CLEAN CREEK MOVEMENT 25 (#*CCM25*)
PROCEEDINGS
of
A Two Days National Conference
on

"PROTECTING WETLANDS FOR OUR COMMON FUTURE"

Organised by
University of Mumbai
Paryavaran Dakshata Mandal,
Association of Teachers in Biological Sciences,
Mangrove & Marine Biodiversity Conservation Foundation of Maharashtra
and
Enviro-Vigil

To Celebrate the "World Wetlands Day"

on
31st January, 2025 (Online mode) &
1st February, 2025 (Offline mode)
at
Kalina Campus of the University of Mumbai

ISBN 978-81-926582-1-6

Paryavaran Dakshata Mandal's Clean Creek Movement

Dr. Prasad Karnik, Vice-President, PDM

Paryavaran Dakshata Mandal (PDM) is an NGO- working in the field of Environment Awareness through Education, training & Research for the last more than 25 years. PDM is implementing Clean Creek Movement (CCM) for the last more than 24 years. With its aim of creating awareness through education & research in Environmental issues, PDM runs CCM for restoration of Thane Creek specifically- with the help of various events, programs and activities. The core focus is on students. The students are the best torch-bearers to enlighten the entire society. Celebration of World Wetlands Day (WWD) on 2nd February and World Mangrove Day (WMD) on 26th July, are the major activities PDM undertake for effective implementation of CCM as it involves not only the local students-teachers & general public, but the local stakeholders also. After establishing CCM in Thane District (Creek belt, mainly), PDM enhanced the scope to Mumbai & Navi Mumbai. Practically, PDM has covered almost entire Mumbai Metropolitan Region (MMR).

2025 bring PDM and thereby the WWD celebration on online platform as well as offline platform. PDM is organizing this conference with Association of Teachers in Biological Sciences, University of Mumbai, Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra, Keshav Srushti and Enviro-Vigil, Thane.
Paryavaran Dakshata Mandal (PDM), Thane- which became the Thane Chapter of the Mangroves Society of India (MSI) later- was one such NGO, working in the fields of Environmental Awareness, Education & Research from late 1990s and initiated "Clean Creek Movement (CCM)" from early 2000s. PDM call it as "Clean" Creek Movement and NOT "Cleaning" Creek Movement as the only practical solution to bring this great Wetland to its former Natural Glory is NOT by Cleaning the creek (that's impossible and hence, impractical) but by Keeping the Creek Clean. This, in turn, is possible by preventing any waste to be dumped in the Creek & nearby Wetland! Thus, reaching out to the local population was inevitable and PDM is doing it for more than 20 yrs. through Students.

PDM started Jal-Saksharata Abhiyan in 2004. CCM was initiated as part of this Abhiyan. Eventually, it became an independent Movement, an on-going project with active participation of local population. First formal World Wetlands Day was celebrated by PDM in 2007 with Thane Municipal Corporation and in 2008, with Birla College Kalyan. From then onwards, WWD became a National Conference, celebrated with very many colleges from Mumbai Metropolitan Region.

We are confident that this Conference and its e-proceedings will create & spread the necessary awareness among the classes & masses locally, and otherwise, too.

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Organising Partners

University of Mumbai

The University of Mumbai, established in 1857, is one of the oldest and premier higher educational institutions in India. The university has been recipient of various prestigious awards, grants and recognitions. In the year 2021, the university has been reaccredited with A++ (score above 3.65) by NAAC. The university has 65 departments and 850 plus affiliated colleges. The university is committed to empower education through innovation, learning and to produce the finest professional and responsible future citizens.

Paryavaran Dakshata Mandal (PDM)

Paryavaran Dakshata Mandal is an Environmental NGO working in the field of Environmental and nearby area. This organization was formed to educate and create environmental awareness amongst the masses. We house various projects like Paryavaran Shala, Green Career Courses, Green Shoppe, Monthly magazine 'Apala Paryavaran', Devrai etc.

Association of Teachers in Biological Sciences (ATBS)

The Association of Teachers in Biological Sciences was founded in 2006 and its main objective is upgradation of learning and teaching in Biological Sciences. It organizes and supports the seminars, conferences, workshops, conventions, competitions etc. in life sciences.

Enviro-Vigil

Enviro-Vigil is an environmental organisation working in Thane city for past 25 years. The organisation is working for a social cause with an objective to generate awareness at the societal level regarding various issues related to the environment with a mission to build strong and self-dependent organisation working to empower the youth to accept challenges of changing world in tune with the sustainable developments.

Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra

Government of Maharashtra has established Kandalvan Orbital in 2012 under the Forest Department to protect and conserve the ecosystem of Kandal forests, research programs on endangered species in coastal and marine ecosystems and improve the quality of life of the people living along the coastal habitats through sustainable livelihood activities. The Kandalvan Chamber has taken up the task of setting up a large number of nurseries for plantation of Kandal forests on degraded areas along the coast. Also, 'Kandalvan Swachhta Missions' are being implemented under various awareness programs.

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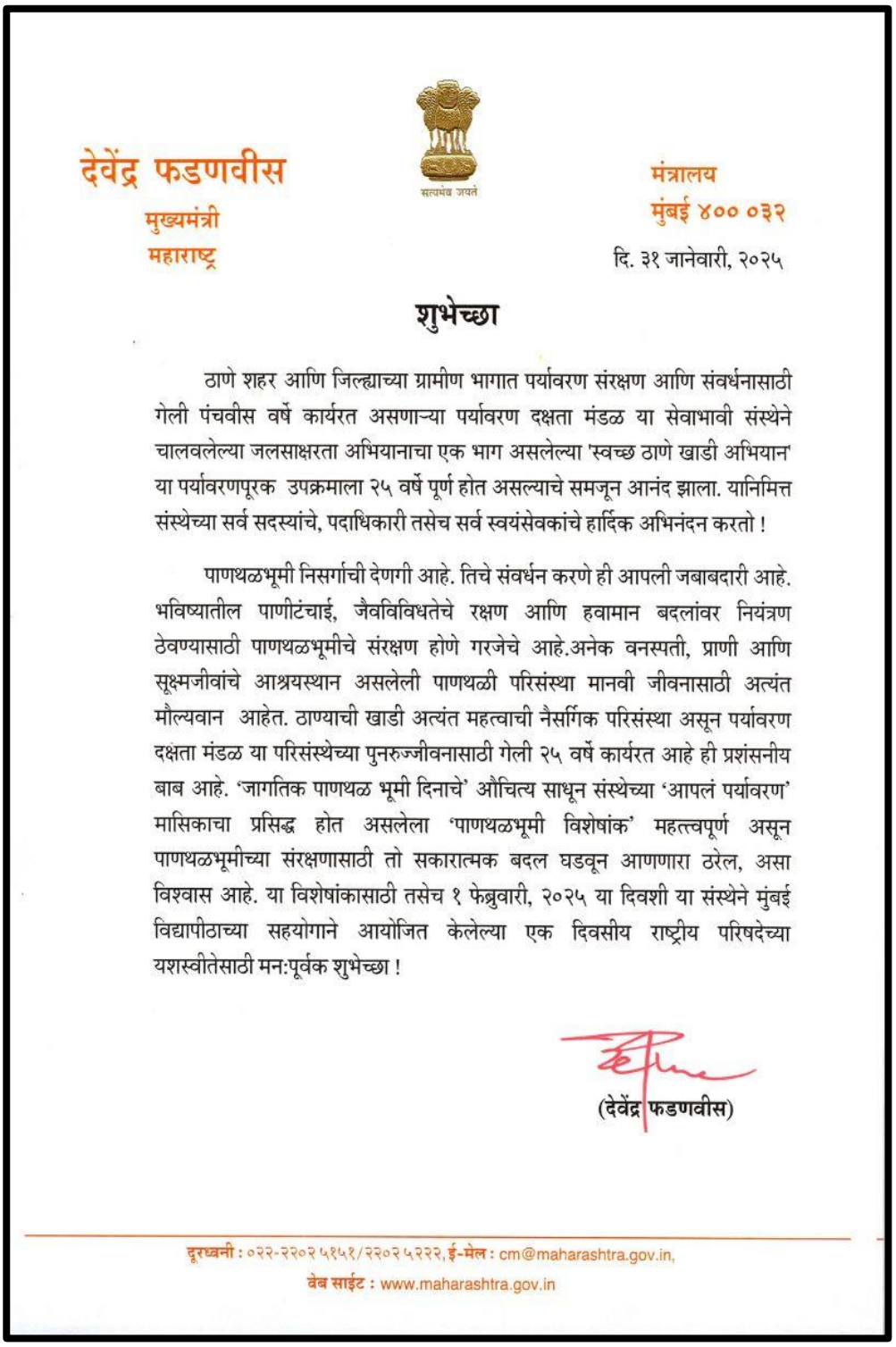
Message by Hon'ble Chief Minister of Maharashtra, Mr. Devendra Fadnavis



देवेंद्र फडणवीस
मुख्यमंत्री
महाराष्ट्र

सत्यमेव जयते

मंत्रालय
मुंबई ४०० ०३२

दि. ३१ जानेवारी, २०२५

शुभेच्छा

ठाणे शहर आणि जिल्ह्याच्या ग्रामीण भागात पर्यावरण संरक्षण आणि संवर्धनासाठी गेली पंचवीस वर्षे कार्यरत असणाऱ्या पर्यावरण दक्षता मंडळ या सेवाभावी संस्थेने चालवलेल्या जलसाक्षरता अभियानाचा एक भाग असलेल्या 'स्वच्छ ठाणे खाडी अभियान' या पर्यावरणपूरक उपक्रमाला २५ वर्षे पूर्ण होत असल्याचे समजून आनंद झाला. यानिमित्त संस्थेच्या सर्व सदस्यांचे, पदाधिकारी तसेच सर्व स्वयंसेवकांचे हार्दिक अभिनंदन करतो !

पाणथळभूमी निसर्गाची देणगी आहे. तिचे संवर्धन करणे ही आपली जबाबदारी आहे. भविष्यातील पाणीटंचाई, जैवविविधतेचे रक्षण आणि हवामान बदलांवर नियंत्रण ठेवण्यासाठी पाणथळभूमीचे संरक्षण होणे गरजेचे आहे.अनेक वनस्पती, प्राणी आणि सूक्ष्मजीवांचे आश्रयस्थान असलेली पाणथळी परिसंस्था मानवी जीवनासाठी अत्यंत मौल्यवान आहेत. ठाण्याची खाडी अत्यंत महत्वाची नैसर्गिक परिसंस्था असून पर्यावरण दक्षता मंडळ या परिसंस्थेच्या पुनरुज्जीवनासाठी गेली २५ वर्षे कार्यरत आहे ही प्रशंसनीय बाब आहे. 'जागतिक पाणथळ भूमी दिनाचे' औचित्य साधून संस्थेच्या 'आपलं पर्यावरण' मासिकाचा प्रसिद्ध होत असलेला 'पाणथळभूमी विशेषांक' महत्त्वपूर्ण असून पाणथळभूमीच्या संरक्षणासाठी तो सकारात्मक बदल घडवून आणणारा ठरेल, असा विश्वास आहे. या विशेषांकासाठी तसेच १ फेब्रुवारी, २०२५ या दिवशी या संस्थेने मुंबई विद्यापीठाच्या सहयोगाने आयोजित केलेल्या एक दिवसीय राष्ट्रीय परिषदेच्या यशस्वीतेसाठी मन:पूर्वक शुभेच्छा !

(देवेंद्र फडणवीस)

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WELCOME ADDRESS

Hon' Dr. Ravindra Kulkarni (Vice Chancellor of University of Mumbai)

This is the 2nd consecutive year of the National Conference on World Wetlands Day. The organisation of this conference prompted University of Mumbai to take utmost care of the wetland in the Kalina Campus of University of Mumbai. Recently we have witnessed arrival of some new birds here. This has encouraged us to take up entire strategic survey of biodiversity (flora and fauna) in the campus. We are required to be very attentive to take care of this wetland. If we register various features of this place at appropriate time then we might be able to register this wetland with Government of Maharashtra and Government of India.

Organising such World Wetlands Day conference on regular basis can be helpful in registering our wetland sooner but with that our responsibility of preserving and undertaking necessary conservation measures increases. The campus of University of Mumbai at Kalina is at the heart of Mumbai. If we maintain the biodiversity and preserve the wetlands then it can be the lungs for entire Mumbai. We would thus serve our beloved Mumbai in a much better way. Carbon neutral Green Group of Kalina Campus, University of Mumbai, is undertaking a lot of initiatives including the development of climate action plan for sustainable university campus. E.g. Development of Miyawaki forest, single use plastic free campus, recycling the waste water, multiple rain water harvesting systems, solar energy covered campus at University of Mumbai etc.

With a similar objective to highlight the significant role of wetlands and accelerate the conservation strategies amongst the younger brighter minds and spread awareness among the masses, the 25th Annual National Conference on 'PROTECTING WETLANDS FOR OUR COMMON FUTURE' is organized by Paryavaran Dakshata Mandal jointly with University of Mumbai, Mangrove Foundation, Association of Teachers in Biological Sciences and Enviro Vigil, Thane.

My sincere appreciation to the organisers Paryavaran Dakshata Mandal, Department of Geography, and the Carbon Neutral Campus Team, University of Mumbai, for the 2nd successive year of celebration of the World Wetlands Day. I wish good luck to all students who have participated in the competitions and I wish the Conference a great success.

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Convener's Address, 31st January 2025

Prof. Purushottam G. Kale, Rtd. Prof. and Head, Department of Zoology, Ramniranjan Jhunjhunwala College, Ghatkopar, Director, Paryavaran Dakshata Mandal, and Founder Secretary, Association of Teachers in Biological Sciences, India.

Namaskar. I wish you all, the representatives of the organizing partners and various committees of the conference; teachers of various Departments of the University of Mumbai and of various institutions and the participants gathered here for the second day of the National Conference on 'Protecting Wetlands for Our Common Future', CCM25, organized by The Paryavaran Dakshata Mandal, Thane; Association of Teachers in Biological Sciences, India; Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra and Enviro-vigil, in this elegant conference hall at the Kalina Campus, University of Mumbai, a very good morning. On behalf of all the organizers I welcome you once again to this inaugural session on the second day's offline proceedings of the conference.

Under the Clean Creek Movement, a flagship project of Paryavaran Dakshata Mandal, this is the 25th Conference. Honorable Chief Minister of Maharashtra, Shree. Devendra Fadnavis was invited for this inaugural function but has conveyed his inability to participate and has graciously sent a message that I shall read out to all of you….

It is globally accepted that the wetlands are crucial for their ecological services, including carbon sequestration to resist the phenomena of global warming and climate change. The international committee for celebration of the World Wetlands Day, chose the theme "Protecting Wetlands for our common future", which was adopted by the organizers for this conference, CCM25. Since Paryavaran Dakshata Mandal was celebrating its Silver Jubilee, the organizers decided to have programs and competitions at various locations across the Mumbai Metropolitan Region. I shall quickly inform you about these.

