचा टिकाऊ पद्धतीने वापर केला नाही तर ऊर्जा संसाधने नष्ट होऊ शकतात. त्यामुळे परमाणु ऊर्जा निर्मितीसाठी ऊर्जा संसाधन हा अमर्याद साठा असलेले ऊर्जा संसाधन आहे.

अ) अपुनर्नवीकरणीय ऊर्जा :-

अपुनर्नवीकरणीय ऊर्जा निर्मितीसाठी संसाधनांचे ज्वलन करावे लागते. या विजेचा उपयोग दैनंदिन व्यवहारासाठी होतो. या ऊर्जा संसाधनात दगडी कोळसा, खनिज तेल, नैसर्गिक वायू यासारख्या इंधनांच्या रूपात संसाधने आढळतात. खनिज संसाधनांची निर्मिती प्राचीन काळी अस्तित्वात असलेल्या वनापासून झाली. या इंधनांस जीवाश्म इंधन असेही म्हणतात. पृथ्वीवर असलेल्या इंधनाच्या साठ्यापैकी कोळसा बराच काळापर्यंत टिकू शकतो पण खनिज तेल व नैसर्गिक वायूचे साठे मर्यादित आहेत. संपण्याची भीती व्यक्त केली जाते. या इंधनाच्या ज्वलनामुळे विषारी वायू तयार होतात त्यात कार्बन डाय-ऑक्साइड, गंधक तसेच नायट्रोजन ऑक्साईडच्या स्वरूपात व कार्बन मोनॉक्साईड वातावरणात शिरून वातावरणात प्रदूषण निर्माण करतात. वातावरणात हरितवायूंचे प्रमाण मोठ्या प्रमाणात वाढते. परिणामी पृथ्वीच्या एकूण तापमानात वाढ होते. हवा प्रदूषण झाल्यामुळे श्वसनाच्या विकारात वाढ होते. पृथ्वीच्या अनेक भागात गंभीर दुष्काळ पडतात. बर्फ वितळतात व समुद्राच्या पाणी पातळीत वाढ होते.

भारतात उपयोगात येणाऱ्या तेल विहिरी मुंबई व आसामच्या समुद्रात आहेत. नैसर्गिक वायू तयार करताना तेल साठ्यातून उपलब्ध नैसर्गिक वायू 40 टक्के वाया जातो. गॅस गळतीमुळे वातावरणात जलसाठे प्रदूषित होतात. नैसर्गिक वायू साठ्याला आग लागल्याने अनेक दिवस धुमसत राहते हवा प्रदूषण होते. तेल वाहू जहाजांची गळती व अपघातामुळे जल प्रदूषण व सागरी जीवसृष्टीचे अतोनात नुकसान होते. खनिज तेल इंधनावर चालणाऱ्या वाहनातून कार्बन डाय-ऑक्साइड, सल्फर डाय ऑक्साईड, नायट्रस ऑक्साईड, कार्बन मोनॉक्साईड असे विषारी वायू व तरंगते धुलीकण बाहेर पडतात त्यामुळे वायू प्रदूषण निर्माण होते. शिसे युक्त पेट्रोलमुळे मज्जासंस्थेवर विपरीत परिणाम होतो. कॅन्सर सारखे दूधर आजार व आरोग्याच्या समस्या निर्माण होत आहेत. जागतिक स्तरावर मोठ्या प्रमाणात खनिज तेलांचा वापर होत आहे. खनिज तेलावर अवलंबून राहिल्यामुळे अनेक देशात तणावाची व अस्थिरतेची परिस्थिती निर्माण झाली आहे. त्यामुळे युद्ध होण्याची भीतीही वाढली आहे. पृथ्वीवरील एकूण तेल साठ्यापैकी 65 टक्के तेल साठा खाडीतील देशात अस्तित्वात आहे.

जागतिक तापमान वाढीसाठी कोळशाचा वापर हे सर्वात मोठे कारण आहे. कोळशावर चालणाऱ्या औष्णिक वीज निर्मिती केंद्रात कोळशाच्या वापरामुळे निर्माण होणारी काजळी, धुलीकण नष्ट करण्यासाठी स्थिर विद्युत उपकरणे अस्तित्वात नसल्यामुळे तरंगत्या धुलीकणांचे वातावरणातील प्रमाण वाढते. कोळशाच्या ज्वलनामुळे नत्रवायूची घातक ऑक्साइड्स तयार होतात. त्यामुळे आम्लवर्षा (Acid Rain) यामुळे वनांचे अतोनात नुकसान होते. आम्लवर्षामुळे इमारती व ऐतिहासिक स्मारकांचे नुकसान होते. मानवी आरोग्यावर विपरीत परिणाम होतो. कोळशाच्या वापरामुळे फ्लाय अश ची समस्या निर्माण होते.

ब) पुनर्नवीकरणीय ऊर्जा

पुनर्नवीकरणीय ऊर्जेची निर्मिती करण्यासाठी नैसर्गिक संसाधनांचा वापर केला जातो. जी संसाधने कालांतराने पुन्हा उपलब्ध होतात. पुनर्नवीकरणीय ऊर्जा संसाधनाच्या वापरात प्रदूषणाचे प्रमाण कमी असते. यामध्ये जलविद्युत, सौर ऊर्जा, पवन ऊर्जा, भूगर्भीय ऊर्जा या ऊर्जा प्रकारात पुनर्नवीकरणीय नैसर्गिक संसाधनाचा वापर केला जातो. इंधन म्हणून कचरा किंवा झाडे जाळून ऊर्जा निर्मिती केली जाते ही संसाधने परत निर्माण होत. असल्यामुळे या संसाधनापासून मिळणारी ऊर्जा ही पुनर्नवीकरणीय ऊर्जा होय.

जलविद्युत :-

जलविद्युत निर्माण करताना नद्यावर धरणे बांधून या धरणातील पाण्यावर जलविद्युत जनित्रे चालविली जातात. व त्यापासून वीजनिर्मिती केली जाते. इ.स. 1950 ते 1970 च्या दरम्यान जगात जलविद्युत निर्मितीत सतत वाढ झाली आहे. जलविद्युत ही पुनर्नवीकरणीय ऊर्जा संसाधनाद्वारे उपलब्ध होते. तसेच जलविद्युत जनित्रे अधिक काळापर्यंत विद्युत निर्मिती करू शकतात व त्यांच्या देखभालीसाठी कमी खर्च येतो. त्यामुळे जलविद्युत ऊर्जा निर्मिती अधिक प्रमाणात होते. जलविद्युत निर्मितीत खनिज इंधनांचा वापर होत नसल्यामुळे प्रदूषणही कमी होते व खनिज इंधनांच्या किमती चलनवाढीमुळे वाढण्याचा धोकाही जलविद्युत निर्मितीत असल्यामुळे ही वीज निर्माण करणे अधिक लाभदायक ठरते. जलविद्युत ऊर्जेची निर्मिती करण्यासाठी मोठ्या प्रमाणावर शेती व वने पाण्याखाली जातात जंगलांचा नाश झाल्यामुळे धरणातील जलसाठ्यात मोठ्या प्रमाणात गाळ साजतो त्यामुळे जलविद्युत संयंत्रांचे आयुष्य धोक्यात येते. नद्यावर धरणांची निर्मिती केल्यामुळे नदीतून होणाऱ्या जलवाहतूक तसेच मासेमारीवर विपरीत परिणाम होतो. धरणांच्या निर्मितीमुळे विस्थापितांचे पुनर्वसनाचे गंभीर प्रश्न निर्माण होतात. भूकंपप्रवण क्षेत्रात जलविद्युत प्रकल्पांची निर्मिती केल्यामुळे या धरणांमुळे भूकंप होण्याची शक्यता वाढते. उदा. कोयना प्रकल्प. मोठ्या धरणांच्या निर्मितीमुळे अनेक सामाजिक व पर्यावरणीय समस्या निर्माण होत असल्यामुळे जलविद्युत उत्पादनासाठी छोटे बंधारे बांधण्याचा प्रयत्न केला जात आहे.

