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Environment and Sustainability

Volume III

Editors

Dr. Mamta Shukla

Dr. Vinayaka K.S

Dr. Gyanendra Kumar

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Editors

Dr. Mamta Shukla

Department of Biotechnology,

Faculty of Engineering and Technology,

KMCLU, Lucknow

Dr. Vinayaka K.S

Department of Botany,

Sri Venkataramana Swamy College,

Bantwal, Dakshina Kannada, Karnataka

Dr. Gyanendra Kumar

Department of Zoology,

National P.G. College,

Lucknow

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PREFACE

We are delighted to publish our book entitled ***"Environment and Sustainability Volume III"****. This book is the compilation of esteemed articles of acknowledged experts in the fields of basic and applied environmental science.*

This book is published in the hopes of sharing the excitement found in the subject. Environmental science can help us unlock the mysteries of our universe, but beyond that, conquering it can be personally satisfying. We developed this digital book with the goal of helping people achieve that feeling of accomplishment.

The articles in the book have been contributed by eminent scientists, academicians. Our special thanks and appreciation goes to experts and research workers whose contributions have enriched this book. We thank our publisher Bhumi Publishing, India for taking pains in bringing out the book.

Finally, we will always remain a debtor to all our well-wishers for their blessings, without which this book would not have come into existence.

- Editors

CONTENT

IMPACT OF ARTIFICIAL INTELLIGENCE ON ENVIRONMENTAL SUSTAINABILITY

Pawanjeet Kaur* and Amardeep Shahi
School of Engineering and Sciences,
GD Goenka University, Gurugram, Haryana
*Corresponding author E-mail: pawanjeet514@gmail.com

ABSTRACT:

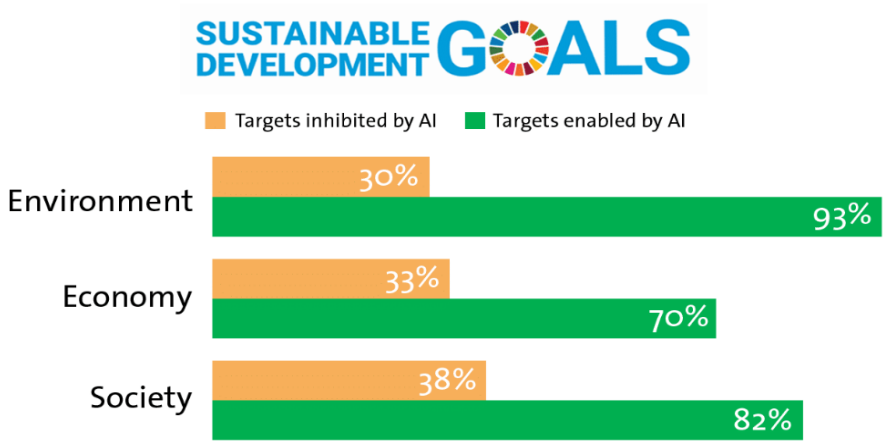
The environment is the base and support for human existence and its protection has become a serious consideration across nations. Artificial intelligence plays a crucial role in improving environmental quality from all points of view. It has emerged as a powerful tool to solve real-world problems. AI techniques have been employed in water treatment and desalination to optimize the process and to propose applied solutions to water and air pollution. AI is also used in detecting energy emissions and helping in their reduction. It helps in monitoring deforestation and predicts extreme weather conditions for land use, vegetation, forest cover, and the fallout of natural hazards. AI can pave the way toward pursuing the Sustainable Development Goals (SDGs) for protecting our environment. AI technologies and algorithms help monitor pollution levels, reduce energy usage, and better understand the effects of climate change. AI can be used to optimize energy generation and demand in real-time. Better AI systems will increase predictability and increase efficiency, and the use of renewable energy. Artificial Intelligence helps to improve significantly towards reaching environmental sustainability in different areas such as biodiversity, energy, transportation, and water. This chapter highlights the rise of artificial intelligence (AI) and its increasingly wider impact on many areas, along with an assessment of its effect on the achievement of the Sustainable Development Goals.

KEYWORDS: Artificial Intelligence, Environmental Sustainability, Waste Management, Renewable Energy, Sustainable Development Goals.

INTRODUCTION:

In recent years, the environmental problems like climate change, pollution, biodiversity loss, land degradation, ocean acidification, natural resources deprivation, etc. have arrived as a huge challenge, due to which the environmentalists developed an interest in new technologies,

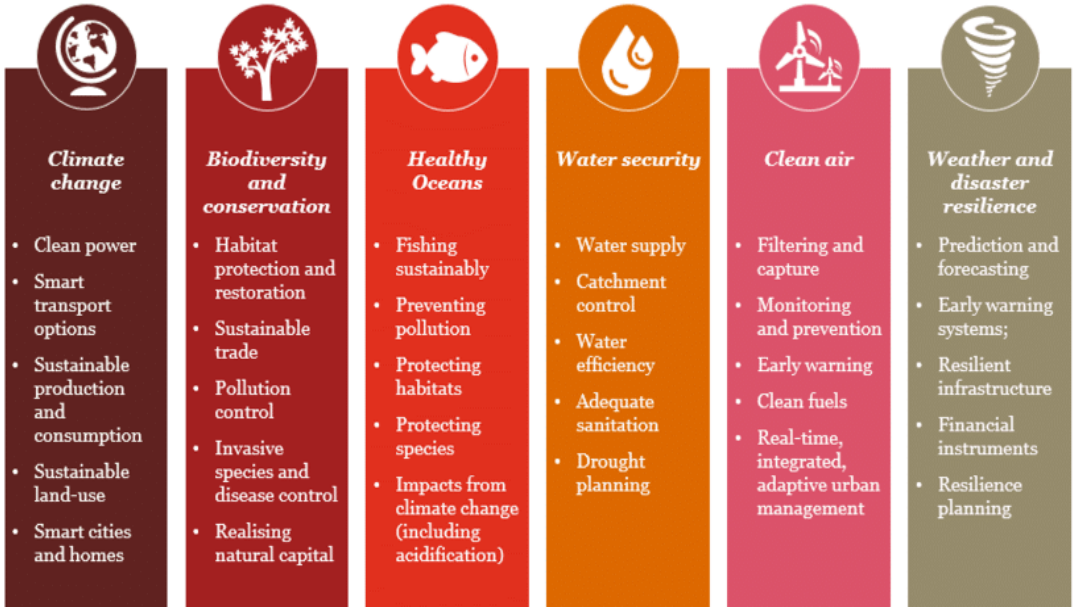
like Artificial Intelligence (AI), Internet of things (IoT) and Machine Learning. AI is applying the power of machine learning to finding patterns in data that can help in almost every environmental sector like natural resources, biodiversity and water conservation, waste and pollution control, and various agricultural practices. Many reputed companies like Microsoft, Google, and Tesla are working on AI-based systems and due to ***Deep Mind AI***, Google has reduced the annual greenhouse gas emissions by 40% by improving the energy efficacy. Tesla's AI-ML technology is not only giving the benefit of *Full Self-Driving*, but also access the traffic condition. Microsoft's AI system ***AI for Earth*** (2017) is launched to resolve climatical variations, agricultural development, water crisis, and biodiversity preservation issues. The demand for AI is incredibly increasing in every field, it is not wrong is saying that AI will lead to environmental sustainability and will contribute the maximum share to the global economy.



How AI is helpful in Environmental Sector?

An evolving Artificial intelligence network of ground-based sensor technologies can track water measures, the sounds of ecosystems, chemicals infused in Earth's soils and the atmosphere above it. As scientists still struggle to predict climate changes and other potential environmental hurdles or bottlenecks due to a lack of algorithms for converting the collected useful data into required solutions, Some of AI's other functions around image and object recognition, conversational assistants, and autonomous systems are also helping to shift the tide in the battle against climate change. AI has the potential to accelerate progress towards a dignified life, in peace and prosperity, for all people and has suggested refocusing the use of this technology, which is responsible for self-driving cars and voice/face recognition smartphones, on sustainable development and assisting global efforts to eliminate poverty and hunger and to protect the environment and conserve natural resources. It will also assist in providing energy access to remote communities, setting up microgrids, and integrating renewable energy

resources. It also conserves the biodiversity or distinct species by tracking them. But then, AI mandates lots of energy for the storage of information needed to control AI systems, as it consists of deep learning models, and ultimate AI systems produce high carbon emanations.



Installation of smart grids in cities can utilize artificial intelligence techniques to regulate and control parts of the neighborhood power grid to deliver exactly the amount of electricity needed, or requested from its dependents, against the use of conventional power grids that can be wasteful due to unplanned power distribution. AI-driven self-sufficient automobiles are the future of the automobile marketplace due to their direction optimization, eco-driving procedures, and ride-sharing facilities, which will ultimately reducing the carbon emissions as well as dropping the overall number of vehicles on the highway.

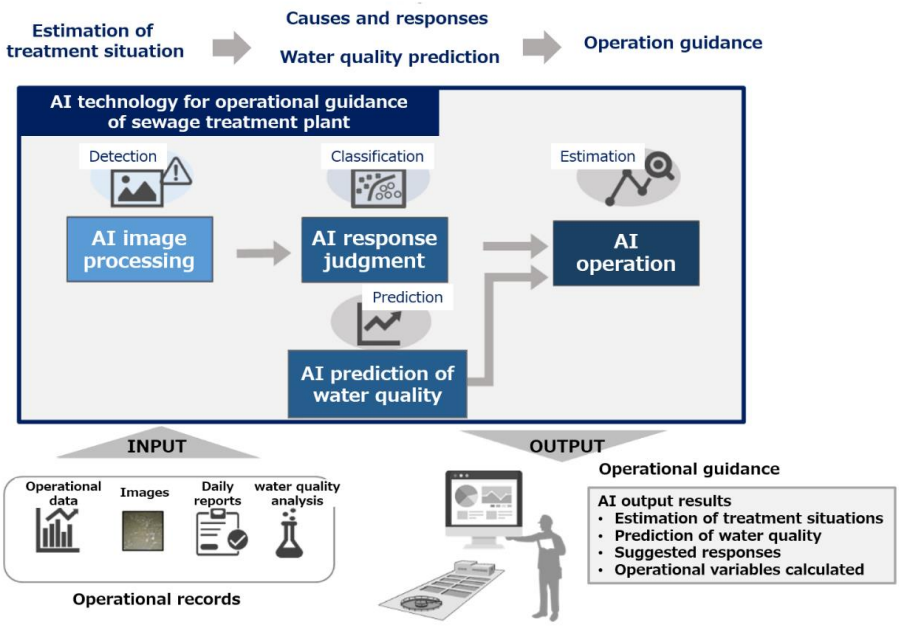
Using AI to counterbalance climate change

Artificial intelligence and machine learning systems can identify even the small changes in the usage of environmental resources, control issues in real-time, and adapt to make sure that industries minimalize waste. So artificial intelligence can support our environment by solving long-term environmental challenges, for example, Microsoft's AI for Earth program is using AI to address environmental damage, where experts conduct environmental research on a global basis and work to fight climate change issues, also can detect the establishments of algal buds that harm freshwater bodies around the world. AI programs and climate informatics can foresee complex weather patterns which can be helpful to study the amount and nature of climate changes along with their short-term impressions worldwide with maximum accuracy. AI is also beneficial for agriculturalists as they can find the ideal time for applying fertilizers or insecticides to the soil, perfect dates for planting, disasters related information or using

renewable energy resources for nonstop power supply, and hence improve the crop yield. AI can track the population of the nation, suitable ecosystems and migration patterns for migrants.

Role of AI in water treatment

With the help of artificial intelligence, the municipalities can properly manage their water storage and wastewater systems, which eventually delivers a clean and disinfected water supply. AI predicts equipment failures with sensors in wastewater treatment plants. AI can lessen the toxins in the water which reduce the water contamination as well as the shortage of clean water. AI can also predict the drought areas, water scarcity, as well as flood areas. AI can also sense the pollution levels, temperature and pH of the oceans. AI senses the quantity and arrangement of toxic pollutants in water, and can increase the efficiency of waste management systems. Hence, many industries are relying on AI for the sanitized water supply in India.



High carbon emissions of AI

Although AI is addressing a few environmental challenges and can be successful in dealing with ecological degradation, it is increasing carbon emissions due to its high voltage graphic processor units and machine learning training which mandate the higher consumption of energy or natural resources. It is not wrong in saying that AI is not appropriate for sustainability management and decision-making in high-resolution local/human-centered data. Sometimes it can exceed the capacity of a human to recognize all the interactions and causations provided by the AI programs. Hence the AI programs require crucial modifications to ensure environmental protection. To address the limitations in AI systems there is a requirement for a smart system, human or machine, that can intensely understand multi-dimensional problems and gives

solutions to complex socio-economic-environmental systems. Although it is increasing the carbon emissions, yet, it supports scientists in finding the innovative materials for solar sheets, heat transfer, and permeable materials for CO_2 scrubbers. A substantial barrier to the development of sustainable societies arises from the complexity of socio-economic-environmental systems, the complexity that a common approach to make sense of this complexity is to develop indexes or collections of indicators.

CONCLUSION:

Artificial intelligence is progressively becoming a part of our daily lives, and its impression can be perceived through the progressions made in the area of environmental sciences and management. With the growing demand for computerization and robotics, the solutions required high accuracy data-study for environmental challenges, and hence almost every sector is moving towards these AI-driven technologies, which can be a total game-changer on the economic front as this field can provide jobs to many jobless engineers if they have the knowledge of Artificial Intelligence (AI). So, there is a requirement to bring in more scientists and inventors to this technology. AI has both advantages and disadvantages for the environment. On one side it is growing the industry efficiency and lower energy costs, but on the other side, the training of AI requires a lot of energy, which uses our valuable natural resources. So, the scientists need to work on that to ensure that the training of AI does not increase carbon emissions. They must certify that the data AI is providing, are transparent, fair, and trustworthy so that on the basis of that it can be helpful in environmental sustainability.

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IMPORTANCE OF ARTIFICIAL INTELLIGENCE IN EVERYDAY LIFE

M. Kiruthiga Devi[1], Unnamalai K[2] and B. Deepa[3]

[1]Department of IT, Dr. M. G. R Educational and Research Institute, Chennai, India

[2]Department of Computer Science, Anna Adarsh College for women, Chennai, India

[3]Department of IT, Sri Sai Ram Institute of Technology, Chennai, India

Corresponding author E-mail: kiruthiga.it@drmgrdu.ac.in, unnamalaik@gmail.com, deepa.it@sairamit.edu.in

ABSTRACT:

In the modern world, artificial intelligence is developing quickly thanks to new cutting-edge breakthroughs every day. Modern computer systems are built to do simple tasks like driving a car, recognising faces, and other menial jobs. The main objective of artificial intelligence is to create more sophisticated and complicated systems that can perform better than humans in any situation. The execution of more challenging tasks like playing chess and completing equations falls under this category. As a result, AI's long-term objective is to advance all human endeavours and offer superior solutions to issues that humans are incapable of solving. Long-term issues will arise from an automated system that performs all human tasks, from driving cars to operating computerized business systems. As a result, the emergence of super AI that engages in self-improvement and sparks an explosion of intelligence would far surpass human intellectual potential. The greatest invention in human history will be the creation of a super AI. As a result, the development of effective disease-fighting techniques and preventative measures has benefited greatly from the development of more complex technologies. Additionally, cutting-edge technology would be very beneficial in the fight against poverty.

KEYWORDS: Artificial Intelligence, Disease-fighting, Cutting-edge, Technology, Face Recognition

INTRODUCTION:

Artificial intelligence, also known as machine intelligence, is the ability of machines to simulate human intelligence. It can act and think like a person since it has been developed and created by developers. AI now plays a significant role in daily life. AI technology is applied in a variety of daily functions. Human effort is reduced by this technology. This technology is being used in many different industries to create autonomous robots that can carry out a variety of

tasks. The equipment can expedite operations and processes while producing accurate results. Since the 1990s, technological advancements have greatly increased, and human performance in many activities has improved even more (Frey and Osborne, 2017). The idea of AI as a field of study was closer to science fiction. However, the concept of AI is no longer a fantasy but rather a reality that permeates our daily lives. As a result, "machine learning" employs neural networks to replicate the functioning of genuine neurons. Machines can now interpret complex data and deliver precise information thanks to AI (Iqbal *et al.*, 2016). The era of AI's greatest advancements and advancements is now upon us. Consequently, AI has been the most cutting-edge technology. As a result, it will take up much of technology's attention for a long time. It is significant to mention that AI has transformed people's lives for the better. Notably, the incorporation of AI technology has a strong connection to enhancing people's daily activities.

AI's effects on daily life:

Artificial intelligence has a significant impact on how we conduct our daily lives. If someone from the 1950s travelled through time and arrived in 2019, they would be astounded by how we navigate with our smartphones, how our questions are answered by virtual digital assistants like Alexa and Cortana, and how dependent we are on social media sites like Facebook, Instagram, and Twitter. To our companion from the past, what is now commonplace and driven by AI would have been completely alien. Artificial intelligence, without a question, plays a significant role in our daily lives. It is utilized in routine tasks like social networking, Self-Driving, parking vehicles, Digital assistants, Face recognition, Personalised Digital Marketing etc.

Social Networking:

Users find it simpler to find and contact friends and colleagues thanks to artificial intelligence. Twitter has started using artificial intelligence behind the scenes to improve their services, from tweet suggestions to preventing offensive or racist content and boosting user experience. Deep neural networks are used to handle a lot of data, and they gradually learn the preferences of users. Facebook's unstructured datasets, which are produced by over 2 billion users updating their status 293,000 times every minute, are being more effectively mined by deep learning. The Torch framework, which focuses on deep learning techniques and neural networks, serves as the foundation for the majority of its deep learning technology. Big data and artificial intelligence are also used by Instagram to target advertising, stop cyberbullying, and remove abusive comments. Artificial intelligence is essential to the platform's ability to display users

stuff they might be interested in, combat spam, and improve the user experience as the platform's content volume increases.

Autonomous vehicles:

Due to increased business interest globally, autonomous vehicle technology with AI innovation is developing. AI is developing to have fully autonomous skills beyond cruise control and blind-spot detection. Deep Reinforcement Learning (DRL), a type of machine learning, is being used to teach vehicles how to operate on their own. Artificial intelligence's job is to foresee potential obstacles, both static and moving when preparing a route. In response to nearby automobiles and other unforeseen conditions, it swerves. Real-time sensor-based orientation to the environment is made possible by Simultaneous Localization and Mapping (SLAM) technology. Toyota, Mercedes-Benz, Audi, Volvo, and Tesla automobiles already have the company's AI-powered technology, which is set to transform driving habits and enable self-driving cars.

Face recognition:

One of the most common applications of artificial intelligence in daily life is face detection. It uses artificial intelligence's image processing technology to recognise faces by measuring the space between two eyes, the face's form, its edges, and other characteristics. Modern cellphones frequently have the face ID unlock feature. Generative Adversarial Neural Networks (GANN) are used in face recognition software to reduce the margin of error. Additionally, the ability to spot Deepfake technology fraud is being developed using these neural networks. Several industries are also working on developing AI software that reads facial expressions to understand mood and intent. Affective computing, often known as emotion AI, is a developing topic of research for gauging customer pleasure.

Digital assistant:

Consumer platforms like Amazon Alexa, Apple's Siri, and Google Assistant conduct searches, make to-do lists, place online orders, set reminders, and respond to questions. Your daily routines can be automated by integrating them with your smart home and entertainment systems. Algorithms are used to train machines to serve customers using chatbots or conversational interfaces. Complex queries needing in-depth answers can be answered by sophisticated chatbots, giving users the appearance that they are speaking with a real customer service agent. Commercial enterprises are saving money by lowering labor costs and improving the customer experience thanks to artificial intelligence in web apps like chatbots. To decode the

vocal orders of their masters, voice assistants like Google Home, Siri, Cortona, and Alexa are supported by AI[8]. These applications use databases from cloud storage systems with the aid of AI in order to return customised search engine results. Additionally, voice assistants are used in the medical field to identify disorders via vocal biomarkers. Voice-based chat boxes are made available for screening and categorization in telehealth apps.

Financial sector:

The AI technology is utilized in the Banking, Financial Services and Insurance (BFSI) sector to manage a wide range of tasks, including stock investing, financial processes, and much more[3]. The use of AI technology can assist the bank offers their clients improved services and hassle-free banking options[4]. One of the most extensively used AI applications across sectors, chatbots offer a good return on investment in terms of cost savings.

Personalized digital marketing:

Brands utilise AI-driven personalisation tools based on consumer data to boost engagement. 88 percent of surveyed consumers believe that more tailored content improves their opinion of a company, according to a OneSpot Research analysis. Recent AI developments assert that they can utilise computer vision to forecast how well an advertisement will function, helping firms target the correct customers and fulfill their needs [1]. Join the Digital Marketing Course in Chennai to learn the inner workings of marketing and become the wolf in the marketing pack. AI marketing tools can help both prospects and retargeted customers, depending on the marketing stage. For clients to choose from the numerous product collections of online stores combine with Augmented Reality. Commercial enterprises are able to optimize their logistics with the help of automated warehouse and supply chain management systems powered by AI, while sentiment analysis helps them stay more in touch with the preferences and behavior of their customers. AI is used by Amazon and other online merchants to compile data on your preferences and purchasing patterns. Then, they customise your browsing experience by making fresh product recommendations based on your preferences.

Security and surveillance:

The security profiles of the corporations and governments that use drone surveillance, AI-based facial recognition, and biometric systems are improving. Despite the advantages, there are unavoidably worries about privacy, espionage, and the "Big Brother" effect. It is nearly impossible for a human to continuously monitor numerous CCTV network monitors at once. Due to this, we were driven to automate these monitoring processes and enhance them using machine learning techniques [2]. Human observers may now concentrate on confirming information and

reacting to urgent circumstances thanks to artificial intelligence. The ongoing monitoring and detecting component of surveillance is handled by AI video monitoring software. Why do we need artificial intelligence when people can do the same thing with ease, one would wonder. Artificial intelligence can identify anomalous behaviour that human eyes would miss for this reason. An extension of AI-based facial recognition software is used in surveillance systems in high-risk public spaces, such as government buildings.

Artificial intelligence's primary function is to enhance cyber security measures. It functions by utilising information from prior threats and discovering patterns and signs that seem to forecast and stop attacks. AI can monitor internal threats or breaches and suggest corrective measures in addition to thwarting external attacks, preventing data theft or abuse.AI-based cyber security solutions can give you the most recent information on national and industry-specific threats, enabling you to prioritise tasks more wisely based on what is most likely to attack your systems rather than just what could be utilised to do so.

Healthcare:

The usage of AI technology in the field of medical science is widespread and has great utility. Analytics, research, and the creation of a personal health care assistant all make use of AI technology. Bots are created to provide customer service. It is used in hospitals to make appointments with 24-hour support. Artificial intelligence's image processing is useful for many different applications, including X-ray imaging, PET scanning, UV imaging, medical CT, and cancer cell image processing[5,6]. AI is becoming more and more crucial in the fields of health and life sciences, powering the computers that identify, examine, and forecast the progression of various diseases as well as those that keep track of patients' health. Robotics and AI technologies are also reducing the physical workload of healthcare workers and automating a number of administrative and regular tasks. Health providers may now work more effectively and efficiently thanks to AI, which has a positive impact on patient outcomes.

Gaming and Entertainment:

AI is used by music services to monitor your listening patterns. Then, they make recommendations for further songs you might enjoy based on the data. For instance, Spotify provides recommendations for recent releases, old favourites, and unexpected discoveries based on your listening preferences. Additionally, Google Play provides customised music recommendations. Its AI-powered suggestions give music that can set the mood for activities by taking into consideration variables like the weather and time of day. For instance, on a Friday night, you might be given the option of listening to dancing music, or on a rainy day, to gentle

acoustic music[10]. These apps utilise AI to sift through ever-growing user data to provide catalogues of music, movies, and TV series that are customised to each user's preferences.New developments in gaming Instead than determining the gamer's thinking, artificial intelligence has focused on providing more engaging tasks to the player. Some of these gaming programmes deliver Cognitive Behavioral Therapy (CBT) using Virtual Reality (VR) headsets for improved patient involvement. AI helps these games as they develop by helping them adapt to the player's behaviour based on analysed cues.

Navigation and Travel:

The programming for artificial intelligence that powers navigational apps like Waze and Google Maps never stops. Based on geographic images provided by the satellite, digital maps are produced. Artificial intelligence is significant because it aids in identifying routes on satellite images obscured by natural overgrowth by the use of predictive algorithms. The imaging techniques based on Convolutional Neural Networks (CNN) and Graph Neural Networks have made routine route adjustments simpler (GNN). Artificial intelligence (AI) is used when navigational apps like Google Maps analyze traffic and roadwork to determine the fastest route to your location. In the example below, Google Maps provides driving instructions based on the quickest path through typical traffic from Berlin to Potsdam. Where there is slower traffic, the route is highlighted in orange.

RISKS AND CONCERNS:

Artificial intelligence (AI) offers numerous advantages and a significant impact on daily life, but it also has some hazards for businesses. They have a close connection to the state and future growth of the sector. They can also be categorised according to the following four features:The complexity of AI algorithms varies depending on the problem at hand[11]. As a result, its creation and upkeep demand highly qualified developers and scientists. However, the industry has made significant progress, leading to the emergence of numerous high-level frameworks like Keras, TensorFlow, Caffe, etc[9]. that don't require in-depth understanding. Numerous factors, including complexity and data volume, affect the quality of a model. To find all links between the data and provide a decent result, early models and AI algorithms were simple. Recent algorithmic improvements allowed AI to perform better than humans. There are still some chores, though, that even even artificial intelligence can automate.