Two pre-conference workshops were conducted. The first one was on 'Research Projects on Wetlands' for guiding the students on designing and working on research projects based on the subthemes of the conference. It was conducted at Ramniranjan Jhunjhunwala College, Ghatkopar, Mumbai, on 11th May, 2024, by Prof. Purushottam Kale. There were 70 students in attendance. The second was conducted on 4th September 2024 at The Geography Department, Kalina Campus, University of Mumbai. Dr. Sanjay Joshi guided the students on research projects on Wetlands while

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Dr. Aparna Phadke explained the construction of maps of the study areas. This workshop was attended by 70 students.

Late Dr. Untawale Memorial Lecture was organized on 4th September 2024 at SIES College, Nerul. Dr. Sanjay Deshmukh was the resource person and the talk was on Status of mangroves in India. Over 250 students and teachers attended it.

Late Dr. Kodarkar Memorial Lecture at BNN College, Bhiwandi, was on 1st October 2024. It was engaged by Dr. Umesh Mundlye on 'Aquatic Ecosystems: Importance, Current Status, Threats and Restoration. Over 200 participants were present for the talk.

Late Dr. Gokhale Memorial Lecture was conducted at B. N. Bandodkar College, on 12th December, 2024. Dr. Sudesh Rathod was the speaker and he spoke on Research work carried out on Thane Creek. Participation was of 160 students and teachers.

A competition of street play on the predetermined topics related to the theme of the conference was conducted for NSS Units of the institutions under the University of Mumbai. The final round of the competition was held in Birla College, Kalyan, on 11th December 2024. In this final round, there were 14 teams with a total of 150 students.

On 2nd January 2025, online competitions for Photography, Short Films and Creative Placards were organized. In all 50 photographs, 7 short films and 15 placards were assessed on the day. The result of all these competitions will be declared and prize distribution will be a part of the valedictory function.

It is my pleasure now to inform you the program scheduled for this day. Dr. Manasi Joshi, President, Paryavaran Dakshata Mandal, will take you through the activities of the Mandal. Following this, Major Pravin Nayak, Treasurer, Association of Teachers in Biological Sciences will talk about the activities of the Association. Shreemati Dhanashree Bagade, Marine Biologist, will then talk about the Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra. The inaugural function will conclude with a vote of thanks, which will be proposed by Dr. Nisha Shaha of Department of Life Sciences, University of Mumbai.

The Key-Note Address will be by Dr. Ritesh Kumar, Director, Wetlands International, South Asia. Then Dr. Prasad Karnik, Director, Paryavaran Dakshata Mandal, will present the current status of Thane Creek. The poster presentation will then be conducted while the group A and Group B oral presentations will be conducted in parallel sessions. The volunteers will guide you and the judges to the respective locations. The lunch break will follow.

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The participants will then gather in this hall for the presentation of the prize-winning street plays, the prize-winning creative placards, the prize-winning short films and the prize-winning photographs. A tea break will follow and then the valedictory function will be there in this same hall.

I wish you all a pleasant and academically satisfying time and hope you will all enjoy the proceeds. Thank you till we meet again.

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Address by Dhanashree Bagade, Marine Biologist at Mangrove Foundation

The Mangrove Cell was constituted by the Government of Maharashtra in the year 2012 in the wake of serious public concerns about mangrove loss in the state, particularly in Mumbai and surrounding areas. Further, the work of the Mangrove Cell was strengthened by the establishment of the "Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra" (Mangrove Foundation) in the year 2015 for the protection, conservation of the biodiversity in coastal areas of the state and to promote sustainable livelihood activities which involve coastal communities. The Foundation is registered under the Societies Registration Act, 1860.

The work of the Mangrove Cell and the Mangrove Foundation involves activities of mangrove restoration, sustainable livelihood practices for conservation of mangroves involving local communities, demarcation of mangrove areas, awareness programmes helping in generating the symbiotic relationship and harmony of humans with nature and many more.

At present several mangrove restorations and livelihood activities like mud crab farming, oyster farming, mussel farming, ornamental fish rearing, fish cage culture, ecotourism etc. are executed by the Mangrove Foundation under the Mangrove Conservation and Livelihood Generation Scheme of the Maharashtra Government.

The tangible benefits derived by local communities from several livelihoods and marine conservation programmes will sow the seeds of community-led conservation of the mangrove and marine ecosystems.

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Keynote Address: 31st January 2025

Adapting to Changing Planet

Dr. Deepak Apte, Managing Director- Srishti Conservation Foundation

This talk is focused on providing a proper background or a wider perspective to conservation. Earth is a beautiful planet sharing nature's best secrets. It has not only survived violent events like series of volcanic eruptions, glaciations, quakes and other tectonic events but is decorated with diverse habitats supporting a vast array of flora and fauna. The beauty of nature can be appreciated by fathoming into the oceans and wandering into the pristine forests.

Presently, though, it is a crowded planet. Crowded with wildlife as well as humans. It also is a 'connected' planet. The marine mammals, sea turtles, catadromous and anadromous fish, a variety of birds are traveling thousands of kilometres for breeding, feeding and other purposes. So also, our cargo ships, fishing vessels, cruise ships are spanning the oceans; the planes are crisscrossing the continents; rails, trucks, passenger vehicles are spanning the countries all the time. The conservation actions cannot be considered in isolation in this connected planet.

Despite the resilience, planet earth at large and its ecology in particular is quite vulnerable. Though man seems to be a negligent entity, our actions are damaging the ecosystems, the atmosphere, the land and the waters. the result is global warming and climate change. The delicate balance of season cycles has been disturbed and an uncertainty has crept into it. The extreme weather events and natural disasters are increasing in frequency and severity.

Srushti Conservation Foundation had followed the changes in the coastline of Maharashtra for example and the report released few years ago highlights the changing nature of Indian coastline. The conservation and protection of mangroves, sand dunes, sandy shores, rocky shores, saltpans, forests and wildlife at large is essential but while doing so it must be kept in mind that one shoe cannot fit all sizes. The conservation policies may be overarching but the solutions have to be site specific.

Survival is through adaptation to the changes. For the last 2,00,000 years humans have been adapting to the changes in the surroundings and surviving. However, the current situation demands resilience related adaptations that man had never foreseen. Even if we succeed in achieving zero carbon emission, it will take a very long time to clear the accumulated carbon in the atmosphere and to stop, if not revert, the increasing global temperature and the climate change.

A proactive strategy will have to be developed for conserving the wildlife and thus the human life. A realignment with the climate reality in planning and executing the developmental projects is the need of time. We must reach out to the youngsters, making them understand climate realities and guiding them for building climate resilient communities. Only then can we succeed in sustaining life on our beautiful planet.

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Dr. Ritesh Kumar
Director, Wetlands International South Asia

Key Note Speech
"Navigating Wetlands conservation in India"

1st February 2025

World Wetlands Day Conference

Journey of wetlands conservation. Wetlands typically are the ecosystems that cross the duality of land and water. They are signature of land, signature of water, most of our policies and programming has been either around land or water. Discussions on understanding the importance of wetlands and the subject of wetland conservation started in late 1920s and 1930s in North America and Canada. Then in 1960s, there was a call for putting International cooperation, arrangement and multilateral environment agreement for wetlands. There are challenges and complexities to define these ecosystems which are ecotonal. Wetland ecosystems demonstrate lot of diversity and and hence are identified by different names such as mudflats, peatland, bogs, marshlands, rice paddies, ponds, coral reefs, mangroves, floodplains aquaculture ponds, fish farms etc. Different parts of our country have different names for wetlands. Adjacent map prepared in collaboration with GIZ shows diversity of wetlands in India. Although wetlands in India occupy just 5 percent of the total land area, they are very crucial and most productive ecosystems. They act as the buffers against extreme weather events like tropical cyclones, floods, storm surges which are becoming more intense due to climate change. etc. Roughly 85 million people directly depend on wetlands for food security and livelihood. Wetlands recharge 14% of utilizable ground water and 6% of utilizable surface water. High altitude wetlands of Himalayas are the sources of 10 largest rivers in South Asia. The carbon storing capacity of wetlands is 40 times more than that of the tropical forests. Wetlands provide habitats for 40% 0f all the fauna (animal species) and 43% of all the flora in India. It provides habitat to 64% fish, 28% reptiles, 42% birds, 100% amphibians. Central Asian Flyway is habitat to 250 species of migratory birds. Several of our cultures, religions and linked with wetlands.

In 1800s, draining wetlands for agriculture was seen as productive activity. In countries like USA, wetlands were considered places of recreation and hunting ducks and some other water birds. In the western world, wetlands were associated with melancholy and diseases. Rome was built on a series of converted wetlands. Washington DC and many other cities in USA were built on wetlands. Even Calcutta in India was built by draining the wetlands. However, the wetlands in India have had more compassionate and diverse roots. In ancient Indian literature, wetlands were called Anupa or Land near water, incomparable to land, incomparable to water and received differential and preferential treatments. Wetland habitats and wetland species were revered by the ancient people. Wetlands existed because of the diverse goverence arrangements from game reserves to community reserves. Vedanthangal in Tamil Nadu is a classic example. Farmers there saw that large number of water birds were flocking in this wetland and their excreta or guano provided rich fertilizer to their farms. So, the farmers themselves put a ban on hunting the water birds and thus conserving the wetlands. Lake Chilika is another good example of community fisheries and wetland conservation. In British India, however, several of these traditions and relationships between communities and wetlands started breaking down. British rulers encroached upon wetlands for development purposes and ended up in transforming these systems form flood dependent to flood vulnerable. Post-

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independence, this disconnect increased even further. Grow More food campaigns in 1950s led to the conversion of large number of wetlands to farmlands for agriculture. During 1970-2014, rapid urbanization took heavy toll on wetlands. Increase of every 1 sq. km. of urban area led to the decline in 25 hectares of wetlands. Moreover, wetlands were considered as the wastelands! With construction of dams and canals for irrigation purposes, wetlands lost their relevance as major sources of irrigation. In 1970s, work of stalwarts like Dr. Salim Ali resulted in bringing several wetlands with high concentration of the migratory birds under the protected area network (PAN) so as to protect them from developmental pressures. In 1971, Ramsar Convention took place. It changed the whole perspective of wetlands protection and conservation. Convention was for the commitment to 'wise use' of wetlands and maintenance of ecological characters. The convention also defined wetlands encompassing all the water bodies and removing the confusion. It declared 10 different types of wetlands including natural and man-made wetlands. The following definition was standardized by the convention as given in Article 1. "Wetlands are the areas of marsh, fen, peatland or water whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters". This placed wetlands into a wide range of ecosystems. The ambit of wetland conservation was broadened and the philosophy of wise use of wetlands was brought in the central premises of wetland conservation. In 1980s, in India, a National Programme on wetland conservation was included in the Seventh Five Year Plan to support the states for implementation of management action plans. In 1987, the first state level wetland authority was established for Lohtak lake in Manipur. In 2005, the National environment Policy was framed which had a provision for regulating the wetland conservation programmes and action plans. In 2010, subordinate legislation under the Environmental Protection act was notified and in 2017 it was replaced by a new version. This version notifies the decentralized governance structure. In every state and Union Territory, a special wetland authority was constituted to perform four major activities. These were providing knowledge and advisory for wetland inventory and management guidance, regulations for notifications, compliance reporting, enforcement etc., coordination for management plan implementation and enabling awareness generation and building convergence for environmental management. After 2014, Govt. of India gave more emphasis on getting the status of Ramsar Site to many wetlands in India. Declaring a Ramsar site of International Importance is based on fulfilment of nine different criteria as given by the Ramsar convention. With the efforts taken by stakeholders, India now has eighty-five wetlands recognized as the Ramsar Sites. Two more are in the pipeline. This is the largest network of Ramsar sites in Asia. In 2023, Govt. of India has launched what is called Amrit Dharohar scheme to promote the conservation and sustainable management of wetlands especially the Ramsar sites. It has four major elements that is optimization of wetland use, species and biodiversity conservation, increase carbon stock, and boost ecotourism and livelihood opportunities for the locals. In the last forty years, sevral tools have evolved for systematic management of wetlands. India is one of the very few countries to have satellite mapping and data on wetlands. Recently, wetlands as small as 0.1 hectare have been mapped. Another tool that is, diagnostic approach to management planning is recommended by a National Wetlands Programme currently known as National Plan for Conservation of Aquatic Ecosystems. A Management Effectiveness Tracking Tool (METT) has also been introduced for Indian wetlands. Integrated management system has been demonstrated in conservation of Chilika lake which was a lagoon sustaining the livelihood of nearly two lakh fishermen. This lagoon underwent decline due to heavy

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siltation near its mouth and eventually lost its connection with the bay. Due to this, the migratory fishes and other migratory species could not enter the wetland. As a result, the fish productivity came down to one thousand metric ton from 8000 tons putting communities into lot of economic presuures and other species were also on a decline. However, a local enterprise and Chilika Development Authority specially constituted for restoration and conservation of Chilika took lot of efforts for restoration. Eventually, a new mouth to the sea was opened and the results were quite encouraging. Fisheries rejuvenated and sustained to about 14000 to 15000 tons. There was also increase in population and habitat utilization by Irrawady Dolphins. Due to all these efforts, the Chilika Lake that was once put in the Red List of Ramsar convention was now selected for the Ramsar Award in 2001. Of course, there have been numerous challenges also. Lake Harike for example experienced excessive growth of water hyacinth to such an extent that the Indian army had to be deployed for its clean-up. However, at that time, the sources of pollutants released into the wetland were not addressed and hence, growth of water hyacinth continued for decades. Although lot of efforts are being taken for management and. conservation of wetlands, unless such chronic issues responsible for degradation of wetlands and coastal areas are addressed, the conservation efforts would be futile. In several wetlands, models of Keoladev Ghana wetland were replicated without assessing the consequences on species diversity. Overall, the conditions of the National wetlands remain to be precarious. Most of the wetlands have continued to degrade with manifold impacts. Wetlands International South Asia maintains a database and Wetland Trends Index which show that nearly 30 percent of wetlands have completely disappeared in the last 30 years. CPCB data also shows that almost 40 percent of the wetlands do not have enough oxygen (DO level) to support propagation of wildlife and fisheries, about 40 percent wetlands have become seasonal or ephemeral. Furthermore, degradation of wetlands to this extent has many adverse consequences. Country faces high water stress, 1 in 5 migratory bird with known global status is threatened, increase in incidences of floods and droughts etc. Due to heavy pollution, wetlands have now become major sources of methane emissions. Encouragingly, the problematique of wetland loss which was focused on the species narrative has shifted to water. Bangalore water crisis (floods and droughts) brought wetlands into news. People were able to relate why wetland degradation was at the heart of the crisis. Other examples of adverse consequences of wetland degradation are observed on the mangrove ecosystems. India had seen a massive loss of mangroves in the 1980s, has seen a consistent increase in area under mangroves due to efforts by the government. But this has somehow resulted in the loss of coastal wetlands. Then there are some sectoral challenges making wetlands vulnerable and detrimental. Water bodies and wetlands are seen as separate entities. Wetlands are getting lost to the ill-planned conservation actions like afforestation or use of lot of concrete for road constructions under the ‘smart cities’ projects. Ponds that are integral to rural landscapes are fast disappearing. Indian government has no data on these local water bodies. Different sectors are viewing wetlands in different ways. The judiciary is trying to fill up the regulatory gaps, The Hon. Supreme Court of India has directed the government to preserve over two lakh wetlands. The National Green Tribunal is taking major steps in wetland conservation. Of course, not all is lost, there are still rays of hope. The International Framework, namely Kunming-Montreal Global Biodiversity Framework has been able to conserve about 30% wetlands effectively. Lately, we are observing increased local action and advocacy for small wetlands. Also, there is an increased policy acceptance by the society. Wetland conservation is a challenge not to be addressed only by the government but needs participation of the society. Wetlands International has been able to connect

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over two million people for action on wetland conservation. But then there are some hurdles in conservation efforts. For example, the data on wetlands is highly centralized, and there is no unified picture of the status and strength. Avenues for learning and capacity development are limited. Wise use of wetlands in the context of multiple rights, ownership and administrative arrangement is yet to be locally anchored. Heavy dependence on techno-managerial interventions precludes local action and participation. Management generally does not build livelihood outcomes as the incentives. Weak accountability, no monitoring of livelihood outcomes are also major hurdles. Inverted financing structure and heavy dependence on central assistance for interventions.