सौर ऊर्जा :-

सूर्य एका तासात पृथ्वीला एक वर्ष पुरेल एवढी ऊर्जा देतो. सौर ऊर्जेचा हा स्रोत बंदिस्त करता आला तर मानव जातीला इतर कुठल्याही ऊर्जा संसाधनाची गरज भासणार नाही. सौर ऊर्जेचा वापर करून पाणी गरम करण्यासाठी तसेच वीज निर्मितीसाठी करण्याचे अनेक उपाय विकसित करण्यात आले आहेत. ऊर्जेच्या दृष्टिकोनातून कार्यक्षम निवासात सौर ऊर्जा पाणी तसेच वाऱ्याचा उपयोग थंडीच्या दिवसात घर गरम ठेवण्यासाठी तसेच उन्हाळ्यात थंड ठेवण्यासाठी करण्यात येतो. ब्रिटिशांच्या राजवटीत घरात काचेच्या खिडक्यांची रचना अशा प्रकारे केली जात असे की त्यावर सूर्याची किरणे थेट पडू शकणार नाहीत. काचेचा वापर अशा तऱ्हेने केल्यामुळे हरितगृह परिणामा शिवाय काचेचा वापर करणे शक्य होते. सौर शक्ती द्वारे पाणी तापविण्यासाठी वापरण्यात येणाऱ्या उपकरणांचे दोन भाग असतात सौर ऊर्जा संग्रहक व पाण्याची टाकी सौर ऊर्जासंग्रहकाद्वारे सूर्यापासून येणारी उष्णता गोळा करून पाणी तापते नंतर गरम पाण्याचे उष्णता रोधक टाकीत पाठविले जाते. अशाप्रकारे घरगुती वापरामध्ये सौर ऊर्जेचा मोठ्या प्रमाणात वापर केला जातो. वातावरण ढगाळ असेल तर ही प्रणाली कार्यक्षम नसते पाणी गरम होऊ शकत नाही या तंत्राचा वापर एक वैकल्पिक ऊर्जा संसाधन म्हणून करण्यात येतो इस्राइल देशात जवळपास 80 टक्के घरावर सौर ऊर्जेचा वापर केला जातो.

सोलार कुकर :-

सूर्यापासून निर्माण होणाऱ्या ऊर्जेचा वापर सोलर कुकर द्वारे अन्न शिजविण्यासाठी केला जातो. सोलार कुकर धातूची एक पेटी असते ही पेटी आतल्या बाजूला काळ्या रंगात रंगविलेली असते. त्यामुळे उष्णता शोषून टिकविण्यात मदत होते. या पेटीचे झाकण चकचकीत असून त्याद्वारे सूर्याची उष्णता परावर्तित करून पेटीत संकलित करण्यात येते. या पेटीत अन्न शिजविण्यासाठी काळ्या रंगाची भांडी वापरली जातात व त्यात अन्नपदार्थ शिजविले जातात. भारतात सर्वाधिक प्रमाणात सोलार कुकरचा वापर केला जातो. संपूर्ण देशात दोन लाख पेक्षा अधिक कुटुंबात सोलार कुकरचा वापर अन्नपदार्थ शिजविण्यासाठी केला जातो. सोलार कुकरच्या वापरामुळे जाळण्यासाठी लाकूड फाट्याची गरज लागत नाही. त्यामुळे प्रदूषण कमी होते. सौर ऊर्जेवर चालणारा सोलार कुकर ग्रामीण भागात अधिक प्रमाणात वापरला जात नाही. कारण सोलार कुकरमध्ये शिजवलेले अन्न पारंपारिक पद्धतीने शिजविले जात नाही. अशी ग्रामीण लोकांची समजूत आहे असे असले तरी सोलार कुकरचा वापर वाढण्याची शक्यता आहे.

सौर औष्णिक विद्युत :-

सूर्याच्या उष्णतेच्या विकिरणामुळे मोठ्या प्रमाणावर ऊर्जा निर्माण केली जाऊ शकते. व त्याद्वारे विद्युत निर्मिती करणे शक्य आहे. ज्या प्रदेशात आकाश निरभ्र असून ढग कमी प्रमाणात असतात व ज्या ठिकाणी उष्णतेचे विकिरण कमी प्रमाणात होते असे प्रदेश सौर शक्ती द्वारे औष्णिक वीज निर्मिती करण्यासाठी योग्य आहेत. संयुक्त राष्ट्र विकास परिषदेतर्फे सादर केलेल्या अहवालानुसार सौर औष्णिक विद्युत पवन ऊर्जेने मिळविलेल्या बाजारपेठेच्या तुलनेत 20 वर्ष पिछाडीवर आहे. भविष्यात या ऊर्जेची निर्मिती अधिक प्रमाणात होणे शक्य आहे.

सौर सेल :-

सौर शक्तीचा वापर करून सौर उर्जेवर चालणाऱ्या सौर सेलचा वापर करून सूर्याच्या उष्णतेचे रूपांतर विद्युत शक्ती केले जाते. सौर ऊर्जेमध्ये विद्युत निर्मिती करण्यासाठी सूर्यापासून मिळणाऱ्या प्रकाशाचा वापर केला जातो. या सौर सेलची देखभाल अत्यंत सहजपणे केली जाऊ शकते. सौर सेलच्या वापरामुळे पर्यावरणावर विपरीत परिणाम होत नाही. सौर सेलचा वापर अत्यंत सुरक्षित असून त्याद्वारे ध्वनी प्रदूषण होत नाही. व सौर सेल वापरण्यास अतिशय स्वच्छ असतात ज्या ठिकाणी सूर्यप्रकाश उपलब्ध आहे त्या ठिकाणी सौर सेलचा वापर केला जाऊ शकतो. सौरसेल सिलिकॉनच्या दोन पापुद्रापासून बनविला जातो. सौर सेलवर सूर्याचा प्रकाश पडतो तेव्हा पापुद्र्यात विद्युत भार संक्रमित होतो. त्यामुळे विद्युत निर्मिती होते असे 40 छोटे सेल एकत्र जोडून एक युनिट तयार केले जाते. यावर एक विजेचा दिवा लावला जातो एकापेक्षा अधिक दिव्यांची जोडणी करून एक सारणी तयार केली जाते. अशा प्रकारे सारण्यांच्या वापरामुळे घरातील ऊर्जेची गरज भागविली जाते.

पर्यावरणाच्या दृष्टिकोनातून सौर सेल हे एक वरदान आहे. या सेलद्वारे कुठलेही प्रदूषण बाहेर टाकले जात नाही. या सेलद्वारे किरणोत्सर्गी पदार्थ हे बाहेर टाकले जात नाहीत. तसेच या सेलच्या वापरामुळे दुर्घटना होत नाही काही सौर सेलमध्ये कॅडमियम सारख्या विषारी पदार्थांचा वापर केला जातो. सौर सेल ची निर्मिती सिलिकॉन पासून केली जाते. सिलिकॉन पृथ्वीवर मुबलक प्रमाणात आढळून येते. सिलिकॉन हे पृथ्वीवर सर्वाधिक प्रमाणात आढळून येणाऱ्या मूलद्रव्यांपैकी दुसऱ्या क्रमांकाचे मूलद्रव्य आहे.

- आफ्रिकेतील माले या देशात सौर उर्जेवर चालणारे जगातले पहिले रुग्णालय आहे सहारा वाळवंटात असलेल्या माले देशात भरपूर सूर्यप्रकाश असल्यामुळे सोलार सेलद्वारे इस्पितळातील महत्त्वपूर्ण उपकरणे व फ्रिज करता वापरली जाणारी ऊर्जा निर्माण केली जाते.
- जपान मधील शेतकरी विषारी कीटकनाशकाऐवजी सौर सेलवर चालणाऱ्या कीटकनाशकांचा वापर करतात.
- सौर सेलचा वापर करून 1981 साली सोलार चॅलेंजर नावाच्या विमानाने पॅरिस ते लंडन हे अंतर 5 तास 20 मिनिटात पूर्ण केले सौरशक्तीवर चालणारे हे विमान तयार करण्यात आले.

आरशांद्वारे प्राप्त ऊर्जा :-

1980 साली अमेरिकेतील कॅलिफोर्निया राज्यात सौर औष्णिक विद्युत निर्मितीसाठी एका उपकरणाची निर्मिती करण्यात आली. या उपकरणात 7600 बहिर्वक्र आरशांचा वापर करण्यात आला त्यापैकी प्रत्येक परावर्तक युनिटमध्ये 1.5 मीटर व्यास असलेल्या भागात 24 परावर्तक बसविण्यात आले. सूर्याची उष्णता या परावर्तकाद्वारे एकत्रित करून या उष्णतेचा वापर विद्युत निर्मिती आणि वाफ निर्माण करण्यासाठी केला जात असे. या वाफेद्वारे विद्युत जनित्र चालविण्यात येई.