CONCLUSION:

Artificial intelligence has significantly enhanced people's lives in a variety of ways, and individuals are no longer the same as they were before AI was developed. As was already said, the application of AI has resulted in time savings, which have increased business and daily human activity production. Additionally, the advancement of AI has led to the reduction of human effort, computerized processes, automated transportation systems, and participation in hazardous employment. It is clear that AI has had a profound impact on people's lives and has worked wonderfully to aid in the automation process of nearly all of their operations. The majority of these approaches require a lot of time and labor-intensive manual labour. Automation of these operations with AI would significantly benefit current activities of people and industries and enable progress. The amount of data and complexity are just two of the numerous factors that affect a model's quality. Early models and AI techniques relied on simple rules to find all relationships in the data and produce accurate results. AI has recently outperformed human performance thanks to breakthroughs in algorithms. Still, there are some chores that even even artificial intelligence can automate

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EFFECT OF PHYSICOCHEMICAL PARAMETERS OF WATER ON DIVERSITY AND DISTRIBUTION OF PHYTOPLANKTON

Pinki Saini*, Shikha Ahalavat and Yugam Dhingra
Department of Zoology and Aquaculture, CCSHAU Hisar
*Corresponding author E-mail: sainipinki60416@gmail.com

ABSTRACT:

Phytoplankton is the first biological element by which solar energy is converted to chemical energy. It evaluates the level of pollution in the aquatic environment. Our mastery of phytoplankton diversity has been developing since Hutchinson's publication on the self-contradiction of the plankton. This study summaries effect of environmental gradients on phytoplankton community and their species richness. Here, we lay out a skeleton of the community of phytoplankton and its relation with environmental factors on its species richness. It reveals the correlation of phytoplankton with environmental gradients like Temperature, Light, pH, salinity, conductivity, dissolved oxygen, etc. It also describes the diversity index by which measurement of different kinds of species in a community takes place. In addition, we discuss species diversity which includes both species richness and species evenness.

KEYWORDS: Phytoplankton, Species richness, Species evenness, Community, Diversity index

INTRODUCTION:

The term 'phytoplankton' refers to the autotrophic component of the plankton that drifts in the water column. They consist of micro and macroscopic suspended or free-floating non-motile or weakly motile unicellular, colonial or filamentous algae. Phytoplankton is the first biological element by which solar energy is converted to chemical energy (Tiwari and Chauhan, 2006). Phytoplankton evaluates the degree of pollution in an aquatic environment (Mondhare and Pangle 1995) as it determines many types of physicochemical parameters of the aquatic body. The density of the phytoplankton community is directly correlated with nutrients and physical parameters of the aquatic environment. It is the best and primary food source for aquatic organisms like many kinds of fishes and zooplankton (Vajravelu *et al.,* 2018).

Phyto-planktons are one of the primary producers in this ecosystem having various groups of organisms. Productivity of aquatic habitat is directly correlated with phytoplankton density (Narasimha, 2013) as they are photoautotrophs. Phytoplankton plays an important role in

the utilization of organic matter and excess nutrient input found in the water column. It alleviates global warming, thereby reducing global CO_2 levels (Kumar *et al.,* 2012). Phyto-planktons not only evaluate the quality of water but also allow understanding of the population and life cycle of a fish community. The quality of water depends upon the nature of microalgae found in that water which directly affects the community and the quality of fish (Araoye, 2002). Thus the quality of phytoplankton also detects secondary productivity (Knosche and Barthelmes, 1998). Akbay *et al.,* 1999 were able to show that the quality of cladoceran and copepod depend upon the quality of phytoplankton, which is also important food for fish in Keban Dam, Turkey. In Nigeria, the qualitative and quantitative characteristics of physicochemical, phytoplankton, and zooplankton composition of various reservoirs were directly proportional to their fisheries potent (Kolo *et al.,* 2010).

Phytoplankton is responsible for the estimation of 80% oxygen of the total planet's oxygen for sustaining life. So, phytoplankton is an important component of the ecosystem, it liberates oxygen during photosynthesis and forms a food web in an ecosystem.

Planktons are minute members of algae communities of aquatic bodies like rivers, seas, lakes, and any others. They include thousands of members belonging to Chlorophyta, Cyanophyta, Euglenophyta, and Bacillariophyceae. Phytoplanktons are regulated by nitrogen and phosphorous dominantly and other environmental factors also. Environmental factors are positive as well as negatively correlated to the growth of phytoplankton.

In this study, we aim to focus on various issues regarding phytoplankton diversity. Some of the important issues are as follows-

- Correlation with environmental gradients (temperature, light, dissolved oxygen, pH, salinity, conductivity)
- Diversity index
- Species diversity
- Community variation with depth

Correlation with environmental gradients

From the environment, phytoplankton is influenced directly as well as indirectly. 1. Directly influences by light as well as temperature by which the process of formation of food, respiration, and reproductive growth takes place. 2. Indirectly it influences by salinity, hardness, and some other factors to which extent of algae can find.

Regular variation in temperature, light intensity, nutrients, and some other limnological factors decide the composition of the community of phytoplankton. In general, they showed their

normal annual cycle of growth while at some time they showed some fluctuations in their normal cycle of growth (Ghosh *et al.,* 2012).

Temperature

A measurement of the average kinetic energy of the atoms or molecules in a system, temperature conveys hot and cold. Higher temperatures can increase some specific phytoplankton species' growth rates because of photosynthetic carbon absorption. Increasing temperature by 10℃ can be doubling the growth of phytoplankton. Water temperature affects phytoplankton growth rate directly as well as indirectly; directly by impacting its metabolic and physiology rate and indirectly by impacting its growth environment. The metabolic processes like respiration, photosynthesis, and nutrient uptake al re temperature-dependent (Chisholm, 1992). Density and viscosity of water also depend upon water temperature, both determine the sinking rate of small particles such as phytoplankton. Changes in sinking rate determine the survivability of phytoplankton (Naselli-Flores *et al.,* 2020). The size of phytoplankton is also determined by temperature. Most studies reported that a change in temperature of 2 to 3℃ changes a few % of body size, this is due to errors in light microscopy. Seasonally, phytoplankton is high during the dry season as compared to the wet season. The optimum temperature range for growth of most micro-algae species was 16℃ to 27℃ (Kumar *et al.,* 2012)

Light

Light plays the most important role for primary producers. The presence of light quality and availability affect the abundance and distribution of phytoplankton. Phytoplankton growth linearly increases with the intensity of light at a limit after that, it starts to decline due to photoinhibition (inhibition of photosynthesis due to higher intensity light damage protein of cell) (Edwards *et al.,* 2015). Due to the presence of chlorophyll, the photosynthetic light absorption of phytoplankton's community is high (blue, ~460-490 nm).

Dissolved oxygen

Oxygen present in water comes from two sources mainly one is from the environment and the other is from plants present in water (i.e. micro algae especially) which is a very good source of oxygen for aquatic animals. Inorganic nutrients increased and cause algal bloom at higher density (Smith *et al.,* 1988*).* People can increase dissolved oxygen by algal bloom for the fish culture. Dissolved oxygen indicates the degree of pollution by organic matter so it has a negative correlation with dissolved oxygen (Ghosh *et al.,* 2012*).* due to high temperature in the dry season, there was recorded low dissolved oxygen (Akpan and offer, 1993a) while due to low

temperature in the wet season, there was recorded high dissolved oxygen (Ochang *et al.*, 2005). A high organic substance is found in the dry season due to low oxygen levels.

Salinity

The amount of salt dissolved in a water body is the salinity of that water body. Salinity showed a positive correlation with the phytoplankton community. At higher salinity of 40 ppt, diatom *Skeletonema costatum* didn't show growth (Rai *et al.,* 2014). Salinity showed decreased growth rate. Cyanobacteria showed a maximum growth rate at a salinity of 9 ppt (Rai et al., 2014). Cyanobacteria have the availability to tolerate halotolerant conditions due to respiration adjustment, increase cyclic electron transfer through the photosystem, and regular intake of Na ion. Some studies reported that higher concentrations of saline in phytoplankton had low chlorophyll content (Kirrolia *et al.,* 2011).

pH

It measures the concentration of hydrogen ions. The pH of any aquatic body decides the solubility and availability of chemical nutrients. Variation in pH can alter the growth of phytoplankton bloom. pH can change the availability of nutrients, carbon dioxide, and trace metals. Changes in pH can also change temperature and dissolved oxygen (Chen *et.al.,* 1994). Growth rate and photosynthesis both become decline at higher pH due to trace metal toxicity and low nutrient availability. Some of the heavy metals were more soluble at lower pH (Chen *et al.,* 1994). So it has a negative correlation with phytoplankton density. On decreasing PH some species of algae such as charophytes and green algae could tolerate the acidic stress. At pH 6.3, the growth of phytoplankton was measured low.

Conductivity

A material can conduct electric current or can say free ions that conduct electricity. There is a negative correlation with phytoplankton density (According to Dalu, Fronenman, and Richoux's hypothesis) because increased salinity in water can decrease chlorophyll content in water. With increasing conductivity, there has seen increasing phytoplankton density (Ghosh *et al.,* 2012).

Diversity index

It is a quantitative measurement that reflects different kinds of species in a community. It is phylogenetic relationships among individuals like richness, dominance, and evenness or divergence. Different kinds of indices are used for calculating species richness and species evenness. These are the Shannon diversity index (H′) (diversity), Simpson diversity index,

Margalef diversity index (species richness), and Pielou's evenness index (equitability). The formulae are as follows;

Shannon Diversity Index (H′)

$$(H') = -\sum (Pi \ln (Pi))$$

Simpson Diversity Index (D′)

$$D' = (1\text{-}D)$$

$$D = \frac{n\,(n-1)}{N\,(N-1)}$$

Pielou's Evenness Index (J′) (Pielou 1966)

$$J' = \frac{H'}{\ln(S)}$$

H′= Shannon Weiner Diversity

S= Total no. of species in a sample

Margalef Diversity Index

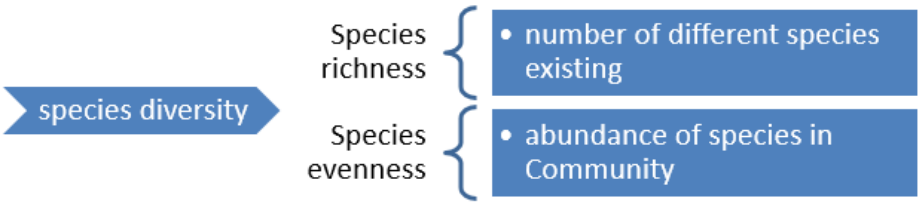
$$(D) = \frac{(S-1)}{\ln(N)}$$

S= number of species

N= total number of individuals in the sample

Species diversity

Species diversity is the most important characteristic of a community. The relative abundance and the number of species define the species diversity of a community. The number of species in a species evenness. Relative abundance can find by counting the number of individuals of each species in a community. It also determines the percentage of each species contributing to the total number of individuals of all species. If species in a sample have the same abundance, species evenness is highest. A pattern of abundance in a community can be determined by the number of individuals per species, percentage cover per species, and biomass per species. The diversity measurement is species richness, i.e. the number of species per unit sampling. Species richness depends upon the presence of nutrients available, nutrient availability, and the combination of N and P.



Case study 1:

Community 1	Community 2
Cyanobacteria 5	Cyanobacteria 7
Green algae 6	Green algae 15
Dinoflagellates 9	Dinoflagellates 8
Navicula 11	Navicula 13
Diatom 13	Diatom 18
	Blue-green algae 11
	Chaetoceros 9

Community 1	Community 2
Diatom	Cyanobacteria
Cyanobacteria	Green algae
Dinoflagellates	Diatom
Navicula	Chaetoceros
Green algae	Dinoflagellates
	Navicula
	Blue-green algae

Species richness

No. of species: 5 No. of species: 7 No. of species:5 No. of species: 7

Species richness: low, Species richness: high Species evenness: low, Species evenness: high

Community variation with depth

The community of phytoplankton varies with depth. Two vertical resources work together, one is light which penetrates the surface to depth and the other is nutrient which is found highest in-depth and low at the surface. The combination of these two vertical resources decides the community.

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BIOMONITORING OF HEAVY METAL POLLUTION

Gajanan M. Deshmukh

Smt. Sindhutai Jadhao Arts and Science Mahavidyalaya,

Mehkar, Dist: Buldana-443301 (M.S.) India

Corresponding author E-mail: gmdeshmukh16@gmail.com

Freshwater ecosystems are the most important water resources used for domestic, irrigation and industrial purposes. It supports wide range of plants and animals which are the important elements of biodiversity. Regular and safe water supply is essential for development and stability. Special interest needs for conservation, management and sustainable utilization of water resources. The rapid development of industrial and agricultural sector promotes the increase of environmental metal pollution. Essential metals such as copper (Cu) and zinc (Zn) are necessary for life, whereas mercury (Hg) and cadmium (Cd) are not useful to perform any biochemical function.

SOURCES AND TOXICITY OF HEAVY METALS

The heavy metal pollution in aquatic environment has been constantly increasing due to release of metal ions by use of fertilizers and pesticides in agriculture, slow leaching of soil or rock to water, domestic use, mining activities, steel plants, tannery and thermal power plants, battery industries resulted in decline of water quality which results into serious environmental problems causing threat to human health. The zinc is essential element abundantly available in nature it is used in catalyst, fertilizers, wood preservation, paints and batteries. The higher level of zinc exposure to human can leads to anemia. Erosion of mineralized rocks is the natural source of copper in aquatic ecosystem. Production of chemical catalysts, electrical equipments, wood preservatives and antifouling agents are the anthropogenic sources of copper in aquatic environment. Acute exposure to copper causes hypotesion, hematemesis, jaundice and coma. Chronic exposure to copper can result into damage of kidney and liver. Lead is highly toxic metal, microscopic in size and invisible to naked eye, exposure to which can cause adverse effect on health. Humans are exposed to lead through drinking water, food, air, bare soil, ceramics and hair dyes. In children's under the age of six low level of exposure can result in stunted growth, kidney damage, learning disabilities and reduced IQ. High levels of lead exposure to child causes fall into coma, become mentally retarded and even death. In adults lead can cause fertility problems, increase blood pressure, nerve disorders and irritability. Cadmium is routinely used in

different industrial processes and its higher concentration causes several health problems in human. Drinking water or eating food with high level of cadmium can causes vomiting, diarrhea and sometimes death. Low level of exposure to cadmium over long period of time can lead to accumulation of cadmium in the kidney the high level of cadmium in the kidney will ultimately damage the kidney. Agricultural and industrial waste increases arsenic level in the aquatic ecosystem. Common symptoms of acute arsenic poisoning are nausea, muscle cramp, abdominal pain, dermatitis, hepatotoxicity, cardiac abnormalities, vascular lesions and haematologic abnormalities (Franzblau and Lilis, 1989).

Heavy metals increase into aquatic ecosystem through human activities, traffic and industrial emissions (Nriagu and Pacyna, 1988, Mukherjee, 1989). Heavy metals are important pollutants among other inorganic contaminants because of their non-degradable nature and capacity to accumulate through tropic level causing a deleterious biological effect on organisms (Jain, 1978). Heavy metals may be uptaken by aquatic organisms through body surface, across the gills and gut lining through which ingestion of food takes place (Sanders, 1997). According to Jin (1992) some heavy metals may convert into the constant metallic compounds with high toxicity, which can be bioaccumulated in the aquatic organisms, magnified in the food chain and ultimately threatening human health.

BIOMONITORING OF HEAVY METALS

Biomonitoring is technique based on analyzing an organisms tissue and fluids which provides knowledge of chemicals that have entered in the body of organism and biological changes takes place in the organism that is the result of chemical on that individual. Biomonitoring indicates the pollution stress applied by the pollutants on organisms. Biomonitoring is assessment of aquatic ecosystem based on organisms living in it. Heavy metals bioaccumulated in the plants and animals when they are exposed to lower concentration of metals for a longer period of time. Biomonitors used in biomonitoring should possess following characters: Biomonitors should be abundant throughtout the ecosystem, pollutants should be accumulated without lethal impacts, biomonitors should be long lived, biomonitors should be sedentary, biomonitors should be easy to sample, biomonitors should provide sufficient tissue for analysis, they can survive under laboratory conditions (Connell et al., 1999; Phillips and Rainbow, 1994). Biomonitoring is carried out mostly by analyzing algae, plants, fishes and invertebrates present in the aquatic environment.

BIOINDICATORS OF HEAVY METALS

Bioindicator is defined as a plant or an animal which indicates the presence of a pollutant in its surrounding area by showing some typical symptoms which can be due to the effects of that pollutant stress (Mhatre, 1991). Perfect bioindicator has following expected characters:

1) It remains alive in water for longer period of time
2) Its life is long enough for the comparison between various age group animals
3) It has main position in the food chain
4) It can accumulate pollutants at higher level without death
5) It has sufficient abundance in the ecosystem
6) Its wide distribution helps for the repetitious sampling and comparison
7) It has suitable target tissue for further analysis
8) It lives in such a position which definitely indicate the local pollution
9) It can detect well dose-effect relationship (yan and lv, 1989)

BIOACCUMULATION OF HEAVY METALS

Bioaccumulation is the process of accumulation of pollutants in the aquatic organisms as compared to water due to uptake by all exposure routes including respiratory surfaces, dermal absorption and uptake of food. The level of bioaccumulation in the body of aquatic organism determines quality of water and sediment. Aquatic organisms accumulate pollutants in their body which is important task in improving water quality which prevent risks to public health. Heavy metal concentrations continuously increased into aquatic ecosystem through various natural and anthropogenic sources. Increased concentrations of metals may lead biomagnifications in aquatic organisms. Bioaccumulation of metals in the aquatic organisms takes place through intake of contaminated water or ingestion of food in the aquatic environment. Heavy metals present in aquatic environment are major risk for number of flora and fauna species of aquatic ecosystem and including humans through food chain (Boran and Altinok, 2010).

Traditionally, heavy metal monitoring has been carried out by analyzing the concentration of heavy metals in water and soil sediment. This technique does not show relation between the metal concentration in environment and availability of metals in the body of aquatic organisms. This technique also unable to show harmful effect of pollutant on aquatic organisms. Thus there is need to use the biomonitoring organisms to assess metal pollution in aquatic ecosystem.

Lentic and lotic ecosystems are important sources of water for living organisms. Water quality is important for use in drinking, aquaculture, agriculture and industrial purposes hence

there is a need to provide special attention for conservation and sustainable utilization of these resources. Pollution of aquatic ecosystem is one of the main environmental problem faced throughout the world. Human health is affected by ingested dosages of heavy metals through drinking water or food causing nausea, stomach problems, vomiting, complications in blood, kidney, lung, pancreas and brain, as well as weakness in immune and nervous systems and even death. Heavy metal pollution is also very dangerous to unborn fetuses and young children's. The health of aquatic ecosystem is severely affected by pollutants from natural and anthropogenic sources. Thus there is an urgent need to remove these heavy metals from wastewater before it entering into aquatic environment.

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ENVIRONMENT AND SUSTAINABILITY

Ravindra B. Tembhurne

S. P. M. Science and Gilani Arts Commerce College,

Ghatanji, Dist. Yavatmal, Maharashtra

Corresponding author E-mail: tembhurne277@gmail.com

INTRODUCTION:

Environment is alarming topic in the future for global discussion than the war and peace, it simple means that it is utmost important than any other topic in the world, so the neglecting of environment is nothing but the "Saw off the branch we're sitting on ". The environment degradation and depletion speed is increasing more and more as the vehicle, industries and tree cutting are taking place speedily whereas the sustainability measures is less implemented. The US Environment Protection Agency regulates the norms and EPA sets standards about quality of water, air, soil, pollution, fumes, factories waste, garbage savage, poisonous gases, hazardous chemicals, medical and other toxic waste and such all things that spoil the environment and its sustainability. Why Europeans use bicycles mostly for their nearby travel, it's for pollution free nation, today most of the country are using the Electric vehicles for it, this is what we expect for environment and sustainability various rules regulation guidelines, laws, and social, customs, tradition awareness to protect the nature and its depletion.

OBJECTIVES:

1) Economic growth and environmental sustainability:

Industrial growth is expected to grow more and more for entire growth social, economic and political but the; companies and industries have responsibility to safeguard the environment too. The degradation takes place from illiterate people also but don't they think that every small item they produce should have warning over its wrappers for throwing elsewhere; the plastic bottle also should have warning not to throw anywhere, as the Himalaya turning quite debris of plastic bottle due to mountaineers and pilgrimages. Economic development is essential but poisonous water, gases, chemical, waste and all type of pollution should be recycled to purify it after use.

2) Securing for future generation:

Today it is frightening situation to utter that, will next generation see the ample natural resources they required in need ? or now we will finish it speedily with greed or with pollution or degradation or with environmental depletion we will finish that it is just a myth, if the such type of environmental harming is continued then one day will be when natural resources scarcity will create great problems to the next generation.

3) Natural resources preservation:

The modern age though depends upon the factories and industries but the natural resources are the main factor for running them and today it is in danger due to global warming, less rain and changes in environment affecting the earth and its environment the, living agents which is most important for life cycle and its rotation is essential if affecting due to environment depletion. So preserving the environment means preserving the resources and protecting our industries and companies and enterprises and businesses.

4) Embedding sustainability in education:

Spreading awareness and planting the themes in children and students will work in future for environment protection they will understand well the importance of environment through education. The will boost the step ahead when the education will be in practical based with social approach and projects and conferences, social activities and programs to uplift the environmental and sustainability.

5) Environmental, Social, and Governance:

The capital goals and achievements for profitability and turnover turns towards them to greediness so this concept should be politely applied by every companies ESG so that the rules regulation, measures to control the environment degradation and pollution as well as the industrial waste before production, before sale, after sale also, how it is then it may spread awareness with advertising, selling strategies, attractive offers. Schemes, etc. this will help to; control the environmental and sustainability.

6) Annual environmental inventory results:

UNEP is monitoring its greenhouse gas emission since 2008 India should commence strategy for environmental monitoring platform and should publish its report with information of greenhouse gas emission, report of waste management, purifying plants, poisonous gas monitoring, ;pollution monitoring from every sector of nation as well as social and native pollution too.

7) Organizing sustainable events:

Environmental Sustainability activity is very important and it is integrated in to large events Such as the Organizing the green and carbon neutral events for improved environmental sustainability Various initiatives is expected for environmental protection and sustainability related with carbon and gas emitting water which is most reasons for pollution.

8) Moving towards renewable energy:

Though the technological development resulting destruction and exploitation of natural resources still it can be helpful to reestablish the environment so for what with renewable energy as well as recycling and purifying as well as the repairing the environment with technology such

as; pollution control management with technology water purification savage management and maintaining the natural resources as it is using renewable energy is best measures toward environmental and sustainability.

9) Eco designing for ecological and environmental sustainability:

It is just conservation approach protecting the creature flora fauna, biodiversity, regenerating capacity, reuse habit and process development promoting biofuels and solar energy to stop depletion and degradation of natural resources for environmental sustainability.

10) Faith based organization for achieving environmental sustainability:

It is believed that the social and cultural as well as religious spiritual faiths beliefs are main drivers for cultural values and economic prosperity. The faith based activities are more protective for environmental sustainability as the human are stronger before laws but more weak before super natural power and faith beliefs etc. so it can be helpful for protecting the environment.

Importance of Environment and Sustainability:

1) For creating ecological balances and promoting natural habitat for all life,
2) Promoting the animal, creatures, species, sustainability and helpful for human life
3) Global warming and Ozone layer solution is environment and sustainability.
4).Poverty and disease are interrelated is eradicated by environment and sustainability.
5) Natural calamities Tsunami earthquake, drought is aim of environment sustainability.

CONCLUSION:

It is concluded that the environment and sustainability is todays burning question with do or die situation as the natural resources are limited the environment is also polluting day by day, the water resources and ice of glaciers are melting by global warming, endanger species and valuable creatures are vanishing so it is emergency to protect these all otherwise it can be seen in books only and next generation will deprive from such benefit.

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A REVIEW ON ORGANIC MANURE USING EARTHWORMS AS WASTE MANAGEMENT

Sindhu M. and Annapoorani C. A*

Department of Zoology, School of Biosciences,

Avinashilingam Institute for Home Science and Higher Education for Women,

Coimbatore- 641043, Tamil Nadu, India

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

ABSTRACT:

Organic waste is generated by agricultural activities and it leads to challenges for its safe disposal, with the waste either burned or land filled. Major environmental challenges associated with waste generation and inadequate disposal causing negative impact on environment. The type of methods that should be applied for proper management of waste depends on the states like liquid or solid or sludge composition of waste. Earthworms have an ability to consume all organic material digests and produce good organic fertiliser called worm casts. Within a short period of time earth worm's intake its food and give us valuable manure and also give products like vermiwash and vermicompost. Vermicompost contains rich nutrients for the growth of plants.

KEYWORDS: Plant waste, Cow dung, Earthworms, Organic manure, Vermicompost

INTRODUCTION:

Biodegradable wastes are the very big query of this century, and their disposal is a magic called vermicompost without troubling the environment (Annapoorani and Sindhu, 2019). The utilization of different types of solid wastes through composting is important for environmental sustainability and restoring soil quality (Goswami *et al.*, 2017). Compared to incineration and landfilling, the appropriate sustainable method to utilize industrial sludge is stabilizing with earthworms and the biotransformed and vermicompost, which can be used as an agricultural soil conditioner (Lee *et al.*, 2018). Environmental and economic impacts of Fertilizers on ornamental plant production have stimulated interest in the greater utilization of organic adaptation such as composts or vermicompost to produce and maintain bedding plants for use in greenhouses, homes, and commercial gardens (Arancona *et al.*, 2008). Vermicomposting helps convert organic wastes like agro-wastes, animal manure, and domestic refuse into highly nutrient fertilizers for plants and soil (Gajalakshmi and Abassi, 2004).