"All of the society framework" involves strengthening site-based management, sectoral mainstreaming and cross-cutting. Wetlands need to be brought in the formal educational framework.

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Lead Lectures

Theme 1. Watershed management and River rejuvenation

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(1) Watershed management:

Hon'ble President of India, Shri Ram Nath Kovind said once that, where there was water, humanity thrived and survived. In the present times, we humans search for water as distant as the moon. At the same time, we have been negligent in preserving water resources on our own planet.

This surely is a case where we are often neglecting the water bodies by either using it as dumping grounds or try to reclaim these to make additional land mass for needs of ever-increasing human population.

But we have to take into consideration that according to NITI Ayog, nearly 600 million Indians do not have access to safe drinking water. Every year, more than 200,000 Indians die due to unsafe water. Though there is adequate amount of rainfall in some parts of India, the lack of water conservation policies makes these areas also dry in some of the months of year. There is urgent need to establish rain water harvesting so that throughout the year, there is no water shortage.

In case of urban areas, there is extremely rapid growth due to population increase and migrations to the cities in search of livelihood. The process of urbanization thus adds pressure on natural resources like rivers, streams and lakes. In rural areas, where the economy is dependent on agricultural practices and allied businesses, water scarcity can become one of the most hindering factor. Thus, watershed management is the ray of hope for all the people of the earth, may be from urban sector or rural landscape.

Principles of watershed management:

- Utilizing the land based on its capability.
- Protecting top fertile soils.

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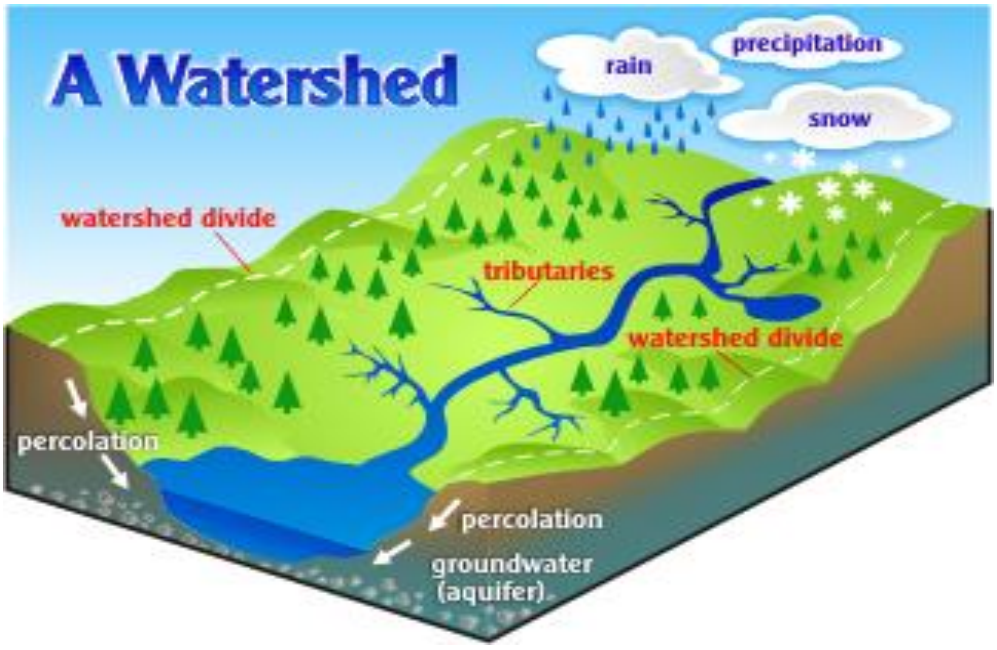
- Minimizing silting up of tanks, reservoirs and lower fertile land.
- *In situ* conservation of rain water.
- Protecting vegetative cover throughout the year.
- Water harvesting for supplemental irrigation.

Some of the best practices to be used in water management have to be considered in the following arenas:

- Agriculture
- Ground water management
- Watershed development
- Water infrastructure
- Climate risk and resilience

In water shed management we have to first define what is the watershed. A watershed is the area of land that drains off into a common waterway, such as a lake, river, stream or bay.

The boundaries of each watershed are broken down into different water regions based on where the water flows. Ridges and hills that separate two watersheds are called the drainage divide.



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In Maharashtra following watershed development programs are undertaken with primary focus on soil conservation, groundwater recharge, and capacity building. Under these specific activities like contour bunding, check dams, plantation drives are undertaken. The most important aspect of these projects is community participation. It is the key component across all such projects.

Some of the noteworthy projects/programmes can be listed out as following:

- **NABARD Watershed Development Project:** One of the major programs in Maharashtra, focusing on soil and moisture conservation techniques like earthen and stone contour bunding, border bunding, and gully control across different terrains.
- **Integrated Watershed Management Programme (IWMP):** A comprehensive program aimed at improving water availability, soil health, and livelihood opportunities through various interventions like rainwater harvesting, afforestation, and farm pond development.
- **Drought Prone Areas Programme (DPAP):** DPAP specifically targets drought-prone regions in Maharashtra, implementing water conservation measures like check dams, percolation ponds, and micro-irrigation systems.
- **Community-Based Watershed Development Projects:** Encourages local participation in planning and implementation of watershed activities, promoting sustainability and ownership of projects

In all the above projects there are certain key components.

These key components of watershed development programs in Maharashtra are as follows:

- **Land use planning:** Identifying suitable land use practices based on slope, soil type, and water availability to minimize erosion.
- **Soil conservation structures:** Building physical structures like contour bunds, check dams, and stone barriers to slow down water flow and prevent soil erosion.
- **Afforestation and plantation:** Planting trees on degraded lands to improve water infiltration and soil stability.
- **Rainwater harvesting:** Techniques like rooftop harvesting, farm ponds, and recharge pits to capture and store rainwater
- **Capacity building and awareness creation:** Training farmers and community members on watershed management practices, promoting sustainable land use, and encouraging participation.

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Along with watershed management some livelihood projects are also taken up especially in draught-prone areas.

Farmer's livelihood project in Vidarbha-World vision India. (2017)

- **Objective**: Sustaining farmers' livelihoods through integrated watershed management and conservation of natural resources.
- **Outcomes**: Many farmers practiced soil and moisture conservation in the operational villages.
- Rise of rainwater harvesting on farmlands→ Enhancement of the groundwater table→ Access to improved irrigation→ Farmers at benefit.
- Groundwater recharge done.
- Though many dams and waterbodies are present in Maharashtra, due to drought → irregular rainfall and poor rainwater harvesting.

DROUGHT PROOFING IN MAHARASHTRA

Soil and Water Conservation Department, Government of Maharashtra took up following work. There was provision to desilting 5270 waterbodies by excavation of about 32.3 million m^3 of silt. This benefited to more than 4,600 villages and over 6.5 million villagers. When the silt was removed, water-storage capacity increased to about 32,300 thousand m^3 (3.2 million water tankers). The excavated silt has been spread across more than 54,000 acres of farmland. Due to this there was increased farm productivity by two to four times, and there was improvement in agricultural incomes by 50% to 100%. By all such projects the conditions farmers are changing.

As against Vidarbha, Sindhudurg is comparatively better as far as wetland and water bodies are concerned.

Sindhudurg is the first district in India to have successfully documented and mapped wetlands, following a judiciary order. There was community participation in the eight-month long process, in which local students, teachers, villagers all of the common people participated. District of Sindhudurg now trains bodies of other districts in the state to replicate its documentation model.

Also, a public interest litigation filed by NGO Vanshakti for preservation of wetlands.

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After this incidence, Bombay High Court had directed the state government to carry out wetland mapping in all the districts.

(2) The Need for Conservation and Rejuvenation of Rivers

Natural lotic ecosystems of rivers are getting worst due to following stress factors:

A. Pollution
B. Deforestation
C. Urbanization
D. Climate change**.**

None of these factors can be controlled owing to current scenario of human population and lack of sustainable decisions.

Therefore, there is urgent need for river rejuvenation. By aiming at rejuvenation programs, following objectives cane be achieved.

- **Ecological Balance**: Healthy rivers are essential for maintaining biodiversity and ecosystem services.
- **Water Security:** Rejuvenation ensures a sustainable and reliable water source for both human and natural systems.
- **Flood Management:** Well-maintained rivers can mitigate flood risks in flood-prone regions.
- **Cultural Importance**: Rivers hold cultural and spiritual significance in many societies, necessitating their preservation.
- **Increase in aesthetics of the landscape:** River-side with corresponding flora adds up to the beauty of the landscape and also attract tourists.

By following the methods of river rejuvenation, following objectives can be achieved:

- **Enhanced Biodiversity**: Restoration of habitats leads to increased aquatic and terrestrial biodiversity.
- **Improved Water Quality:** Reduced pollution levels make water safer for both consumption and recreation.
- **Flood Mitigation**: Natural riverbeds and floodplains can effectively manage excess water during floods.

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- **Sustainable Water Supply**: Rejuvenation ensures a continuous and reliable water source for various needs.
- **Cultural Heritage Preservation**: Historic sites and cultural landmarks along riverbanks are conserved.

River rejuvenation in India

- Ministry of Environment, Forest and Climate Change released Rs. 19,000–crore Detailed Project Reports (DPRs) on rejuvenation of 13 major rivers through forestry interventions.
- Ravi,Beas, Sutlej, Yamuna, Brahmaputra, Narmada, Godavari, Mahanadi, Krishna, Cauver y, Jhelum, Chenab, and Luni are these 13 rivers. The length of 13 rivers, having 202 tributaries within the delineated riverscapes, is 42,830 km. The Brahmaputra Riverscape has the highest number of tributaries (30) covering 1,54,456 sq km area.
- Area/landscape expected to be Rejuvenated: The 13 rivers collectively cover a total basin area of 18,90,110 square kilometers that represents 57.45% of the geographical area of the country.
- Idea behind these detailed project report: This project was modelled on the lines of the work done as part of the National Mission for Clean Ganga (NMCG) in 2015-16 for the river and acknowledging that the growing water crisis is on account of degradation of river ecosystems,
- The project adopted a multi-scale, multi-stakeholder, multidisciplinary and holistic approach so as to accomplish broad objectives of 'Aviral Dhara' (uninterrupted flow), 'Nirmal Dhara' (clean water), and ecological rejuvenation.

Approach for doing river rejuvenation:

- Afforestation for the rivers is done by cultivating timber species, medicinal plants, grasses, shrubs and fuel, fodder and fruit trees near the river banks.
- Holistic riverscape approach for forestry interventions is done in three types of landscapes viz. natural, agriculture, and urban.
- Conservation interventions including soil and moisture conservation measures, riverine and riparian wildlife management, and wetland management.

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- Supporting activities such as policy level interventions, strategic and adaptive research, capacity development, awareness creation, project management and participatory monitoring & evaluation.

Potential Benefits of the Proposed Interventions:

- **Increase in Forest Cover**: Increase the cumulative forest cover of 7,417.36 sq km across 13 riverscapes.
- **Help in Sequestration of CO_2**: Sequestration of CO_2 to the extent of 50.21 million tons of CO_2 equivalent in 10-year-old plantations while the value of estimated CO_2 sequestered in 20-year-old plantations would be 74.76 million tons of CO_2.
- **Help in Groundwater Recharge**: Recharge groundwater, reduce sedimentation, generate Rs. 449.01 crore from non-timber and other forest produce.
- **Employment Generation**: Significant contribution towards employment generation by way of nearly 344 million man-days of work.
- **Achieving International Commitments:** Efforts to help India meet its international climate commitments:
  - **Creation of an additional carbon sink** of 2.5 -3 billion tons of CO_2 equivalent through additional forest and tree cover by 2030 under the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC),
  - **Restore 26 million hectares of degraded lands** by 2030 and Halt biodiversity loss by 2030 under Convention on Biological Diversity (CBD) and Sustainable Development Goals.
  - At the COP26 meeting, India promised to reduce its projected carbon emission by one billion tons by 2030, meet 50% of energy requirements with renewable energy by 2030,
  - Enhancing non–fossil energy capacity to 500 gigawatt by 2030,
- Reduction in the carbon intensity of its economy by 45% by 2030 and achieve net zero emission by 2070.

As a humble global citizen on this mother earth, we have to be united to crate awareness about all such environmental problems.

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Why we have to have awareness!

- Increasing urbanization and changing climatic trends exert immense pressure_on water resources.
- In a country where 51% of rural households do not have access to individual piped water and about a billion people live with water scarcity for at least one part of the year, water management plays an undisputedly critical role
- Prominence of renovation and rejuvenation of the traditional water bodies are of prime importance to the role of the community in water management and livelihood patterns.
- The consequences of neglecting river health can be dire, leading to water scarcity, ecosystem collapse, and social unrest.

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Theme 2

Conserving estuarine systems for food security

Kauresh D Vachhrajani

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An ecosystem is a complex matrix in which biotic and abiotic components interact and influence each other directly or indirectly. Estuaries are amongst the critical zones that form an ecotone which serve as buffer; linking land, freshwater habitat and the marine habitat. Estuaries have been studied with reference to hydrodynamics, oceanographic influences, biotic diversity and its nutritional enrichment. During last couple of decades, the anthropogenic activities have induced changes in varied aspects of estuarine ecosystem. Estuaries are very good natural food resources for the fauna itself as well as for the human being. It serves as the breeding, nursing and larval settlement grounds, besides providing routes for the migratory animals, especially during their reproductive states. Estuarine conservation, therefore, is of prime importance.