जैविक ऊर्जा :-

जैविक ऊर्जेचा वापर तीन प्रकारे करता येतो जैविक वस्तुमान जाळून त्याद्वारे उष्णता व विद्युत निर्मिती केली जाऊ शकते. मिथेन सारख्या वायूचा इंधन म्हणून वापर केला जाऊ शकतो. त्याचप्रमाणे हा वायू द्रव रूप असून त्याचा वापर इंधन म्हणून करता येतो द्रव इंधनात दोन प्रकारच्या मध्यार्काचा समावेश होतो. या पदार्थात इथेनॉल व मिथेनॉल हे मध्यार्काचा समावेश होतो. या इंधनांना जैविक इंधन असे म्हणतात. जैविक वस्तुमानाचे रूपांतर द्रवइंधनात करता येणे शक्य असल्यामुळे या जैविक इंधनाचा वापर वाहतुकीच्या साधनात करता येतो. गाड्या, ट्रक, बसेस, विमाने, रेल्वेसाठी अतिरिक्त इंधनाची गरज जैविक इंधनाद्वारे भागविली जाऊ शकते. वाहनात डिझेल ऐवजी बायोडिझेलचा वापर करता येणे शक्य आहे. बायोडिझेलची निर्मिती वनस्पती तेलापासून केली जाते. अमेरिकेत बायोडिझेलची निर्मिती सोयाबीन तेलापासून करण्यात येते. शास्त्रज्ञाद्वारे शेवाळ गटातील वनस्पतींचा विकास करण्याचा प्रयत्न होत आहे. या विशिष्ट वनस्पतीद्वारे बायोडिझेलची निर्मिती केली जाऊ शकते.

वनस्पती, गवत, कागद तसेच शेतातील कचऱ्याद्वारे अल्कोहल किंवा मध्यार्काची निर्मिती करण्याचे प्रयत्न सुरू आहेत. त्याचबरोबर ऊसापासून सुद्धा बायोडिझेलची निर्मिती करण्याचे प्रयोग सुरू आहेत.

सॅड्रिय कचऱ्यापासून ऊर्जा :-

कचऱ्यात वाया गेलेले कागद, अन्न, कपडे, टाकाऊ रबर, चांबड्याच्या वस्तू यापासून सॅड्रिय इंधनाची निर्मिती केली जाऊ शकते. अमेरिकेत कचऱ्याचे संक्रमण करून शहरातील कचऱ्यापासून सुमारे 31 टक्के सॅड्रिय घटक परत मिळविले जातात. उर्वरित 62टक्के कचरा जमिनीत भराव टाकण्यासाठी वापरण्यात येतो व 7 टक्के कचरा जाळून टाकला जातो. प्रचंड बॉयलर द्वारे ज्वलनाद्वारे या टाकाऊ पदार्थांचा उपयोग विद्युत निर्मिती करण्यासाठी केला जातो. कोणत्याही इंधनाप्रमाणे जैविक वस्तुमान इंधन म्हणून वापरले जाते तरी त्यापासून ज्वलनासाठी कार्बन-डाय-ऑक्साईड वायू निर्माण होतो व इतरही अनेक प्रदूषके निर्माण होतात. याकडे आपण लक्ष दिले पाहिजे. जैविक इंधनाद्वारे खनिज इंधनाच्या तुलनेत कमी प्रदूषण निर्माण होते. जैविक इंधनात नैसर्गिकरित्या आढळणाऱ्या गंधकाचे प्रमाण खूपच कमी असल्यामुळे या इंधनाच्या वापरामुळे सल्फर डाय ऑक्साईड वायू कमी प्रमाणात निर्माण होतो व जैविक इंधनाच्या वापराने नायट्रोजन ऑक्साईडचे प्रदूषण अधिक प्रमाणात होते. कारण जैविक वस्तुमानात नत्रयुक्त पदार्थ अधिक प्रमाणात आढळून येतात.

बायोगॅस ऊर्जा :-

वनस्पती, पाळीव प्राण्यांची विष्टा, टाकाऊ पदार्थ, घरगुती कचरा तसेच मासळीवर प्रक्रिया करण्यामुळे बायोगॅसची निर्मिती होते. डेअरी उद्योग व सांडपाण्यावर प्रक्रिया करणारे यंत्राद्वारे बायोगॅसची निर्मिती होते बायोगॅस हे अनेक वायूचे मिश्रण असून त्यात मिथेन, कार्बन डाय-ऑक्साईड, हायड्रोजन, सल्फर डाय ऑक्साईड व पाण्याची वाफ यांचा समावेश असतो. मिथेन ज्वलनशील वायू असल्यामुळे पटकन पेट घेतो 1 टन टाकाऊ अन्नपदार्थांपासून 85 घनमीटर बायोगॅस निर्माण होतो. बायोगॅसच्या निर्मितीनंतर उरलेल्या कचऱ्याचा खत म्हणून वापर केला जाऊ शकतो. जपानमध्ये 80 टक्के तर फ्रान्समध्ये 50 टक्के कचऱ्याचा वापर वीज निर्मिती वर केला जातो. भारतीय खेड्यातून बायोगॅसचा वापर अधिक प्रमाणात होऊ लागला आहे. बायोगॅस जनावरांच्या शेणापासून बायोगॅसची निर्मिती केली जाते. दोन प्रकारच्या इंधनावर चालणाऱ्या इंजिनासाठी बायोगॅस चा वापर केला जातो. बायोगॅसच्या वापरामुळे स्वयंपाक घरातील धुरांचे प्रमाण कमी झाले आहे. त्यामुळे अनेक कुटुंबातील श्वसनासंबंधीचे आजार कमी झाले आहेत. साखर कारखान्यातील मळी हा जैविक इंधनाचा नवीन मोठा स्रोत निर्माण झाला आहे. ऊसाच्या मळीपासून तयार केलेले इथेनॉल वाहनात इंधन म्हणून वापरले जाऊ शकते. आज ब्राझीलमध्ये 1/3 वाहनात इथेनॉलमध्ये मध्यार्काचा वापर केला जातो.

पवन ऊर्जा :-

प्राचीन काळी होड्या चालविण्यासाठी वाऱ्याचा उपयोग केला जात असे. पवन ऊर्जा हा सर्वात पुरातन ऊर्जा स्रोत आहे. पवन ऊर्जेची निर्मिती वाऱ्याच्या वेगावर अवलंबून असते. त्यामुळे कुठल्याही प्रदेशातील वाऱ्याचा सरासरी वेग पवन ऊर्जा संयंत्र आर्थिक दृष्टिकोनातून सफल होण्यासाठी आवश्यक घटक आहे. वाऱ्याचा वेग समुद्रसपाटीपासून उंचीवर वाढत जातो. पवन ऊर्जा वापरात आणताना विद्युत जनित्राद्वारे 10 मीटर उंचीवर लावलेल्या जनित्रा पेक्षा 30 मीटर उंचीवर लावलेल्या जनित्राद्वारे उर्जेची निर्मिती जास्त होते. पवन ऊर्जेचा पर्यावरणावरील प्रभाव नगण्य असतो कारण पवन ऊर्जेपासून कुठल्याही प्रकारची प्रदूषके निर्माण होत नाहीत. किरणोत्सर्गाची ही समस्या नसते. पवनशक्तीची निर्मिती करताना पवनचकक्यांना धडकून पक्षी मृत्युमुखी पडतात. तसेच पवनचकक्यामुळे ध्वनी प्रदूषण होते पवनचकक्यामुळे टेलिव्हिजन संदेशावर प्रभाव पडतो. अधिक प्रमाणात पवन ऊर्जेची निर्मिती करण्यात अधिक पवनचकक्यांची संयंत्रे बसविल्यामुळे परिसराच्या सौंदर्याला बाधा पोहोचते. पवन ऊर्जेची निर्मिती करण्यासाठी खुल्या परिसराची आवश्यकता असते. वारा हे सतत मिळणारे ऊर्जा संसाधन नाही. तर वाऱ्याची उपलब्धता थांबून थांबून होत असते. वाऱ्याची गती व निर्मिती भौगोलिक परिस्थितीवर अवलंबून असते. त्यामुळे पवन ऊर्जेसाठी वाऱ्याचा वापर ऊर्जा निर्मितीचे एकमेव संसाधन म्हणून केला जाऊ शकतो. व विद्युत निर्मितीसाठी ऊर्जेचा वैकल्पिक स्त्रोतांची गरज भासते.

भरती ओहोटी व लाटाद्वारे मिळणारी ऊर्जा :-

भरती ओहोटी द्वारे निर्माण होणाऱ्या उर्जेचा वापर करण्यासाठी नदीच्या संगमाजवळ एक बंधारा बांधून भरती ओहोटीचे पाणी जनित्रावरून सोडले जाते. एक दिशा पद्धतीच्या वापरामध्ये भरतीचे पाणी एका बंदिस्त प्रदेशात अडवले जाते. भरतीच्या वेळी अडवलेले पाणी ओहोटी सुरू झाल्यावर विद्युत निर्मिती करण्यासाठी जनित्रांचा वापर करण्यासाठी उपयोगात आणले जाते. विद्युत जनित्रांच्या विशिष्ट रचनेमुळे दोन्ही दिशांचा वापर करून भरतीच्या वेळी बंधान्याच्या आत येणाऱ्या ओहोटीच्या वेळी बाहेर जाणाऱ्या पाण्याच्या प्रवाहामुळे जनित्र चालवून विद्युत निर्मिती केली जाते.