Vermicomposting is a promising technology that converts various bio-degradable wastes into organic fertilizer while recovering all the important nutrients in the trash. It improves soil quality and enhances microbial activity (Nurhidayati *et al.,* 2018; Sharmaa and Garga, 2020). Vermicompost is a good organic fertilizer preparing through interaction between earthworm and microorganism, which breakdown the nutrient substrate from organic waste as manure (Sindhu and Annapoorani, 2021). Vermicomposted organic material has also been reported to reduce P fixation by soils through the complicated metals that react with P by organic acids, competition between organic acids and orthophosphate for adsorption sites, and release of release P by organic material during decomposition (Guppy *et al.,* 2005). Vermicompost improves the soil's physical, chemical, and biological qualities while also contributing to molecular organic soil enrichment (Ansari and Jaikishun, 2011; Chauhan and Singh, 2013).

Earthworms protect millions of 'nitrogen-fixing' and 'decomposer microbes' in their gut. Earthworms are considered farmers friends and an indicator of soil quality because they contribute enriched soil to an agricultural field. These worms are major producers of natural manure without any factories and gifts of farmers (Annapoorani, 2014). However, some of the main limitations of using vermicompost are the need for its high utilization to achieve optimal performance and the presence of its organic phosphates, which are not available to plants (Alikhani *et al.,* 2017). The vermicomposting of press mud has utilized cow dung, sawdust, and other organic amendments in different proportions to optimize the initial feedstock material's carbon-to-nitrogen (C/N) ratio vermiconversion. For instance, (Khwairakpam and Bhargava, 2009) used sawdust in combination with pressmud to produce vermicompost by monoculture and polyculture of *Eisenia fetida*, *Eudrilus eugeniae*, and *Perionyx excavatus*. Prakash and Karmegam (2010), Sangwan *et al.* (2010) found that the addition of cow dung (50%) is suitable for the conversion of press mud into vermicompost using the earthworms, *Perionyx ceylanensis* and *E. fetida*. Further, the addition of cow dung to soil is essential for earthworm activity and reproduction using providing nutrients and ambient conditions, which is helpful for the recovery of nutrients from press mud (Bhat *et al.,* 2016; Bhat *et al.,* 2017).

The vermicompost is the significant value to the end-users like farmers for replacing chemical fertilizers and procuring better prices for the organic produce using such composting material locally available at a much lower cost (Ramnarain *et al.,* 2019). The actions of earthworms in the vermicomposting include substrate aeration, mixing, grinding, fragmentation, enzymatic digestion, and microbial decomposition of the substrate in the digestion path way of earthworms (Sharma *et al.,* 2005). The survival, biomass production and reproduction of earthworms are the best indicators to evaluate the vermicomposting process (Suthar, 2006). Applying leguminous green manures to the soil is a good management practice for improving

soil organic matter and fertility. The leguminous green manure plants are nitrogen-rich because of their ability to fix atmospheric nitrogen associated with Rhizobium bacteria, hence resulting in soil nitrogen enrichment when applied (Tejada *et al.*, 2008; Zhou *et al.*, 2020). Agriculture waste or garden waste is a remaining product present in the field which does not bear profit. wastes belong to one or other part of the plant itself like straw, short stem, flowers, buds, coir, peel of the fruits or vegetables, petals and sepals of maize etc., More and more rich nutrients are from these solid wastes like nitrogen, potassium, phosphorus, and micronutrients. Before preparing organic fertilizer like vermicompost, at the first step, we should compost plant materials.

METHODS OF VERMICOMPOST:

1. Substrates for vermicomposting

Bio-degradable wastes like Crop residues, flowers waste, animals waste, paper waste, weed bio-mass, Vegetable and fruits waste, Food waste, Leaf litter, Hotel refuse, Sewage sludge, dead plants and Wastes from Agro-Industries, Bio-degradable portion of urban and rural wastes, anything can be easily broken down into co2 and methane.

2. Basic needs of earthworms

The Five basic things are needed in essentials Compost

3. Living environment

Different types of Layers, including organic materials that provide the worms with plant debris, agricultural waste materials, etc. Animal dung is the major source for the worms to create a living environment.

4. Food source

Annelid worms are voracious feeders of decayed organic matter, and Under ideal conditions, they can consume more than their body weight.

They will eat nearly anything organic (that is, plant, paper, coir, dried leaves, twigs or animal origin, the dung of animals), but they prefer some foods to others.

5. Moisture content

Worms breathe through their skins in wet conditions and do not live in dry conditions without a humid climate. The layers must absorb and retain water in organic materials like dry vegetables, and plant sources absorb water and hold very well.

6. Materials required

- Vermi bin - Vermi Composting Bin is the ideal solution for converting waste into valuable Compost.
- Thatch roof - It is an essential item and is required for securing the vermi beds.
- Cow dung - These manures act as a food source for the earthworms

- Water – To maintain moisture.
- Vermi worm - The African earthworm (*Eudrilus euginae*), Red worms (*Eisenia foetida*) and composting worm (*Peronyx excavatus*) are promising worms used for vermicompost production. All three worms can be mixed for vermicompost production. The African worm (*Eudrilus Eugenius*) is preferred over the other two types because it produces higher vermicompost production in a short period and more young ones in the composting period.
- Waste materials – Solid waste, kitchen waste, agricultural waste,

METHODS OF VERMICOMPOSTING:

Two major methods are followed in vermicomposting a pit and Windrows or heaping method.

1. Pit method

Using bricks, construct a 3 x 2 x 1 m (L x W x D) pit over the ground surface. The size of the pit may vary as per the availability of raw materials.

1.1. Different types of materials required for the pit method

Coir pith, Sugarcane bagasse, Water hyacinth, Tea dust, Banana pseudo stem, Pond soil, Eggshell, Dried plants, Vegetables and Fruits waste.

Fill the pit with the following four layers

- First layer - Sand or sandy soil, 5-6 cm thick, as the top layer. This layer aids in the drainage of surplus water in the pit.
- Sub-layer - Paddy straw or another crop residue of 30 cm above the first layer, providing aeration to the pit.
- Terroir layer - Dried old dung over a paddy straw or dried coconut leaf layer at a thickness of 20-30 cm helps initiate microbial activity.
- Final layer - Pre-digested material about 50 cm (Shade dried plant and vegetable waste mixed with cowdung in the ratio of 1:1 combined with butter milk for work on the organic material for compost process)
- Inoculate earthworm @ 100 worms per square meter area or 10 kg earthworm in 100 kg organic matter.
- Spritz the bed and the gunny bag with water. Maintain a moisture level of 50-60% in the pit by spraying it with water regularly.

2. Windrows method

- Fill with the organic wastes like new plants in the form of a heap. The size of the bed may vary as per the availability of organic waste.

- After loading, should cover the bed with a jute sack or dry agriculture wastes such as rice-bran, banana-leaf, maize residue etc.
- Sprinkle water over the covered vermibed to maintain 40% moisture in the bed.
- Forming a lump of organic waste by hand can be used to wet humidity. It should easily lump together.
- Bed should be mixed thoroughly to prevent it from becoming compact.
- After 2-21/2 months, the vermicompost can be gathered, and after every six weeks, fresh vermicompost can be picked.
- Sprinkling Water to the bed stopped before 2-3 days collecting the vermicompost. Earthworms burrow down into the damp soil, and the Compost is collected from the top without disturbing the earthworms in the bottom layers of vermibed soil. Vermicompost harvested will be dark brown and free-flowing.
- Gathered Compost should be kept in a cool and dark place.

3. Harvesting the compost and worms

- Manual harvesting involves hand-sorting, sieving, machine and picking the worms directly from the Compost by hand. This process can be facilitated by fitting the source of light all around the site and gathering the cast material easier to collect. At the same time, the worms are penetrated to the bottom layer because of negative phototropism.
- The migration method is based on the worms' tendency to move to new regions to find new food or avoid favourable conditions, such as dryness or light. The worms are forced downward by strong light. The difference with the screen system is that the worms go down through the screen into a prepared, preweighed container of moist raw cow dung.

NUTRITIVE VALUE OF VERMICOMPOST:

The nutrients content in vermicompost varies depending on the waste materials used for compost preparation. Agricultural waste differentiates into herbs, shrubs and different types of trees and sludge various the content of molecules. So the waste materials are heterogeneous, there will be a wide range of nutrients available in the Compost. Only a limited number of nutrients will be accessible. The most frequent nutrients found in vermicompost are as follows Organic carbon : 8.52– 16.92%, Nitrogen : 0.6 – 1.70%, Phosphorous : 0.2 – 0.40%, Potassium : 0.17 – 0.68%, Sodium 0.09 – 0.50%, Calcium and Magnesium :26.78 to 52.40 meq/100g, Copper :1.9 –8.23 mg kg-1, Iron : 1.9 – 8.10 mg kg-1, Zinc : 4.60 – 10.40 mg kg-1, Sulphur : 129 – 537 mg kg-1.

VERMIWASH:

Vermiwash has maintained in vermicomposting setup brown coloured leachate produced during the vermicomposting process by the action of earthworms. In-pit method, we can collect vermiwash in the tap attached at the bottom. The sprinkling water to the Compost reaches all over the area covers, including worms bathing, secreting external glandular secretion, which prevents bacterial and fungal infections on the worms and is applicable for plants growth and yield without disorders. It is a good source of macronutrients and micronutrients, crucial for soil health and crop production.

BENEFITS OF VERMICOMPOST

- Vermicompost is an odourless, dark brown biofertilizer rich in microorganisms, micro and macronutrients produced by vermiculture look like the humus.
- Vermicompost is an excellent soil additive and acts as an effective biofertilizer.
- According to studies, the presence of earthworms in the soil increases the protein content of several cereal grains.
- Vermiproducts improve soil structure, infiltration, air porosity, nutrient and water holding capacity by increasing soil organic matter (SOM). SOM functions as a "glue" to bind soil particles into aggregates and improves soil structure, infiltration, air porosity, nutrient and water holding capacity.
- Application of term products compensates for soil carbon loss, thus maximizing crop production over time.
- Vermiproducts are rich in microbial diversity, including beneficial nitrogen, phosphate, potassium for the plant.
- Earthworms help to keep the population of these beneficial bacteria in the soil growing. Soil organic matter provides these helpful soil bacteria with a nutritious food source and aids in their growth in the soil.
- Microbes are responsible for transforming, releasing, and cycling macro micronutrients to make them available for plants.
- Vermiproducts, specially vermicompost, maintain the optimal pH level of the soil.
- Earthworms restore disease suppressive soil. Earthworms act as vehicles for carrying those microbes with antimicrobial activity against various fungal and bacterial pathogens in soils.

ADVANTAGES:

- Vermicompost has several advantages:
- It converts organic wastes, crop residues, and animal wastes efficiently.
- It's a long-lasting, nutrient-rich soil conditioner.
- It aids in the reduction of harmful microorganism populations.
- It is a low-cost, easily adjustable nutritional supplement for organic food production that is economically viable and environmentally safe.

PROBLEMS IN VERMICOMPOSTING:

- Putting an excessive amount of "greens" in the garbage might result in ammonia, nitrogen coupled with hydrogen. Add some carbon sources, such as paper and dry leaves, to counteract the odours.
- Pests like rats and flies are attracted to bad odours.
- *Eisenia foetida* worms can attack native worms in natural locations, so use plastic nets around the bins. Allowing access to natural areas is prohibited.
- Rain and bright light drastically affect the worms.

CONCLUSION:

Earthworms excreta (vermicast) is a nutritious organic fertilizer rich in humus, NPK, micronutrients, beneficial soil microbes; nitrogen-fixing, phosphate solubilizing bacteria, actinomycetes, and growth hormones auxins, gibberellins and Cytokinins are a good alternative to artificial fertilisers since they encourage plant growth and protect them. Thus, vermiculture not only results in the management of solid waste but also produces excellent nutrient-enriched vermicompost. It is beneficial for sustainable organic agriculture and maintaining a balanced ecosystem.

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A REVIEW ON NESTING BEHAVIOUR OF WETLAND ASSOCIATED AVIFAUNA

Devendra Singh Porte*[1], Lokesh Kumar Tinde[1], Vikas Chandra[2] and Amita Paikra[1]

[1]Department of Rural Technology and Social Development,

[2]Department of Biotechnology,

Guru Ghasidas Vishwavidyalaya (A Central University),

Bilaspur-495009, Chhattisgarh, India

*Corresponding author E-mail: portedevendra26@gmail.com

ABSTRACT:

The nest building, breeding, egg laying, hatching, developing the nestlings are a vital and anxious work in the birds community. The birds construct their nests mainly to shelter, care and protect their eggs and particularly their growing nestlings from predatory animals and from adverse climate conditions during the breeding period. The main aim of this review article is to collect and present the important researches which thrown light on the breeding biology, nest construction skill and nesting habitat of various wetland birds. Therefore, the information about the nesting activity of wetland avifauna will further support the protection of these ecologically important birds' species as well as their nesting site in order to provide them natural environment for their breeding and survival.

KEYWORDS: Nesting site, breeding, nest construction, egg laying, nestlings, protection

INTRODUCTION:

The nesting activities of birds are vigorously affected by various extrinsic factors such as quality and quantity of food materials, accessibility of nesting and roosting area, atmospheric conditions, position of the nesting area, inter-specific competition for resources, presence of predators and anthropogenic disturbance (Reale and Blair, 2005, Lima, 2009; Fink *et al.,* 2010; Herring *et al*., 2014; Ajitha and Josh, 2015; Jedlikowski and Brambilla, 2017; Jiang *et al.*, 2017). There are huge variations in the shape, design of the nest, size, structure, materials used *etc*. Birds make a variety of nest such as ground nest, cavity nest, plat form nest and modified cupped nest *etc*. Pattern of nest construction differs from species to species (Hansell, 2000), way of life and their surrounding area (Collias and Collias, 2014).

Nest success is related to nesting site characteristics (Tieleman *et al*., 2008). Nest site selection can be influenced by several factors and inter specific competition (Martin, 2001; Nalwanga *et al.*, 2004). Birds build their nest either solitary or colonial. The colonial nesting of water birds is known as heronries which play important role in an ecosystem. Herons are recognized as important biological indicator of environmental change in wetlands because of its position at top carnivorous level or trophic level which can signal the changes occurring in the lower trophic level. Generally, there are four distinct groups of heron's *viz*., the bitterns, the tiger herons, night herons and day herons. The day herons are *Syrigma*, *Pitherodius*, *Ardea*, *Egretta*, *Bubulcus*, *Agamia*, *Butorides* and *Ardeola*. There are four species of pond heron's *viz*., *Ardeola grayii* (Indian pond heron), *Ardeola baccus* (Chinese pond heron), *Ardeola speciosa* (Javan pond heron) and *Ardeola idea* (Malagasy pond heron).

Indian pond heron, *Ardeola grayii* (Order: Ciconiformes, Family: Ardeidae), commonly called as paddy bird was selected for this study. This bird is an important biotic component of the food chain of the ecosystem and controls the insects in agricultural fields. It has old world origin (Europe, Asia and Africa). This bird was first described by Colonel W.H. Sykes in 1932 who gave it the scientific name in honour of John Edward Gray. The Indian pond herons are the inhabitant of ponds, pools, rivers, stream, tidal flats, flooded grassland, paddy fields, canals, ditches and breed in marshy wetlands of warm countries such as South African countries, Burma, Bangladesh, Malaysia, Singapore, Southern Iran, India, Myanmar and Sri-Lanka. Its breeding period varies with latitude. This egret like paddy bird is earthy brown in colour with glistening white wing tail and white streaks in the breast. During breeding season, it shows observable colour change. It acquires maroon hair like plumes on back and long occipital crest (Ali, 2003; Roshnath and Josh, 2014). Occasional reports of pink or red legs during breeding season have been noted in southern, western and northern India (Sundar, 2004). The nesting behaviour of *Ardeola grayii* is relatively less understood except for the some discrete information from some part of India and Bangladesh (Yesmin *et al*., 2001; Begum, 2003; Seedikkoya *et al*., 2008, 2012; Jaman *et al*., 2012; Fazili, 2014).

Bird shows different and unique behavioral pattern by which they sustain their life on earth. Behavioral ecology of avian fauna deals with all the adaptive behavioral circumstances such as, flying, singing, escaping, roosting, feeding, preening, nesting, mating, breeding, parenting of nestlings, territory defense, predation, migration, navigation and communication, *etc.* exhibited throughout the life (Bhatt and Kumar, 1999; Stutchbury and Morton, 2001; Sethi *et al*., 2010, 2011 and 2012). Wetland bird play important role in ecosystem service therefore, the

present review article was planned to explore the nesting aspects of various wetland birds in order to catch the concerns of ethnologists, ecologists and environmentalist to take important steps toward the conservation of these bird species.

RESEARCH METHODOLOGY:

We systematically searched databases from online searching tools including Scopus, Google Scholar and Research Gate *etc.* to collect the relevant literature and reviewed 132 relevant articles of this field**.** We have taken words such as "nesting ecology", "nesting site", "nesting materials", "nesting behaviour", "waterbird's nest" and "period of nest construction" *etc*. as keywords during searching of relevant research database.

The avifauna:

Birds are one of the developed, economically important endothermic groups of animal having many attractive features including highly developed mode of locomotion called flying. The capacity of flying is helpful in their survival through shifting from one habitat to another during unfavourable period or during extreme adverse environmental conditions. It is the second largest diversified class of vertebrate after the fish. It is estimated that India harbours approximately 1300 species of the world avian fauna which comprises 14.5% of the total avian fauna (Urfi, 2010). The nesting colonies of Ciconiiform and Pelecaniform wetland avian fauna, universally recognized as heronries or egretries, are spatio-temporal aggregation of nests at favorable locations for the period of breeding season. A wide range of wetland avian fauna breed during monsoon, when food resources are plentiful (Ali, 2002; Balakrishnan and Thomas, 2004).

Period of nesting

The timing of nest construction is one of the most significant features affecting the breeding or reproductive performance in avian fauna. It has been suggested that the early breeder are likely to produce larger clutches and more surviving young ones as compared to the late breeder (Lack, 1968). However, in several bird species the photoperiod acts as the most important cue to initiate gonadal maturity and courtship and nesting while, ambient temperature and food accessibility are utilized for finer scale choices regarding the timing of nesting and breeding. Wide feeding ground is essential for breeding Ciconiiforms (Kingsford and Johnson, 1998). Avifauna that uses wetlands for breeding depends on the physical and biological attributes of the wetland.

Necessity of nest construction and nesting sites

Like fish and amphibians, birds also exhibits parental activity that includes, selection of nesting site, construction of nest, egg laying, protection, incubation and hatching the egg and

feeding and protecting the young ones. Nest construction is a species specific innate activity. Various factors *viz*., breeding season, suitable nesting sites, availability of nesting materials, food availability, predators, atmospheric conditions, anthropogenic disturbance affect the nesting activity of birds (Dial 2003; Lima, 2009; Fink *et al*., 2010; Sethi *et al*., 2010; Mainwaring *et al.*, 2014*;* Ajitha and Josh, 2015; Jiang *et al*., 2017).

A good nesting site generally provides protection against predators, offers adequate stability and materials to support and construct the nest, and is located near sufficient feeding area (Hafner, 2000). Habitat feature such as the quality of nesting tree has been recognized as one of the most essential criteria of habitat choices (Baxter and Fairweather, 1998). Knapton *et al*. (2000) reported the effect of human disturbance and introduction of exotic plants and animals on nesting success of birds. Sarkar *et al.* (2009) reported that birds prefer indigenous trees for nesting and very few nest were observed in orchard and garden having introduced tree and plantation. Several workers (Hilaluddin *et al.*, 2006; Raval, 2011; Das *et al*., 2014; Joshi, 2015) have reported the negative effect of exotic plant on nest success. Invasive plant adversely affect birds nesting success by drawing the birds into new area which are previously unsuitable for them and expose them to unfamiliar risk (Chace and Walsh, 2006; Beachy and Robinson, 2009; Rodewald *et al.,* 2010),

Nesting behaviour

Ninety percent of avian fauna show bi-parental nesting activity (Mandal, 2010). Generally male collect the nesting material to the nesting site and female build the nest. The bird show great variation in their nest morphometry, nest composition, nest planning, nesting site and even nesting trees (Raval, 2011). Birds occupy territory around the nesting and foraging site and defend it during breeding period. Ciaranca *et al*. (1997) reported that mute swan occupy and defend large territories (up to 6 ha) of wetland habitat during nesting, brooding, and foraging activity. Pattern of nest construction differ from species to species, way of life and surrounding area (Collias and Collias, 2014). Colonial nesting is advantageous against predation and selection of suitable partner by increasing the choice available in species (Begum, 2003). Ajitha and Jose (2015) studied the nesting behavior of the colonial breeding water birds and reported that the little cormorant (*Phalacrocorax niger*) was found as most abundant species and Pond heron (*Ardeola grayii*) were found in smallest number.

Heronry is a group of nesting wetland birds belonging to the orders Ciconiformes, Pelecaniformes, and Suliformes, which includes herons, egrets, storks, pelicans, ibises, spoonbills, darter, and cormorants, that show clustering of nests (Reza *et al.*, 2010; Roshnath *et*

al., 2013). Narayan *et al.* (2006) reported heronry with mixed species like the great cormorant, Darter, Open billed Stork along with Grey heron from Kerala. Pramanik *et al.* (2010) reported the breeding of Night heron (*Nycticorax nycticorax*), Gray heron (*Ardea cinera*), Cattle egret (*Bulbulcus ibis*) and little egret (*Egretta garzetta*) together every year. Anoop *et al.* (2015) reported nine avian species belonging to three families in the Panamaram heronry, Kerala and observed a total of 442 nests. They also reported the nesting of *Bubulcus ibis* in the heronry for the first time from the district.

The colonial wetland birds generally use urban area for nesting and feeding purpose (Urfi, 2010). The attraction of heronry birds to towns and urban area for nesting are well documented in many parts of India (Sashikumar and Jayarajan, 2007; Urfi, 2010) as well as in other countries (Andrew, 2004; Barcena *et al*., 2004; Vennesland and Butler, 2004; Vergara *et al*., 2006; Angehr and Kushlan, 2007). Street trees are main nesting site for wading birds (Sashikumar and Jayarajan, 2007; Nagendra and Gopal, 2010). These birds need suitable safety measures from anthropogenic threats.

Parasharya and Naik (1987) studied the breeding biology of the Indian Reef heron. Cattle Egrets showed roosting associations with Indian Pond Heron *Ardeola grayii*, House Crow *Corvus splendens* and Common Myna *Acridotheres tristis* (Gopal *et al.*, 2004). Kler *et al.* (2014) worked on the nesting behavior of *Bubulcus ibis* throughout the breeding period *i.e.,* April to July and reported the Dhek tree (*Melia azedarach*) and Pilkan tree (*Ficus lacor*) as the shelter trees for their nest construction. First egg was laid during last week of May and the peak of egg laying was obtained at the end of the May to June. The clutch size of Cattle Egret was 3-4 eggs. The breeding pairs leave the nests after finishing their reproductive period at the end of July. Jha (2012) classified the Black-crowned Night Heron, Little Egret, Cattle Egret, Darter and Grey Heron as the early arriver, Intermediate Egret, Indian Pond Heron, Great Egret, Black-headed Ibis, Purple Heron and Asian Open bill as late arrivers and Eurasian Spoonbill, Little Cormorant and Indian Cormorant as very late arrivers in the heronry. Behrouz (2013) investigated the reproductive status of water-birds on Persian Gulf, south Iran and recorded 11 breeding species of water birds in 10 islands of Persian Gulf.

Huang (2015) worked on the breeding habitation of the Little Tern in relation to dam development. He suggested that species adaptive behaviors should be taken as a chief parameter for the assessment of environmental impacts caused by anthropogenic activities such as dam development. The birds that nest on the ground are more susceptible to depredation of their eggs and young ones (Salek and Smilauer, 2002). Fletcher *et al.* (2005) suggested that the

anthropological threats to ground nesting birds are direct (damage to nest) or indirect (habitat destruction). Kumar (2015) studied on the local species of Lapwings from Punjab and reported Yellow-wattled Lapwing, *Vanellus malabaricus* as a rare bird in Punjab. He also made observations on the foraging, nesting and nesting behavior of Yellow-wattled Lapwing. Kumar and Sharma (2011) and Muralidhar and Brave (2013) suggested that Red-wattled Lapwing adapt the local unfavorable condition and choose a nest location to minimize human and cattle interference.

Mustahson (2014) studied reproductive aspects of purple moorhen, *Porphrio porphyrio* in Hokersar wetland at Ramsar site of Jammu and Kashmir. He reported that subsequent to the pair formation nesting sites were selected in thick developing vegetation, dominated by *Typha* and *Phragmites*. Both of the sexes worked for building nest on an average in 6 days. Bhatt *et al.* (2009) reported that reduction in water retention in summer, weed infestation, variations in food availability in different seasons and threat of predation on the breeding activity of birds affected the avifauna diversity. A more precise review of literature on various aspect of nesting behaviour of terrestrial and wetland avifauna has been summarized in the Tables 1 and 2.