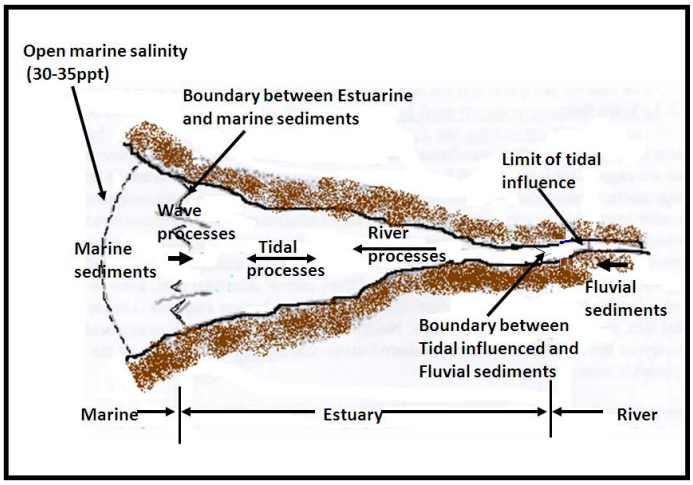

Figure 1: Generalized processes occurring at the estuary. Salinity levels are considered for partitioning of the estuary.

Figure 1 describes the generalized mechanism at estuarine scale wherein the estuarine system is acted upon by tidal and riverine processes which generates the hydrodynamics in terms of physical and chemical attributes. Along with this it allows sediment sorting and deposition as well as confluence of marine and fluvial sediments. The prolonged exposure of estuarine intertidal area during low tides challenges the organisms posing them desiccation stress. Apart from this natural stress, pace in human development has intoxicated the rivers and estuaries. At the end of the 20th century there were about 40,000 large dams in the world. Considering the human benefit apart, the consequences may lead to the altered freshwater flow rate in estuaries.

There are different variable that act upon the estuarine systems.

1. Sea Side Variables: Occurring on different moon days, twice in a day:

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a. Variations in the volume of water, tidal amplitude, tidal Velocity
b. Variations in the distance travelled by water in an estuary
2. The River Side Variables: Usually, occurring seasonally:
a. Variations in volume and velocity of water
b. Variations in the silt content and nutritional enrichment
3. The Estuarine Variable:
a. Depth and width of channel,
b. Vertical terrain profile of the bank,
c. Water velocity and energy gradation,
d. Vertical movement and mixing of marine and freshwater
e. Barriers: Meandering of channel, Islands present, Erosional and depositional regions
4. The Pollutant discharges:
a. Location of discharge, duration of discharge
b. Volume of discharge, Composition of discharge
c. Time of discharge (during receding tides or not)

I shall discuss the Mahi River estuary and its current status to justify the conservation needs. Here, the food value of the estuary is not estimated nor I aim to describe its nutritional potentials. But, since the Mahi estuary is polluted and with other such similar significantly polluted estuaries like, Sabaramati, Narmada and Tapi; it contributes to the pollution enhancement in the Gulf of Khambhat which is a major food resource and livelihood resource for people the conservation becomes a bigger issue.

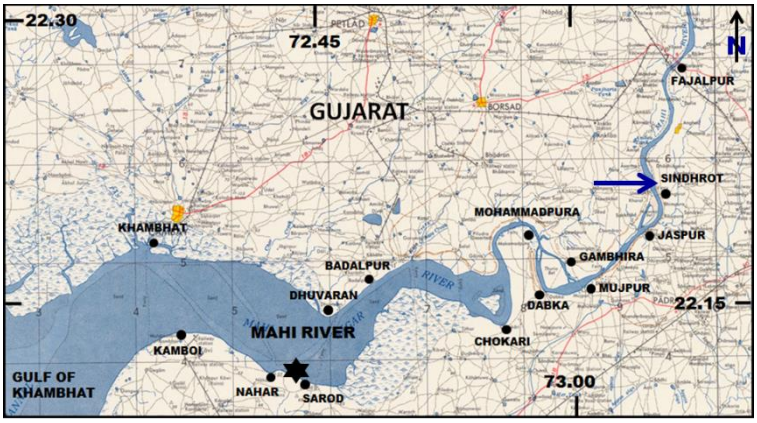

Figure 2: The Mahi estuary extends up to Fajalpur but due to formation of earthern bund, it is now restricted to Sindhrot. An effluent laden Mini River confluence between Jaspur and Sindhrot. An industrial effluent channel, originating from Vadodara's industrial areas, opens at J Point near Sarod (Star) into Mahi estuary.

Figures 2 and 3 exhibit the extent of possibilities of the gulf pollution. Besides pollution discharges from Mahi estuary, the industrial effluent is discharged from other industrial areas and through the other estuaries. Further, the mouth of the Gulf of Khambhat is around 200 km wide and narrows down towards northern apex to around 30 km before Khambhat where the mouths of Mahi and Sabarmati estuaries are located. Huge volume of water enters the gulf during high tide and hence, the tidal height and current speed (more than 3m/sec) are very high towards the northern apex of the gulf. The mouth

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of Sabarmati estuary is comparatively narrow and raised compared to that of Mahi estuary, therefore, the gulf water enters the Mahi estuary and reaches up to Sindhrot in few hours.

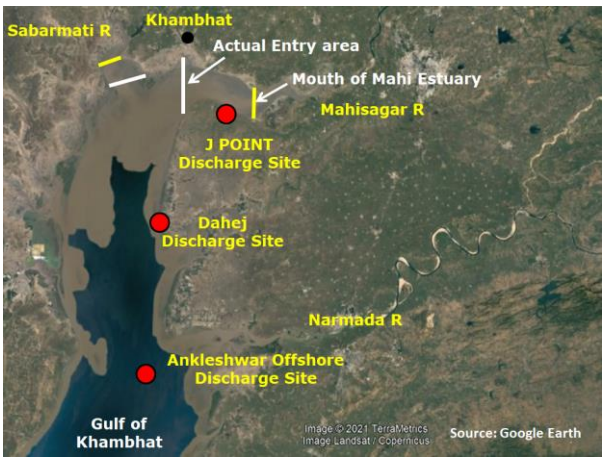

Figure 3: Shows the location of Mahi and Sabarmati estuary mouths opening into the Gulf of Khambhat. Also, the pollution discharge sites originating from different industrial areas is located in the map to exhibit the pollution burden in the gulf.

Whatever pollutants are released into the gulf through different estuaries during low tide reach the inner estuarine regions during high tides and pollute again the entire estuary. Therefore, it is important to understand the movement of water during low and high tides, the movement of pollutants during low and high tides. This will vary with the volume at the site of discharge, concentration of different pollutants, volume of riverine flow, marine water inputs on different lunar cycle and extent water reach into the estuary. The industries have developed along the gulf with the possibility of easy discharge of effluent since it was believed that the solution of pollution is dilution. However, recent studies by NIO, Goa and IIT, Mumbai have reported that the water movement in the northern apex of the gulf does not allow the pollutant to be released into the open sea and they move and settle in the gulf between the Narmada confluence region and the mouth of Mahi estuary. Therefore, the strategy, policy and research studies require transdisciplinary inputs to understand the behaviour of pollutant movement and migration in the estuaries of the Gulf of Khambhat.

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Theme 3

Quantitating the Eco-system Services of Wetlands

Dr. Aparna Phadke, Assistant Professor, Dept. of Geography, University of Mumbai, Kalina

I. Introduction:

Wetlands are one of the vital elements in climate change mitigation. Despite several efforts to conserve wetlands in India, they are disappearing rapidly. Rapid spatial transformations lead to land use and land cover changes in urban and rural areas. Various development projects like transport infrastructure, real estate development, port developments, coastal tourism, and other newer land uses are responsible for compromising the wetlands. The destruction of wetlands in urban regions is most rapid, as commodification and commercialisation of natural elements often lead to the destruction of wetlands in urban environments. As the ecological and economic significance of the wetlands is not realized, the urban communities and various stakeholders are least concerned about the environmental issues, including wetland destruction. The materialistic consumption, in fact, has taken over the concept of sustenance and preservation in everyday life, economic and political policy preferences. Ironically, the rural areas have also been engulfed in a similar logic of preferring the 'development' discourse over natural conservation. The resultant disconnect of rural communities is one of the major setbacks to the conservation efforts – so to wetland preservation and conservation as well.

To make various stakeholders, including communities, policy makers, and politicians, it is important to quantify and represent the services provided by the natural elements in terms of economic benefits. Quantitating wetlands thus becomes a vital initial step to achieve sustainable wetland development and conservation.

II. Quantitating the wetlands

Wetland services are typically categorized into provisioning, regulating, supporting, and cultural services (Woodward & Wui, 2001). The services also can be further divided into broad categories as economic services and ecosystem services.

Wetlands are major sources of aquatic food supply, like fisheries, and agriculture. They contribute to 25 percent of fish production in India (USANASFOUNDATION, 2023). The wetland also offers various ecosystem services like protection. For example, regulating the floods, retaining water to improve the penetration of surface water to recharge the aquifers, and act like a sponge. They are also responsible for shoreline stabilization and protection from storms(ramsar.org, accessed in 2025). Wetlands also play an important role in nutrient recycling, specifically the sulfur and nitrogen cycles. The wetlands provide one of the best habitats for unique species of flora and fauna. If the wetlands are preserved in their natural form, they offer much better services than the so-called intensive uses through artificial embankments for tourism purposes, 'beautification' projects, and the like(ramsar.org, accessed in 2025).

Wetlands also have cultural and aesthetic significance. Most of the cultures across India have waterbodies, farm fields, forests, and trees as the elements of worship and mutual respect. These are the places that offer peace, relaxation, and connection with nature.

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It is, hence, important to quantify the 'value' and represent what wetlands can offer in terms of economic value. For the valuation of wetland, three methods are used – a) Market-based methods, b) Contingent valuation and Cost-benfit analysis (Emerton, 1998). The market-based methods involve calculating the values of services the wetland ecosystem provides at market rates. What could be the price of replacing the ecosystem with human-made infrastructure is analysed and compared. Contingent valuation considers the people's and communities' willingness to pay for ecosystem services. Cost-benefit analysis offers a comparison. The comparison is between the costs - what if the wetland ecosystem is degraded and if it the conserved.

To apply such valuation methods, baseline data needs to be created. There could be various ways of collecting and documenting the baseline data. The role of geography and geospatial technologies becomes highly imperative as spatial and nonspatial data can be collected together using various user-friendly tools and mobile based applications.

III. Innovative methods to document the wetland details

In documenting the wetlands and collecting the baseline data related to biodiversity, water quality, soil quality, high and low flood lines, and the like, geospatial technologies that are user-friendly can be used. KOBO toolkit is one of such user-friendly applications that allows recording the geolocations and characteristics present in the geolocation. As it is user-friendly, the communities can also be trained in mapping the wetlands and their different features, assets, and biodiversity. Thus, it can be something that is called "People's Science" to involve the communities and other stakeholders in collecting baseline data and emerging with the valuation of the wetland. Figures 1 shows how a water analysis is carried out at the wetland located at University of Mumbai by the wetland documentation committee.

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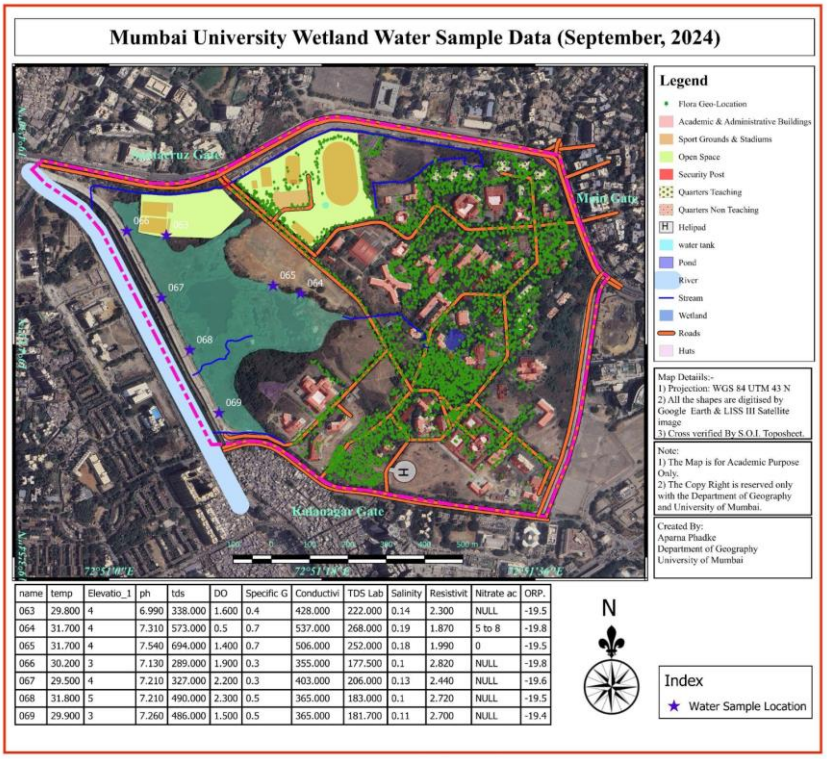
Figure 1 : Water Sample Data, University of Mumbai



name	temp	Elevatio_1	ph	tds	DO	Specific G	Conductivi	TDS Lab	Salinity	Resistivit	Nitrate ac	ORP.
063	29.800	4	6.990	338.000	1.600	0.4	428.000	222.000	0.14	2.300	NULL	-19.5
064	31.700	4	7.310	573.000	0.5	0.7	537.000	268.000	0.19	1.870	5 to 8	-19.8
065	31.700	4	7.540	694.000	1.400	0.7	506.000	252.000	0.18	1.990	0	-19.5
066	30.200	3	7.130	289.000	1.900	0.3	355.000	177.500	0.1	2.820	NULL	-19.8
067	29.500	4	7.210	327.000	2.200	0.3	403.000	206.000	0.13	2.440	NULL	-19.6
068	31.800	5	7.210	490.000	2.300	0.5	365.000	183.000	0.1	2.720	NULL	-19.5
069	29.900	3	7.260	486.000	1.500	0.5	365.000	181.700	0.11	2.700	NULL	-19.4