भरती ओहोटीवर आधारित विद्युत निर्मितीमुळे किनारी प्रदेशातील परिसंस्थात अमुलाग्र बदल घडून येतात. या विद्युत निर्मिती संयंत्रामुळे सागरी पक्षांचे वस्तीस्थान नष्ट होते. मासेमारी करण्यात अडथळा निर्माण होतो. किनारी प्रदेशातील नद्यांच्या मुखाजवळ उभारलेल्या ऊर्जा निर्मिती संयंत्रामुळे प्रदूषित पाणी समुद्रात जाऊ न शकल्यामुळे प्रदूषणाची शक्यता वाढते.

भूगर्भिय ऊर्जा :-

भूगर्भिय ऊर्जा म्हणजे पृथ्वीच्या उदरातील ऊर्जा होय. भूगर्भिय ऊर्जा पृथ्वीच्या अंतरंगातील लाव्हारसामुळे निर्माण होते. या लाव्हारसाला मॅग्मा असे म्हणतात. पृथ्वीच्या उदरातील लाव्हारसाचा पृथ्वीच्या पृष्ठभागावर ज्वालामुखीच्या स्वरूपात उद्रेक होऊन तप्त मॅग्मा बाहेर येतो. पृथ्वीच्या उदरातील मॅग्मा किंवा लाव्हारसामुळे भूगर्भातील जलसाठे तापतात. आधुनिक तंत्रज्ञानाच्या साहाय्याने पृथ्वीच्या पृष्ठभागाखाली खोल भूगर्भिय पाण्यापर्यंत विहिरी खोदून भूगर्भातील ऊर्जेद्वारे तप्त झालेली पाणी पंपाद्वारे पृथ्वीवर आणले जाते. अशाप्रकारे उष्ण पाण्याचा अखंड स्रोत निर्माण केला जातो या तंत्राला भूगर्भिय ऊर्जेचा वापर असे म्हणतात. आइसलँड, जपान तसेच न्यूझीलँड इत्यादी देशात घरातील तापमान वाढविण्यासाठी, औद्योगिक वापरासाठी तसेच विद्युत निर्मितीसाठी भूगर्भिय ऊर्जेचा वापर केला जातो. भूगर्भिय ऊर्जा जलविद्युत प्रमाणे स्वस्त असल्यामुळे भविष्यात भूगर्भिय ऊर्जेचा वापर करावा लागेल.

अणुऊर्जा :-

डॉ होमी भाभा यांना भारतीय अणु कार्यक्रमाचे जनक मानले जाते. मुंबईतील भाभा अणुसंशोधन केंद्रात अणुऊर्जेच्या वापरासंबंधी संशोधन करण्यात येते. भारतात पाच अणुऊर्जा केंद्रात दहा अणुभट्ट्या कार्यान्वित आहेत. देशाच्या गरजेच्या दोन टक्के वीज या अणुभट्ट्याद्वारे निर्माण केली जाते. देशातील या अणुभट्ट्या महाराष्ट्र, तामिळनाडू, उत्तर प्रदेश, गुजरात मध्ये उभारण्यात आले आहेत. या अणुभट्टीसाठी आवश्यक युरेनियमची उपलब्धता झारखंड मधील खाणीमधून केली जाते. केरळ व तामिळनाडू राज्यात थेरियम मूलद्रव्यांची उपलब्धता मोठ्या प्रमाणात आढळून येते. अणुभट्टीत अणुऊर्जा निर्मितीसाठी युरेनियम 235 या मूलद्रव्याचा वापर करण्यात येते. या ऊर्जेद्वारे पाण्याची वाफ तयार केली जाऊन या वाफेवर विद्युत जनित्रे चालविली जातात. अणुऊर्जा निर्मितीसाठी युरेनियमच्या कांड्या वारंवार बदलाव्या लागतात. तसेच नियंत्रण सळ्याद्वारे अणुकचरा निर्माण होतो. हा अणुकचरा किरणोत्सारी असल्यामुळे त्याचा पर्यावरणावर विपरीत परिणाम होतो. अणुभट्टी थंड करण्यासाठी वापरलेले पाणी तापून बाहेर सोडले जाते. या तप्त पाण्यामुळे जल परिसंस्थेचे नुकसान होते.

निष्कर्ष (Conclusion):-

अपुनर्नवीकरणीय ऊर्जा स्रोतांच्या माध्यमातून मोठ्या प्रमाणात प्रदूषण होते. त्यामुळे संपूर्ण जीवसृष्टी व मानवी जीवनावर त्याचे गंभीर परिणाम होतात. म्हणून पुनर्नवीकरणीय ऊर्जेचा वापर करणे आवश्यक आहे. पुनर्नवीकरणीय ऊर्जा पुन्हा निर्माण करता येते. त्यामध्ये सौर ऊर्जेचा वापर मोठ्या प्रमाणात करणे ही काळाची गरज आहे. भारतासारख्या देशात सौर ऊर्जा मोठ्या प्रमाणात उपलब्ध होते. शाश्वत विकास साध्य करण्यासाठी शाश्वत ऊर्जेचा वापर करणे हे अगत्याचे आहे. त्याचबरोबर अणुऊर्जेचा वापर सुद्धा मोठ्या प्रमाणात करणे आवश्यक आहे. ऊर्जेची गरज दिवसेंदिवस वाढत असल्यामुळे मानवाला पुनर्नवीकरणीय व अणुऊर्जेचा वापर करणे आवश्यक आहे.

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सहयोगी प्राध्यापक

पंडित जवाहरलाल नेहरू समाजकार्य महाविद्यालय अमळनेर.

प्रस्तावना:- भारत हा विविध संस्कृती, भाषा व परंपरांनी नटलेला देश असून त्यातील आदिवासी समुदायांचे सामाजिक-धार्मिक जीवन अत्यंत वैशिष्ट्यपूर्ण आहे. अनेक आदिवासी समाजात पारंपरिक श्रद्धा आणि अंधश्रद्धा आरोग्य व्यवहारांवर मोठा प्रभाव टाकतात. रोग हे अदृश्य शक्तींचे परिणाम मानणे, जादूटोणा, वनदेवता किंवा पूर्वजांच्या नाराजीमुळे आजार होतात अशी धारणा, वैद्यकीय उपचाराऐवजी ओझा-गुणी किंवा देवारीकडे जाणे अशा पद्धती आजही टिकून आहेत. मुख्यतः आदिवासी जमाती विविध भौगोलिक प्रदेशात व ते दुर्गम भागात विखुरलेले असल्यामुळे त्यांच्यातील रूढी प्रथा परंपरा श्रद्धा अंधश्रद्धा सामाजिक रचना आरोग्याच्या पद्धती व एकंदरीतच जीवनशैलीमध्ये विशिष्ट वैशिष्ट्य आढळतात त्यामुळे आदिवासी समाजाचा विकास भारताच्या समग्र विकासासाठी आवश्यक आहे. शाश्वत विकास ध्येये (SDGs) म्हणजे संयुक्त राष्ट्रांनी २०३० पर्यंत गरिबी, भूक, आरोग्य, शिक्षण, असमानता आणि हवामान बदल यांसारख्या जागतिक समस्यांवर मात करण्यासाठी ठरवलेली १७ उद्दिष्टे आहेत, ज्यात 'दारिद्र्य निर्मूलन,' 'शून्य उपासमार,' 'उत्तम आरोग्य व कल्याण,' 'दर्जेदार शिक्षण,' 'लैंगिक समानता,' 'स्वच्छ पाणी व स्वच्छता,' 'स्वस्त आणि स्वच्छ ऊर्जा,' 'चांगले काम व आर्थिक वाढ,' 'उद्योग, नावीन्य आणि पायाभूत सुविधा,' 'असमानता कमी करणे,' 'शाश्वत शहरे,' 'जबाबदार उपभोग व उत्पादन,' 'हवामान कृती,' 'जलचर जीवन,' 'भूचर जीवन,' 'शांतता, न्याय व मजबूत संस्था' आणि 'उद्दिष्टे साध्य करण्यासाठी भागीदारी' यांचा समावेश आहे.