Table 1: Summary of important studies on nesting behaviour of terrestrial avian fauna

SN	Species	Outcome	References
1	Red Bishops (*Euplectes orix*)	Males that build more nests have enhanced reproductive success	Friedl and Klump, 2000
2	Clay-colored sparrow (*Spizellap allida*), Savannah sparrow (*Passerculuss andwichensis*), Bobolink *Dolichonyxo ryzivorusi*)	Few vegetation features influenced the densities of birds and each species responded differently to vegetation variables. Clay-colored sparrow nesting success improved with increasing range of nest cover within the surrounding vegetation	Winter *et al*., 2005
3	Veeries (*Catharus fuscescens*)	Selected nest sites with low levels of predatory white-footed mice (*Peromyscus leucopus*) activity.	Schmidt *et al*., 2006
4	Australian reed warblers (*Acrocephalus australis*)	Built multiple nests within their territories, which consist of one “type 1” nest that is structurally capable of holding eggs and nestlings, while “type 2” nests that are not structurally capable of holding eggs and nestlings.	Berg *et al*., 2006

5	Starlings (*Sturnus vulgaris*) and Spotless starlings (*Sturnus unicolor*)	Mostly male showed maximum involvement in nest construction activity while females occasionally add feathers to nests.	Veiga *et al*., 2006
6	Orange-crowned Warblers (*Vermivora celata*)	Adaptive breeding habitat selection	Peluc *et al*., 2008
7	Blue tits (*Cyanistes caeruleus*)	supplemented female built heavier nests than unfed control female	Mainwaring and Hartley, 2009
8	Indian Grey Hornbill (*Ocyceros birostris*)	Nesting started early in March and ended in late June. The average nesting period was 87 days. The female sealed in the nest cavity for an average of 76 days and the nestlings fledging an average of 13 days. The nesting material materials included the hornbill's own faeces, mud, cattle dung and tree bark.	Santhoshkumar and Balasubramanian, 2010
9	Blue Tits (*Cyanistes caeruleus*)	Nest size positively correlated with the fladging success	Smith *et al*., 2012, Lambrechts *et al*., 2012
10	Bush Lark (*Mirafra cantillans*)	Breeding activities started during monsoon at June-July which extends up to the end of October.	Hippargi *et al*, 2012
11	Zebra finches (*Taeniopygia guttata*)	Preferred nest material based on the structural properties of the material. The selection of nesting material is not entirely genetically predetermined.	Bailey *et al*., 2014
12	35 Passeriformes and 11 non-Passeriformes birds	Studied 381 nests of 46 species; observed 220 active nests belonging to 44 species; number of nests was significantly higher in evergreen forests as compared to the dry forests	Pinho and Marini, 2014
13	*Paroaria capitata*, *Myiozetetes similis*, *M. cayannensis* and *Columbina talpacoti*	Nesting associations between birds and wasp increased reproductive success of birds as stings of insects protect the offspring against predators; predation of wasps by birds controls the insect	Almeida and Anjos-Silva, 2015

Table 2: Summary of important studies on nesting behaviour of wetland avian fauna

SN	Species	Outcome	References
1	Sarus crane (*Grus antigone antigone*)	Nests composed of aquatic vegetation and submerged in water; circular or oblong with a broad base and a depression in the center	Mukharjee *et al.*, 2000
2	Terns (*Larosterna inca*)	Preferred nesting site was crevices to minimize predation rates	Verlando and Márquez, 2002
3	Lesser black-backed gulls (*Larus fuscus*)	Choose tall plants as nesting trees which protect the nest and chick from cold waves	Kim and Monaghan, 2005
4	Coots (*Fulica atra*), mallards (*Anas platyrhynchos*) and moorhens (*Gallinula chloropus*)	Emergent and floating plants beneficial for nest construction along with breeding success	Sanchez-Zapata *et al.*, 2005
5	Eider ducks (*Somateria mollissima*)	Females breeding in sheltered nests exposed with milder temperature, laid larger clutches with higher hatching rates than females nesting in exposed nests at cooler temperatures	D'Alba *et al*., 2009
6	Eurasian Thick-knee (*Burhinus oedicnemus*)	Only a single nest was cited as first breeding record from Sholapur city	Hippargi *et al*, 2012
7	Chestnut-bellied Sandgrouse (*Pterocles exustus*), Yellowed-Wattled Lapwing (*Vanellus malabaricus*)	The breeding cycle start in phases initiated from last week of February and extended up to end of October	Hippargi *et al*, 2012
8	White-breasted waterhen (*Amaurornis phoenicurus*)	Breeding period started from February to July with the breeding activities found in April	Akhtar *et al*., 2013
9	Red-wattled Lapwing (*Vanellus indicus*)	Breeding activity from a few days before the nest construction; started nest construction at end of the February to May	Muralidhar and Barve, 2013

10	Great egrets (*Ardea alba*) and white ibises (*Eudocimus albus*)	Breeding success depends upon environmental variables and wetland water depth, prey availability, region and age	Herring *et al*., 2014
11	Sarus crane (*Grus antigone antigone*)	The main anthropogenic threats to the hatching success and survival of sarus cranes in the Rupendehi district were egg theft and the hunting of cranes for meat	Gosai *et al.*, 2016
12	Little crake (*Zapornia parva*) and Water rail (*Rallus aquaticus*)	Nest survival and nest site selection depends upon vegetation density, vegetation height and water depth	Jedlikowski and Brambilla, 2017
13	Heronry birds	22 species of heronry birds builds 1928 nests on 174 trees in urban areas	Roshnath and Sinu, 2017

CONCLUSION:

The detailed information on bird diversity, distribution, feeding and breeding ecology and activities are very much essential for conservation and management of birds in their natural habitat owing to its importance in pollination, in pest control, as scavenger in cleaning the ecosystem and in ecological food web. The richness, density and visit-frequency of avian fauna depend on the land use pattern and seasons. In other terms, biodiversity has become an issue of universal alarm in mega-biodiversity countries. Thus, by improving the quality of wetlands the diversity and distribution of avian fauna can be conserved. Hence, this review article supports the conservation of nesting site and natural environment of wetland avian community as well as biodiversity.

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FORAGING BEHAVIOUR OF WETLAND BIRDS: A REVIEW

Devendra Singh Porte*[1], Lokesh Kumar Tinde[1], Vikas Chandra[2] and Amita Paikra[1]

[1]Department of Rural Technology and Social Development

[2]Department of Biotechnology,

Guru Ghasidas Vishwavidyalaya (A Central University),

Bilaspur-495009, Chhattisgarh, India

*Corresponding author E-mail: portedevendra26@gmail.com

ABSTRACT:

Bird shows different and unique behavioural pattern by which they sustain their life on earth. Behavioural ecology of avian fauna deals with all the adaptive behavioural circumstances such as, flying, singing, escaping, roosting, feeding, preening, nesting, mating, breeding, parenting of nestlings, territory defence, predation, migration, navigation and communication, *etc.* exhibited throughout the life. Foraging behaviour is essential for their survival, growth, and reproductive fitness. The primary objective of this review article is to document the diverse researches focused on foraging behaviour of various wetlands associated avian fauna. Consequently, the information on the behavioural pattern of wetland birds will be pertinent and important for the ethnologists studying wetland habitats and associated fauna.

KEYWORDS: Wetland habitat, wetland birds, foraging behaviour, distribution, conservation.

INTRODUCTION:

The ornithological studies are important to understand the life of birds in natural habitat, their conservation and management strategies. The Indian subcontinent serves as an excellent ground for the growth and development of the biodiversity. India is one of the 12 mega-biodiversity recognized for its wealthy flora and fauna (Venkataraman, 2011). Birds are the natural dweller of the aquatic and terrestrial habitat. They are found in all types of water such as fresh, marine and brackish. Wetlands are important habitat for the terrestrial as well as the wetland avian communities. According to Ramsar convention of the IUCN, "wetlands are submerged or water saturated land, natural and man-made, permanent or temporary filled, that is static or flowing, fresh, brackish or salt including areas of marine water". It is assumed that the Indian freshwater wetlands maintain 20% of the identified range of biodiversity of the country (Manjunath and Ravikiran, 2016).

The bird's diversity is an important biological marker to evaluate the fitness of both terrestrial and aquatic habitat qualities in all respect (Chamberlain *et al*. 2005; Li *et al*. 2009; Rotenberry and Wiens, 2009; Frederick *et al*., 2009; Mistry and Mukherjee, 2015). Several wetlands have degraded by the declining quality of water, decrease in water level due to the agricultural practices, indiscriminate urban development, anthropogenic infiltration, pollution and other human activities (Stewart, 2007; Mainwaring *et al*., 2014; Jedlikowski and Brambilla, 2017).

Habitat use, feeding techniques and time are the main important parameters for feeding activity. The quality and quantity of food material plays a major role in determining the distribution pattern of birds (Koul and Sahi, 2013). The feeding behavior involves all the strategies and techniques exhibited by the bird during searching and taking of food within the foraging ground. It is an important activity which shows the ability of animals for their existence and reproduction (*Danchin et al*., 2008). The present review article is the sum of various research works on the feeding ground and foraging behaviour of wetland and water birds. The main purpose of this review article is to gather knowledge from different research work done in the field of foraging ecology of wetlands associated avian fauna. Therefore, the present review article is helpful to attract the brain of ethnologists and ecologists in this felid which further support the conservation and protection of wetland birds and their natural habitats.

RESEARCH METHODOLOGY:

We thoroughly explored databases, like Research Gate, Scopus and Google Scholar to find out the relevant literature. We reviewed 177 relevant articles**.** We used words such as "wetlands", "wetland birds", "wetland habitat", "foraging behaviour", "foraging guild" and "foraging time" *etc*. as keywords in the title of articles while searching the online database.

Wetland habitat:

Wetland constitutes a treasury of biodiversity. They are complex water and land interactive system and are supposed to be most fertile and productive site in the world but ecologically fragile, liable to degradation and degeneration under the existing anthropogenic pressure (Gupta and Singh, 2003; Bellio and Kingsford, 2013; Lafferty *et al.*, 2013; Sulaiman *et al*., 2014; Joshi, 2015; Gosai *et al.*, 2016). It is an important wildlife habitat providing breeding, nesting and feeding ground for wetland avian fauna. The word wetland bird is used to refer those avian species that live in or around the water. They adapt to this specific ecological niche for

their survival. The adaptations comprise webbed feet, bills and legs adapted to forage in water surface and the capability to dive for capturing the prey.

Wetland supports large number of migratory and resident species of birds (Paracuellos, 2006). India has 243 species of water birds and 67 species of wetland dependent and associated birds (Kumar *et al.,* 2005), almost half of which are migratory and come to the subcontinent from northern latitude of Russia, China, Central Asian countries, Mongolia and the Persian gulf where their breeding grounds are located. Pasha *et al.* (2004) studied the avian diversity in the wetlands of Pench Tiger Reserve, Madhya Pradesh and reported that migratory waterfowls were very common in this area and the dead leaves scattered on the reservoir formed a good nesting site for many water birds. Bird's species richness, density and their frequency of visits are dependent on the land use pattern and seasons (Bolwig *et al.,* 2006). Upadhyaya and Saikia (2010) studied on the habitat use pattern of the Cotton Pygmy-goose, *Nettapus coromandelianus* in a wetland of Assam, India and observed that during pre-monsoon and monsoon season these birds used the habitat enthusiastically.

Wetland ecology and distribution of avifauna:

The good abiotic and biotic environment directly affects distribution, diversity and density of avifauna. Any alteration in the habitat may lead to change in avifauna. Richness, abundance and community structure are frequently used by ecologists to recognize the diversity of species in their usual occurrence (Magurran**,** 2004). The wetland birds have very limited habitat requirement. Therefore, they are very susceptible to changed habitat conditions. Thus, they act as best indicator of wetland function (Guptha *et al.*, 2011). Soini (2006) observed that majority of the species of birds were restricted to a single land cover category which indicated that the changes in land use cause over exploitation of habitat and consequently animals restricted to one suitable land cover. Habitat fragmentation also affects the species viability (Cornelius *et al*., 2000; Herkert *et al.,* 2003).

The fragmentation usually leads to species decrease or eventually species absence. The findings of Gregory and Gaston (2000) and Brandle and Brandl (2001) supported the correlation that local abundance and distribution of the bird species are related to habitat usage and area availability for their whole life. Acharya *et al*. (2010) studied distribution patterns of endemic and threatened birds of the Eastern Himalaya in Sikkim, India and found that 10 species were endemic to Sikkim among them five species were restricted to one to three habitats but densities varied among the habitats. Some researchers (Marsden and Whiffin, 2003; Zhijun and Young, 2003; Fischera *et al.*, 2011) reported that bird species richness, density and frequency decreases

due to intensive agricultural practices. Cattle Egret was reported as the most common beneficial species in agricultural habitats of Ludhiana (Kler, 2009; 2010; Kler and Kumar 2013). The avian community composition acquires damage by the alteration in vegetation composition either due to natural or any anthropogenic disturbances (Rahayuninagsih *et al.*, 2007).

A more precise review of literature on avifaunal distribution and diversity on wetland habitat has been outlined in the Tables-1 and 2.

Table 1: Some important avifaunal distribution and diversity in wetland habitat of India

SN	Study site	Outcome	References
1	Lake Bari, Udaipur, Rajasthan	32 species belonging to 18 families reported	Bhatnagar *et. al*., 2008
2	Jajiwal pond, Rajasthan	62 species of birds belonging to 26 families reported	Mohan and Gaur, 2008
3	Wetland Birds around Kurukshetra, Haryana	54 species belonging to 5 orders, 15 families and 36 genera recorded	Kumar and Gupta, 2009
4	Wetlands in semiarid zone of Gujarat	Water fowl census done	Deshkar *et al.*, 2010
5	Coimbatore, Trichy, Perambalore and Thiruvarur district, TN	14208 birds belonging to 78 species and 33families, among these 47 wetland species recorded	Guptha *et al*., 2011
6	Kuttanad wetlands, Southern Vembanad-Kole Rasmer site, Kerala	225 birds belonging to 15 orders and 59 families recorded	Narayanan *et al.*, 2011
7	Bamanwada Lake of Rajura, Chandrapur, MS	58 species belonging to 9 orders and 29 families reported	Chilke, 2012
8	Ousudu lake, Puducherry,	41 avian species belonging to 18 families; Relative density varies with season; summer > monsoon >winter	Kumaran *et al.*, 2012
9	Singhori wild life Sanctuary, Raisen, MP	173 species belonging to 16 orders, 49 families and 9 subfamilies recorded	Talmale *et al.*, 2012
10	Selected reservoir of Bokaro district, Jharkhand	37 species belonging to 23 families recorded	Gupta, 2013
11	Five location in Lucknow district, UP	71 species belonging to 9 orders and 21 families recorded	Kanaujia *et al.*, 2013

12	Muchi Lake Wetland near Pandhakawada, Yavatmal, MS	34 species of birds belonging to 10 different orders; 27 species resident; 7 species migratory or seasonal resident	Pawar and Wanjari, 2013
13	Lake in Bhopal, MP	Impact of various factors on distribution of wetlands birds; Sixty eight species recorded	Vyas and Veerwal, 2014
14	Udhayamarthandapuram Bird Sanctuary, Tiruvarur district, Tamil Nadu	40 species belonging to 14 families recorded	Ramamurthy and Rajakumar, 2014
15	Hokerser wetland, Kashmir	58 species belonging to 27 families recorded	Mudasir, 2014
16	Sakhya Sagar and Madhav Lakes, Madhav National Parks, Shivpuri, MP	73 wetland avian species belonging to 8 orders and 18 families recorded	Arya *et al*., 2014
17	Maldah district, West Bengal	62 water birds species belonging to 21 families recorded	Chowdhury and Nandi, 2014
18	Kolleru wetland in Andhra Pradesh	A total of 232 species belonging to 62 families and 115 genera	Rao *et al.,* 2015
19	Urban lake of Bangalore city, Karnataka	42 species of water birds recorded	Rajashekara and Venkatesha, 2014
20	Jakhau Creek, Gulf, Kachchh, India	65 water birds species belonging to 17 families recorded	Prajapati and Dharaiya, 2014
21	Gaddena Nagu Project, Bhainsa town, Madhole Adilabad, Telangana	70 species belonging to 41 families recorded	Sainath *et al.,* 2015
22	Nizam Sagar Project district Nizamabad, Telangana	65 species of birds belonging to 38 families recorded	Jalander *et al*., 2015
23	Mini river of Vadodara district of Gujarat	Fifty one bird species recorded	Rathod *et al*., 2015
24	Munderikadavu bird sanctuary, Northern Kerala	82 species of birds belonging to 36 families and 13 orders recorded Lowland vegetation had the highest species richness (46 species) followed by upland (41 species), aerial (38 species), emergent vegetation (22 species) and paddy fields (21 species)	Roshnath and Shruthi, 2015

25	Telineelapuram, Tekkali Mandal, Srikakulum, AP	72 species belonging to 61 genera and 35 families recorded	Rao and Rao, 2015
26	Mangla dam, AJK	188 species belonging to 57 families and 17 orders recorded	Khan and Ali, 2015
27	Kolleru Wetland, Andhra Pradesh	13 species belonging to family Ardeidae, among which 5 species of herons, 4 species of egrets and 4 species of bitterns recorded	Rao *et al.*, 2015
28	Nal Sarovar, Ahmadabad, Gujarat	2658 individuals belonging to 33 genera, 36 species and 20 families	Chatterjee *et al.*, 2015
29	Ahiran lake district Murshidabad, West Bengal	30 species belonging to 29 genera and 12 families recorded	Mistry and Mukherjee, 2015
30	Meenachil river basin, Kerala	92 avian species belonging to 36 families and 15 orders recorded	Vincy *et al.*, 2016
31	Magadi Bird sanctuary, Gadag district, Karnataka	33 wetland bird species belonging to 11 families recorded	Manohara *et al.*, 2016
32	Kunda reservoir, Dhar, MP	22 species belonging to 15 families recorded	Rawal *et al.*, 2016

Table 2: Some important avifaunal distribution and diversity in wetland habitat outside India

SN	Study site	Outcome	References
1	Wetlands in Adamawa state, Nigeria	42 species recorded; 36 species during dry season; 39 species during wet season	Akosim *et al.*, 2007
2	Chesapeake Bay, USA	The coastal urbanization, even at low levels, significantly affects the integrity of wetland bird communities.	DeLuca *et al*., 2008
3	Bundala, Sri Lanka	Anthropogenic activities affect the migratory wetland bird communities.	Kaluthota *et al*., 2008
4	Malala, Embillikele, and Bundala lagoons, Sri Lanka	Pelicans, Egrets, Herons, Cormorants, Painted stork, terns, Sand pipers were the dominant wetland bird. Salinity, water depth and abundance of aquatic macrophytes were the key determinants of avian diversity and distribution.	Chandana *et al*., 2008

5	Chashma Barrage, Wildlife Sanctuary Mianwali and Marala Headworks Sialkot, Pakistan	46 waterfowl species belonging to 26 genera from 11 families under 6 orders recorded	Akbar *et al.,* 2009
6	Dagona-Waterfowl Sanctuary, Borno State, Nigeria	Diversity and distribution of wetland birds	Lameed, 2011
7	Southern California	Diversity and distribution of wetland birds; The distribution of shorebirds and other water birds low where human activities were high	Lafferty *et al.,* 2013
8	Bundala National Park and Embilikele lagoons, Sri Lanka	Diversity and distribution of wetland birds; Human actions like pollution had detrimental effects on bird communities.	Bellio and Kingsford, 2013
9	Kallar Kahar Lake, Pakistan	Species–habitat relationship; The Little Grebe (*Tachybaptus ruficollis*) species more frequently in shallow wetland. The reed vegetation *viz.*, *Phragmites* and *Typha* provided shelter and nesting sites while planktons and crustaceans, algae such as *Spirogyra* spp. and submerged plant material such as *Chara* spp. provided feeding site.	Bilal *et al*., 2013
10	Kilombero Wetland, Tanzania	Studied Species–habitat relationship and reported 126 species, belonging to 88 genera and 45 families	Ntongani *et al*., 2013
11	Hadejia-Nguru wetlands, Nigeria	Recorded 119 avian species and suggested that farms around the wetlands increased avian abundance as well as avian diversity. Also reported that the wetlands faced pressure from anthropogenic activities that effects wetland avian communities	Sulaiman *et al*., 2015
12	Negombo Estuary, Sri Lanka	Recorded 48 bird species of which 47 species were residents. The distribution was found to be the highest at undisturbed habitats as compared to the areas affected by anthropogenic land-use activities.	Jayathilake and Chandrasekara, 2015

13	Rupandehi District, Nepal	Studied population structure, behavior, and current threats in Sarus cranes. Agricultural fields and wetland areas contained the highest number of Sarus cranes. Population of sarus crane in the area declined. A single flock contained 13 cranes was observed. Sarus crane facing multiple anthropogenic threats to their survival	Gosai *et al.*, 2016
14	Poyang Lake, the largest freshwater wetland in China	Studied relationship among avian community, diversity, abundance in associations with landscape characteristics.	Dronova *et al*. 2016

Behaviour of avifauna:

Behaviour is the action of animal toward the external and internal stimuli. Locomotory, feeding, parental, migratory, defensive, communication, territoriality, aggressive, sexual behaviour, singing, preening, *etc* are some important behaviour found in birds. Birds usually display them due to different needs including security from predators, maintenance of wing and feather, mating activity and getting food and water *etc*. They protect themselves from predators in various ways. Few birds may use their bills and talons, but most of the birds try to avoid predators by hiding from them by camouflage and other types of cover such as grasses, bushes, etc. whereas, few species get safety in a flock (National Wildlife Federation, 2001). Birds' also sound alarm calls to inform the flock. Bird songs, on the other hand, are habitually very complex, and are different from species to species. Generally, adult males sing during mating season (Perennou, 1989; Sethi *et al*., 2011). Akhtar *et al.* (2013) reported that white breasted water hen spent most of the daily time for foraging (35.46%) and feeding (26.75%).

Feeding behaviour:

Most of the birds are known to exhibit feeding early in the morning and late in the evening (Sivakumaran and Thiyagesan, 2003). Verma (2010) reported the availability of light as an important factor in *Hirundo rustica* as it showed early roosting in cloudy weather and during the months of February-April and late roosting in clear weather and during the months of September-January. Oriental Darter (*Anhinga melanogaster*) showed more or less steady foraging rate throughout the day with a minor decrease in the noon time. The condition of weather affects the timing of the roosting behaviour of birds (Narayanan and Thomas, 2016). Thus, light plays an important role in the biology of the avian system. In avifauna, the annual change in day length is the important environmental cue to synchronize feeding, migration and

breeding activities within the regular seasonal transformation in natural state (Ramenofsky, 2012). Monthly variations in the diet of Cattle Egrets *Bubulcus ibis coromandus* in and around Chandigarh were analyzed by Sodhi (1989). There is also evidence to demonstrate that the feeding activity time of avifauna coincide with the activity timings of insects in insectivorous birds (Stelzer and Chittka, 2010).

Foliage composition, food resources and accessibility of food in the wetland are the main factor that influence bird density, diversity and distribution (Wilcox *et al.,* 2002; Malik and Joshi, 2013; Devkar *et al.*, 2016). Generally, the birds are herbivores, frugivorous, grainivorous, insectivorous, carnivorous, omnivorous, predators and some birds are scavengers (Pandotra and Sahi, 2014; Anthal and Sahi, 2017). Birds are obligatory or facultative in the selection of type of food. Mallards mainly eat plant material specially halophytes but also feeds on invertebrates and insects in Turkey (Green and Selva, 2000). Birds are generalized as well as specialized feeders. Near threatened Oriental Darter (*Anhinga melanogaster*) was specific in their food preference and fed on seventeen species of fish and prawn (Narayanan and Thomas, 2016). Grey Herons and Little Egrets are predominately piscivorous birds but also eat crustaceans, amphibians, reptiles, other invertebrates, and small birds and mammals (Snow and Perrins 1998*; Pistorius, 2008).* Little Egret (*Egretta garzetta)* choose mainly the wetland as feeding sites and generally feed on fish and other aquatic animals (Post *et al*., 2009).

Eldridge *et al.* (2009) reported that the Sandpipers foraged mostly on aquatic dipterans, larvae of family Chironomidae as primary food items. Larger sandpiper species foraged in deeper water and took larger larvae. Stafford *et al.* (2010) reported that grains not collected during harvesting are naturally the most favoured food of avifauna in rice fields. Water running in rice fields creates environment ranging from saturated mud flats to shallow water, thus attracting various avian guilds for their food demands. The bird occupy different zone of the water for feeding purposes. Great Cormorants which is a solitarily foraged feed at Vourkari inlet, Greece feed on bottom-living prey (Van and Voslamber, 1995). Great Crested Grebes feed on fish at various depths of the water column and Sandwich Terns plunge feed on small surface-dwelling fish (Brenninkmeijer *et al.,* 2002). Dave *et al.* (2015) reported that wading birds normally choose less water depth for foraging purposes.

Birds are solitarily or colonial feeder depending upon the type of species and the characteristics of wetland or surrounding fields. Sridhara *et al.* (1983) reported that *Himantopus himantopus,* Little egret and Cattle egret were found in flocks of 20 to 30 in the morning and evening during feeding but remained solitary for most of the day. Ghazoul and Hellier (2000)

suggested that the avian feeding guilds act as an ideal indicator for the monitoring the entire healthy functioning of the ecosystem. Red wattled Lapwing and Black-winged stilt feed solitary. The Cotton Pigmy Goose, *Nettapus coromandelianus* is the smallest of wild ducks and generally found to forage in flocks (Ali, 2002). Great egret and Great blue heron regularly feed as single individuals while White ibis and Wood stork mostly feed in flocks (Smith, 2005). *Egretta garzetta* tends to feed in dense aggregations during early morning in flocks and later in the day the birds dispersed over the feeding area and foraged alone (Yukiko, 2003). It was also seen in large flocks picking insects from the freshly ploughed fields (Patankar *et al*, 2007).

Birds use number of techniques for obtaining food. The feeding techniques used by the animal depend upon the type of food they consumed. The wetland avifauna mainly used three types of foraging techniques *viz*., tactile-hunting species technique, visual-feeding technique and pause-travel species techniques (Norazlimi and Ramli (2015). *Ardea herodias* employed three feeding techniques *viz*., standing, walking slowly and feet first diving (Roshnath and Jose, 2014; Roshnath, 2015). Green (1998) reported that Mallards mainly foraged by upending and head and neck dipping in Turkey. Cormorants and Shags are well adapted to dive in shallow waters (Wilson and Wilson, 1992). The dives from the water surface were interspersed with resting period or surface pauses (Casaux, 2004). Maheswaran and Rahmani (2001) observed that >60cm water depth is not suitable for Black-necked Stork. Zeenath and Zacharia (2010) worked on the feeding activity as well as the diving pattern of Little Cormorant *Phalacrocorax niger* at Kallampara backwaters, Kerala, India. They observed that the dive length was linked to surface resting time. Moreover, the period of dives decreased with increase in the number of dive cycles per bout. They explored the exact relation between body weight, dive period and diving capability.