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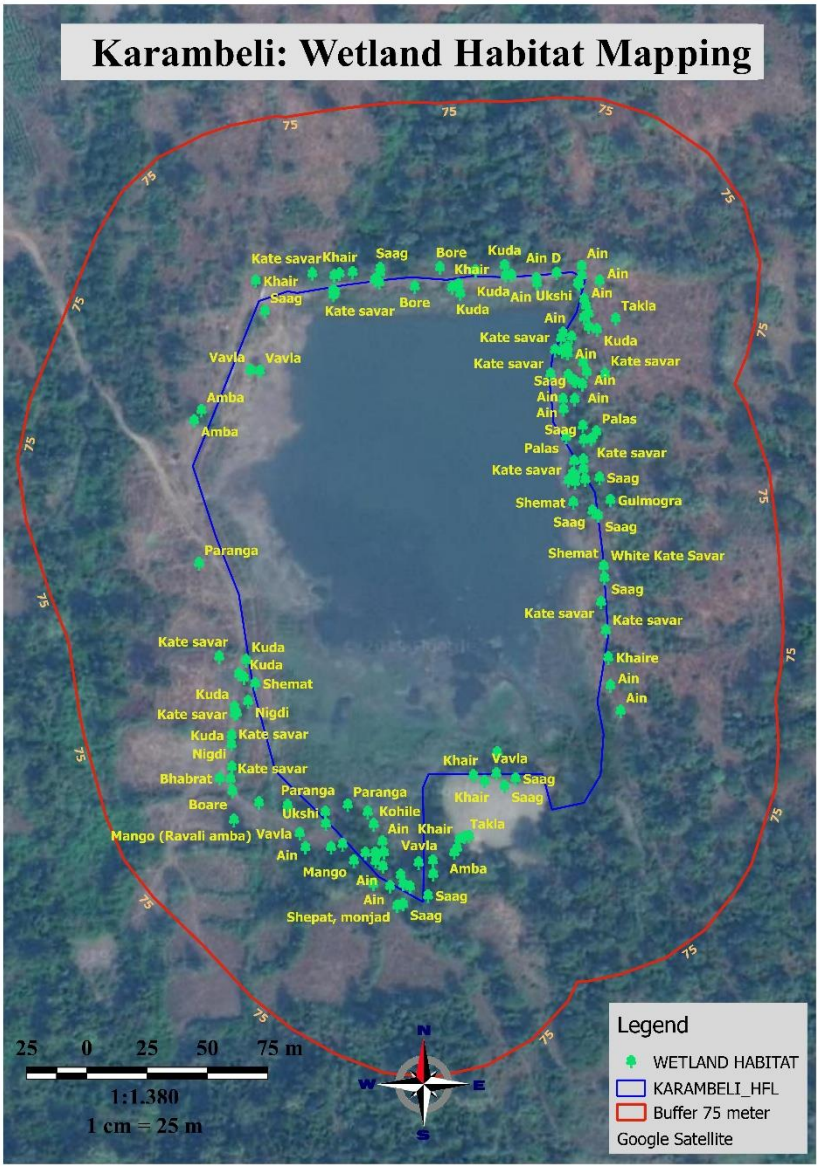
Figure II : Documentation of the wetland Flora at Karambheli Wetland



Source: Avishkar Presentation on Wetland Habitat Mapping by Mr. Nikhil Gawai and Mr. Kapil Ashtekar

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Figure III : Documentation of the wetland HFL at Karambheli Wetland

Source: Avishkar Presentation on Wetland Habitat Mapping by Mr. Nikhil Gawai and Mr. Kapil Ashtekar

IV. Conclusion

The documentation of wetland at the University of Mumbai as well as at Karambheli has been done by involving the community members like students, local barefoot botanists. The documentation can be seen as a classic combination of spatial and nonspatial data. Such data offers a spatial and temporal analysis and can also be used for various future predictions and planning. The conservation becomes easier with such kind of approach as the datasets have locations that can express locational and function corelations and coexistances.

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Theme 4: Wetlands and Tourism

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The International Tourism Society (TIES) defines ecotourism as a responsible travel to natural areas that conserves the environment and sustains the well-being of local people[1]. This is making a significant contribution to GDP of several countries in the world and has impacted the local residents, both positively as well as negatively. If systematic studies are undertaken to analyse the ways in which ecotourism is impacting the environment, the policy makers and local governing bodies can prioritise the activities such as to make ecotourism a sustainable and 'green' venture in a true sense.

Beneficial Effects[2-10]

1. **Increased Income to the locals**: Data pertaining to the employment opportunities, actual monetary income, income generated from home stays, remuneration for assistance in wildlife surveys, etc. need to be generated and updated from time to time.
2. **Improved literacy**: The need to communicate with tourists makes the locals improve on their communication and language skills. They educate their wards better and gender equality status improves due to tourism.
3. **Increased awareness towards conservation**: Wildlife surveys are conducted more frequently and thoroughly in the ecotourism hotspots than elsewhere, though it is now mandated for every local governing council to maintain and update a biodiversity register, the degree to which the locals get 'connected' to wildlife and their conservation, also needs to be ascertained regularly.
4. **Improved water quality**: For drinking water supply, the quality of water in the local water bodies is maintained by the residents and the local governing bodies.
5. **Improved Culinary and Dietary skills**: The demand for local and healthy cuisines by the tourists leads to conservation of local agro-products and the culinary skills as well as awareness towards healthy diet, of the locals improve.
6. **Aesthetic sense**: To attract tourists, the camp-sites as well as the surroundings need to have an aesthetic appeal. The locals as well as the local governing bodies improve their aesthetic understandings and maintain the tourists' accommodations as well as the public places, neat, clean and beautiful to ensure better income from tourism.
7. **Improved Hygiene**: Emulating the practices of the tourists, the awareness towards safe and hygienic practices of the locals improves. The local governing bodies too undertake regular pest control, vaccination programs, proper waste disposal, etc. that improves the health status of the community.

Deleterious effects[1,2,3,4, 11-16]

1. **Stress on rare, spectacular species**: Tourists exert stress on the rare and spectacular species, they want to sight and photograph. The affects the activities of wild life, altering their mating, breeding, rearing and feeding mechanisms and this needs to be assessed. Captivating and/or killing of rare species, for trophies/ souvenirs, too needs quantification. Introduction of invasive species knowingly or unknowingly by the tourists is a threat to native flora-fauna and needs to be logged.
2. **Habitat fragmentation and destruction**: The activities undertaken to improve the facilities for tourists (constructing roads/ tracks, accommodations, recreation/ exhibition centres, etc.) often fragment and/or damage the habitats, which needs to be documented. Campfires, demand for food

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prepared on wood stove encourages collection of lumber from the wild, and the smoke pollutes the air, putting pressure on the flora and fauna.

3. **Deaths due to tourism**: Road accidents, fences (particularly when electrified) to protect the camp-sites and tourists, shock on singling by tourist vehicles, and illegitimate fishing and/or hunting by/for tourists causes death of large and/or rare animals, which needs to be logged.
4. **Spread of epidemics**: Zoonotic diseases can be spread due to seasonal outbreak of tourism. Moreover, several parasites are common to humans and wild animals so that there is a threat of epidemics in such seasons. This claims a systematic study.
5. **Unhealthy food**: Despite the warnings, tourists often offer eatables to fish and water birds, which causes physiological disorders in wild them. A careful survey of this may be useful. Inappropriate waste disposal also leads to habituation and dependence of wild animals on the food not natural for them.
6. **Migration barriers**: Indeliberate construction of facilities for tourism and of small and large bunds in flowing waters may often block the migration paths of fish and other animals, putting a pressure on them. This too needs to be investigated properly.
7. **Alteration of distribution** (spatial/temporal) **of animals**: Tourism pressure often causes shifting/ relocation of individuals or groups of animals to relocate. A scientific study of it is necessary. Most of the wild creatures are shy and tourist activities may pressurise them to relocate. The degree of shyness varies and needs a systematic investigation. Alteration in intra- and inter- specific interactions due to anthropogenic stresses causing alteration in species composition/ distribution claims a methodical investigation.
8. **Alteration in species composition of the community**: Improper waste management, letting untreated waste water and sewage in to the water bodies, etc. may often cause an increase in the variety as well as population density of scavengers, thereby altering the natural food chains and food web. Prey-predator relationships may also get altered due to improper management practices. A careful study of this is necessary.
9. **Alterations in the quality of soil/sediments**: Compaction of soil by constant foot fall, removal of vegetation, increased erosion due to exposure of soil, loss of organic carbon, and contamination due to refuse dumps, oil spillage, leaching of excess fertilizers and pesticides, etc. alters the quality of soil and sediments. The impact of this on flora-fauna needs be registered appropriately.
10. **Air pollution**: The vehicular traffic, air conditioners in tourists' accommodations, vehicular traffic, campfires, cooking, use of aerosol cans, etc, leads to air pollution and subsequently water pollution. The effect of this too claims systematic investigation.
11. **Light pollution**: The luxurious tourist resorts are with ample lights disturbing the natural day-night cycle and circadian rhythm of plants and animals in the area. This also disturbs the energy flow in the ecosystem. A systematic investigation of this is apt.
12. **Social influence**: On one hand, the demand for local music and dance necessitates the revival of ancient traditional music and dance but on the other hand lures the locals to the glamourous way of life. This shakes the very foundation of their simple lifestyle and philosophy. Particularly the youngsters are influenced more by the life-style of the visitors. Though, this is difficult to accommodate into empirical research, it needs to be put on record.
13. **Competition for resources**: Due to the remoteness of the natural habitats, the essential commodities are often difficult to access. This leads to a competition between tourists and local residents for the resources. Due to their monetary status, the tourists are advantaged, depriving the locals of their share of these resources. This often leads to deficiency diseases among them. This too can be properly studied.

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The long-term impacts of ecotourism, social and cultural dynamics, and the integration of technology into ecotourism activities are the general areas in which researchers can focus. The complex relationships between ecotourism and sustainable development can be elucidated so as to provide insights to the policymakers and developers to develop and manage ecotourism projects in a way that would maximize their contribution to the sustainable development.[16, 17, 18]

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Research Papers and Review Articles: Group A

Application of Geographical Information System and Remote Sensing in Wetland Quantification and Conservation: A Case Study of Mumbai University Wetland

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2. Assistant Professor, Department of Geography, University of Mumbai

Abstract:

Wetland is the nervous system of any landscape especially when it comes to the metropolitan areas where the global cities are under tremendous pressure on fresh air, macro-climatic conditions, and habitat to the animals. Mumbai City and suburban spaces are likely to be identical in the context of the climate and space suffocation. In such a scenario, wetlands play an important role in maintaining the ecological balance, enhancing urban resilience, and providing a number of other ecosystem services. The spatial location of Bandra Kurla Complex, BKC, is the best example of the concrete jungle, degraded micro-climate, urban heat island, very poor AQI, and many more. The wetland at Kalina Campus, Mumbai University having a total area of approximately 33.5 acres, not only serves as a unique habitat, but also improves the quality of air and provides green spaces ensuring relaxation and recreation to the stressed-out students in the midst of the concrete jungle of BKC. However, being vulnerable to the anthropogenic stresses, the wetland is in dire need of conservation. Employing GIS and Remote Sensing technology, the wetland has been mapped, and the critical areas for intervention have been identified for planning the sustainable conservation and development efforts. The high flood line and low flood line are important buffer regions for any kind of sustainable development. With the power of remote sensing, the researcher has attempted to find the most suitable location for the nursery for biodiversity in the wetland as well as the buffer regions of the wetland. The importance of Mumbai University wetlands in urban landscapes, emphasising their ecological, social, and economic benefits. Utilising Geographic Information System (GIS) mapping.

Key Words: Geographical Information System, High Flood Line, Remote Sensing.

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Introduction:

Wetlands are one of the most vital ecosystems, contributing significantly to environmental stability and biodiversity preservation. They serve as natural water filtration systems, mitigate flooding, and help maintain a balanced ecosystem. In highly urbanised areas like Mumbai, wetlands offer invaluable environmental services, such as improving air quality and acting as carbon sinks. However, these ecosystems are under severe threat due to land-use changes, encroachments, and pollution (Mies, 2024). The Mumbai University Wetland, a 33.5 acre (as per the Google Earth measurement for 2009) urban wetland, which decreases as time passes, is a key component of the city's ecological network. The increasing pressure of urban expansion and industrial activities has resulted in its degradation, necessitating urgent conservation efforts. Integrating GIS and remote sensing technologies provides an effective means for monitoring, analysing, and implementing conservation strategies for such critical ecosystems.

Importance of Wetlands in Urban Areas:

Wetlands provide numerous benefits to urban environments, supporting both ecological and societal well-being:

Water Filtration and Purification: Wetlands act as natural filtration systems, trapping pollutants, sediments, and toxins from stormwater and runoff before they reach larger water bodies. This function helps improve overall water quality, making it safe for consumption and recreational use.

Flood Control and Water Regulation: Wetlands absorb excess rainwater, reducing the impact of floods in low-lying urban areas. Their capacity to store and gradually release water mitigates the severity of flash floods and enhances water retention during dry periods.

Biodiversity Conservation: Urban wetlands provide habitats for a wide range of flora and fauna, including endangered and migratory species. They serve as breeding grounds for birds, amphibians, and other aquatic life, that contribute to the ecological diversity.

Climate Regulation and Carbon Sequestration: Wetlands reduce the urban 'heat island effect' by cooling the surrounding areas. They also act as carbon sinks, absorbing and storing large amounts of carbon dioxide, which helps mitigate climate change (Kosciusko County Solid Waste Management District, 2024).

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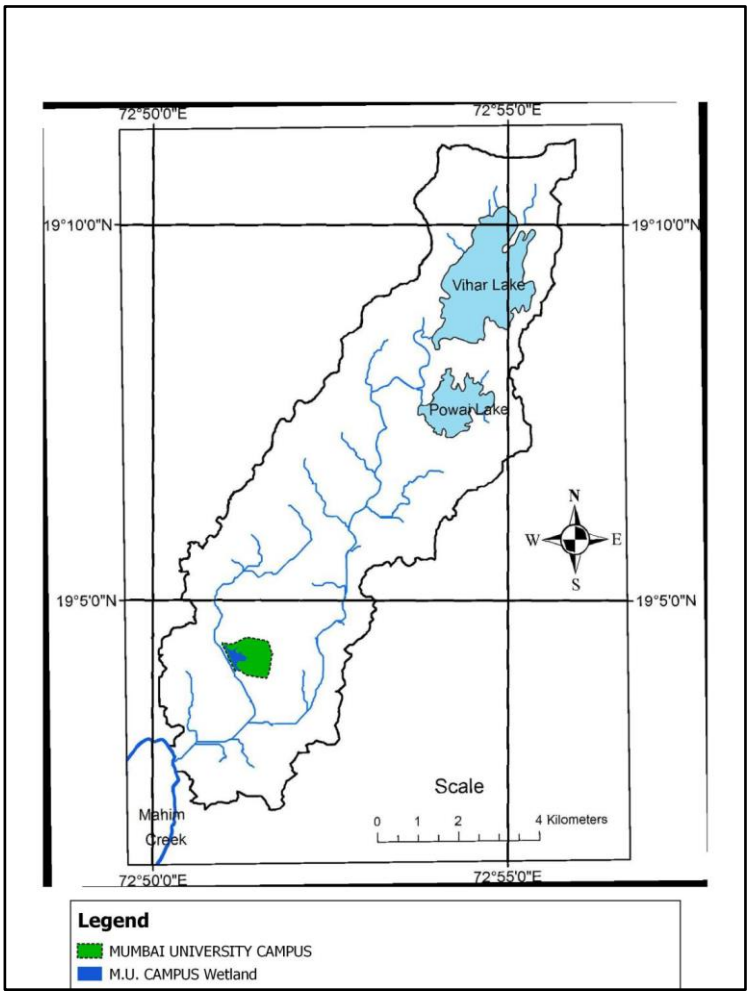
Recreational and Aesthetic Value: Wetlands enhance the quality of urban life by offering green spaces for recreational activities such as bird-watching, hiking, and eco-tourism. They contribute to mental well-being by providing serene environment away from urban stressors.