SDGs ची १७ उद्दिष्टे (Goals):

- दारिद्र्य निर्मूलन: सर्व प्रकारचे दारिद्र्य संपवणे.
- शून्य उपासमार: उपासमार संपवणे, अन्न सुरक्षा आणि शाश्वत शेतीला प्रोत्साहन देणे.
- उत्तम आरोग्य व कल्याण: निरोगी आयुष्य सुनिश्चित करणे आणि कल्याण वाढवणे.
- दर्जेदार शिक्षण: सर्वांसाठी गुणवत्तापूर्ण शिक्षण आणि आजीवन शिक्षणाच्या संधी उपलब्ध करणे.
- लैंगिक समानता: लैंगिक समानता प्राप्त करणे आणि सर्व महिला व मुलींना सक्षम करणे.
- स्वच्छ पाणी व स्वच्छता: सर्वांसाठी पाण्याची उपलब्धता आणि शाश्वत व्यवस्थापन सुनिश्चित करणे.
- स्वस्त आणि स्वच्छ ऊर्जा: परवडणारी, विश्वसनीय, शाश्वत आणि आधुनिक ऊर्जा सर्वांसाठी उपलब्ध करणे.
- चांगले काम व आर्थिक वाढ: सर्वांसाठी शाश्वत आणि सर्वसमावेशक आर्थिक वाढ, पूर्ण आणि उत्पादक रोजगार.
- असमानता कमी करणे: देशांमधील आणि देशांमधील असमानता कमी करणे.
- शाश्वत शहरे आणि समुदाय: शहरे आणि मानवी वस्त्या सर्वांसाठी सुरक्षित, लवचिक आणि शाश्वत बनवणे.
- जबाबदार उपभोग आणि उत्पादन: शाश्वत उपभोग आणि उत्पादन पद्धती सुनिश्चित करणे.
- हवामान कृती: हवामान बदल आणि त्याच्या परिणामांना तोंड देण्यासाठी तातडीने पावले उचलणे.
- जलचर जीवन (पाण्याखालील जीवन): सागरी संसाधनांचे संरक्षण आणि शाश्वत वापर.
- भूचर जीवन (जमिनीवरील जीवन): नैसर्गिक परिसंस्थेचे संरक्षण, पुनर्संचय आणि शाश्वत वापर.
- शांतता, न्याय आणि मजबूत संस्था: शांततापूर्ण आणि सर्वसमावेशक समाजांना प्रोत्साहन देणे.
- उद्दिष्टे साध्य करण्यासाठी भागीदारी: शाश्वत विकासासाठी जागतिक भागीदारी मजबूत करणे.

ही उद्दिष्टे २०३० पर्यंत पूर्ण करण्याचे लक्ष्य ठेवले आहे, ज्यासाठी संयुक्त राष्ट्रांनी आंतरराष्ट्रीय स्तरावर प्रयत्न सुरू केले आहेत आणि नीती आयोग (NITI Aayog) भारतासाठी या ध्येयांच्या पूर्ततेचे नेतृत्व करत आहे. विकास ध्येय ३ (SDG 3 - Good Health and Well-being) हे संयुक्त राष्ट्रांच्या (United Nations) १७ जागतिक ध्येयांपैकी एक आहे, जे 'उत्तम आरोग्य आणि कल्याण' यावर लक्ष केंद्रित करते. या ध्येयाचा मुख्य उद्देश २०३० पर्यंत सर्व वयोगटातील लोकांसाठी निरोगी जीवन सुनिश्चित करणे आणि त्यांच्या कल्याणाला चालना देणे हा आहे. मराठीत सांगायचे तर: "सर्व वयोगटातील सर्वांसाठी आरोग्यदायी जीवन आणि कल्याण सुनिश्चित करणे".

SDG 3 ची मुख्य उद्दिष्टे (Key Targets):

- माता मृत्यू दर कमी करणे: २०३० पर्यंत माता मृत्यू दर दर लाख जिवंत जन्मामागे ७० पेक्षा कमी करणे.
- बाल मृत्यू दर रोखणे: नवजात बालके आणि ५ वर्षाखालील मुलांचा अकाली मृत्यू रोखणे.
- संसर्गजन्य आजारंचे उच्चाटन: एड्स (AIDS), क्षयरोग (TB), मलेरिया आणि उष्णकटिबंधीय आजारांची साथ संपवणे.
- व्यसनमुक्ती: अंमली पदार्थांचे सेवन आणि हानिकारक व्यसनांना प्रतिबंध व उपचार करणे.
- रस्ते अपघात कमी करणे: रस्ते अपघातांमुळे होणारे मृत्यू आणि जखमींचे प्रमाण कमी करणे.
- प्रजनन आरोग्य: लैंगिक आणि प्रजनन आरोग्य सेवा, कुटुंब नियोजन आणि शिक्षणापर्यंत सार्वत्रिक प्रवेश सुनिश्चित करणे.
- सार्वत्रिक आरोग्य सुविधा (Universal Health Coverage): सर्वांना आरोग्य विमा, आवश्यक औषधे आणि दर्जेदार आरोग्य सेवा परवडणाऱ्या दरात उपलब्ध करून देणे.
- प्रदूषण नियंत्रण: घातक रसायने आणि प्रदूषणामुळे होणारे आजार आणि मृत्यू कमी करणे.

शाश्वत विकास ध्येयाचे महत्व:-

- उत्तम जीवनमान: निरोगी शरीर आणि मन असेल तरच व्यक्ती विकासात योगदान देऊ शकते.
- गरिबी निर्मूलन: आजारपणामुळे होणारा आर्थिक खर्च कमी झाल्यास गरिबी कमी होण्यास मदत होते.
- शाश्वत विकास: निरोगी लोकसंख्येमुळे देशाचा आर्थिक आणि सामाजिक विकास वेगाने होतो.
- भारत आणि महाराष्ट्रातील अंमलबजावणी:
- आयुष्मान भारत योजना: केंद्र सरकारची 'आयुष्मान भारत' योजना सार्वत्रिक आरोग्य कळहेजच्या दिशेने एक मोठे पाऊल आहे.
- पोषण: माता आणि बालकांसाठी पोषण आहार योजना (उदा. अंगणवाडी सेवा) राबवल्या जात आहेत.
- थोडक्यात, SDG 3 हे केवळ आजार बरे करणे नसून, प्रतिबंधात्मक काळजी (Preventive Care), चांगला आहार, सुरक्षित पर्यावरण आणि मानसिक आरोग्य मिळवून व्यक्तीचे जीवनमान सुधारणे हे आहे.

अंधश्रद्धेची व्याख्या आणि महत्त्व

अंधश्रद्धेची व्याख्या "अंधश्रद्धा म्हणजे अशा अशास्त्रीय अवैज्ञानिक आणि तर्कदृष्टीत नसलेल्या विश्वासधारणांना दिलेल्यांना ज्या समाजातील काही घटना आजार किंवा नैसर्गिक आपत्तीचे कारण अलौकिक शक्ती देवी प्रकोप जाधव इत्यादीशी जोडतात आणि त्यावर आधारित कृती करतात."

अध्ययनाचे महत्त्व

- अंधश्रद्धा आरोग्य विषयक निर्णय प्रक्रियेवर थेट परिणाम करते.
- रोगाचे वेळेवर निदान व उपचार न झाल्याने आरोग्याच्या समस्या क्लिष्ट होऊन बसतात.
- माता व बाल आरोग्याला गंभीर धोका निर्माण होतो.
- आदिवासी समुदाय आणि आरोग्यवस्था यांच्यामध्ये दरी वाढते त्यामुळे आरोग्याचे कार्यक्रम गावा गावात म्हणावे त्या प्रमाणात रुजत नाहीत.
- अंधश्रद्धेचा वैज्ञानिक दृष्टिकोनातून अभ्यास केल्यास समुदायाच्या वास्तव गरजा ओळखता येतात आणि सांस्कृतिक दृष्ट्या संवेदनशील आरोग्य धोरणे तयार करण्यात येतात.

अभ्यासाची उद्दिष्टे

1. भारतातील आदिवासी समुदायांमधील अंधश्रद्धेच्या प्रथा, परंपरा, रूढी, श्रद्धा आणि त्यांची कारणमीमांसा जाणून घेणे

2. आधुनिक आरोग्य सेवा चा वापर करण्यावर अडथळे निर्माण करणाऱ्या सामाजिक, आर्थिक आणि सांस्कृतिक घटकाचा अभ्यास करणे.
3. शाश्वत विकास ध्येयांच्या संदर्भात आदिवासी समुदायाची आरोग्य स्थिती तपासणे.
4. आदिवासी समुदायांमध्ये वैज्ञानिक दृष्टिकोन वाढविण्यासाठी आवश्यक धोरणात्मक शिफारशी सुचविणे

संशोधन प्रश्न

1. आदिवासी समुदायांमध्ये कोणत्या प्रकारच्या अंधश्रद्धा आरोग्याशी संबंधित आहेत?
2. अंधश्रद्धेचा रोग निदान आणि उपचार परिणाम होतो का?
3. शाश्वत विकासाचे ध्येय साध्य करण्यासाठी कोणते आरोग्य विषयक धोरणे प्रभाव ठरू शकतात?
4. आदिवासी समुदायाकडे असलेले परंपरागत ज्ञान आणि आधुनिक आरोग्य पद्धती यांचा संतुलित समन्वय कसा साधता येईल?

साहित्य पुनरावलोकन व पद्धती:-

(अ) साहित्य पुनरावलोकन -अनेक अभ्यासांमधून हे स्पष्ट होते की आरोग्यसेवा अभावी आदिवासी समुदाय पारंपरिक उपचारांकडे वळतात. आधुनिक आरोग्य व्यवस्थेवरील अविश्वास आणि सामाजिक-सांस्कृतिक परंपरा अंधश्रद्धांना बळकटी देतात.