Several studies have documented foraging ecology of Indian pond herons (Andrews and Mathew 1997; Seedikkoya *et al.*, 2012). Indian pond heron had topmost niche width when compared with other herons (Sodhi, 1992). The adult heron delivers same size and composition of prey to nestling that they themselves consumes (Kushlan, 1978). Hence dietary composition during breeding season can reflect the prey selection by the bird. The primary food of heronry birds includes crustaceans, aquatic insects, fishes and amphibians (Sodhi, 1986). Indian pond heron feeds on dragonflies (Santharam, 2003), bees (Prasad and Hemanth, 1992), earthworms (Raza, 1993). Indian Pond Heron is chiefly a solitary ground feeder, feeding on animal matter, mainly aquatic in nature (Ali and Ripley, 2001). Seedikkoya *et al.* (2012) reported the selection of fishes, insects, tadpole, arachnids, and crustaceans by herons from the foraging ground and

also reported scavenging behavior of Pond Heron on Sardine heads. *Nettapus coromandelianus* is almost aquatic species and choose deep freshwater seashore, rivers, marshes and dams, particularly those with floating plant matters (Ghadigaonkar *et al*., 2016). It prefers the aquatic vegetation available in the water surface and also consumes the seeds and flowers of aquatic plants and sometimes feed on aquatic insects. Thus, they are omnivores. A more precise review of literature on various aspect of feeding behaviour of avifauna has been outlined in the Table-3.

Table 3: Some important studies on feeding behavior (food, feeding pattern and techniques applied) of avian fauna

SN	Species	Outcome	References
1	Little egret (*Egretta garzetta*), Cattle egret (*Bubulcus ibis*), Red knots (*Calidris canutus*)	Little egret preferred fish and other aquatic animals. Cattle egret feed on insects and other arthropods and the Red knots feed on hard shelled mollusks and soft-bodied arthropods	Zhu and Zou, 2001
2	Black-nacked stork (*Ephippiorhynchus sp.*)	Mostly feed on fishes, frogs, crabs, snails and other aquatic animals	Maheswaran and Rahmani, 2002
3	Great Blue Herons (*Ardea herodias*), Great Egrets (*Casmerodius albus*), Wood Storks (*Mycteria americana*), White Ibises (*Eudocimus albus*)	The water level and vegetation were important factor for feeding. The herons and egrets showed solitary feeding pattern while the torks and ibises generally feed in flocks	Bancroft *et al*., 2002
4	Great Crested Grebe (*Podiceps cristatus*)	Studied duration of diving in three pairs of adult and their 10 young. The mean dive duration was 31 seconds for adults before hatching, 41 seconds for adults with young, and 25 sec for immature	Vogrin, 2003
5	Japanese Cormorant (*Phalacrocorax. filamentosus*)	Mostly preferred marine habitat as feeding ground and feed on small aquatic animals and vegetations	Watanuki *et al.*, 2004

6	Blue herons (*Ardea herodas),* Great egrets (*Ardea alba*) and Little blue herons (*Egretta caerulea)*	The Blue herons feed on American gizzard shad (*Dorosoma cepedianum*), goldfish (*Carassius auratus*) and giant water bugs. The Great egrets preferred golden shiners (*Noremgonus crysoleucas*) and goldfish (*Carassius auratus*) and the Little blue herons feed on dragonflies *Odonata*, golden shiners, green sunfish *Lepomis cyanellus*, and water bugs	Werner *et al*., 2005
7	Sandpiper (*Calidris melanotos*)	Feeding increased large fat reserves in the body, which supplied to requirements of energy for migration and reproduction	Krapu *et al*., 2006
8	Painted Stork (*Mycteria leucocephala*)	Nocturnal foraging activity reported and it feed on fish and other aquatic animals	Kannan and Manakadan, 2007
9	Wilson's phalarope (*Phalaropus tricolor*), piping plover (*Charadrius melodus*), Baird's sandpiper (*Calidris bairdii*), least sandpiper (*Calidris minutilla*), long-billed dowitcher (*Limnodromus scolopaceus*), and stilt sandpiper (*Calidris himantopus*)	Mostly prefer the shallow water areas for roosting	Cariveau and Risk, 2007
10	Caspian Gull (*Larus cachinnans)*	Observed seasonal and age related feeding efficiency	López de Casenave *et al*., 2008a
11	Pectoral Sandpiper (*Calidris melanotos*), Shite-rumped Sandpiper (*Calidris fuscicollis*), Baird's Sandpiper (*Calidris bairdii*) and Semipalmated Sandpiper (*Calidris pusilla*)	Foraged in wetland habitat and feed on aquatic dipterans, larvae of family Chironomidae.	Eldridge *et al.,* 2009

12	White- breasted Kingfisher (*Halcyon smyrnensis)*	Mainly feed on insects of Coleoptera, Hemiptera, Hymenoptera and Orthoptera and other Arthropods and less on vertebrates.	Asokan *et al*., 2009
13	Small Bee-eater (*Merops orientalis)*	Diet composed of insects belongs to Coleoptera, Hymenoptera, Hemiptera , Orthoptera, Odonata, Lepidoptera and Diptera along with Beetles	Mahinderan and Urfi, 2010
14	Black Drongo (*Dicrurus macrocercu)*	Due to high temperature avian fauna shifted to lower altitude to higher altitude with faster rate than previously reported rate.	Chen, *et al*., 2011
15	Carmorants (*Phalacrocorax* spp.) and White-breasted water hen (*Amaurornis phoenicurus*)	The Carmorants mostly attempted diving for during feeding while the White-breasted water hen spent most of the daily time (35.46%) for searching food and feeding as compared to the other activities such as, hiding, moving, preening, calling, resting activities etc.	Akhtar *et al*., 2013
16	Wading birds (Grey Heron, Indian Pond-Heron, Black-crowned Night-Heron, Purple Heron, Western Reef-Egret, Asian White Ibis, Eurasian Spoonbill, Little Egret, Intermediate Egret, Great Egret, Black-necked Stork, Black Stork, Painted Stork and Asian Open-billed Stork)	The wading birds usually preferd less water depth for feeding. Aggregation of wading birds takes place at lower water depth.	Dave *et al*., 2015
17	Black-backed gull (*Larus dominicanus*)	Effect of light on feeding activity	Pugh and Pawson, 2016
18	Zebra Finches (*Taeniopygia guttata castanotis*)	Studied the effect of feeding in incubation. The ecological conditions specifically food quality affected the development and reproduction.	Wilson *et. al*., 2017

CONCLUSION:

Although, the current article shown that the wetland birds are the significant biological part of the ecosystem and also facilitate to control the insect in the farming area. The illegal hunting of wetland birds species for food particularly during the monsoon frightening the survival of these birds. The study of foraging activity could be very essential for conservation of wetland associates avifauna. Public awareness is necessary to shield the feeding ground and natural wetland habitat for the future of these birds' species.

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THREE PILLARS OF SUSTAINABILITY: SOCIAL, ECONOMIC AND ENVIRONMENTAL

Damini R. Motwani* and Rahul L. Meshram

Department of Biochemistry,

DRB Sindhu Mahavidyalaya, KTR Marg,

Panchpaoli, Nagpur 440017, Maharashtra (India)

(Affiliated to RTMU Nagpur University Nagpur)

*Corresponding author E-mail: daminimotwani7@gmail.com

ABSTRACT:

The three pillars of sustainability (social, economic and environmental) commonly represented by three intersecting circles with overall sustainability at the centre, has become ubiquitous. The study indicate overall positive attitudes toward three pillars of sustainable development. The concept of sustainable development has become a top priority for local, regional, and global organizations. Sustainable development should become a basis practice for everyone in the world, including business organisations, the university system, families, and government agencies. The usefulness of sustainable development relies on the increasing interest in three pillars.

KEYWORDS: three-pillars, sustainable development, environment, social, economic and organizations.

INTRODUCTION:

Sustainability is a social, economic and ecological concept. Sustainability means of configuring civilisation and human activity so that society members are able to meet their needs and express their greatest potential in the present and future by preserving biodiversity. Sustainability affects every level of organisation, from the local neighbourhood to the entire world. In other words, sustainability help by providing best for people and the environment both now and in the indefinite future. Nowadays people object to the term “sustainable development” as an umbrella. Sustainability development term as it implies continued development, and so the objectors insist that it should be reserved only for developmental activities.

Environment is known as the total planetary inheritance and the totality of all resources. Environment includes all the biotic and abiotic factors that influence each other. All living elements like the birds, animals and plants, forests, fisheries etc are biotic elements. Abiotic elements include air, water,rock, sunlight, land etc. Environmental study includes study of inter-relationship between these biotic and abiotic components of the environment.

Functions of the Environment:

The environment performs four vital functions

(i) It assimilates waste

(ii) It sustains life by providing genetic diversity and biodiversity

(iii) It also provides aesthetic services like scenery etc.

(iv) It supplies resources

Resources (Renewable and Non-Renewable resources):

The resources which can be used without the possibility of the becoming depleted or exhausted are Renewable resources. Examples of renewable resources are fishes in the ocean, trees in the forests etc.

Non-renewable resources, on the other hand, are those which get exhausted with extraction and use, for example, fossil fuel.

The environment goes on performing these functions without any interruption as long as the demand on these functions is within its carrying capacity. This explains that the resource extraction is not above the rate of regeneration of the resource and whatever wastes are generated are within the assimilating capacity of the environment. When the carrying capacity of the environment is affected it fails to perform its third and vital function of life sustenance and absorb degradation. The result is environmental crisis.We all can see this situation today all over the world. The increasing population of the developing countries and the affluent consumption and production standards of the developed world have placed a huge stress on the environment. Lot many resources have become extinct and the wastes generated are beyond the absorptive capacity of the environment. Absorptive capacity means environment ability to absorb degradation.

Increasing pollution rate has dried up rivers and other aquifers. We all together are extracting both renewable and non-renewable resources has exhausted some of these vital resources. Now a days humans are trying new technology and research to explore new resources. Bad environment affects human health, degraded environmental quality decline in air and water quality have resulted in increased incidence of respiratory and water-borne diseases. Many

global environmental issues such as global warming and ozone depletion also contribute to increased financial commitments for the government. From this it is clear that the opportunity costs of negative environmental impacts are high.

When civilisation just began, environmental pollution was under control. Before countries took to industrialisation, the demand for environmental resources and services was much less, carrying capacity was fulfil.

Industrial revolution to meet the growing needs of the expanding population changed the things. The result was that the demand for resources for both production and consumption went beyond the arte of regerneration of the resources; the pressure on the absorptive demand for enviroinmental resources and servies but their supply is limited due to overuse and misuse.

SUSTAINABLE DEVELOPMENT:

Economy and Environment are interdependent and need each other. Therefore, development that ignores its repercussions on the environment will lead to dustruction of the environment that sustains life forms. What is needed is sustainable development: development that will allow all future generations to have a potential average quality of life that is at least as high as that which is being enjoyed by the current generation. The concept of sustainable development was emphasised by the United Nations Conference on Environment and Development (UNCED), which defined it as: 'Development that meets the need of the present generation without compromising the ability of the future generation to meet their own needs'.

Read the definition again. You will notice that the term 'need' and the phrase 'future generations' in the definition are the catch phrases. Edward Barbier defined sustainable development as one which is directly concerned with increasing the material standard of living of the poor at the grass root level — this can be quantitatively measured in terms of increased income, real income, educational services, health care, sanitation, water supply etc. In more specific terms, sustainable development aims at decreasing the absolute poverty of the poor by providing lasting and secure livelihoods that minimise resource depletion, environmenta degradation, cultural disruption and social instability. Sustainable development in right sense is a development that meets all basic needs particularly of the poor majority, for employment, food, energy, water, housing, and ensures growth of agriculture, manufacturing, power and services to meet these needs.

The present generation can promote development that enhances the natural and built environment in ways that are compatible with

(i) Conservation of natural assets

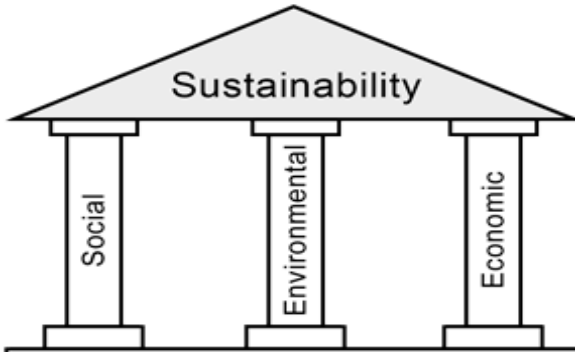
(ii) Preservation of the regenerative capacity of the world's natural ecological system

(iii) Avoiding the imposition of added costs or risks on future generations.

Use of Non-conventional Sources of Energy: India is mainly dependent on hydro and thermal plants to meet its power needs, but this may lead to adverse environmental impacts. Carbon dioxide which is a green house gas is emitted by large use of thermal power plants. Thermal power plants produces fly ash which, if not used properly, may cause pollution of water bodies, and other components of the environment like land forest etc.Hydroelectric projects may affect the natural flow of water in catchment areas and the river basins. Solar rays and wind power are good examples of conventional sources of energy.

Nowadays many efforts are being taken to tap these energy resources

- Government has taken various measures to safeguard the environment, it is also necessary to adopt a path of sustainable development.
- Sustainable development meets the need of the present generation.
- Conservation and preservation of natural resources would lead to sustainable development.



The Three Pillars of Sustainability

The principle says that for solving completes ustainability problem all three pillars of sustainability must be sustainable.

The three pillars of sustainability are social sustainability, environmental sustainability, and economic sustainability. The three pillars of sustainability aim to guarantee the planet's integrity and to improve the quality of life.

SOCIAL SUSTAINABILITY:

Social sustainability has fundamental importance. Social sustainability claims that poverty education is the primary goal of sustainable development. “Hunger man focus on food” rather than on environment awareness. Social sustainability claims at identifying and managing business impacts, both positive and negative, on people. For example, affordable housing, physical and mental medical support, education training opportunities, employment opportunities, access to support, and of course safety and security.

Social Sustainability explains the laws to support the necessity of overall population and the development of improving politics in areas like education and leisure. Social sustainability pillar assumes that the searching for a sustainable society have the idea of having a well-caring and healthy society. This pillar explains healthy work relationship, in order to favor the personal and collective development of all people.

ECONOMIC SUSTAINABILITY:

Economic sustainability explains the stability about economic capital, hence the widely accepted definition of economic sustainability “maintenance of capital”. Economic sustainability is an integrated part of sustainability and we must use, safeguard and sustain resources both human and material to create long-term sustainable values by optimal use, recovery and recycling. Economic sustainability explains the traders the role and importance of environment.

Economic sustainability involves subjects like distribution and consumption of goods and services. Sustainable attitude is beneficial in financial area because they reduce materials, energy and water, reducing also their bill in the end of the month. Hence, there is a cyclic process of benefits between sustainability and economy.

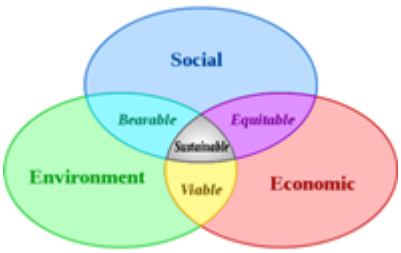
ENVIRONMENT SUSTAINABILITY:

Environmental sustainability is the responsibility to conserve natural resources and protect global ecosystems to support health and wellbeing, now and in the future. Humanity must learn to live within the limitations of the biophysical environment.

Environmental pillarplay important role in the environmental preservation, the natural resources and the diminishing of the damage caused to the environment. Every companies study the ways to accomplish their operations causing the lowest possible impact to the environment.

It is fundamental that the three pillars of sustainability interact among them in a harmonious way, because without these three pillars the sustainability does not support itself.

Balance between economic, environmental and social factors in equal harmony is illustrated with a sustainability Venn diagram, as shown below:



Taking these three pillars of sustainability further if we only achieve two out of three pillars then we end up with:

- Social + Economic Sustainability = Equitable
- Social + Environmental Sustainability = Bearable
- Economic + Environmental Sustainability = Viable

Only through balancing economic + social + environmental can we achieve true sustainability and a truly circular economy.

SUGGESTIONS TO MAINTAIN THE THREE PILLARS OF SUSTAINABILITY:

Green growth is necessary

Environmental degradation could become a major constraint in sustaining future economic growth. Further, it may be impossible or prohibitively expensive to clean environment later.

Green growth is affordable

Environmental taxes could potentially be used to yield positive net environmental and health benefits with minimal economic costs.

Green growth is desirable

India needs to value its natural resources, and ecosystem services to better inform policy and decision-making especially since India is a hotspot of unique biodiversity and ecosystems.

Conclusion

The important features of sustainability are integration, community involvement, precautionary behaviour, equity between and within generations, continual improvement and ecological integrity. The three pillars of sustainability development that is Economic, environmental and Sociol need to be well understood in the successful planning, development and management as a whole.

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METHODS OF ENZYME IMMOBILIZATION AND ITS APPLICATIONS WITH SPECIAL REFERENCE TO CATALASE

Suchita C. Warangkar* and Kalyani D. Kulkarni

Department of Microbiology,

Netaji Subhashchandra Bose College, Nanded 431605, Maharashtra, India

(Affiliated to S.R.T.M. University, Nanded, MS, India)

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

ABSTRACT:

Immobilized catalase enzymes are used extensively for a variety of applications. Depending on the type of application, the immobilization method and carrier material can be selected. The immobilized catalase enzymes can be separated from the reaction mixture and reused, and also immobilized to prevent the enzyme from being exposed to harsh conditions, high temperatures, surfactants and oxidants, etc. The immobilized enzymes are also widely used in the food industry, Pharmaceutical industry, bioremediation, detergent industry, textile industry, etc. The enzyme immobilization improves the operational stability and is also due to the increased enzyme loading that causes the controlled diffusion. Several hundred enzymes are immobilized and used for various large-scale industries. The immobilization technique reduces the cost of wastewater treatment and this paper reviews the methods and applications of immobilized enzymes.

KEYWORDS: Catalase, Immobilization, Applications.

INTRODUCTION:

Catalase was first noticed by Louis Sacques Thenard in 1818. In 1900, Oscar Low was the first to give it the name Catalase (Loew, 1990). Catalase is a very common enzyme found in plants, animal cells and all microorganisms in nature, either as another organ or in the form of isoenzymes in cell organelles (Gulseren Gorenek *et al.*, 2009). Catalase are abundant enzymes in nature (Esra Basak and Tulin Aydemir; 2012). It has a molecular weight of 232 kDa, found in 1938 (Loew, 1990). In 1938, catalase was crystallized from beef liver by James B. Summer and Alexander Dounce; 1887. Catalase enzyme (EC 1.11.1.6) is an oxidoreductase enzyme crucial in quenching reactive oxygen species (ROS) (Kaushal *et al.*, 2018). Reactive oxygen species (ROS) play an important role in the survival of all living organisms. Highly reactive and reduced

metabolites of O_2 such as superoxide anion and hydrogen peroxide (H_2O_2) are formed in organisms during cellular respiration. When ROS are formed excessively in the cell, they damage DNA, proteins and lipids, leading to loss of cell function, oxidative stress and programmed cell death (PCD). To regulate oxidative stress, the eukaryotic cell produces various ROS scavenging enzymes such as superoxide dismutase (which reduces oxygen to H2O2), glutathione peroxidase and catalase (Foyer and Nocter; 2000; Mori and Schroeder; 2004). Catalase enzyme found mainly in aerobic and anaerobic microorganisms such as *Methanosarcina barkri* (Brioukhanov *et al.*, 2006). It has one of the highest turnovers of any enzyme, having the ability to decompose more than a million molecules of hydrogen peroxide per molecule of enzyme (Abbott *et al.*, 2009).

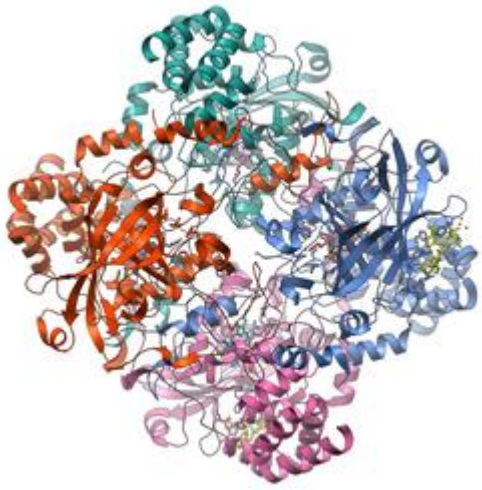

Figure 1: Catalase structure (PDB ID 1DGB, 1DGF, 1DGG, 1DGH, 1F4J, 1QQW)

Catalase is a tetramer of four polypeptide chains, each over 500 amino acids long. It contains four porphyrin heme groups that allow the enzyme to react with hydrogen peroxide. Catalase is normally located in a surrounding cellular bipolar organelle called the peroxisome (Kaushal *et al.*, 2018). The physiological function of catalase has not yet been fully understood, but it has been assumed that catalase has a protective function against free radicals composed of oxygen (Gulseren Gorenek *et al.*, 2009). Louis Jacques Thenard, who discovered hydrogen peroxide, proposes that the breakdown is caused by an unknown substance. Cells use catalase to catalyze the conversion of hydrogen peroxide into less reactive molecules of oxygen and hydrogen peroxide (Nisha *et al.*, 2012). Hydrogen peroxide is a substrate of catalase enzyme (Gulseren Gorenek *et al.*, 2009). Hydrogen peroxide is a harmful by-product of many normal

metabolic processes, in order to prevent damage to cells and tissues it had to be converted into other less reactive or dangerous substances. To this end, catalase is commonly used by cells to rapidly catalyze the decomposition of hydrogen peroxide into less reactive gaseous oxygen and water molecules.

Catalase reaction:

The presence of catalase in a microbial or tissue sample can be detected by adding hydrogen peroxide and observing the reaction. The oxygen production can be recognized by the formation of bubbles. This simple test, visible to the naked eye without any tools, is possible because catalase has a very high specific activity that produces a detectable reaction, as well as the fact that one of the products is a gas. Catalase has a fairly wide working range from an optimal pH of between 4 and 11(Chelikeni *et al.*, 2004 and kennley *et al.*, 1990). Catalase has been biochemically genetically studied, purified and characterized from many plants such as: Seeds of Black Gram (*Vigna mungo*), Dill (*Anethum graveolens*), Parsley, *Nicotina tobacum*, Cotton, *Pinus teada*, Sunflower, Pumpkin (Arabaci *et al.*, 2013).

$$H_2O_2 + H_2R \rightarrow 2H_2O + R$$

Enzyme immobilization:

Enzymes are biocatalysts that carry out all major biochemical reactions in an organism's body. Their unique feature is that they remain unchanged after the reaction is complete. Therefore, they can be used again and again. But the limitation of soluble enzymes is their isolation from the product and the substrate. Most of the enzymes in the living organism are attached to the cell membrane or enclosed in the cells. This observation led to the concept that purely isolated enzymes actually perform better when immobilized on a solid support. The term immobilized enzyme is used to denote enzymes that are physically entrapped or localized in a defined area of space while maintaining their catalytic activities and which can be used repeatedly and continuously. Immobilization is advantageous because it facilitates work-up of the product isolation. Some of the potential advantages and disadvantages of immobilization are highlighted below (Kumar, 2018).

Soluble Enzyme + Substrate---------- Product (single time usage of enzyme)

Immobilized Enzyme + Substrate---------Product (Repeated usage of enzyme)

Advantages of enzyme immobilization:

1. Easy recovery of the product

2. Product is free from enzyme, so there is no cost of purification of enzyme.
3. Enzyme can be used repeatedly
4. The enzyme generally get stabilized after adsorption

Disadvantages of enzyme immobilization:

1. Loss of catalytic properties for some enzymes
2. Some enzymes become unstable
3. Additional cost of immobilization
4. Differential limitations.

Intensive studies in the field of enzyme immobilization began in the mid 1950's and have continued ever since. The first industrial use of immobilized enzymes was reported in 1967 by Chibata and co-workers, who immobilized *Aspergillus oryzae* aminoacylase for the resolution of synthetic, D/L-amino acids into the corresponding optically active enantiomers. At present, the use of immobilized enzyme is well established in various industries.

Methods of Immobilization:

The various methods of enzyme immobilization are broadly classified as

1. Reversible immobilization
   a. Adsorption
2. Irreversible immobilization
   a. Covalent coupling
   b. Entrapment and microencapsulation
   c. Cross linking

The advantage of reversible immobilization over irreversible systems as follows:

1. No chemical modification of the enzyme is required
2. If the enzyme gets activated during use, it can be replaced in reversible immobilization.
3. The immobilization of enzyme by adsorption of bio affinity can be accomplished rapidly.

REVERSIBLE IMMOBILIZATION

Adsorption:

Immobilization by adsorption is the simplest and fastest method. Adsorption depends on experimental variables such as pH, type of solvent, ionic strength, amount of enzyme and adsorbent, time and temperature. Due to the relatively weak binding forces between protein and adsorbent (hydrogen bonds, van der Waals forces, hydrophobic interactions, etc.), close control

of these variables is required. Enzymes can be immobilized by simply mixing the enzymes with the matrix under appropriate pH and ionic strength conditions. The adsorption process is based on Van der Waal forces, ionic and hydrogen bonding, and hydrophobic interactions, which are very weak forces, but in large numbers confer sufficient bonding strength. Adsorbed enzymes can be protected from agglomeration, proteolysis, and interaction with hydrophobic interfaces. In order to prevent chemical modification and damage to the enzyme, the existing surface properties of the enzyme and support must be taken into account. Adsorption by a physical method generally involves multipoint protein adsorption between a single protein molecule and a number of binding sites on the immobilization surface. The main disadvantage of this method is that the enzyme is easily desorbed by factors such as pH, temperature changes, and changes in substrate and ion concentrations. Some advantages of adsorption methods are enlisted as follows

- Easy to carry out
- No reagent are required
- Minimum activation step involved
- Comparatively cheap method Less disruptive to protein than chemical methods

IRREVERSIBLE IMMOBILIZATION

Covalent coupling

Covalent coupling is the most commonly used approach to immobilization, in which covalent bonds are formed between surface amino acids of the enzyme and the matrix. Hydrophilic amino acids that are likely to be present on the protein surface can be used for this purpose. -Amino group of lysine residue, cysteine (via SH), tyrosine, histidine, aspartic and glutamic acid, tryptophan and arginine are mainly involved in bond formation. A variety of chemical reagents and protocols are available for covalently attaching an enzyme to the matrix.