Aim of the research:

Mumbai University Wetland is one of the finest wetlands and habitats, for all the biodiversity is intact within the wetland, and though the surrounding region is a densely populated concrete jungle. Thus, for the betterment of the Humans as well as the fauna this the wetland is the central micro-climate relief point of the area. The study area map (figure 1) clearly shows location of the wetland.

Figure 1: Case Study Location: - Mumbai University Wetland



Source: Mumbai University Biodiversity Audit Report (Biodiversity Audit Team,, 2021)

Problem Faced by the Mumbai University Wetland:

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The Mumbai University Wetland is particularly affected by the following challenges:

Rapid Urbanisation and Encroachment: The continuous expansion of infrastructure, projects, and institutional spaces has led to significant wetland encroachment, reducing its size and functionality. As per the Google Earth time series image, the wetland expansion was 33.5 acres in 2009, which reduced and remained 29.5 acres in 2020. It has reduced further and to 27.4 acres in 2024 (Figures 2, 3 & 4).

Figure 2: Wetland Area in 2009

Source: Google Earth Timeseries Map (Approximate Area calculated by author)

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Figure 3: Wetland Area in 2020

Source: Google Earth Timeseries Map (Approximate Area calculated by author)

Figure 4: Wetland Area in 2024

Source: Google Earth Timeseries Map (Approximate Area calculated by author)

Degradation of Wetland Areas: Waste disposal, effluent discharge, and land-use changes have contributed to the deterioration of water quality and habitat conditions, leading to ecosystem imbalances.

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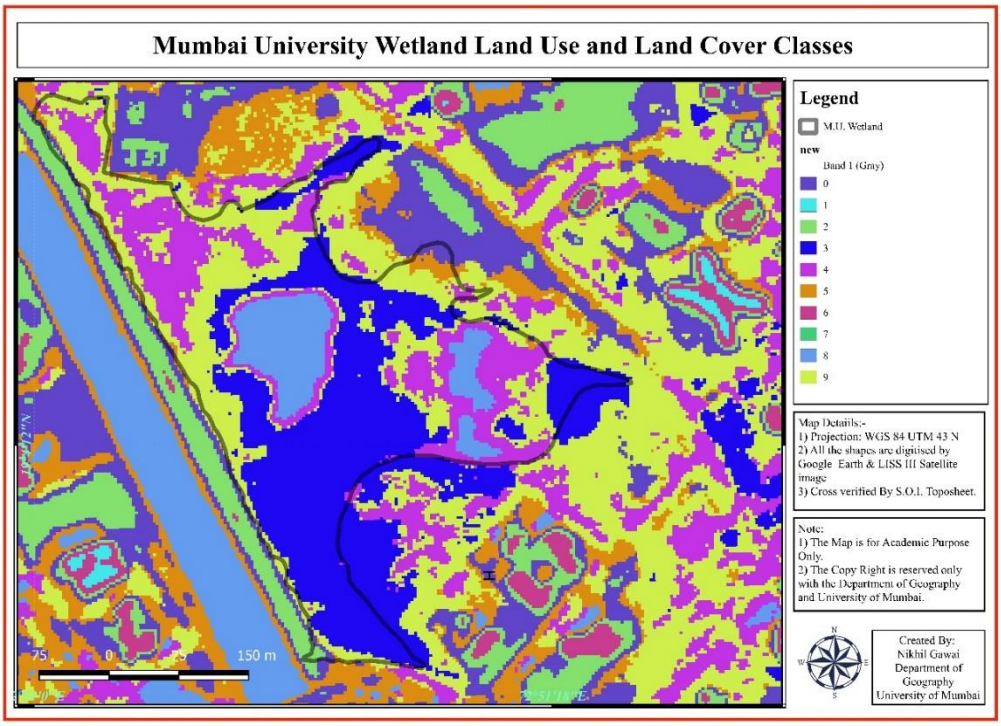
Loss of Biodiversity and Habitat Space: Habitat destruction, pollution, and human activities have resulted in the decline of native plant and animal species, disrupting the food web and ecological interactions within the wetland.

Figure 5: Wetland Land Use Land Cover Classes 2025



Source: Created by Author in QGIS software and the Satellite Image is Retrieved from Planet website (Planet, 2025).

1. **Satellite Imagery Acquisition:** High-resolution images from Google Earth Imagery and Planet exlorer website by which, one can detect changes in wetland extent and land-use patterns.
2. **Use and Land Cover (LULC) Analysis:** Using GIS software and data from Planet explorer to get an approximate idea of land cover data that are compared to determine wetland loss and urban expansion trends.
3. **Flood Line Identification:** High Flood Line (HFL) and Low Flood Line (LFL) are delineated by creating the random polygon based on time series satellite imageries of Google

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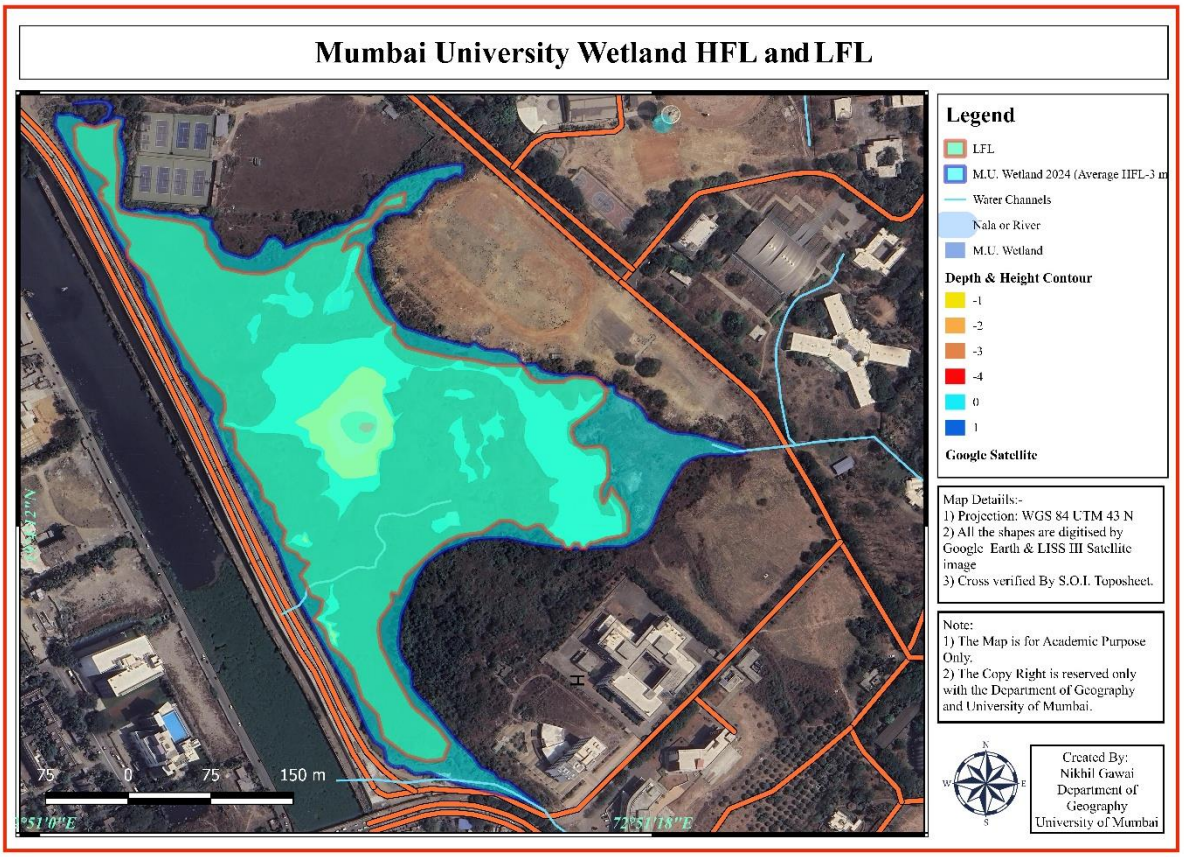
Earth, which can help further for analysis to establish protective buffer zones. It also helps to make a sustainable decision for the forestation and its location.

Figure 6: Wetland High Flood Line and Low Flood Line



Source: Google Earth Timeseries Map (Approximate Area calculated by author)

The 75-meter buffer zone was delineated for no future development as per the wetland brief documentation board or the National Wetland records.

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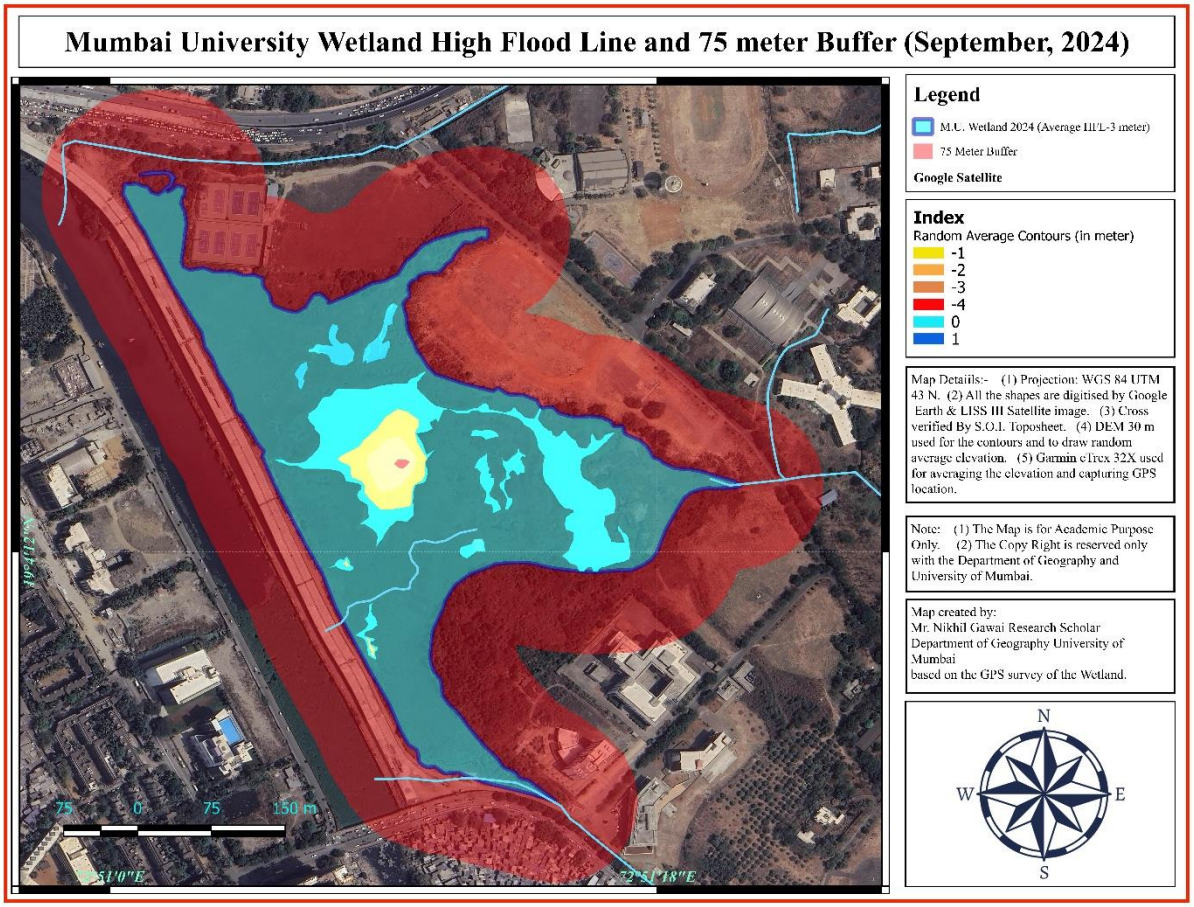
Figure 7: - Mumbai University Wetland 75 meter buffer from High Flood Line



Source: Google Earth Timeseries Map (Approximate Area calculated by author)

Identifying High and Low Flood Lines

- **High Flood Line (HFL)** represents the maximum flood extent during peak rainfall events. This information is crucial for preventing construction in flood-prone areas and ensuring urban resilience.
- **Low Flood Line (LFL) d**efines the minimum flood level, helping to create sustainable buffer regions that would safeguard wetlands from encroachment.
- **B**y integrating flood line data into urban planning frameworks, policymakers could design sustainable infrastructure while preserving wetland functionality.

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Result and Discussion:

Mumbai University Kalina Campus faces intense pressure from the surrounding urban expansion, especially from the neighbouring Bandra Kurla Complex (BKC). The campus's rapid development has made conserving this internal wetland more urgent. Geographic Information System (GIS) technology is vital in this conservation effort by providing high-resolution spatial data for precise monitoring and detailed assessments. GIS-driven insights allow for better policy-making and environmental management, supporting informed decisions essential for the long-term protection of the campus wetland. Continuous GIS-based monitoring not only tracks changes but also evaluates the effectiveness of conservation actions over time.

Protecting the Mumbai University wetland offers significant ecological and social benefits. It naturally enhances air and water quality through filtration, which is increasingly important amid the pollution challenges faced by the city. The wetland also contributes to local climate regulation, including temperature moderation and carbon sequestration, supporting broader climate change mitigation efforts. Additionally, a thriving wetland within the university fosters environmental awareness among students and the larger community, offering green spaces that improve mental well-being and encourage community engagement with nature.

Policy interventions are urgently needed to safeguard the wetland from illegal land-use changes, encroachment, and industrial pollution. Legislative protection, active community participation, and public awareness campaigns can build a strong foundation for conservation. Furthermore, integrated management approaches involving Mumbai University, local authorities, NGOs, and scientific researchers will be the key to sustainable wetland stewardship.

Looking forward, integrating Artificial Intelligence with GIS tools can develop predictive models to detect early signs of wetland degradation. Adopting advanced remote sensing techniques, such as hyperspectral imaging and LiDAR, will further improve the accuracy of wetland assessments. Establishing a long-term ecological restoration and monitoring program within the campus would ensure continuous improvement of the wetland's health.

Conclusion:

The wetland located within Mumbai University's Kalina Campus is a precious natural resource under threat from rapid urbanisation around BKC. Protecting it requires immediate and coordinated

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action, combining cutting-edge technology, robust policy frameworks, and strong community involvement. The future sustainability of this vital ecosystem depends on the urgent and committed efforts of all stakeholders.