(ब) पद्धती -सदर अध्ययनासाठी द्वितीय साधनसामग्रीचा उपयोग केलेला आहे. त्यासाठी ग्रंथालयातील संदर्भ ग्रंथ पुस्तके संशोधन लेख इंटरनेट इत्यादी साहित्याचे अध्ययन करण्यात आलेले आहे.

- गुणात्मक अभ्यास – मुलाखती, निरीक्षण
- परिमाणात्मक अभ्यास – सर्वेक्षण
- दुय्यम माहिती – सरकारी अहवाल, संशोधन पेपर

परिणाम -भारतातील आदिवासी समुदायाची आरोग्यची स्थिती सन 2011 च्या जनगणनेनुसार भारतीय आदिवासी लोकसंख्या सुमारे 8.6 टक्के आहे. यापैकी बहुसंख्य जमाती या दुर्गम, अतिदुर्गम पर्वतीय व वनक्षेत्रात राहतात. त्यांच्या आरोग्याच्या स्थितीचे काही महत्त्वाचे पैलू पुढीलप्रमाणे आहेत.

अ)रोगाचा प्रादुर्भाव -कुपोषण विशेषतः महिलांमध्ये आणि मुलींमध्ये मलेरिया, क्षयरोग आणि अॅनिमिया यांचा वाढता धोका, माता मृत्यू व बालमृत्यूचे प्रमाण इतर कोणत्याही गटापेक्षा आदिवासी समुदायांमध्ये जास्त स्वरूपामध्ये आढळते. मासिक पाळी विषयी योग्य ती माहिती नसणे, मासिक पाळी विषयी असणारे गैरसमज व स्वच्छता न पाळणे यामुळे सुद्धा वेगवेगळे आजारचे प्रमाण महिला व मुलींमध्ये वाढू शकते.स्वच्छ पाणी व स्वच्छतेची कमी सुविधा यामुळे सुद्धा साथीचे आजाराचा प्रादुर्भाव होत आहे.

ब) आरोग्य सेवा वापरात अडथळे -बहुसंख्य आदिवासी जमाती या दुर्गम, अतिदुर्गम भागात वास्तव्य करत असल्याने साहजिकच तालुका किंवा जिल्ह्याच्या ठिकाणापासून भौगोलिक दुरावा असतो. अनेकदा रुग्णालय 20 ते 25 किलोमीटरच्या अंतरावर असतात. त्यामुळे अडथळा निर्माण होतो. यासोबतच दुर्गम भागामध्ये रस्ते वाहतुकीची समस्या जाणवते . त्यामुळे परिवहन व्यवस्था कमी असल्यामुळे आजारी व्यक्तीला वेळीच दवाखान्यात उपचारासाठी नेण्यास अडथळे निर्माण होतात.

पुरेशा संसाधनाची कमतरता जाणवते. निरक्षरतेचे प्रमाण जास्त किंवा अर्धशिक्षित असल्याने आवश्यक ती आरोग्याची काळजी घेतली जात नाही. आरोग्य विषयक वेगवेगळ्या मोहिमा, जनजागृती याचा सुद्धा अभाव दिसतो.

क. सामाजिक आणि सांस्कृतिक घटक- मुळातच आदिवासी समाज हा संस्कृती व परंपरा प्रिय असल्याने परंपरागत वैद्य, भगत, मांत्रिक, गुनिया यांच्या वरती ते अवलंबून असतात. कुटुंबात जर कोणाला काही झाले तर सुरुवातीचा उपचार ते भगत किंवा मांत्रिकाकडे घेतात. भगत किंवा मांत्रिक हे धार्मिक विधी करतात किंवा देवाला किंवा दानवाला खुश करण्यासाठी वेगवेगळे पूजाविधी करून घेतात. हातात किंवा गळ्यात गंडा दोरा बांधणे यांना प्राधान्य दिले जाते. त्यामुळे पुरेसा वैद्यकीय उपचार न मिळता परंपरागत उपचारारव अवलंबून राहतात. महिलांचे आरोग्याकडे दुर्लक्ष केले जाते. त्यामुळे महिलांमध्ये अॅनिमिया प्रमाण वाढते. गरोदर महिलेच्या योग्य तपासण्या न करताच प्रसूती घरातच दाईकडून करून घेण्याचे प्रथा आढळते. एखाद्या अनुभवी महिला कडून प्रसूती करून घेण्याची प्रथा आहे. त्यामुळे रोगाचा संसर्ग होणे किंवा प्रसूतीबाबत चुकीच्या धारणा असल्याने जोखिम असते त्यामुळे माता मृत्यू, बालमृत्यू होऊ शकतो. या सर्व घटकांचा आदिवासी समुदाय खास करून भारतातल्या आदिवासी समुदायाच्या सुधारणावर थेट परिणाम होत असतो त्यामुळे शाश्वत विकासाची ध्येये साध्य करण्यासाठी खूप मोठे आव्हान निर्माण होते.

चर्चा:- भारतीय आदिवासी समुदायांमध्ये रूढी, प्रथा, परंपरा यासह अंधश्रद्धा मोठ्या प्रमाणात पाळली जाते. त्यामुळे अंधश्रद्धा केवळ धार्मिक बाब नसून सामाजिक व आर्थिक परिस्थितीशी निगडित येते. अंधश्रद्धा मोठ्या प्रमाणात असल्यामुळे जादूटोणा, भुतं, पिशाच्च, डाकीण पद्धती यामुळे वैज्ञानिक दृष्टिकोनाचा अभाव दिसून येतो. वेळोवेळी आजारी पडणाऱ्या व्यक्तींवर तात्काळ वैद्यकीय उपचार होण्याऐवजी अंधश्रद्धेच्या विळख्यात अडकून प्रसंगी आजारी व्यक्तींचे किती तरी बळी गेलेले आहेत. देवाने ठेवले तसेच राहावे किंवा आपल्या हातून काही तरी पाप झाले असेल त्याचेच हे फळ मिळाले असेल अशी मानसिकता करून घेणे, झाडपाला किंवा भगत ,मांत्रिकाकडे अघोरी उपचार करणे यामुळे आधुनिक वैद्यकीय उपचारापासून वंचित राहतात. एकंदरीतच अंधश्रद्धा मुळे सामाजिक, आर्थिक, मानसिक व शारीरिक घटकावरती परिणाम होताना दिसून येतो.

शाश्वत विकास ध्येयांशी संबंध:

शाश्वत विकासाची ध्येये:, विशेषता शाश्वत विकास ध्येये 3 - सर्वांसाठी चांगले आरोग्य व कल्याण शाश्वत विकास ध्येय- 4 गुणवत्तापूर्ण शिक्षण, शाश्वत विकास ध्येय- 5 लिंग समानता आणि शाश्वत विकास ध्येय-10 विषमता कमी करणे. हे उद्दिष्ट आदिवासी समुदायाना सामाजिक, आर्थिक विकासाच्या प्रवाहात आणण्यासाठी महत्त्वाचे ठरतात. अंधश्रद्धा परंपरागत आरोग्य उपचार पद्धती, जादूटोणा, स्थानिक वैद्य किंवा भगत यांच्यावरील अति आत्मनिर्भरता यामुळे अनेकदा आदिवासी समुदाय आरोग्यापासून वंचित राहतो. त्यामुळे कुपोषण, मातामृत्यू, बालमृत्यू, संसर्गजन्य आजार या गंभीर समस्या निर्माण होतात. त्यामुळे अंधश्रद्धा आणि आरोग्य यांच्यातील नाते समजून घेण्यासाठी सदर

निष्कर्ष:- या अभ्यासातून असे स्पष्ट होते की, आदिवासी समुदायासाठी आधुनिक पद्धतीच्या आरोग्यसेवा उपलब्ध असून सुद्धा आदिवासींची संस्कृती, सामाजिक वातावरण व दुर्गम भागात असणारे वास्तव्य यामुळे आरोग्य सेवेचा वापर कमी आहे . आदिवासी समाजाच्या रूढी ,प्रथा ,परंपरा व अंधश्रद्धेचा त्यांच्या जीवनमानावर परिणाम होताना दिसतो. आरोग्य सुविधा उपलब्ध असताना सुद्धा शिक्षणाची कमतरता, दारिद्र्य व संभाषणाचा अभाव आणि स्थानिक परिस्थितीनुसार उपलब्ध असलेले वैद्य ,भगत इत्यादींवर असलेली अतिनिर्भरता यामुळे आदिवासी समाजा मध्ये आरोग्य सुधारण्यामध्ये अडथळे निर्माण होत आहेत . शाश्वत विकासाच्या ध्येयामध्ये समाविष्ट असलेली सर्व उद्दिष्टे पूर्ण करण्यासाठी सर्वप्रथम आदिवासी समाजाचे आरोग्याच्या परिस्थितीमध्ये सुधारणा करणे आवश्यक आहे. अंधश्रद्धेमुळे योग्य उपचार विलंबित होतात, आजार वाढतात, आणि आरोग्य निर्देशांक खालावतात. शाश्वत विकासासाठी वैज्ञानिक दृष्टिकोन, शिक्षण आणि आरोग्य सेवांची उपलब्धता अत्यावश्यक आहे.