Most commonly used methods of covalent bonding are:

1. **Diazoation:** It is based on the diazo linkage between protein and aryldiazonium electrophilic groups of the matrix.
2. **Formation of peptide bond:** bond formation between amino/carboxyl groups of support and amino or carboxyl group of the enzyme
3. **Poly functional reagents:** use of bi-functional or multifunctional reagent (glutaraldehyde) which forms bonding between the amino group of the support and amino group of the enzyme.
4. **Amidination reaction:** The matrix containing amido ester functional groups can be used for immobilization of protein.

5. **Thiol–disulphide interchanged reaction:** This methods is used for protein bonding via thiol groups of both carrier and protein.
6. **Akylation and arylation:** This methods is based on alkylation of amino, phenolic and thiol groups of protein with reactive matrix containing halides, vinyle, sulphonile and others.

Advantage of covalent bonding method:

- Strong linkage of enzyme to the support
- No leakage or desorption problem
- Comparatively simple method
- A variety of support with different functional group available
- Wide applicability

Disadvantage of covalent bonding method:

- Chemical modification of enzyme leading to functional loss or conformational loss
- Enzyme inactivation by change in the conformation at active site

This can be overcome through immobilization in the presence of enzyme substrate or a competitive inhibitor.

Entrapment

Entrapment and encapsulation are based on the entrapment of an enzyme within a constraining structure, yet strong enough to release an enzyme while allowing penetration into a substrate. However, due to diffusion limitations, such methods are often unsuitable for the immobilization of enzymes that hydrolyze macromolecular substrates.

Methods of entrapment

- Inclusion in the gels: enzymes trapped in gels
- Inclusion in fibre
- Inclusion in microcapsules: enzymes entrapped in microcapsules formed by monomer mixtures such as polyamine, calcium alginate

Advantage of entrapment method:

- Fast and less time consuming
- Cheap (low cost matrix available)
- Mild conditions are required
- Less chance of conformational change in the enzyme

Disadvantage of entrapment method

- Leakage of enzyme

- Pore diffusion limitation
- Chance of microbial contamination

Cross linking:

This method involves the attachment of biocatalysts to each other through bi- or multi-functional reagents or ligands. In this way, insoluble aggregates of very high molecular weight are typically formed. Networking is a relatively simple process. It is not a preferred method of immobilization because it does not use a support matrix. So they are mostly gelatinous and not particularly solid. Since the binding is of the covalent type, the biocatalyst immobilized in this way often undergoes conformational changes with a resulting loss of activity. Nevertheless, it finds good use in combination with other carrier-dependent immobilization technologies, namely to minimize the leakage of enzymes already immobilized by adsorption. Recent advancement to cross linking method is the formation of Cross Linked Enzyme Crystals, Cross Linked Enzyme Aggregates and Spheres.

Advantage of Cross linking method:

It is used mostly as a means of stabilizing adsorbed enzyme and also for preventing leakage

Disadvantage of Cross linking method:

Cross linking may cause significant changes in the active site of enzyme which may lead to loss of activity

Characteristics of solid support:

Main component of immobilized enzyme is the support materials. Ideal support material should posses following characteristic:

1. Large surface area
2. Permeability
3. Hydrophilic character
4. Insolubility
5. Chemical mechanical and thermal stability
6. High rigidity
7. Suitable shape and particle size
8. Resistance to microbial attack
9. Regenerability

Support materials are classified into two categories based on their Morphology.

1. Non porous support like glass
2. Porous support like silica

Porous support has high surface area as compare to non porous Support.

Support material are classified into two categories based on their chemical nature

1. Organic Support Material
2. Inorganic Support Material

Organic support material are further classified as:

1. Natural Support Material
2. Synthetic Support Material

Natural organic supports include Polysaccharides and proteins. Some of the commonly used Polysaccharides are

- **Alginate:** These are polymers of n-acetyl glucouronic acid, having hydroxyl group which can be derivatized easily.
- **Chitosan and chitin:** chitosan is deacetylated chitin.
- **Cellulose:** a linear polymer of D-glucose units (two are shown) linked by β(1→4)-glycosidic bonds

Synthetic support are the largest number of support materials available for protein immobilization due to their physical and chemical characteristic.

- DEAE cellulose
- polyvinyl chloride (PVC)
- UV-activated polyethylene glycol (PEG)
- Gluteraldehyde-activated nylon
- cyclodextrin glucosyltransferase

Inorganic materials as supports:

The surface of most inorganic support is mainly composed of oxide and hydroxyl group, such as silanol group in glass, provide mild reactive surface for activation and protein binding.

Zeolites:

Zeolites are microporous crystalline solids with well-defined structures

CHOICE OF CARRIER MOLECULES:

Catalase has been extensively immobilized on numerous support materials such as chitosan, dextrome, asymmetric, cellulose membrane, nylon membrane, eggshell, magnesium silicate, Eupergit E, microbeads such as cellulose, acetate and alginate beads with organic polymers (Arabaci *et al.,* 2013). Different types of gels are also used, such as porous gel, glass, silica gel, hydrogel and some organic as well as inorganic materials are used to make immobilized enzyme (Alkane *et al.,* 2009). In the second half of 20^{th} century, carrier-binding immobilizations were developed. For almost 50 years, investigations into applications of carrier-bound immobilized enzymes have continued. These supports can be in a variety of physical forms such as microspheres, membranes, films, and synthetic or natural polymers. The choice of materials to be used is practically unlimited. They can be effectively separated from the reaction medium, allowing immobilized enzymes to be recovered and reused after the reaction (Yasemin *et al*., 2013). Magnetic nanoparticles are also used to immobilize catalase such as Fe_3O_4 or $Fe_2O_3NiO_2$ H_2O. Iron in these forms is non-toxic, cheap, biocompatible, and easy to produce. The Fe_3O_4 magnetic bacteria, commercial super magnetic particles, magnetic chitin particles and various magnetic composite particles are used as carriers for immobilization. The magnetic particles could get additional properties and biocompatibility by combining with some molecules like poly vinyl alcohol, methyl methacrylate, glycidyl methacrylate and chitosan. The activity, stability, resistance to reaction conditions and selectivity of the enzyme can be increased (Yasemin *et al*., 2013). In biocatalytic systems, catalase is mainly used in the immobilized state. The biocatalytic activity of catalase immobilized on cellulose has been studied in non-aqueous solvents (Wang *et al.,* 1995). It was used to develop an organic-phase amperometric biosensor by immobilizing the enzyme in a polymer film on a glass-carbon surface. The effect of the polyacrylamide matrix for immobilization on the catalytic activity of immobilized catalase was studied in aqueous solutions (Horozova *et al.,* 1998). Commercial use of catalase is limited to its native form (Justyna *et al.,* 2011; and Alkane *et al.,* 2009). Numerous attempts have been made to immobilize the enzyme (Tukel *et al.,* 2004) to enable its repeated use in H_2O_2 decomposition processes, however, the immobilization methods used appeared to be overly complicated and expensive. Choice of support, enzyme type and reaction medium (pH, temperature, type of medium) depends on the application (Yasemin *et al.,* 2013).

Immobilization of catalase on various carrier molecules:

Cellulose acetate beads:

Catalase is immobilized by entrapping it in cellulose acetate beads. This encapsulation was performed by a cross-linking and encapsulation process. First the cellulose acetate beads were prepared (900 mg cellulose in 5 ml acetone), then this solution was added dropwise into the Hexane solution using a syringe at 25°C, finally the crystalline beads formed. Then catalase was immobilized after the activation of cellulose acetate beads by $Ce(SO_4)_2$ (the principle of Catalase bound to cellulose acetate beads by covalent bond), in this case the hydroxyl groups of cellulose acetate were oxidized to aldehyde groups $Ce(SO_4)_2$ and activated. Then catalase was immobilized by the crosslinking agent glutaraldehyde (Hatic *et al.,* 2009).

Alginate beads:

Immobilization of catalase was accomplished using both the capture and crosslinking methods. When encapsulating, alginate is used as the base matrix. Catalase is immobilized (80 mg in 8 ml Tris-HCl buffer) by adding 2% alginate and 2 ml catalase to the solution. Then add the CaCl2 solution containing glutaraldehyde drop by drop. Beads formed and decanted, stored at 4°C in damp filter paper (Gulseren *et al*., 2009)

Calcium alginate gel:

Immobilization of *Aspergillus niger* catalase by encapsulation in calcium alginate gel. The process is extremely simple and inexpensive, and the alginate can be recovered from a deactivated biocatalyst for reuse in immobilization. The 25 ml of sodium alginate solution at 2% or 4% w/w was prepared and 30 micron loaded with Catalase by stirring for 5 minutes. Then transfered to a beaker with 0.1 mol. Per dm^3 of $CaCl_2$; stired well and using a syringe dropwise addition formed the beads. The beads were separated and stored in the refrigerator at 4°C (Justyna *et al*., 2011)

Chitosan-bentonite complex:

Immobilization of catalase on chitosan beads is one of the most commonly used techniques as it is simple and inexpensive. Chitosan, due to its inert nature, proves attractive for the purpose of enzyme immobilization; moreover, it is an inexpensive and hydrophilic carrier material and also biocompatible, biodegradable and non-toxic, making it one of the most important immobilization methods. Amino groups present on chitosan facilitate covalent attachment of the enzyme to the carrier (Grigoras *et al.,* 2017). The literature suggests that immobilization can occur either by entrapping the enzyme in the chitosan beads or by covalently binding it to the transparent chitosan films. The use of glutaraldehyde as a crosslinking agent for

chitosan beads is more applicable in biochemical engineering because of its good biocompatibility and mechanical strength enzyme (Cetinus *et al.*, 2007 and Zhang *et al.*, 2012) to immobilize catalase bentonite to form the chitosan beads instead of glutaraldehyde. The chitosan-bentonite beads were formed for the purpose of catalase immobilisation and the stability and function of the catalase-immobilized chitosan-bentonite complex beads was compared to the glutaraldehyde-enhanced chitosan beads, making them the commonly used catalase A crosslinker can replace bead formulations that require glutaraldehyde. (Kaushal *et al*., 2018)

Chitosan:

Chitosan is said to be a good support for catalase immobilization. It is a tetrapolysaccharide obtained from the alkaline deacetylation of chitin, which is the most abundant polysaccharide on earth after cellulose. Chitosan is biocompatible, biodegradable, hydrophilic, non-toxic, antibacterial organic support used for immobilization. Physical modification could increase chitosan's adsorption properties, and chemical modification not only can increase its adsorption properties preventing its dissolution in strong acids, improve mechanical strength and surface area. Chitosan anion resin modified by glutaraldehyde and amino acids (Basak *et al*., 2012).

Kinetic parameters:

The immobilized catalase on cellulose acetate beads shows activity measurement of both free and immobilized catalase was performed for 10.5 µm hydrogen peroxide at 240 nm using an UV/Vis spectrophotometer. The activity of the immobilized catalase was accepted as micromoles per minutes. The highest activity for both free and immobilized catalase is at pH 7. The pH profile was much broader with respect to the most suitable buffer for free enzyme, Tris-HCL buffer, and shows a maximum enzyme activity at 50µm. The effect of temperature on both free and immobilized catalase enzyme is identified and 35°C is the optimal temperature for them. Immobilized catalase in alginate shows maximum activity at optimum pH and temperature corresponding to the activity on cellulose acetate beads. The maximal activity of catalase from *Aspergillus niger* obtained when immobilized on 2% and 4% calcium alginate gel (pH 7).

The Data shows that maximum activity is obtained at 4% gel. An increase in the maximum temperature indicates high enzyme stability. This is confirmed by measuring the activity fluctuation during storage on the biocatalyst. Biocatalysts show more stability at 4% gel, but more than 7 days they show a gradual loss of activity over time. The kinetic parameters of immobilized catalase and free catalase were determined by measuring the reaction rate at different substrate concentrations ranging from 2 to 10 mM at optimum, temperature and pH.

The kinetic parameters Km and Vmax are calculated from the Linewaver-Burk plot. The Km value of the free enzyme is lower than that of the immobilized enzyme system. The free enzyme catalase has a higher affinity for its substrate, with the Vmax of the free enzyme being higher than that of the immobilized system.

Km and Vmax values for both beads comparable and almost the same with a small difference. The two beads show nearly the same enzyme kinetic properties. Where Km was given as 35 m and Vmax as 32mmoles for catalase immobilization on chemically cross-linked chitosan beads (kaushal *et al.,* 2018). After chitosan immobilization of catalase, the kinetic parameters viz Km values were obtained higher than that of free catalase. When Immobilized bovine liver catalase on chitosan films pretreated with glutaraldehyde; it was found that Km remained almost same but Vmax was decreased. Thermal stability was enhanced by covalent attachment to the solid support; since the chemical bond between the enzyme and the concentrate prevents denaturation of the enzyme at high temperature. Various immobilized system showed some development in its stability properties with respect to native enzyme (Nisha *et al*., 2012).

Biochemical properties of the immobilized catalase:

The biochemical properties of the immobilized catalase are different when compared to the free catalase, this is due to the change in environment of the immobilized catalase. When physical and chemical properties of the support matrix and interactions of enzyme with matrix or with substrates or products change; the kinetic properties of the immobilized catalase are also modified. In general, the rate of the enzyme-catalyzed reaction decreases as the matrix restricts the diffusion of the substrate to the catalase. The Km of catalase changes even after immobilization due to diffusion limitations. If the matrix is positively charged and the substrate is also positively charged due to electrostatic repulsion, the substrate will not come close to the enzyme, hence Km will be altered. Sometimes the 3D structure of the catalase is also altered, which also leads to a change in the kinetic properties of the catalase. The performance of the immobilized catalase can be further improved by studying the structural changes of the immobilized catalase.

Biomedical applications of immobilized enzymes:

Immobilized enzymes are used in medicine from 1990 onwards, immobilized enzymes are used for the diagnosis and treatment of diseases in the medical field. The inborn error of metabolism can be overcome by replacing the encapsulated enzymes (i.e., erythrocyte-encapsulated enzymes) instead of waste metabolites, the RBC acts as a carrier for the exogenous

enzyme drugs, and the enzymes are inherently biocompatible, hence there is no immune response. Enzyme encapsulation by electroporation is the simplest type of immobilization in the biomedical field and is a reversible process for which enzymes can be regenerated. The enzymes, in combination with the biomaterials, provide biological and functional systems. The biomaterials are used in tissue engineering application to repair the defect. The advantage of enzyme immobilisation in biomedicine is that the free enzymes are consumed by the cells and are not active with prolonged use, therefore the immobilized enzymes remain stable to stimulate growth and repair the defect. Cancer therapy has been improved with new methods. The nanoparticles and nanospheres are commonly used as enzyme carriers for the delivery of therapeutics.

Food industry application:

The purified enzymes are used in the food industry, but during purification the enzymes are denatured. Therefore, the immobilization technique makes the enzymes stable. The immobilized enzymes are used to make syrups. Immobilized beta-galactosidase used for lactose hydrolysis in whey to produce baker's yeast. The enzyme is bound to a porous silica matrix by covalent bonding. This method is not preferred because of its cost and the other technique developed by Valio in 1980, where the enzyme galactosidase was linked to resin (food grade) by cross-linking. This process has been used for various purposes such as confectionery and ice cream.

Biodiesel production:

Biodiesel consists of mono-alkyl esters of long-chain fatty acids. Biodiesel is produced by triglycerides (vegetable oils, animal fats) with esterification of alcohol (methanol, ethanol) in the presence of the catalyst. The production of the catalyst is a disadvantage of high energy demand, recovery of glycerol and side reactions that can affect environmental pollution. Therefore, the biological production of liquid fuel with lipases is of great importance with rapid improvement nowadays. Lipase catalyzes the reaction with less energy requirement and mild conditions required. But the production of lipase is expensive, hence the immobilization of lipase, resulting in repeated use and stability. Immobilization of lipase includes several methods: entrapment, encapsulation, cross-linking, adsorption and and covalent bond. Compared to covalent bonds, inclusions and crosslinks, the adsorption method for immobilization has been widely used in recent years. In the biological production of biodiesel, the methanol inactivates the lipase, so the immobilization process is advantageous for the production of biodiesel. The low cost of lipase, Candida sp. as origin, are more of industrial use. The nanostructured supports

are with high porosity, natural material activated carbon, celite, zeolite. The supports for lipase immobilization by covalent binding of olive pomace, resins, polyurethane foam, chitosan, silica and magnetic nanostructures. Compared to the natural carrier material chitosan used for enzyme binding, the immobilized lipase maintains its stability for 10 cycles of pomace, esterification while maintaining 80% residual activity.

Wastewater treatment:

The increasing consumption of fresh water and water bodies is mixed with polluted industrial waste water and the waste water treatments are currently required. The dye effluents come from the textile industry, the paper industry, the leather industry and the effluents are rich in dyes. These effluents pose a threat to the environment and are carcinogenic even in low concentrations. Nowadays, enzymes are used to break down the dyes. The enzymes used in wastewater treatment are preoxidases, laccase, azoreductases. These enzymes can lose their activity due to harsh conditions such as extreme temperature, low or high pH, and high ionic strength; to overcome this problem, immobilized enzymes are used. The horseradish peroxidases are encapsulated in calcium alginate beads, this method is still under laboratory scale research. The immobilized laccase enzyme has the ability to degrade anthracinoid dye, lancet blue and ponceau red dyes. The adsorption process is widely used because of its easy regeneration. During the covalent immobilization process, the conformational change occurs in the enzyme, which affects the activity of the enzyme. In the case of single enzyme nanoparticles, the enzyme is protected by a nanometer-thick substance since it provides the large surface area. SEN has the ability to maintain its activity in extreme conditions. SEN is also used in the removal of heavy metals from wastewater. Lipase has the ability to break down oil and fats into long-chain fatty acids and glycerol. The immobilized lipase is of great interest for the hydrolysis of oils and fats for the treatment of waste water from the food industry. The disadvantage of conventional treatment methods is slow biodegradability, oil and fats are absorbed on the sludge surface. Researchers are now focusing on treatment with immobilized lipase. Lipase immobilized on the sol-gel/calcium alginate with the size of 82m, immobilized lipase. Immobilized lipase that has been run smoothly for 100 days in continuous slurry does not produce foam in the reactor.

Textile industry:

The enzymes of microbial origin are of great interest in the textile industry. The enzymes like Cellulase, Amylase, Liccase, Pectinase, Cutinase etc. are used for various textile applications like washing, biopolishing, desizing, denim finishing, treatment of wool etc. Among these enzymes, cellulase has been widely used since ancient times until now. The textile industry

now turned to the enzyme process instead of using harsh chemicals that pollute and damage fabrics. The processing of substances with enzymes requires high temperatures and an increased pH value, the free enzymes cannot withstand the extreme conditions. Therefore, the enzyme immobilization for this process is able to withstand extreme loads and maintain its activity for more than 5–6 cycles. Polymethyl methacrylate is covalently linked to cellulase. In this method, the nanoparticle is synthesized with cellulase as the core particle. Endoglucanase is a component of cellulase enzyme, Endoglucanase is microencapsulated with gum arabic is a natural polymer with biodegradable properties used as matrix for encapsulation of endoglucanase. The encapsulation of endoglucanase prevented them from retaining their activity in the presence of detergents.

Detergent industry:

The detergent industry also uses enzymes to remove stains. The enzymes used in the detergent industry are proteases used to remove blood, egg, grass and human sweat stains. Amylase is used to remove starch-based stains such as potatoes, sauces, chocolate. Lipase is used to remove oil and grease stains and also to remove stains in cuffs and collars. Cellulase is used on cotton-based fabrics to improve softening, lighten color, and remove stains. Today, biotech detergents are used extensively in the detergent industry. Compared to synthetic detergents, the bio-based detergents have good cleaning properties. The enzyme-based detergents can be used in small amount compared to synthetic detergents, they have increased biodegradability, do not affect the environment, work well at low temperatures, and these are the advantages of enzymes in the detergent industry. The immobilized enzymes are also used in immobilized enzymes. Proteases hydrolyze the proteins and protease cannot be used on keratin based wool and silk fabrics which cause adverse damage to the garment. So Protease cannot be used directly for woolen and silk garments, Protease loses its stability in the presence of surfactants and oxidizing agents, therefore Protease is immobilized by covalently linking to Eudragit S-100 using carbon di imide coupling.

Preparation of biosensor:

An immobilized catalase-based Clark electrode for the detection of highly toxic chemical azide in fruit juices such as black cherry juice, orange juice and apricot juice was developed by Sezginturk and coworkers (2005) who can detect azide in the range 25 M to 300 M in fruit juices. Similarly, a polyaniline-based catalase biosensor for the determination of hydrogen peroxide and azide in various biological samples was also constructed (Singh *et al.*, 2009). The use of immobilized *Aspergillus niger* catalase on a modified SiO_2 support in a batch reactor to

remove traces of hydrogen peroxide used during milk pasteurization was studied by Akertek and Tarhan (1995). A catalase-based biosensor system was prepared by immobilizing enzymes on a dissolved oxygen probe membrane using gelatin to determine the degree of decomposition of hydrogen peroxide in milk samples in the dairy industry (Yildiz *et al.*; 2004). Another catalase-based amperometric biodevice for detecting calcium in milk and water samples was developed by Akyilmaz and Kozgus (2009) by immobilizing enzymes on Teflon membranes. The detection limit of 1mM to 10mM and a reaction time of one minute was recorded for this biodevice.

Based on the enzyme activity of catalase in infected milk samples, a fast and straightforward biosensor-based method to detect mastitis infection in milk was developed (Futo *et al.*, 2012). Hnaien *et al.* (2010) pioneered the construction of conductometric biosensors by co-immobilization of catalase and ethanol oxidase for the detection of ethanol in food. Aruldoss and Kalaichelvan (2014) also developed an amperometric catalase-based biosensor to estimate alcohol concentration in alcoholic beverages. This biodevice was also able to determine calcium levels within 3 minutes in cow milk samples. Kroll and co-workers (1989) developed a catalase-based method for determining the contamination of bacterial colonies in food samples with a detection limit of 10^3 cells/ml. Jasass and Fung (1998) suggested that catalase activity can be used as an index of microbial load to determine bacterial contamination in food samples. Similar catalase-based detection methods for foodborne pathogens such as Listeria monocytogenes and Staphylococcus aureus have also been developed to eliminate the microbial population from food (Patel and Beuchat, 1995; Majumdar *et al.*, 2013).

CONCLUSION:

Enzyme immobilization is a widely used technique in various industries, food industry, pharmaceutical industry, detergent industry, textile industry. This process is used because of its technical and economic advantages. The immobilized enzyme has more shelf life and increased stability which is required in all enzymatic biochemical applications. Catalase has been immobilized and used in various large scale processes. This stabilization process can reduce enzyme costs and enhances operative Stability of Catalase enzyme.

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ROLE OF RESEARCH AND DEVELOPMENT IN CHEMISTRY FOR SUSTAINABLE DEVELOPMENT

Pawan P. Kalbende

Department of Chemistry,

Jagadamba Mahavidyalaya, Achalpur City, Dist-Amravati, (MS), India.

Email: pawankalbende@gmail.com

ABSTRACT:

Human life is encircled by an enormous variety of chemical products which have been invented by researchers and produced by the chemicals industry which is the main source of environmental pollution. So, we are facing the problem with environmental concerns including the unsustainable use of non-renewable natural resources, the degradation of ecosystems and the disruption of the environmental systems that support human life. The general public now expects scientist to work to minimise and reduce hazardous effects on human health and the environment associated with the production and use of chemical products. For this reason, chemists and chemical engineers have a great influence on, and thus bear a responsibility for protecting the global environment. So, research and development in chemical sciences can and must play a key role in developing the processes, products and monitoring mechanisms that the Sustainable Development Goal (SDG) envisages.

INTRODUCTION:

What is sustainable chemistry?

Sustainable chemistry is the design, manufacture and use of efficient, effective, safe and environmentally benign chemical products and processes. Within the broad framework of sustainable development, government, academia and industry should strive to maximise resource efficiency through activities such as energy and non-renewable resource conservation, risk minimisation, pollution prevention, minimisation of waste at all stages of a product life-cycle and the development of products that are durable and can be re-used and recycled[1].

One of the most important and remarkable events in the 70-year history of the United Nations (UN) occurred on 25 September 2015, when government agreed on a collective global mission to transform the planet to achieve a sustainable future[1]. This mission is spelled out in 17 Sustainable Development Goals (SDGs) with a target date of 2030; progress towards them will

be measured against 169 specific indicators[2]. These SDGs represent a profound shift in the world's approach to development over the past 15 years. Whereas the Millennium Development Goals agreed by governments at the UN in 2000 focused on specific problems of the world's poor and shaped the development aid policies of the richest countries, the new SDGs embrace a global vision of development for all, based on the core principle of sustainability and with responsibility shared by all countries. It is clear, however, that the SDGs will not be achieved without a massive effort.

As a new and specific focal area of scientific research, sustainable chemistry was first articulated in the early 1990s and has gained wider currency in the last few years. Despite these early examples of sustainable chemistry research, the concept was not adopted until recently for a number of reasons. While there has been tremendous innovation in the design of chemical products and processes since the beginning of the 20th century, the driving force was not the minimisation or reduction of environmental impacts due to the production and use of these products. These impacts were not identified until the later part of the 20th century.