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Desecration of lakes in City of Dreams

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Abstract

As an integral part of sustaining the ecosystems, providing resources and maintain human well-being, lakes play a vital role in all the perspectives. Lakes not only help to mitigate the climate change by reducing the amount of greenhouse gases in the atmosphere but also regulate the local and regional climate changes by absorbing the heat during the day and releasing it at night. This phenomenon moderates the temperature in the vicinity, which supports the growth of a wide range of plants, animals and microorganisms. Rapid development, urbanization, and concretization leads to deterioration of the lake ecosystem. Along with the depletion of the biodiversity, quality of water and soil is also getting degraded drastically. Present review focuses on the desecration of the lakes located in Mumbai, which are having a long history and religious significance. It serves as an alert that effluent treatment is required to bring these lakes into biodegradable belt and to ensure that local dumping limits are maintained. Illegal constructions, encroachment reclamation, and dumping along the lakes should be stopped and appropriate measures should be taken in order to conserve and protect the lake ecosystem in the metropolitan city like Mumbai.

Introduction

Mumbai a metropolitan city also known as the City of dreams, located in the western coast of India in the state of Maharashtra, has a great diversity. It not only has the coastal region but also shares the other natural resources like rivers, creeks, mangroves, forests, wetlands and lakes, which are responsible for the ecological diversity of the city. Known as the 'City of Dreams', Mumbai attracts a large number of migrants seeking employment and better opportunities. However, this rapid influx contributes to population pressure, unplanned urban expansion, strain on civic infrastructure, and increased stress on natural resources, including water bodies and green spaces.

In spite off being located in the coast, Mumbai has sources of fresh water lakes in Bandra, Sion and Walkeshwar. The lake located in Bandra, commonly known as the Bandra Talao, one of the oldest fresh water sources of water, is said to be having history of 200 years. The lake located in Sion just beside the Sion fort also shares the long history having an origin in 17th century during the Chatrapati Shivaji maharaj period. It is said that the horses and cattle used to be bought to the lake from the Sion fort, which is just located in the vicinity. One more lake having a spiritual importance and is

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linked to historic Ramayana, named Baan ganga, a freshwater source, is located in Walkeshwar in South Mumbai. It holds cultural and historical significance in the region.

Fig. 1. Showing Bandra lake

Fig. 2. Showing Sion Talav

Fig. 3. Showing Baanganga

Objective

This review paper aims to highlight the declining water quality of freshwater sources in metropolitan cities like Mumbai, primarily due to domestic wastewater discharge into the lakes.

The review paper shows the necessity of prevention of dumping domestic waste, encroachment, and construction to conserve the water quality of lakes as wetland.

Methodology

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The research is carried out on the basis of the various articles and research papers. The articles showing the present condition of the lakes in Mumbai have been considered. Researchers have analyzed water quality using various parameters such as pH, electrical conductivity, total dissolved solids, biological oxygen demand, and plankton analysis. Researchers also carried out heavy metal analysis by ICPAES from the water sample. All the data from the research papers were thoroughly analyzed. Additionally, various articles were reviewed and considered during the analysis.

Result and Discussion

Bandra Talao, a 200-year-old lake in Bandra and a designated Grade-II heritage structure, reflects the deteriorating state of urban freshwater bodies. Observations reveal widespread littering, with plastic bottles, chip packets, food containers, and juice boxes floating across the surface. Additionally, ongoing construction activity encroaches upon the lake, while residents from nearby slums are frequently seen dumping waste directly into the water (The Hindu, July 9, 2018).

Similarly, Sion Lake is subjected to extensive human interference. It is regularly used for washing, bathing, and conducting religious rituals such as idol immersions. These practices contribute to increased organic load and nutrient content, indicating clear signs of eutrophication. Such conditions disrupt the ecological balance of the lake and degrade water quality.

In light of these issues, a study was conducted to assess the water quality of these freshwater sources using various physico-chemical parameters (Gangotri Nirbhavane & Kshama Khobragade).

In a positive initiative, the Brihanmumbai Municipal Corporation (BMC) has undertaken a project to rejuvenate the historic Banganga Lake, focusing on its ecological and cultural restoration (Loksatta article).

The literature reviewed reveals a critical need for integrated lake management strategies, regular monitoring, and public awareness to ensure the sustainability of urban freshwater ecosystems in Mumbai.

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Insensitivity of the local governing body towards the state of wetlands: A case study of Thane Creek at Kolshet, Thane (W), Maharashtra, India.

Pournima Milind Shirgaonkar and Purushottam Gopalkrishna Kale,
Paryavaran Dakshata Mandal, Thane.

Abstract:

The present study investigates the impact of anthropogenic stresses on the Thane Creek at Kolshet Village (Long. 72°.55' to 73°.00' E and Lat. 19°.00' to 19°.15' N) and the unpardonable deeds of the local governing body. Using primary and secondary data, the changes that have occurred in the geophysical, chemical and biological parameters of the Creek, at Kolshet Village, over the past 7-8 years, have been analysed. An attempt has been made to correlate these changes with the anthropogenic stresses.

At least protection, if not conservation, of the wetlands in general, and of Thane Creek in particular, is supposed to be a prime duty of the local governing body. We have, however, observed an apparent insensitivity of Thane Municipal Corporation towards this. The lapses on part of the local and state governance are very serious, particularly while India is assuming a leading role in cutting down the carbon emission and is trying hard to restore nature to its pre-industrialization period. The role of NGOs and the common citizens has been emphasized.

Key Words: Thane Creek, anthropogenic stresses, NGOs

Introduction:

Thane Creek is one of the Asia's largest creeks, a defining feature of the landscape of Thane and Mumbai. Thane Creek is home to an extraordinary range of marine life. Of the total area of Thane Creek (6522 Ha), 1990.5 Ha has been declared as the 'Thane Creek Flamingo Sanctuary' by the Government of Maharashtra in 2015 and is now the largest wetland area declared as a Ramsar site in Maharashtra. Thane Creek is often described as an inlet of the Arabian Sea. The creek extends northward, forming a narrow tip, which is connected to the Ulhas River Estuary at the Mumbra retibandar. Along the 26 km length of the creek, vast swathes of exposed tidal mudflats, often ranging up to 150 m wide, dot both banks. This can be noticed along the upper region of the Thane Creek, at the Kolshet area. The vegetation is found along the bank of the creek on either side and is characterized by a widespread growth of mangroves, dense and tall in several stretches. However, the population of Thane city has exploded in the past few decades putting an enormous pressure on Thane Creek. Debris dumping and clearing of mangroves have become the most critical threats. Paryavaran Dakshata Mandal, a Non-Government Organization in Thane has been tirelessly working for more than two decades to convince the people staying in the vicinity of the Creek to refrain from dumping their refuse in the Creek and the Thane Municipal Corporation to take measures to prevent solid waste from flowing in to the Creek water through the drains. By involving local stakeholders and common people, a significant contribution to the conservation of the Creek areas rich in biodiversity is necessary, without compromising resource use and livelihood of the locals.

Study Area:

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The image in figure 1 reveals the overall location and expanse of Thane Creek. The upper reaches of Thane Creek at Kolshet village (Longitude 72º.55' to 73º.00' E and Latitude 19º.00' to 19º.15' N) were selected for the current study and this has been marked in figure 2. Along the banks of Thane Creek, extensive mudflats are exposed at low tides near Kolshet, and these had a dense growth of mangroves.

The presence of mangroves along both banks has made the Creek highly productive. According to the local fishermen, a few decades back, the Kolshet area of Thane creek use to produce an excellent catch of fish and crustaceans, which in recent years has dwindled to a bare minimum. This decline in fishery was mainly attributed to the changes in water quality. Moreover, the human population in the city adjoining the creek has doubled in the past 10 years. The sewage and domestic wastes are released into the creek. The creek is also indiscriminately used as a dumping ground for large quantities of solid waste, especially construction debris. To improve connectivity between Kolshet and Kalher, the government is constructing the 'Kolshet-Kalher Bridge'. Dumping debris and construction is sure to decrease the fertility as well as the expanse of the mudflats on both the banks.

Fig.1 The location and expanse of Thane Creek, relative to the geographical area.

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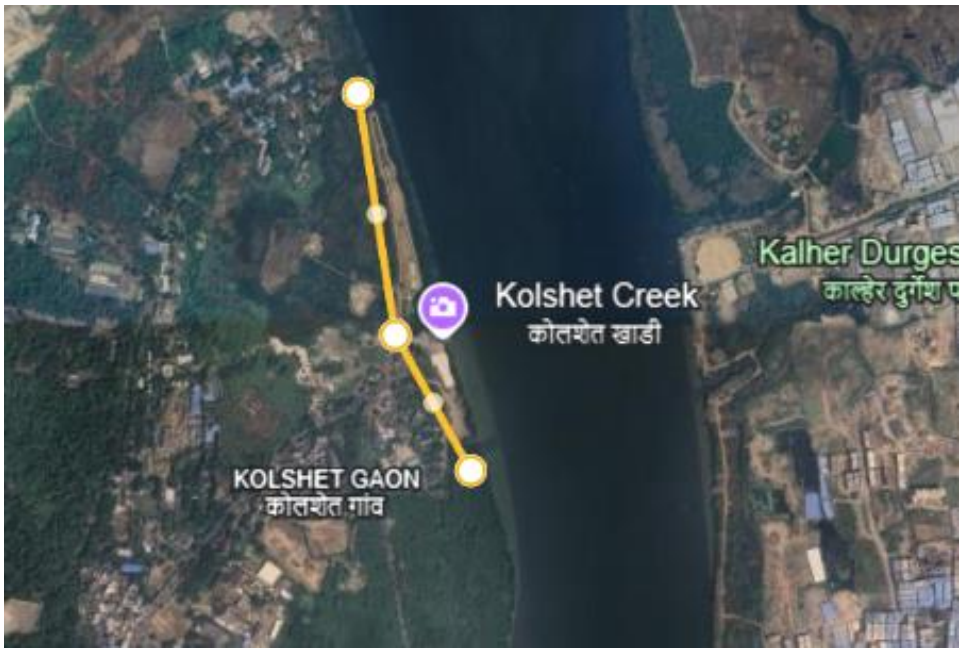
Fig.2 Study Area of Thane creek at Kolshet Village.



Materials and Methods:

To analyse the geophysical changes that have occurred in the Creek in the Kolshet area, satellite images of the area were downloaded from 'Google Earth'. Several visits were paid to the study area on foot and in boat to collect the data. The water and sediment samples were collected from the study area for the analysis of physical and chemical parameters using the resources of Paryavaran Dakshata Mandal. These samples were analysed for us by the Enviro Care Laboratory, Thane. Subsequently, the stakeholders, fishermen, and local residents were interviewed to collect the information on the study site.

The biodiversity study was mostly based on personal observations, communication with stakeholders, and analysis of water samples. We used the transect and opportunistic methods to study the biodiversity. A straight-line walk covering 1 km was undertaken and the plants as well as animals and birds encountered were recorded. The biodiversity was explored during the daylight hours only, especially early morning. The plants within the study area were observed, and photographs were taken in the field to identify the species. The birds were sighted using binoculars and were also photographed.

Results and Discussion:

The results of analysis of water samples are mentioned in Table 1. The mangrove species (Table 2) and the mangrove associate species (Table 3) recorded along the banks of Thane Creek in the Kolshet region have been tabulated. Only the avifauna encountered over the duration between January and December of 2024 has been given in Table 4 below.

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Table 1: Parameters investigated during the study

Sr. No.	Parameter	Methods	Dec. 2023	Dec.2024
1	Biological oxygen demand (BOD)	Winkler's method	43 mg/lit	187 mg/l
2	Chemical Oxygen demand (COD)	Canelli *et al*., 1976	146 mg/lit	553 mg/l
3	Dissolved Oxygen (DO)	Winkler's method	1.84 mg/lit	0.6 mg/l
4	Total dissolved solid (TDS)	Gravimetric method	7140 mg/l	12542 mg/l
5	Total Suspended Solids (TSP)	Gravimetric method	23 mg/l	50mg/l
6	Temperature	Digital thermometer	29 Celsius	25 Celsius
7	pH	Digital pH meter	5.0	6.72
8	Salinity	Argentometric method	4399 %	11610 %
9	Oil and Grease	Spectrophotometric Meter	1.0 mg/lit	1.01 mg/l
10	Conductivity	Conductivity Meter	10500 µmhos	14230 µmhos
11	Nitrate	Colorimetric method	12.68 mg/l	18.1 mg/l
12	Light Penetration (LP)	Sechi disc	46 cm	44 cm

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Table 2: List of true mangrove species found along the Thane Creek kolshet village

Sr. No.	Name- Common	Scientific Name	Family	Habit
1	Tiwar	*Avicennia officinalis*	Avicenniaceae	Tree
2	Tiwar	*Avicennia marina*	Avicenniaceae	Tree
3	Chipi	*Sonneracia apetala*	Lythraceae	Tree

Table 3: Mangrove Associates and co-occurring species found along the Thane Creek kolshet village

Sr. No.	Common Name	Scientific Name	Family	Habit
1	Sea Holly	*Acanthus ilicifolius*	Acanthaceae	Shrub
2	Karanjvel	*Derris trifoliate*	Fabaceae	Climber
3	Rhodes grass	*Chloris gayana*	Poaceae	Herb
4	Alligator weed	*Alternanthera philoxeroides*	Amaranthaceae	Herb
5	Miswak	*Salvadora persica*	Salvadoraceae	Shrub
6	Rui	*Calotropis gigantean*	Apocynaceae	Shrub
7	Pimple	*Ficus religiosa*	Moraceae	Tree
8	Bhamburdi	*Blumea spp.*	Asteraceae	Shrub
9	Caster	*Ricinus communis*	Euphorbiaceae	Shrub
10	Vad	*Ficus benghalensis*	Moraceae	Tree
11	Sessile Joy-weed	*Alternanthera sessilis*	Amaranthaceae	Shrub

Table 4: The terrestrial, wetlands and migratory birds observed along the Creek in Kolshet during Jan. 2024 to Dec. 2024

Sr.No.	Common Name	Scientific name
1	Black winged stilt	*Himantopus Himantopus*
2	Black-tailed godwit	*Limosa limosa*
3	Common sandpiper	*Scititis hypoleucos*
4	Whiskered tern	*Chlidonias hybrid*
5	Grey heron	*Ardea cinerea*
6	Black-winged kite	*Elanus caeruleus*
7	Western marsh harrier	*Circus aeruginosus*
8	Black kite	*Milvus migrans*
9	Rock pigeon	*Columba livia*
10	White-breasted waterhen	*Amaurornis phoenicurus*