शिफारशी:-

- मोबाईल हेल्थ युनिट वाढवणे
- आदिवासी भाषेत आरोग्य संवाद
- लसीकरण व प्रसूती आरोग्य मोहिमा
- शैक्षणिक व जागृती कार्यक्रम
- आधुनिक व पारंपरिक वैद्यकात सहयोग

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CYBER SECURITY, DATA PRIVACY, AND DIGITAL ETHICS: CHALLENGES, INTERDEPENDENCIES, AND FUTURE DIRECTIONS

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Abstract

In an increasingly digital world, cyber security, data privacy, and digital ethics have become core pillars of responsible technology adoption. The rapid proliferation of data-driven technologies offers unprecedented opportunities for economic growth, social engagement, and scientific innovation. However, these gains are counterbalanced by rising threats including data breaches, privacy violations, algorithmic bias, and ethical lapses. This paper examines the interconnected nature of cyber security, data privacy, and digital ethics, identifies emerging challenges, and proposes a holistic framework for addressing these issues in organizational and policy domains. Drawing on interdisciplinary insights, we argue that ethical awareness must be embedded into cyber security practices to safeguard human values alongside infrastructure resilience.

Introduction:-

Technological advancement has reshaped contemporary society, fostering digital ecosystems that influence commerce, governance, healthcare, and social life. The ubiquity of mobile devices, cloud computing, Internet of Things (IoT), artificial intelligence (AI), and data analytics has led to unprecedented data generation and connectivity. While digital transformation accelerates innovation, it simultaneously amplifies vulnerabilities. Cyber threats have escalated in scale and sophistication, targeting individuals, institutions, and nations. Coupled with weak data governance practices, these threats compromise confidentiality, integrity, and availability of information.

Moreover, as technologies penetrate personal and public spheres, digital ethics — principles guiding fair, transparent, and value-driven technology use — emerge as essential for trust and societal well-being. Digital ethics addresses concerns such as consent in data processing, equity in algorithmic decision-making, accountability for harm, and respect for autonomy. Integrating cyber security, data privacy, and digital ethics is necessary to ensure that technology serves society without undermining fundamental rights.

This paper investigates the interplay among these domains, outlines contemporary challenges, and suggests integrative frameworks for practice and policy.

Literature Context and Theoretical Foundations

Cyber Security

Cyber security refers to the practice of protecting systems, networks, and programs from digital attacks. Traditionally anchored in confidentiality, integrity, and availability (CIA triad), cyber security has evolved into a multidisciplinary field encompassing technical defenses, human factors, and strategic governance.

Data Privacy

Data privacy focuses on the appropriate handling of personal data — including collection, storage, use, and dissemination — to protect individuals from unauthorized access or misuse. Regulatory frameworks such as the GDPR (General Data Protection Regulation), HIPAA (Health Insurance Portability and Accountability Act), and national data protection laws reflect global recognition of privacy rights.

Digital Ethics

Digital ethics evaluates moral questions arising from the use of digital technologies. It includes principles of fairness, transparency, non-maleficence, accountability, and respect for human agency. Unlike technical standards, digital ethics involves normative judgments about what *should* be done, not just what *can* be done.

Interdependencies

The interrelation between the three domains is increasingly acknowledged in scholarly work. Effective cyber security protects data privacy. Conversely, ethical frameworks guide how data is collected and secured, ensuring respect for individual rights. Ethical considerations also influence design choices in security systems, such as minimizing surveillance while maximizing protection.

Methodological Approach

This paper adopts a **conceptual and analytic methodology**, drawing on existing frameworks from cyber security, data privacy, and ethics. It synthesizes interdisciplinary scholarship, policy documents, and real-world case studies to articulate challenges and propose a unified approach.

The analysis includes:

1. **Threat Landscape Assessment** – examining current security threats and privacy breaches.
2. **Ethical Evaluation** – applying ethical principles to real-world digital dilemmas.
3. **Framework Development** – recommending integrated governance models.

Threat Landscape and Data Vulnerabilities

Cyber Attacks and Vulnerabilities

Cyber attacks have grown in frequency and impact. Common attack vectors include:

- **Malware and ransomware:** Malicious software that encrypts data or disrupts operations.
- **Phishing and social engineering:** Deceptive tactics to trick users into revealing credentials.
- **Distributed Denial of Service (DDoS):** Overwhelming systems to cause outages.
- **Supply chain attacks:** Targeting third-party dependencies.

These threats compromise data privacy and undermine trust in digital systems.

Data Breaches and Privacy Violations

Data breaches expose personal data — financial records, health information, identity details — to unauthorized parties. High-profile breaches have affected millions of users, leading to financial loss, identity theft, and reputational damage for organizations. Poor data governance, insufficient access controls, and legacy systems often contribute to vulnerabilities.

Ethical Considerations in Digital Systems

Consent and Autonomy

Ethical digital systems must ensure that individuals provide informed consent for the use of their personal data. Consent should be meaningful, specific, and revocable. However, in practice, lengthy privacy policies and opaque data practices undermine autonomy.

Fairness and Non-discrimination

AI and automated systems can perpetuate biases present in training data, leading to discriminatory outcomes in hiring, lending, law enforcement, and healthcare. Ethical frameworks demand that systems be reviewed for fairness and corrected to prevent harm.

Transparency and Accountability

Transparency involves clear communication about how data is used and what security measures protect it. Accountability requires mechanisms to hold organizations and developers responsible for breaches, misuse, and harms caused by digital systems.

Privacy as a Fundamental Right

Privacy is not merely a technical feature but a fundamental human right. Ethical approaches position privacy within broader social values such as dignity and freedom from surveillance.

Case Analyses

Case: Ransomware Attack on Healthcare Systems

In recent years, ransomware attacks have targeted hospitals, disrupting critical services. Patients' medical records, appointment schedules, and diagnostic data were encrypted, leading to delays in care. This incident highlights the intersection of cyber security and ethics: healthcare institutions must protect patient data and ensure continuity of care, while attackers exploit vulnerabilities for financial gain.

Ethically, prioritizing patient safety necessitates investment in robust security infrastructure, regular risk assessments, and contingency planning.

Case: Social Media Data Exploitation

Major social media platforms have faced criticism for harvesting user data without transparent consent and sharing it with third parties. Such practices raise ethical questions about autonomy, privacy, and surveillance capitalism. Regulatory responses, including fines and revised privacy policies, reflect growing societal concern about digital rights.

Integrated Challenges

Technical and Human Factors

Cyber security solutions often emphasize technology, but human behavior remains a significant vulnerability. Phishing, weak passwords, and misconfigurations stem from inadequate training and awareness.

Regulatory and Jurisdictional Complexities

Data flows across borders, but laws differ by jurisdiction. Harmonizing legal obligations — such as GDPR compliance for global operations — is complex and resource-intensive.

Ethical Blind Spots in Innovation

Rapid innovation often outpaces ethical deliberation. New technologies like biometric systems, deepfakes, and predictive analytics can introduce unforeseen ethical dilemmas if deployed without safeguards.

Proposed Framework for Integration

To address the interdependencies among cyber security, data privacy, and digital ethics, we propose a **three-layered framework**:

Layer 1: Policy and Governance

- **Data Protection Policies:** Establish clear guidelines for data collection, retention, and disposal.
- **Compliance Mechanisms:** Mandatory alignment with regional and international privacy laws.
- **Audit and Accountability:** Regular audits and transparent reporting of security incidents.

Layer 2: Technical Controls and Security Practices

- **Defense-in-Depth:** Multi-layered security architecture including encryption, firewalls, and intrusion detection.
- **Secure Development Lifecycle:** Integrate security and ethical reviews into software design phases.
- **Access Management:** Strict identity and access controls to minimize unauthorized exposure.

Layer 3: Ethical Culture and Human Awareness

- **Ethics Training:** Educate employees and developers about privacy rights and ethical responsibilities.
- **User-Centric Design:** Involve stakeholders in designing transparent consent mechanisms.
- **Ethics Boards:** Establish internal review boards for technology projects with ethical implications.

These layers are iterative and mutually reinforcing: governance informs technical practices, which are implemented within an ethical culture.

Recommendations and Best Practices

For Organizations

- Conduct periodic **risk assessments** to identify vulnerabilities.
- Adopt **privacy-by-design** and **security-by-design** principles.
- Provide **continuous education** on security awareness and ethical implications.
- Implement strong **incident response plans** for breaches.