"Sustainable chemistry" is relatively a novel concept and scientific area that aims to improve the efficiency with which natural resources are used to meet human needs for chemical products and services. In this connection, it can contribute to achieving a cleaner, healthier and sustainable environment and improving the image of chemistry as a problem solving science in society. The concept of sustainable chemistry based on social as well as practical aspects associated with the development of chemical products using innovative technologies. Reports of sustainable chemistry have been reported in the scientific literature for decades; however, these early examples were random in nature and not driven by any consistent concept or a particular focus on human health and environmental impacts of traditional chemical research and chemical activities.

The concept of sustainable development described in 1992. Since then, it has been recognised globally by governments, academic institutions and industry. The main attention was focused on R&D in the development of environmentally benign chemicals during the last decade. These efforts have been limited, however, to independent activities within each segment of a given discipline or individual company. In parallel to this work, Organisation for Economic Co-operation and Development (OECD) governments were examining their own policies to see whether new and innovative approaches could be established which would result in more effective techniques for managing risk from chemical products and processes. In February 1998, the OECD Joint Meeting of the Chemicals Committee and Working Party on Chemicals,

Pesticides and Biotechnology, endorsed the start of work on a "sustainable chemistry" initiative. As a first step, workshop took place in Venice in October 1998, was hosted by the Inter-university Consortium, Chemistry for the Environment (Italy) and co-sponsored by the governments of Germany, Italy, Japan and the United States in co-operation with the International Union of Pure and Applied Chemistry (IUPAC) and the Business and Industry Advisory Committee to the OECD (BIAC). The workshop focused on the following policies:

1. Identify the types of sustainable chemistry activities already underway.
2. Identify effective techniques and approaches in the field of sustainable chemistry considering problems and highlighting solutions.
3. Identify activities that could further the development and use of sustainable chemistry.

It was evident from the responses to the survey and the presentations and interventions made during the workshop that considerable interest and enthusiasm exist among governments, industry, NGOs and academia both for sustainable chemistry's basic concepts and for practical applications. Further, many stated that it was imperative to integrate sustainable chemistry thinking into the fields of chemistry and environmental sciences, and throughout the vast array of industrial sectors that they affect. One of the major recommendations made at the Venice workshop, and later endorsed by the Joint Meeting, was that although OECD cannot fund or carry out actual research, it should encourage Member countries to undertake such research and facilitate the development of effective research activities in institutions and other organisations. In response, a second survey was carried out which indicated that a number of organisations had undertaken work on R&D in sustainable chemistry and many were interested in co-operative research at the fundamental level, and many saw value in the establishment of an information exchange network to promote co-operation. The results of this survey were used as a foundation for discussion at a second workshop on sustainable chemistry held in Tokyo. One of the main objectives of the workshop was to develop guidance to assist OECD countries and others in developing effective research and development programmes[3, 4]. The sustainable development goals are as follows.

1. End poverty in all its forms everywhere.
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
3. Ensure healthy lives and promote well-being for all ages.
4. Ensure inclusive and quality education for all and promote lifelong learning.
5. Achieve gender equality and empower all women and girls.
6. Ensure access to water and sanitation for all.

7. Ensure access to affordable, reliable, sustainable and modern energy for all.
8. Promote inclusive and sustainable economic growth, employment and decent work for all.
9. Build resilient infrastructure, promote sustainable industrialization and foster innovation.
10. Reduce inequality within and among countries.
11. Make cities inclusive, safe, resilient and sustainable.
12. Ensure sustainable consumption and production patterns.
13. Take urgent action to combat climate change and its impacts.
14. Conserve and sustainably use the oceans, seas and marine resources.
15. Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.
16. Promote just, peaceful and inclusive societies.
17. Revitalize the global partnership for sustainable development.

Role of Chemistry in the SDGs

The chemical sciences provide understanding of the physical and chemical properties of atoms and molecules and practical methods for creating new molecular structures with useful applications. Chemistry is a 'platform' or 'central' science for studying the fundamental aspects of a range of established and emerging sciences including biochemistry, nanoscience, molecular and synthetic biology, physics and soft condensed-matter physics; as well as many major practical advances seen in such fields as agriculture, biotechnology, energy, ecology, the environment, genetics, information technology, materials and medicine; and the dramatic rises in overall human wealth and well-being during the past two centuries[5]. The chemical sciences can and must play a key role in developing the Sustainable Development Goals [6, 7]. But to do so, all domains of chemistry academia, industry, funding agencies, the professional bodies and associations at national and international levels need to become involved and adopt the SDGs as a central concern and as a driving force for reform.

At the outset, it is vital that chemistry has played a dual role in the unfolding picture of global development. On the positive side, the knowledge and products contributed by chemistry providing sources of energy; a host of materials including polymers, plastics, semiconductors and solid-state display devices; agents for crop protection and plant growth; pharmaceuticals and much else have been a major factor in the advances in human wealth, health and well-being over the past two centuries and justify chemistry's claim to be the 'quality-of-life' science par excellence [8, 9]. It promises to go on being the source of innovative new products and processes,

including smart materials for better lifestyles, catalytic processes for light harvesting towards hydrogen production and carbon dioxide fixation, new vaccines and drugs for currently incurable diseases, 'nanobots' for drug delivery and sensors for disease diagnosis, to name but a few. Increasing energy consumption, industrial activity, population growth and urbanization add pressure to the planetary system and it is clear that major changes are now needed if multiple crises (relating to food, water, climate and energy) are to be avoided and humanity is to move to a path of sustainability.

Chemistry must now engage vigorously as one of the key forces that can identify and implement solutions to avert or mitigate potential crises and provide sustainable processes and products for the future. As the basis of a wide range of technologies in combination with its time-tested and well-established capacities for innovation chemistry can help to meet all of the SDGs to varying degrees. In particular, the chemical sciences are central to (i) the development of clean and sustainable forms of energy, for example, through efficient capture of solar energy, clean fuel cells and carbon capture, storage and reuse; (ii) the application of green chemistry principles and processes to manufacturing and for materials substitution; (iii) ensuring the efficient and affordable recycling of resources in short supply including 'endangered elements' and natural products; and (iv) developing new analytical techniques needed for more effective monitoring of the environment. Chemistry is also a key resource for addressing risk in an evidence-based and rational manner which acknowledges that no human activity can be entirely risk-free but that acceptable levels can be identified by risk assessment, management and mitigation. Thus, the SDGs provide an unrivalled opportunity for chemistry to embrace grand challenges and to make a positive contribution to the worldwide effort towards sustainability[10, 11].

Scope and benefits of sustainable chemistry

The ultimate goal of sustainable chemistry is to contribute to the realisation of a "sustainable society", with the help of chemical technology. Chemical technology development for pollution prevention is universally regarded as a high priority area of sustainable development. Innovative technology development for waste treatment, although an important and necessary activity, is a priority primarily in countries confronted with a serious problem from accumulated chemical wastes. There can be significant human health and environmental benefits from sustainable chemistry. A minor change in product or process design can result in significantly lower hazard and associated risk by substantially reducing or completely

eliminating hazardous material used in or generated from the product or process. In addition, energy consumption can be minimised and renewable resource utilisation maximised[11, 12].

In addition to the benefits to human health and the environment, sustainable chemistry technologies in some cases are economically competitive for and advantageous to the companies that apply them. In the second OECD survey on sustainable chemistry, governments indicated that they support sustainable chemistry research because it is an economically efficient and non-regulatory way of improving the protection of human health and the environment. Chemical manufacturers with active sustainable chemistry research programmes listed long-term profitability that is compatible with environmental protection and the protection of the health and safety of employees and customers as an objective. In addition to providing environmental, health and economic benefits, sustainable chemistry promotes the idea that chemistry can be used for beneficial purposes, such as remedying environmental problems. It can help alter the perception of some members of the public that chemistry is a field of science that harms human health and the environment in spite of the benefits it may bring. Moreover, sustainable chemistry can attract prominent young students to the field of chemistry. Also, because of the scientific innovation and rigour at the core of sustainable chemistry, academic institutions that responded to the second survey on sustainable chemistry indicated that they had gained an increased scientific understanding of the properties of chemicals and chemical processes through their work on sustainable chemistry[13].

Methods for assessing sustainable chemistry products and processes

It is often necessary for government, industry and others to judge whether a product or process falls within the definition of sustainable chemistry, or to prioritise products or processes amongst several options. Therefore, it is important for them to develop criteria and methods for assessing sustainable chemistry products or processes. Although ideally these criteria should be practical and similar across countries which is actually very difficult, and may not be practical, to develop common rigorous criteria because benefits and disadvantages of a sustainable chemistry product or technology sometimes depend on cultural, economic and other factors which vary across countries. Therefore, simple and clear criteria that contain only essential factors will be most useful and most likely to be accepted universally. Such fundamental criteria should include the following factors:

1. Determination of the impact on human health and the environment.

2. Determination of the safety of workers or users throughout the production processes or life cycle of products.
3. A comprehensive evaluation of energy consumption and resource use.

Based on these fundamental criteria, each country or organisation needs to establish its own specific criteria that reflect its particular situation. Based on the specific situation and knowledge levels of users, the most appropriate methods can be selected. In the case of research and development, the methods should be optimised for evaluating and selecting technological options that fit the research targets of research managers, researchers and engineers to the maximum extent possible. In the case of funding, specialists such as politicians, industry leaders and others will use the methods, and therefore only simple and general methods are suitable. Ideally, the development of these methods should contain a comprehensive evaluation of the inter-relationships among products and processes throughout the entire life cycle of the products, from then use of raw materials to production, and end use to recycling and disposal. This should also include an assessment of the potential risks posed by new or modified products and processes being considered. Life Cycle Assessment (LCA) has been used (and may be the most promising tool) to evaluate the environmental load caused by a product. Thus, it is not an easy task for a country or organisation to develop independently an assessment method on sustainable chemistry without any supporting guidelines[14].

Parameters of sustainable chemistry R&D

i) Use of renewable, recycled and alternative feedstocks.
ii) Increased energy efficiency or using less energy for the same or greater output.
iii) Developing alternative synthetic pathways, such as the use of catalysis and biocatalysis, photochemistry, and biomimetic synthesis.
iv) Designing simpler and alternative reaction processes and conditions that increase selectivity and reduce energy consumption and release of hazardous chemicals.
v) Designing chemical products to minimise impacts on human health and the environment.
vi) Designing chemical products that have inherently less hazardous properties, reduced toxicity, flammability and explosion potential.
vii) Avoidance of substances that is persistent, bioaccumulative and toxic.
viii) Pursuing product and process designs that take into consideration the impacts on human health and the environment by reducing the use and generation of hazardous materials.

ix) Developing processes that contribute to the minimisation of the releases of pollutants and the formation of by-products, residues, and wastes.

x) Pursuing process designs that are practical and widely applicable in a variety of manufacturing processes.

xi) Developing technological or operational systems that reduce energy and resource consumption and promote the cyclic utilisation of materials and chemicals.

xii) Developing innovative products that enable materials to be recycled into chemical resources, thus preserving environmental resources.

Collaboration and role of sectors for developing R&D on sustainable chemistry

Practically all the chemical manufacturers, research organisations and academic institutions responding to the second survey on sustainable chemistry said that they were actively involved in sustainable chemistry research. Some government departments and industrial or professional societies are also involved in related research. There was widespread support for an international information exchange mechanism on sustainable chemistry research. Chemical companies indicated that they would, in general, be prepared to exchange the results of pre-competitive research, but information about new products under development and improved processes is often confidential. Overall there was considerable support for further co-operative research in specific areas of sustainable chemistry.

The promotion and implementation of sustainable chemistry relies on a number of key factors: government, academia, industry, professional societies and NGOs. Each can play an important role either independently or working in collaboration with other actors. For academia and industry, sustainable chemistry is a voluntary way to move toward a sustainable environment and society. For government, sustainable chemistry is a non-regulatory way of making regulations work more effectively. Collaboration of the key actors is essential to make sustainable chemistry activities like R&D, education and information exchange as effective as possible. Collaboration across different regions and disciplines will further promote and enhance sustainable chemistry globally. The following sections describe approaches that the various actors can consider in order to promote the application of sustainable chemistry. Although these approaches can be considered in typical situations common to many countries, it is important to understand that they may not always be applicable to every situation in every country[15, 16].

1. Role of government

Governments can promote sustainable chemistry R&D using basically two different approaches. The policy they select will depend on the situation of the country. Under one approach, governments can establish and fund programmes on sustainable chemistry R&D. Governments, in general, can provide funds for basic and pre-competitive research which aims to improve practical manufacturing processes such as scale-up of lab-scale processes, develop new infrastructures, or modify existing infrastructures. Practically, governments can orient sustainable chemistry R&D programmes by adjusting the distribution of funds for fundamental and applied research or by commanding competitive and targeted funds depending on policies. Under the other approach, governments can facilitate the consideration and application of sustainable chemistry R&D by supporting efforts which aim at educating and informing industry and the general public of the importance and benefits of sustainable chemistry. One possible role for government would be to identify incentives and disincentives for the promotion of sustainable chemistry and to use this information to modify or develop their policies accordingly. When appropriate, the use of incentives, such as a reduction in taxes or the use of subsidies can be an effective way of supporting R&D by academia and industry in the field of sustainable chemistry[17, 18].

2. Role of academia

In many countries, a primary role of academia is to meet the requirements of society and industry, and to define cutting edge research by continuously challenging innovative chemical technologies while steering efforts towards sustainability. It is also the responsibility of academia to expand the technical options available to industry. Many members of society are concerned about the potential adverse effects of chemicals on human health and the environment, but at the same time they are strongly dependent on the availability and benefits of the innovative chemical products that are introduced to the market. As such, it is important that academic research be cutting edge, practically applicable to industrial processes and products, and considerate of the impacts to human health and the environment. Education and training of the public and workers about the importance of sustainable chemistry R&D is another essential role of academia. Such educational activities should not be limited to students but should also cover engineers, managing directors, other workers in the chemicals industry and also common peoples. Academia also can enhance the credibility and accountability of chemistry within society by educating and enlightening the public about safer products and process designs.

3. Role of industry

Industry should be aware of potential adverse effects of their products and processes on human health and the environment. Sustainable chemistry can be a voluntary and effective way for industry to prevent these adverse effects. The primary role of industry is to design and manufacture products in line with the concept of sustainable chemistry. Industry considers that society and the market successfully accept a new product only when the product meets societal needs or demands. The response of society to a given product often depends on the cost to be borne by individuals or the public. In addition, public perception of the environmental impacts of a product can affect its market value. Industry is, therefore, encouraged to continue improvement, incremental or revolutionary, of its manufacturing processes and products according to the environmental, social and economic principles of sustainable chemistry. Small and medium-sized chemical enterprises engaged in R&D may have the potential to promote challenging technological innovation in sustainable chemistry as they may be less bound by existing technologies. Sustainable chemistry, by its very nature, puts more emphasis on the development of new and innovative technologies and it needs to be promoted throughout the chemicals industry. A synergetic effect would be expected through effective co-ordination or collaboration between both of these initiatives[19, 20].

4. Role of professional societies and NGOs

The role of professional societies and NGOs is to help activate and develop discussion on sustainable chemistry research and results, and on how those results meet societal objectives. Specifically, professional societies provide journals and symposia, which encourage peer review to maintain scientific quality. Professional societies can also provide professional accreditation and career planning, which promote life-long service in the fields of interest to sustainable chemistry. Moreover, professional societies can facilitate establishing assessment criteria and international standards regarding sustainable chemistry R&D. In some cases, NGOs may be engaged in the verification and evaluation of new sustainable chemistry technologies in collaboration with academia. Both professional societies and NGOs provide publicity, information dissemination, and an interface between the scientific community and interested members of the public. Another important role of NGOs is to provide feedback to improve sustainable chemistry programmes so that they meet societal needs. Proposals based on such feedback can have a significant impact on the decision-making processes for R&D programmes[21, 22].

CONCLUSIONS:

Chemical sciences occupy a pivotal position in establishing the sustainable development goals. Chemistry can re-imagine itself as a champion and driver of sustainable development, transforming its image from often being seen as the source of environmental pollution and degradation to being recognized as the core sustainability science and plays a key role in developing practical, sustainable and ethical solutions to many of the world's greatest challenges in the twenty-first century. To do so, it will need to undergo radical reforms that amount to a redesign of the field encompassing chemistry's image, approaches and practices that will affect education, research and its funding patterns, and engagement with other disciplines, industry and society. We believe that these changes are desirable because the world needs chemistry's best endeavours to avert or mitigate the many global crises that are currently unfolding. We also believe that the proposed changes will reinvigorate the entire field of chemistry and transform its appeal as an ethical science worthy of investment and esteem by society.

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ENVIRONMENTAL IMPACT OF COAL MINING ON WATER REGIME

Ved Prakash Singh[1], Sumeet Kishore*[2] and Mritunjay Kumar[2]

[1]J P University, Chapra

[2]Jharkhand Rai University, Ranchi

***Corresponding author E-mail:** sumeet.kishore@jru.edu.in

INTRODUCTION:

In his poem The Rime of the Ancient Mariner (1772-1834), poet Samuel Taylor Coleridge (1772-1834) coined this phrase (1798).

"Water, water, everywhere, but not a drop to drink" is a common misquote.

The above quote not talking of philosophical sense but has a great meaning in literal term. About 71 percent of the Earth's surface is water-covered, and the oceans hold about 96.5 percent of all Earth's water.

To break it down, the seas hold 96.5 percent of all the Earth's water as salt water, while freshwater lakes and frozen water locked up in glaciers and the polar ice caps account for the remaining 3.5 percent. Almost all of that fresh water condenses into ice, accounting for 69 percent of it. If all that ice could be melted and the Earth's surface were perfectly smooth, sea levels would rise to a height of 2.7 kilometres.

Aside from the water that exists as ice, there is also a massive amount of water beneath the Earth's surface. If you gathered all of the Earth's fresh water into a single mass (as shown in the image above), the volume would be approximately 1,386 million cubic kilometres (km3).

Meanwhile, the volume of water that exists as groundwater, rivers, lakes, and streams is mildly more than 10.6 million km3, or slightly well over 0.7 percent. When interpreted in this light, the limited and precious nature of freshwater becomes abundantly clear.

Water can also be found in the air as water vapor, rivers and lakes, icecaps and glaciers, soil moisture and aquifers. Water doesn't stay stationary for long.

Two of our planet's long-standing mysteries are the origin of water on its surface and the fact that it has more water than any other rocky planet in the Solar System.

It was once thought that our planet formed dry 4.6 billion years ago, with high-energy impacts creating a molten surface on the infant Earth. According to this theory, water was brought to the world's oceans by icy comets, trans-Neptunian objects, or water-rich meteoroids (protoplanets) colliding with the Earth in the outer reaches of the main asteroid belt.

Recent research by the Woods Hole Oceanographic Institution (WHOI) in Woods Hole, Massachusetts, has pushed the date of these origins back even further. According to this new study, the world's oceans date back 4.6 billion years, when the inner Solar System's worlds were still forming.

This conclusion was reached after examining meteorites thought to have formed at various points in the Solar System's history. Carbonaceous chondrites, the oldest meteorites discovered in the Solar System, were discovered to have the same chemistry as those originating from protoplanets like Vesta. This includes the presence of significant water.

These meteorites have been dated to the same time period as water was thought to have formed on Earth – approximately 11 million years after the formation of the Solar System. In short, meteorites appear to have been depositing water on Earth in its early days.

While these findings do not rule out the possibility that some of the water that covers 71 percent of Earth today arrived later, they do suggest that there was enough already here for life to begin earlier than previously thought.

For coal preparation plants and dust suppression, open-pit mining need a lot of water. Mines obtain (and withdraw) surface or groundwater supplies from neighbouring agricultural or household users to satisfy this demand, which decreases or stops the productivity of these enterprises. After mining, these water resources are rarely restored to their natural habitat, resulting in a permanent decrease in agricultural production. Due to a decreased demand for dust-suppression water, underground mining has a comparable (but smaller) effect; nonetheless, adequate water is still required for coal-washing.

Surface mining may have a negative impact on groundwater resources. These implications include the draining of usable water from shallow aquifers, changes in flow direction within aquifers, pollution of usable aquifers underneath mining operations owing to infiltration (percolation) of poor-quality mine water, and enhanced precipitation infiltration on spoil heaps. Where coal (or carbonaceous shale) is present, increased infiltration may result in:

- Increased runoff of poor-quality water and erosion from spoil piles
- Recharge of poor-quality water to shallow groundwater aquifers
- Poor-quality water flow to nearby streams

This might pollute groundwater and neighbouring waterways for a long time. Acid mine drainage, hazardous trace elements, high dissolved solids concentration in mine drainage water, and higher sediment loads released to streams all contribute to stream quality degradation. When coal surfaces are exposed, pyrite reacts with water and air, forming sulfuric acid. The acid enters the waterways when water drains from the mine; as long as rain falls on the mine tailings,

sulphuric acid production occurs, whether the mine is running or not. Waste and coal storage heaps can also contribute silt to waterways. The water that has leached from these heaps may be acidic and contain dangerous trace elements.

To mitigate these problems, water is monitored at coal mines. The five principal technologies used to control water flow at mine sites are:

- Diversion systems
- Containment ponds
- Groundwater pumping systems
- Subsurface drainage systems
- Subsurface barriers

The above mentioned principal technologies is being used to bring out the sustainability in the water regimn . Various laws and rules is imposed to the mining industry so that water being effected by the company for beneficiary of the mineral industry doesn't led to an unsustainable environment and at no cost we can take a risk of using and polluting water at such extent so our future generation may suffer . for this attainment of sustainability mining industry is now beginning to introduce certain controlled water flow system to fist and foremost stop the disposal of mine based acidic waste to water rather the industry itself is responsible for proper disposal or destruction of the toxic waste rather than just dumping it in the water bodies .

Processes like Mechanical Dewatering & Sedimentation thickness as well as modification in ph. are some ongoing methods used by the mining industries to rewind the damage already done and in the future more advanced techniques like mechanical raining by cloud seeding may also apply to take us closer to a stronger sustainable environment.

Moreover the chapter includes the impact reasons as well as the measures company takes or are planning to take for a subsequent reduction of water based pollution due to the mining industry leading ways to achieve a sustainable environment with water regime in consideration to a great limits .

IMPACT OF MINING ON WATER REGIMN:

Hampering of water regime is due to various reason highlighted ones being overuse of water and disturbing the water cycle as well as water table . But in making the water unusable the major activities that comes to existence is mining.

Water contamination from discharged mine wastewater and seepage from tailings and waste rock impoundments damages fresh water, as does the high use of water in ore processing.

Human activities such as mining are increasingly threatening the water supplies on which we all rely.

Heavy metal poisoning of groundwater as a result of mining activities is a global environmental issue. The leachate produced by mine waste and overburden dumps has the potential to damage nearby water supplies. It includes overburden, run-of-mine rock, as well as waste, slurry, and tailings from preparation/beneficiation/extraction operations. Heavy metals contamination in soils is assessed using data on total content of specific heavy metals. Huge volumes of water are dumped on the surface throughout the mining process to help with the operation. Groundwater is our country's primary supply of drinking water, yet once contaminated, it's difficult to restore its purity. As a result, there is a need and concern for groundwater quality conservation and management.

Mining is the most booming industry with a large economic value and having a huge potential at economical level it comes with certain disastrous consequences.

Various studies at the ground level shows the real face and value to be paid for mining with interference with natural resources.

India is a country where still 2/3rd of the power is dependent on coal. And as of now there is no alternative for coal.

The most disastrous consequence of mining is on the local people because they are the one who are directly and relatively

COAL WASHERIES:

The fresh water is seen to be of black colour full of carbon content and ash, no crop can grow with such water rather it destroys the fertility of the soil. The water used for washing of coal get mixed with the fresh running water making it contaminated.

After coal is processed, the process water includes more major components of coal, such as Na, K, Mg, and Ca, than the washeries raw input water. This indicates that the entire or maximum transfer of these components is taking place.

Effects of this increase in harmful component in water can be seen on the crops and all plant and marine life existing near any mines. The drinking water gets so contaminated that it is not at all suitable to be used as drinking Water and people with agriculture as their main occupation suffers a great deal of loss in life hood.

Prevention from coal washeries

Not just taking of the problem the solution after some study is that Mn should be dealt with for a better reduction in water pollution, followed by a reduction in pH issues. Mechanical

dewatering and sedimentation thickeners can be used to remove the solids. We may also modify the pH of water to make it more basic rather than acidic, which will prevent Manganese from breaking down in the water. Manganese concentrations can also be reduced by using chlorine-dioxide, chlorine, ozone, potassium permanganate, or lime and lime-soda softening, followed by filtering. In addition, elements such as arsenic, lead, cadmium, iron, nickel, copper, zinc, and chromium were found to be below acceptable levels in all three washeries, indicating that they pose no threat to the environment.

ACID MINE DRAINAGE:

Acid rock drainage (ARD) or acid mine drainage (AMD) is a natural process that produces sulphuric acid when sulfides in open-pit rocks mix with water and air. When the water reaches a specific degree of acidity, a bacteria called Thiobacillus ferrooxidans boosts the process, speeding up both the acidification and oxidation processes. The acid is subsequently washed away from the mining area by rains or surface drainage.

The resultant fluids are extremely toxic, and when mixed with groundwater, there is a substantial danger of aquatic life extinction and stream usage restrictions for leisure, public drinking water, and industrial water sources, thus rendering the water useless. AMD is most commonly found in operating and abandoned coal mines. In the mid-Atlantic area, it is also regarded one of the major water pollutants.

Prevention of AMD

Acid Mine Drainage is a critical issue that affects a wide spectrum of public stakeholders. To begin addressing AMD's very real challenges, the government must:

- to avoid the loss of aquatic habitat due to acid mine drainage in the future,
- Inventory and clean up acid-producing mining sites that already exist.
- enhance public access to information about AMD treatment and reclamation monitoring and enforcement, and
- to avoid future AMD by enhancing environmental risk assessment and implementing a liability-prevention strategy in future AMD mine evaluations

HEAVY METAL CONTAMINATION:

Heavy metal contamination of water and soil is hazardous to human health; however, when the location in question is an agricultural region, the problem becomes much more urgent. The cause for this is the entry of potentially harmful heavy metals into the human body via the

food chain, which might be natural or manmade. As a consequence of study investigations, not only conventional ailments but also numerous malignant disorders have been discovered.

When metals like cobalt, arsenic, copper, zinc, lead, cadmium, and silver, which are exposed in underground mines or contained in excavated rock, come into contact with water, they produce heavy metal pollution.

As a result, before beginning agricultural activities, agricultural soil and water must be thoroughly studied. Appropriate sampling and laboratory analyses should be carried out and assessed. In this regard, contamination sources (natural or anthropogenic) must be identified and the existence of contamination assessed.

Gold and mercury, for example, are non-essential heavy metals with no biological importance for living creatures. When consumed, however, they are extremely hazardous. Even if just a trace amount of heavy metals are detected in water sources, they can still constitute a hazard and cause major health problems in people and other aquatic life. Because heavy metal concentrations rise up the food chain, humans are increasingly vulnerable to major health consequences.

EXPLOSIVE:

Water quality impacts due to the introduction of nitrate to explosive have significantly increased .shells of explosive or the magazine of the explosive containing various harmful chemicals when directly introduced to the water body causes the water to get contaminated and causes various diseases like body ache , fever , nausea .

The explosives used in opencast mines and the residue of the explosive is also disposed in the running water. Even the underground working explosive left over are washed away in the water causing disastrous effects.

The water gets so contaminated that the animal also cannot drink or use it.

Prevention from explosives

It is becoming increasingly critical to manage the risk of nitrate pollution of surface and ground water near mine sites. Explosives are the primary source of nitrates in a working mine. Given that explosives are a necessary element of the mining process, limiting their usage is the most rational way to reduce nitrate levels. The following strategy is focused on raising economic costs:

1. Develop and put into practice explosive management techniques.
2. Assess and enhance the blasting efficiency currently in place.
3. Replace the explosive with one that is more water resistant.
4. Consider your therapy alternatives.

CONCLUSION:

To reduce water pollution caused by mining activities, procedures such as installing water treatment facilities (Effluent Treatment Plants or ETPs) to remove pollutants from mine water, storm water, and workshop output, and installing sewage treatment plants have been implemented (STP). Still water is the resource that is very much necessary for the survival of human and the activities that are held responsible for contamination are being studied and various methods are being implemented for the reduction of any such activities. India depends on coal for its energy production almost 2/3rd of the energy produced by India is through the coal. Stopping mining activities is so not an option for it and so proper measures after studies on certain parameters are been suggested and worked upon that are mentioned above.

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STUBBLE BURNING IS A CHALLENGE FOR NORTH INDIA: AN INTRODUCTIVE OVERVIEW

Mamta Shukla[1] and Nikhil Agnihotri*[2]

[1]Department of Engineering & Technology

Faculty of Engineering and Technology, KMCLU, Lucknow

[2]Faculty of Science

SKJD Degree College Mangalpur Kanpur Dehat

*Corresponding author E-mail: nikhil.azolla@gmail.com

ABSTRACT:

Stubble (para la) burning during October and November results in the extensive formation of smoke clouds over the Punjab region and maybe one of the main reasons behind the increase in air pollution levels in these areas. Thus, in the present study, an attempt has been made to evaluate the impact of stubble burning. For this study data and literature were taken from different published reports in research journals, newspapers, and government notices and guidelines. It has been estimated that the stubble burn area was reduced by 32% and 40% during the study period for Patiala and Ludhiana regions, respectively. According to available data, the burning of crop residue released about 149 million tonnes of carbon dioxide, more than 9 million tonnes of carbon monoxide, 0.25 million tonnes of oxides of sulfur, and 1.28 million tonnes of particulate matter, and 0.07 million tonnes of black carbon. As evident, it contributes to a lot of greenhouse gas emissions. According to a recent study conducted in Punjab, pollution caused by stubble burning has significantly affected lung function at the local level and has proved to be particularly harmful to women in rural Punjab.

KEYWORDS: Air quality; Waste treatment; Stubble burning, Air pollution, Remote sensing.

INTRODUCTION:

The process of burning farm residue is one of the major causes of air pollution in parts of north India, deteriorating the air quality (Bhuvaneshwari *et al.,* 2019). Along with vehicular emissions, it affects the Air Quality Index (AQI) in the national capital and National Capital Region (NCR). Stubble burning by farmers in Haryana, western Uttar Pradesh, and Punjab in north India is considered a major cause of air pollution in Delhi and its adjoining regions. Paddy stubble (parali) burning is practiced mainly in the Indo-Gangetic plains of Punjab, Haryana, and UP to clear the fields for Rabi crop sowing (Beig *et al.,* 2020). The paddy crop is harvested between the first and last weeks of October in Punjab and Haryana. Then, farmers sow the wheat crop from the first week of November until the middle of December.

Stubble (Parali):

Stubble burning is a method of removing paddy crop residues from the field to sow wheat from the last week of September to November. Stubble burning is a process of setting on fire the straw stubble, left after the harvesting of grains, like paddy, wheat, etc. It is usually required in areas that use the combined harvesting method which leaves crop residue behind (Chawala & Sandhu, 2020).

After the ripening of the paddy crops, only the upper portion is harvested and the lower portion is left behind. The lower portion remains on the field with roots underneath. With mechanized tools for harvesting, the crop is cut from even a higher part which leaves stubble with slightly increased length (Mor *et al.,* 2021). This leftover part of the crop has no utility for the farmers. Therefore, to clear the field for the next sowing season, farmers usually burn this dry stubble which in turn becomes the reason for the pollution.

CAUSES BURNING OF STUBBLE:

Stubble burning has been practiced by farmers from all over the world although many governments have prohibited the practice to various degrees. In this section, we will see why farmers in northern India burn stubble (Zhuang *et al.,* 2017).

In the 1960s, as part of the Green Revolution, farmers in Punjab and Haryana were encouraged to do wheat-paddy crop rotation to make India self-reliant in grains production. As a result and because of assured procurement of rice and subsidies, rice acreage increased. The Punjab Preservation of Subsoil Water Act (2009) made it mandatory for farmers to transplant paddy late during the Kharif season to prevent loss of water. This gives the farmers very little time between harvesting the rice crop and preparing the field for the next winter crop. Hence, stubble burning is a quick, cheap, and easy way to clear the field of any rice chaff residue (Thind *et al.,* 2018).

One reason for the large quantity of rice stubble left behind after harvesting is the increased modernization and mechanization of agriculture. Mechanized harvesting extracts the rice grains only leaving behind huge residue (Singh et al, 2009; Singh *et al.,* 2021). Manual harvesting is not an option for farmers because of the huge labor charges and the increased time is taken. Earlier, the stubble used to be used by farmers as hay to keep animals or homes warm, and even for cooking. However, these uses of stubble have now become outdated.

Also, rice straw is not considered suitable as fodder for animals because of its high silica content (this is true for the non-basmati variety of rice). Despite the Punjab government making available tractor-mounted ‘happy seeders’ to cut down the rice stubble and sow wheat seeds simultaneously, many farmers find the prices of these machines or their rents prohibitive. So,

they continue to burn stubble (Singh *et al.,* 2015). To use a 'happy seeder' machine, farmers have to shell out Rs.1000 per acre of land as machine rent and a further Rs.2000 for diesel.

A few other machines/devices have been introduced by the government. However, many farmers cite suitability as an issue (Singh *et al.,* 2020). Also, stubble burning requires only a matchbox whereas the adoption of these machines incurs additional costs for the farmers.

Advantages of Stubble Burning: (I) It is the cheapest and quickest way to deal with crop waste. (II) It destroys weeds including those that are resistant to herbicides. (III) It kills other pests also, such as slugs. (IV) It can decrease nitrogen tie-up.

IMPACT OF STUBBLE BURNING

Stubble burning is now recognized as one of the significant activities that degrades ambient air quality as it is one of the major sources of aerosol and gaseous pollution (Andreae and Merlet, 2001). A study has reported that humans are responsible for about 90% of biomass burning with a negligible percentage of natural fires contributing to the total amount of vegetation burned (Weinhold, 2011). It has increased over the past decade due to excessive use of combined harvester that leaves stalks that are about one foot tall and cannot be tilled back into the soil. Burning is considered the easiest and most economical option for the management and removal of stubble. Due to a lack of awareness or non-availability of suitable technologies, it is generally practiced in many countries (Smith *et al.,* 2017). Annual biomass burned in Asia at an enormous scale, the residue of crop burning in India and China are 84.0 Tg and 110.0 Tg, respectively (Streets *et al.,* 2003). The period of crop residue burning depends upon the harvesting period, and it varies from region to region. Various studies have shown that rice stubble burning produces a large number of pollutants (RSPM, NOx, and SO2) in a short burning period, resulting in a sudden environmental impact (Streets *et al.,* 2003; Mittal *et al.,* 2009; Singh *et al.,* 2015). The amount of RSPM produced and its impact is quite significant as it has greater residing time in the air because of the balance between the downward acting force of gravity and aerodynamic drag force (Singh *et al.,* 2015).

Moreover, the harvesting period of rice is the winter season in the study region, and the impacts of the emissions and the potential for health effects are pronounced due to the prevailing weather conditions (inversion condition) i.e., very poor dispersion and poor dilution of the smoke. The smoke plume emitted from the stubble burn area gets confined close to the ground and drifts almost intact, rather than dispersing and diluting itself downwind. That further deteriorates the ambient air quality and impacts human health and surrounding. Thus the estimation of the burned area holds importance in quantifying total stubble burn and pollutants emitted (Vadrevu *et al.,* 2011). In the present study, estimation of stubble burn area (with the

help of remote sensing) and its impact on ambient air quality due to various pollutants emitted has been found (Agnihotri, 2020).

Loss of soil nutrients

The Director of Krishi Vigyan Kendra, Kapurthala said that the burning of stubble not only pollutes the environment but also destroys the nutrients of the soil. 25 kg of potash and five kg of nitrogen is destroyed in one acre by setting straw on fire (Agnihotri, 2018; Agnihotri, 2020). Two kg of phosphorus is wasted. The loss of 70 percent of the micro-neutron of the land due to fire will not be compensated at any cost. If stubble is mixed in the field for three consecutive years, then the need for chemical fertilizers will be reduced by 45 percent.

Loss of beneficial living organisms in the soil

The burning of crop residue damages the micro-organisms present in the top layer of the crop. This affects the biological quality of the soil. Burning of stubble affects the fertility of the soil more than the damage to the environment (Saxena *et al.,* 2021; Kumar & Gautam, 2022). Burning just one tonne of straw destroys soil nutrients like 5.5 kg nitrogen, 2.3 kg phosphorous, 25 kg potassium, and 1.2 kg sulfur. Many useful bacteria and pests present in the soil are also destroyed by the heat of the stubble fire.

Magnification in Air pollution

In Punjab, Haryana, and UP, pollution caused by stubble burning reaches Delhi-NCR with winds, affecting the air quality here. Also, the risk of ARI increases up to three times in people of such districts where stubble burning is done on a large scale. Also, due to the greenhouse gas produced by it, the environment is harmed (Vadrevu *et al.*, 2011). This is the reason that children (below 5 years) and the elderly (above 59 years) in urban areas are at higher risk of acute respiratory infection (ARI) due to crop residue burning than those living in rural areas happens more.

According to a report by the International Food Policy Research Institute, Gases like methane and carbon monoxide are to be emitted by the burning of stubble. Due to toxic fumes, the risk of getting lung problems, shortness of breath, cancer, and other diseases also increase. The air contains dust particles and other polluted gases (Kumar & Gautam, 2021). In winter, all these elements come together in fog and come down considerably. If at this time a person goes out for a walk or runs in the morning, then these polluted elements and gases reach the lungs by breathing. This greatly increases the chances of getting asthma and respiratory diseases. In such a situation, for those who are already suffering from this disease, it has very serious consequences.

The study noted that the risk of ARI is 50 times higher in Haryana than in southern states such as Andhra Pradesh and Tamil Nadu. Study co-author Suman Chakraborty from the University of Washington said the negative health effects of crop burning also reduce people's

productivity and can have long-term adverse effects on the economy and health (Ravindra *et al.*, 2022).IFPRI researchers and co-authors say that the smoke from agricultural crop residues by farmers in Haryana and Punjab, especially in Haryana and Punjab, increases the risk of ARI by three times for people living in districts such with poor air.

Impact on Human health

Stubble burning is being done these days in the agricultural states of Punjab and Haryana. The report claims that an estimated 44 to 51 million metric tonnes of paddy residue are burnt in Punjab alone. The pollution caused by this reaches Delhi-NCR with the winds. The study says that the burning of paddy residue alone caused 66,200 deaths in India in 2015 alone. Not only was this but the soil fertility also affected badly due to the burning of residue. In addition, the greenhouse gas produced by it also harms the environment (Bajracharya *et al.*, 2021).

SOLUTIONS TO STUBBLE BURNING PROBLEM

A few solutions (Jethva *et al.*, 2019; Raza *et al.*, 2022) to the problem of stubble burning are discussed below.

- Incentivize farmers for not burning the stubble and provide economic value for the crop residue. The stubble can be converted into fodder or organic fertilizer or fuel. The government should also subsidize or incentivize the industries that are engaged in converting stubble into economically viable products.
- Efforts should be made to improve the combined harvester that farmers use to harvest the crop. The current machine used leaves behind a huge residue. Improvement should be made in the technology used in such machines so that minimal residue is left behind.
- Encourage and incentivize the farmers to go for early paddy, to give them enough time to harvest and thereafter prepare their fields for the next Rabi crop.
- Encourage farmers to sow alternate crops and shift them away in the long run from paddy to maize, fruits, vegetables, and cotton.
- Use machinery like the Happy Seeder to remove the stubble. The government should make these machines available and economically viable for farmers.
- Penalize farmers that indulge in stubble burning. Despite penalties, many farmers engage in this practice because they find it cheaper to pay the fines rather than incurring the expenses for the alternatives for stubble burning. The government can also consider reinterpreting the MSP scheme to disallow the benefits of the scheme to farmers who practice crop residue burning.

- The government has to increase monetary incentives for avoiding stubble burning and also make machines that counter stubble burning an affordable, viable, and accessible option for farmers.
- Farmers have a difficult time unlearning the practice of stubble burning and they should be educated about its ill effects and also offered attractive alternatives.
- Eminent agricultural scientist M.S. Swaminathan has suggested that the Delhi, Haryana, and Uttar Pradesh governments could set up 'Rice Bio Parks', where farmers could convert stubble into products including paper, cardboard, and animal feed.

CONCLUSION:

The country suffers a loss of about Rs 2 lakh crores due to stubble burning in North India. Open stubble burning releases large amounts of toxic pollutants into the atmosphere, which contain harmful gases such as methane, carbon monoxide, volatile organic compounds, and carcinogenic polycyclic aromatic hydrocarbons. After being released into the atmosphere, these pollutants spread into the atmosphere, can undergo physical and chemical changes, and ultimately cause adverse effects on human health by forming a thick blanket of smog. This loss is in the form of expenditure on diseases along with the economics of air pollution. According to a recent study conducted in Punjab, pollution caused by stubble burning has significantly affected lung function at the local level and has proved to be particularly harmful to women in rural Punjab. All age groups (10-60 years) showed a two- to three-fold increase in most symptoms including shortness of breath, skin rash, itchy eyes, etc. The highest number of respiratory complaints were reported by the elderly population (>40-60).A decline in lung function was reported as a 10-14% decline in lung function in men and about 15-18% in women of all age groups.

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A REVIEW ON PLANKTON DIVERSITY WITH EMPHASIS ON PHYSICO CHEMICAL PARAMETERS

Ajit K. Gedam[1] and Vasant K. Dongare*[2]

[1]Jijamata College of Science, Bhenda Factory, Ahmadnagar, M.S.

[2]Sundarrao More Art's Commerce & Science College, Poladpur, Dist: Raigad, M.S.

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

ABSTRACT:

Jakhar (2013) reported Phytoplankton forms the sole base of food chain in aquatic system as they act as energy transducers and convert the solar energy into chemical energy of food. Zooplankton passes this food energy to the higher trophic levels and thus provides a link between energy producers and the consumers. These organisms are important biological indicator of water quality and trophic status of aquatic ecosystem as they respond quickly to the environmental changes. Halyal and Kaliwal (2007) reported that the distribution and population density of zooplankton species depend upon the physico-chemical factors of the environment. Statistical analysis showed that there exists a significant relation between the biological and non-biological factors.

KEYWORDS: phytoplankton, zooplanktons, biodiversity.

INTRODUCTION:

Jakhar (2013) reported Phytoplankton forms the sole base of food chain in aquatic system as they act as energy transducers and convert the solar energy into chemical energy of food. Zooplankton passes this food energy to the higher trophic levels and thus provides a link between energy producers and the consumers. These organisms are important biological indicator of water quality and trophic status of aquatic ecosystem as they respond quickly to the environmental changes.Zooplanktons are playing important role in biomonitering of water pollution (Tyor *et al.,* 2014). Shaikh *et al.* (2013) observed that the abundance and distribution of zooplanktons depend upon variety of ecological factors. The nature and pattern of fluctuation in population density of zooplanktons depend upon temperature, light, pH, dissolved oxygen and various other factors of the water body.

Nearly all fishes depend upon zooplanktons for food during their younger stages and some fishes continue to eat zooplanktons in their entire lives (Madin *et al.*, 2001). Because of

their central position in aquatic food webs, zooplankton communities are reliable indicators of aquatic ecosystem. According to Das and Kar (2016) Aquatic biodiversity is threatened primarily by human abuse and mismanagement of both living resources and the ecosystems that support them. Most of the ponds are getting polluted due to domestic waste, sewage, industrial and agricultural effluents. The requirement of water in all lives, from micro-organisms to man is a grave problem today because all water resources have reached a point of crisis due to unplanned urbanization and industrialization.The study of zooplankton isnecessary to evaluate the fresh water reservoir in respect to their ecological and fishery status (Goswami and Mankodi, 2012).

Many people have worked on phytoplankton and zooplankton diversity and gave their opinions, few of them are as follows, Khanna *et al.* (2012) studied the analysis of water samples for plankton diversity of river Ganga, In this study of river Ganga, among the zooplankton, Protozoa, Rotifera, Cladocera, Copepoda, Ostracods constitute the main component. Kohle *et al.* (2013) studied qualitative and quantitative evaluation of the variation in Godavari River Nasik district. Rotifers formed dominated group over other group of organisms. This study revealed that the water of river Godavari is contaminated of sewage and other industrial effluents.

Jos *et al.* (2012) studied seasonal fluctuations in diversity of zooplanktons of Achencovil River, Kerala. This study showed zooplankton community comprised of 28 species belonging to Cladocera 11species, Copepoda 9 species and Rotifera 8 species.This study also revealed that different groups of zooplankton have their own peak periods of density, which is affected by local environmental conditions. From the earlier work on the zooplanktons, it shows that studies have been done on the seasonal variation and zooplankton diversity in river but negligible work has been carried out on composition and seasonal variation in zooplankton.therefore the main objective of present study is to determine zooplankton composition and seasonal variation of this area.

RESULT AND DISCUSSION:

Halyal and Kaliwal (2007) reported that the distribution and population density of zooplankton species depend upon the physico-chemical factors of the environment. Statistical analysis showed that there exists a significant relation between the biological and non-biological factors. The benthic fauna constituting the food of fish can be utilized for extensive culture operation so that the nutrients in the reservoir are not only properly cycled but also serve as a check on further eutrophication.

Many workers from Maharashtra studied the phytoplankton and zooplankton diversity and gave their views, few of them are as follows, Hajare (2008) studies on monthly variations of phytoplankton in a freshwater tank of Talsande, Maharashtra and found that the phytoplankton in tank was reppresented by Chlorophyceae, Cyanophyceae, Bacillariophyceae, Euglenophyceae and Dinophyceae. The values of percentage composition of each group of phytoplankton indicated that Cyanophyceae (35.77%) formed largest group followed by Bacillariophyceae (34%), Chlorophyceae (27.4%) and Euglenophyceae (2.24%). Maximum density of phytoplankton was reported during summer, and minimum during monsoon. Jadhav S.,et al (2012) gave quantitative information on the seasonal variations of zooplankton and selected physico-chemical variables a large man-made reservoir in the Osmanabad district during this she recorded 5 species of rotifer, Cladocera by 4 species and Copepods represents 2 species whereas Ostracoda showed 2 species. Among zooplankton, particularly Cladocera was the dominant group. Bimbisar *et al.* (2014) too worked on phytoplankton population and recorded a total of 20 species of phytoplankton were recorded during the present study period. These include 13 species of Chlorophyceae, 4 species of Cyanophyceae and 3 species of Bacillariophyceae. Plankton samples were collected at regular intervals of one month at 3 stations and the phytoplankton fluctuates monthly and its productivity was high during summer and low during rainy season. Shinde *et al.* (2011) worked on seasonal variations, correlation coefficient and biodiversity indices of phytoplankton during January to December 2009 in the Harsool-Savangi dam, Aurangabad (M.S.) India. A total of 35 taxa were recorded of which 15 were Chlorophyceae, 7 Bacillariophyceae, 7 Cyanophyceae and 6 Euglenophyceae. We present correlation coefficient, percentage wise compositions, biodiversity indices and population density of these phytoplanktons taxa. Maxima were recorded at the north site in summer and minima at the south site during the monsoon.

Dede and Deshmukh (2015) studied the zooplanktons composition and seasonal variation in Bheema river near ramwadi village Solapur district Maharashtra and reported a total of 21 species among these 9 species belongs to tu rotifera, 5 belong to copepoda, 5 belong to cladocera and to belong to ostracoda while numerically rotifera was the dominant group and the seasonal variation shows an average abundance of species in winter season, lower in monsoon and maximum occurrence in summer season.

Umadevi (2013) reported the abundance, composition and distribution of zooplankton in relation to water quality parameters in Karanja River in Karnataka. 36 species of zooplankton were identified as a total, which included 14 species of Rotifera 11 species of Cladocera 8

species of Copepoda and 3 species of Ostracoda. According to Narsimanet *et al.* (2018) temperature has influence on the zooplankton diversity. Therefore, increased temperature due to global climate change might have influence on the zooplankton production. Assessment of zooplankton biodiversity will be useful to monitor the health (water quality) and wealth (fishery productivity) of this lake system in the near future. Mustapha (2010) observed that the total zooplankton to be positively correlated with phosphate, nitrate, DO, conductivity and TDS, whereas a negative correlation was observed between total zooplankton with carbon dioxide, transparency, temperature and total alkalinity. Sharma (2010) noted positive correlation between Chlorophyceae and DO, pH and calcium whereas; calcium had negative correlation with Bacillariophyceae during winter season.

Water temperature, turbidity and transparency and dissolved oxygen favoured rotifer population (Chandraseker, 1996). Shayestehfar et al. (2010) found negative correlation of air and water temperature with DO and an inverse relationship of DO with Cladocera, Ostracoda, Copepoda, Rotifera. Sinha and Sinha (1993) observed positive correlation of total zooplankton with temperature, DO, chloride and phosphate. Whereas Jhingran (1997) recorded positive correlation of total zooplankton with potassium, total hardness and iron.

CONCLUSION:

In the present study it was observed that many workers found positive correlation between the biotic and abiotic factors of the ecosystem, each and every factor have its specific role in the ecosystem, Few species show high tolerence to the abiotic factore by surviving at harsh conditions while few of them are low tolerent. Both phytoplankton and zooplankton act as a bioindicators and they play a vital role in the ecosystem.

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Environment and Sustainability Volume III

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About Editors

Dr. Mamta Shukla is an Associate Professor of Biotechnology in Faculty of Engineering and Technology, Khwaja Moinuddin Chishti Language University, Near IIM, Lucknow. She has experience of teaching more than 12 years in UG and PG in Biosciences. She has written many national and international papers in reputed journals. She has also worked as Vice President for a scientific company ioncure pvt. Ltd for two years. She has given internship in scientific writing to approximately 70 students during this period and also worked in different health issues online campaign like epilepsy and mental health. She is also working as a consultant in some companies and NGO. She also works for social welfare and associated in some motivational webinars also. She has written two e-books on Spices of ganga and immuno booster Indian recipes available on kindle. These books got international reviews for its good content. Some other books and papers are in pipeline. There are 4 patents on her credit.

Dr. Vinayaka K.S has presently working as an Assistant Professor and Head of Botany Department at Sri Venkataramana Swamy College, Bantwal, Dakshina Kannada, Karnataka. Specializing in Ecology and Cryptogammic Botany. He has been teaching and conducting research in Botany for the past one and half decade. His research interest includes Biodiversity, Lichenology, Phytochemistry, Bioprospecting, Plant Taxonomy, Microbiology, Green energy and Phytomedicine. He has published over 120 research paper in National and International journals and has authored 08 books. He acted as the editor for national level book and is presently working as the editor-in-chief for few national and international level journals. Dr. Vinayaka K.S has received many research awards and grants like DST Young Scientist, Radhakrishna Shikshana Ratna award, National Science Foundation (NSF) Travel award, Visiting Scientist grants etc.

Dr. Gyanendra Kumar is serving as Assistant Professor and Head of Department of Zoology, National P.G. College, Lucknow. His subject areas of interest are Zoological, Entomological and Environmental Sciences. He has published several international research papers of high repute. He has authored many book chapters and contributed as book editor. He has actively participated and presented scientific papers in several national and international conferences. He is member of several academic bodies and Board of Referee. He has contributed as subject expert in several organizations and selection committee. He was awarded with 'Best Educator Award' and 'Vigyan Ratna Puraskar'. He is dedicated in serving the society by conveying and spreading the knowledge in the field of Science.

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