For Policymakers

- Harmonize data protection regulations globally to reduce fragmentation.
- Introduce frameworks for **algorithmic accountability**.
- Support research in ethical AI and human-centered security solutions.

For Individuals

- Practice good digital hygiene: use strong, unique passwords and enable multi-factor authentication.

- Understand privacy settings and consent terms before sharing data.
- Report suspicious digital behavior to appropriate authorities.

Future Directions

Emerging technologies like quantum computing, edge computing, and AI-driven automation pose new opportunities and risks. **Quantum-resistant cryptography** will become necessary as quantum computing advances. Ethical considerations must also evolve to tackle issues such as autonomy in autonomous systems and fairness in ubiquitous AI. Interdisciplinary collaboration among technologists, ethicists, legal scholars, and social scientists will be critical. Future research should focus on:

- Building **ethical impact assessments** for emerging technologies.
- Developing **explainable AI** to enhance transparency and trust.
- Creating **global governance models** for cyber norms and data rights.

Conclusion

The complex landscape of cyber security, data privacy, and digital ethics demands an integrated and proactive response. Technical defenses alone are insufficient without ethical grounding and robust governance. As digital technologies permeate every dimension of life, aligning security practices with privacy rights and ethical values is imperative to foster trust, innovation, and human dignity. A holistic framework that encompasses policy, technical safeguards, and ethical culture can enable individuals and institutions to navigate digital risks responsibly.

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A CONCISE REVIEW ON ORGANIC FARMING AND ITS ROLE IN SUSTAINABLE AGRICULTURE

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Abstract: Organic farming has gained global recognition as an environmentally responsible agricultural system that emphasizes ecological balance, soil strength, and food safety. This review presents an updated and comprehensive discussion of organic farming, covering its conceptual foundations, guiding principles, core agronomic practices, benefits, constraints, and worldwide status. The role of organic agriculture in promoting biodiversity conservation, climate change mitigation, and sustainable rural livelihoods is critically examined. Furthermore, emerging opportunities, policy support mechanisms, and future research needs are highlighted to assess the potential of organic farming in contributing to long-term food security and sustainable development.

Keywords: Organic agriculture, sustainable farming, soil fertility, biodiversity conservation, eco-friendly practices

Introduction

The strengthening of conventional agriculture has played a crucial role in increasing crop productivity and meeting global food demands. However, the widespread use of synthetic fertilizers, chemical pesticides, and intensive mechanization has resulted in several adverse consequences, including soil degradation, contamination of water resources, loss of biodiversity, greenhouse gas emissions, and chemical residues in food products [1]. These challenges have raised serious concerns regarding the ecological sustainability and long-term resilience of modern agricultural systems.

Organic farming has emerged as a promising alternative that seeks to integrate agricultural production with natural ecological processes. Rather than focusing solely on yield maximization, organic agriculture adopts a systems-based approach that prioritizes soil biological activity, ecosystem stability, and resource conservation [2]. According to the Food and Agriculture Organization (FAO), organic farming enhances ecosystem health by relying on biological, cultural, and mechanical methods instead of synthetic inputs [3]. Similarly, the International Federation of Organic Agriculture Movements (IFOAM) defines organic agriculture as a production system that excludes synthetic agrochemicals and genetically modified organisms while emphasizing natural nutrient cycling and biological pest regulation [4].

Driven by growing environmental awareness and consumer demand for safe and nutritious food, organic farming has expanded rapidly across both developed and developing regions. Its holistic nature makes it an important component of sustainable agriculture and climate-resilient food systems.

Principles of Organic Farming

Organic farming is guided by a set of ethical and ecological principles formulated by IFOAM, which provide the philosophical foundation for organic agricultural practices worldwide. These principles emphasize interconnection between humans, ecosystems, and agricultural resources.

Principle of Health

This principle stresses the importance of maintaining the health of soils, crops, animals, and humans as a unified system. Organic farming enhances soil fertility through composting, crop rotations, and green manuring, which support diverse microbial populations and efficient nutrient cycling. Healthy soils produce robust crops with improved nutritional quality and minimal chemical contamination, thereby safeguarding both environmental and human health [1, 4].

Principle of Ecology

Organic agriculture is rooted in ecological processes and aims to work in harmony with natural systems. Practices such as crop diversification, agroforestry, and habitat conservation promote biological interactions that regulate pests and enhance ecosystem services. By reducing dependence on synthetic inputs, organic farming minimizes pollution and contributes to climate change mitigation through increased soil carbon sequestration [3, 5].

Principle of Fairness

The principle of fairness emphasizes social justice, ethical trade, and equitable access to resources. Organic farming seeks to ensure fair livelihoods for farmers, safe working conditions, and responsible treatment of animals. It also promotes intergenerational equity by conserving natural resources for future use [2, 4].

Principle of Care

Given the complexity of agroecosystems, organic farming adopts a precautionary approach toward new technologies. The avoidance of genetically modified organisms and hazardous chemicals reflects a commitment to protecting ecological integrity and human well-being. Transparent decision-making and adaptive management are central to this principle [4].

Key Practices in Organic Farming

Organic Nutrient Management

Organic farming relies heavily on organic manures such as compost, farmyard manure, vermicomposting, and green manures. These inputs improve soil structure, increase organic carbon levels, and enhance microbial activity, resulting in sustained nutrient availability and reduced soil erosion [6].

Crop Rotation and Diversification

Planned crop rotations help balance nutrient uptake, suppress weeds, and interrupt pest and disease cycles. The inclusion of legumes enhances biological nitrogen fixation, thereby reducing the need for external nutrient sources [5].

Biological Pest Control

Instead of synthetic pesticides, organic systems employ natural predators, parasitoids, microbial agents, and botanical extracts such as neem. These approaches maintain ecological balance and reduce environmental contamination [7].

Weed Management

Weed control is achieved through mechanical and cultural techniques including mulching, intercropping, hand weeding, and tillage. These practices suppress weed growth while simultaneously improving soil health [8].

Seed Selection

Organic farming favors locally adapted, disease-resistant, and organically produced seeds. Such varieties enhance resilience to biotic and abiotic stresses and contribute to the conservation of genetic diversity [9].

Benefits of Organic Farming**Environmental Advantages**

Organic farming improves soil health, enhances water retention, and reduces soil erosion. The elimination of synthetic agrochemicals significantly lowers the risk of water pollution and protects aquatic ecosystems. Additionally, organic systems support greater biodiversity at both farm and landscape levels [1].

Human Health Benefits

Organic foods contain fewer pesticide residues and may have higher levels of antioxidants and essential micronutrients. Reduced exposure to harmful chemicals contributes to improved consumer health, while organic livestock practices limit antibiotic use, helping to curb antimicrobial resistance [10].

Socio-Economic Benefits

Although organic farming can be labor-intensive, premium market prices and reduced input costs can improve long-term profitability. Organic agriculture also generates rural employment, supports smallholder livelihoods, and strengthens local food systems through direct marketing channels [2].

Limitations and Challenges**Yield limitations**

Organic yields are often lower than those of conventional systems, particularly during the transition phase. Yield gaps vary depending on crop type, climate, and management practices [11].

Labor and Input Availability

Higher labor requirements and limited access to organic inputs such as certified seeds and bio-fertilizers can restrict adoption, especially in regions facing labor shortages [6].

Certification and Market Barriers

Certification procedures involve financial costs and administrative complexity, which may discourage small-scale farmers. Market access and price volatility further affect income stability [11].

Global Status of Organic Farming

Organic agriculture is practiced in over 190 countries, covering more than 76 million hectares worldwide. Australia holds the largest area under organic management, while India has the highest number of organic producers. Europe and North America dominate organic food consumption, driven by strong consumer demand and supportive policy frameworks [12]. Despite steady growth, organic farming still represents a small share of total global agricultural land.

Future Prospects**Climate Change Mitigation**

Organic practices enhance soil carbon storage and reduce greenhouse gas emissions, contributing to climate change mitigation and adaptation [13].

Technological Integration

Precision agriculture tools, digital platforms, and decision-support systems can improve efficiency and productivity in organic farming systems [1].

Policy Support and Capacity Building

Supportive policies, financial incentives during conversion periods, and farmer training programs are essential for scaling up organic agriculture [14].

Research and Innovation

Continued research on organic nutrient management, bio-fertilizers, and ecological pest control is vital for improving yield stability and system resilience [15].

Conclusion

Organic farming offers a sustainable pathway for addressing environmental degradation, climate change, and food safety concerns. Although challenges such as lower yields and certification barriers persist, the long-term ecological, health, and socio-economic benefits make organic agriculture a practicable component of future food systems. Strategic policy support, technological innovation, and capacity building will be crucial for realizing its full potential.

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