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11	Marsh Sandpiper	*Tringa stagnatilis*
12	Little stint	*Calidris minuta*
13	Little egret	*Egretta garzetta*
14	Indian pond heron	*Ardeola grayii*
15	Rose ringed parakeet	*Psittacula krameria*
16	House crow	*Corvus splendens*
17	Clamorous reed warbler	*Acrocephalus stentoreus*
18	Oriental magpie robin	*Copsychus saularis*
19	Asian koel	*Eudynamys scolopaceus*
20	Asian palm swift	*Cypsiurus balasiensis*
21	Tibetan sand plover	*Anarhynchus atrifrons*
22	Glossy ibis	*Plegadis falcinellus*
23	Common tailorbird	*Orthotomus sutorius*
24	Ashy prinia	*Prinia socialis*
25	Common myna	*Acridotheres tristis*
26	Indian spot-billed duck	*Anas poecilorhyncha*
27	Green sand piper	*Tringa ochropus*
28	Common green shank	*Tringa nebularia*
29	White throated kingfisher	*Halcyon smyrnensis*
30	Alexandrine parakeet	*Psittacula eupatria*
31	Greater coucal	*Centropus sinensis*
32	Common kingfisher	*Alcedo atthis*
33	Medium egret	*Ardea intermedia*
34	Brown headed gull	*Chroicocephalus brunnicephalus*
35	Little tern	*Sternula albifrons*
36	Black headed ibis	*Threskiornis melanocephalus*
37	Eastern cattle egret	*Ardea coromanda*
38	Great egret	*Ardea alba*
39	Large billed crow	*Corvus macrorhynchos*
40	Plain prinia	*Prinia inornata*
41	White eared bulbil	*Pycnonotus leucotis*
42	Indian pied starling	*Gracupica contra*
43	Spotted dove	*Spilopelia chinensis*
44	Red wattled lapwing	*Vanellus indicus*
45	Spot breasted fantail	*Rhipidura albogularis*
46	Chestnut tailed starling	*Sturnia malabarica*
47	Indian robin	*Copsychus fulicatus*
48	Western yellow wagtail	*Motacilla flava*
49	Gull billed tern	*Gelochelidon nilotica*
50	Little cormorant	*Microcarbo niger*
51	Red vented bulbul	*Pycnonotus cafer*
52	Purple rumped sunbird	*Leptocoma zeylonica*
53	Little swift	*Apus affinis*

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54	Painted stork	*Mycteria leucocephala*
55	Asian green bee-eater	*Merops orientalis*
56	Indian golden oriole	*Oriolus kundoo*
57	Black Drogo	*Dicrurus macrocercus*
58	Long tailed shrike	*Lanius Schach*
59	Red whiskered bulbul	*Pycnonotus jocosus*
60	Yellow eyed babbler	*Chrysomma sinense*
61	Purple sunbird	*Cinnyris asiaticus*
62	Scaly breasted munia	*Lonchura punctulata*
63	Gray breasted prinia	*Prinia hodgsonii*
64	Jungle babbler	*Argya striata*
65	House sparrow	*Passer domesticus*
66	Wood sandpiper	*Tringa glareola*
67	Curlew sandpiper	*Calidris ferruginea*
68	River tern	*Sterna aurantia*
69	Northern shoveler	*patula clypeata*
70	Pied avocet	*Recurvirostra avosetta*
70	Western reef heron	*Egretta gularis*
72	Dusky crag martin	*Ptyonoprogne concolor*
73	Wire tailed swallow	*Hirundo smithii*
74	Easten red rumped swallow	*Cecropis daurica*
75	Green winged teal	*Anas crecca*
76	Common redshank	*Tringa tetanus*
77	Temminck’s stint	*Calidris temminckii*
78	Black headed gull	*Chroicocephalus ridibundus*
79	Lesser black-backed gull	*Larus fuscus*
80	Eurasian Spoonbill	*Platalea leucorodia*
81	Blyth’s reed warbler	*Acrocephalus dumetorum*
82	Barn swallow	*Hirundo rustica*
83	Garganey	*Spatula querquedula*
84	Slaty-breasted rail	*Lewinia striata*
85	Indian Gray hornbill	*Ocyceros birostris*
86	Copper smit barbet	*Psilopogon haemacephalus*
87	Lesser white throat	*Curruca curruca*
88	Jungle myna	*Acridotheres fuscus*
89	Yellow throated sparrow	*Gymnoris xanthocollis*
90	Common rosefinch	*Carpodacus erythrinus*

Wetland flora and fauna play a crucial role in maintaining the health of wetland ecosystems. The interviews of the fishermen and other residents in Kolshet, along the Creek, revealed that the human activities, particularly dumping of construction debris and refuse, have significantly altered the topography, reducing area of mudflats and has also been responsible for impeding water circulation. This obstruction has contributed to flooding of the nearby areas during the monsoon and in spite of

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repeated complaints and applications lodged with the Thane Municipal Corporation as well as local corporator, no action has been taken. The ignorance of the local governing body, according to most of the persons interviewed, has escalated to this pathetic condition of the banks of the Creek. Vanashakti, an NGO, had filed a complaint with the authorities of Thane Municipal Corporation; Collector office, Thane; SEIAA, Maharashtra; MCZMA; Mangrove Cell, Maharashtra and the Environment Department of Maharashtra. In this complaint the violations of CRZ notifications-1991 and 2011 as well as of the High court orders dated 6/10/2005, 27/1/2010 and 17/09/2018. No action has yet been taken on this.

Both the banks of Thane Creek at Kolshet Village are heavily polluted with plastic, domestic waste, religious offerings (nirmalya), and construction debris. The conservation of wetlands and their biodiversity requires collective efforts from the individuals and communities. Despite its current challenges, Thane Creek plays a vital role in maintaining the water table and controlling floods. The construction debris of the bridges connecting Mankhurd with Vashi, commissioned in 1973 and another commissioned in 1997 was not removed from the site causing obstruction to the flow of water and same has been the case with the bridges connecting Kalwa with Thane, commissioned in 1905 and 2023. The recent construction of the Thane Creek Bridge III, comprises two separate three-laned bridges, each 1.8 kilometers in length, being built across Thane Creek channel connecting Mumbai and Navi Mumbai by the Maharashtra State Road Development Corporation (MSRDC) expected to open by February 2025, in the study area, is sure to help manage the traffic and reduce the travel time but has already caused a permanent reduction in mudflat areas. Rathod (2016) has reported that most of the peripheral CRZ along both the banks of Thane Creek have been encroached either for construction or for the other anthropogenic activities. Mangrove Foundation Report (2020) has clearly stated that the width as well as the expanse of Thane Creek has significantly reduced since 1972. Nitsure et al. (2002) and Quadros et al. (2009) too have raised concern about the anthropogenic stresses affecting the survival of the natural flora and fauna along the Creek. Apparently, the local governing council, state Government and the Central Government are least bothered for the Creek ecosystem and despite the complaints against it, are relentlessly pushing ahead the developmental projects.

Our observations indicate a decline in the Creek water quality, which has directly impacted fishery production. Owing to the deteriorating water conditions, the fishermen are being forced to abandon their traditional fishing activities. Additionally, the quantity of silt in the creek has increased, leading to the growth of mangroves within the creek area. The changes in topography have resulted in the replacement of mangroves by terrestrial plants and alterations in local fauna. Rathod and Patil (2009) too share similar observations on Thane Creek. The reports published by Quadros (2001), Athalye *et al.* (2003), Rathod (2003) and Borkar *et al.* (2007) are in line with our observations. Singare *et al.* (2010), Singare (2012), Singare *et al.* (2013) and Basavaiah *et al.* (2017) have studied the pollutants, their distribution and effects on the inhabitants of Thane Creek. Currently, only three species of mangroves are found surviving along the Kolshet Creek, though SACON (2016) reported 15 species of mangroves along the Creek banks. Borkar et al. (2007) have analysed the threats to mangroves of Thane Creek.

Throughout the year, we recorded around ninety species of birds, including terrestrial, migratory, and wetland species. During their study, SACON (2016) reported a total of 155 birds including 76 wetland and shore birds along the Creek. However, the overall diversity of bird species in the Kolshet Creek area has decreased, highlighting the need for conservation efforts to restore the ecological balance of this wetland ecosystem.

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Fig. 3 Status of Thane creek –Kolshet area in the Year 2010, 2020 and 2024

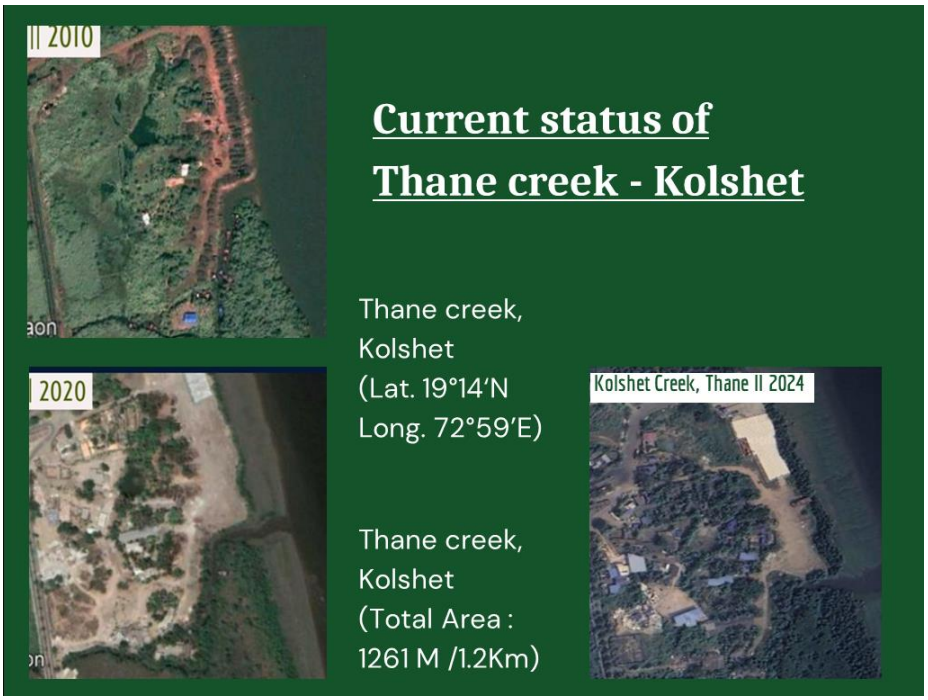

Fig. 4 Kolshet-Kalher bridge construction on Thane Creek- Kolshet village 2024

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Call for Action and Conservation

The creek ecosystem supports a unique biodiversity owing to the edge effect. It is a zone of overlap between terrestrial, freshwater and marine environments. Accordingly, it has a unique mix of features. It serves as a carbon sink and also helps sequestering heavy metals and other toxic substances, necessitating its protection and conservation. To safeguard Thane Creek, we must stop dumping waste and construction debris while promoting sustainable construction practices (as has been stated by Athalye *et al.*, 2012). Installing waste collection bins and dedicating Nirmalya Kalash to flower waste can help manage pollution effectively. Regular waste collection by municipal authorities is crucial to maintaining cleanliness. Additionally, raising awareness among visitors, the general public, and students can foster a sense of responsibility toward conservation. Continuous monitoring of flora and fauna, along with data collection and analysis, can guide future development efforts. By taking these steps, we can ensure the preservation and sustainability of our valuable creek ecosystem.

Acknowledgement

This study was made possible by Paryavaran Dakshata Mandal, a Thane-based NGO dedicated to Creek conservation since 2005. Special thanks to Mr. Anand Daki and his team for their field support, Dr. Prasad Karnik for assistance in species identification and documenting the Kolshet area, and Mrs. Shreelata Menon and Mr. Ganesh Shende for photographs. We appreciate Mr. Akhil Menon's help in sorting the bird list and Mr. Prakash Gharat for gathering stakeholder perspectives.

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Using avifauna to quantify the ecosystem services of the Ulhas River Estuary: Case study of Bhopar, Maharashtra.

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Abstract:

To convince the policy makers at the levels of local, state and central governance to conserve the wetlands, quantification of its ecosystem services is necessary. Though it requires assessing several factors and their interaction, it is possible to use biodiversity or a taxonomic group thereof as an indicator of the health and the trend of changes in the ecosystem. When compared with the flora and most of the faunal members, avifauna in the ecosystem responds to the changes in various abiotic and climatic parameters since they can choose simply to shift to an adjacent system with better living conditions. However, the avifauna is quite resilient and adapts to such changes by altering its species composition and/or abundance of individual species.

The present study has been carried out at Bhopar, a village located along the Ulhas River Estuary (URE), accessible from Dombivli, a suburb in Brihan Mumbai and under the governance of Kalyan-Dombivli Municipal Corporation. The changes in land use pattern and bird diversity over the duration from the year 2021 to 2024 has been followed in the study. Besides the primary observations made in 8 months every year, excluding the monsoon months, the available secondary data, related to avifauna over the three years of our study, has also been used. The pattern of change in the diversity of avifauna in this area has been analysed in a view to relate it to anthropogenic changes. The changes in URE as a bird habitat were related to the species diversity and abundance of the avifauna. From our observations, use of avifauna to assess the health of URE and to recon the need to conserve the ecosystem for sustained ecosystem services has been suggested.

Keywords: Quantification of ecosystem services, Ulhas River Estuary, Bhopar, Wetlands, avian diversity, land use pattern.

Introduction:

Wetlands are special ecosystems that offer a wide range of social, economic, and ecological benefits and services. The most common and most important of these is supporting biodiversity. A plethora of microhabitats available in these systems provide niches that are occupied by a variety of microorganisms, plants, and animals. Avifauna, among them, is rather easily noticeable and accessed. Both migratory and resident wetland birds are further essential for ecological services like pest control, nutrient cycling, and water purification. They also support leisure and cultural activities like ecotourism and birdwatching. Despite the high bird diversity in wetlands, efforts to conserve them remain insufficient. These ecosystems and their bird populations face significant threats from human activities such as solid waste disposal, erosion, agricultural expansion, urbanization, livestock overgrazing, and more. Therefore, immediate conservation measures are essential to enhance the survival of birds in these vulnerable and unprotected wetlands. *(Mesfn et al., 2024)*

India's Coastal Regulation Zone (CRZ) regulations protect mangroves, wetlands, and other ecologically sensitive regions from pollution and invasion (*Rathod, 2016*). In order to preserve

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ecological balance and ensure the continuous provision of essential ecosystem services, activities in various coastal regulatory zones are restricted (*CRZ Notification, 2011*). These constraints are meant to ensure sustainable development practices.

Quantifying ecosystem services (*Brown et al., 2014; Potschin, & Haines-Young, 2016; Wong et al., 2022*) is essential to convince policymakers at local, state, and central levels to prioritize wetland conservation. Biodiversity, particularly avifauna, serves as a reliable indicator of ecosystem health and changes over time. Birds are sensitive to abiotic and climatic shifts, often responding by relocating to better habitats or adapting through changes in species richness and abundance. This makes them valuable for monitoring ecosystem trends.

Dombivli, a suburban city near Mumbai under the governance of Kalyan-Dombivli Municipal Corporation, is situated along the Ulhas River Estuary in Thane district of Maharashtra, an ecologically significant region known for its rich biodiversity. Despite numerous threats to habitats, Dombivli city and its surrounding hotspots continue to support a remarkable diversity of avian species *(Prathamesh Desai et al. 2020).* This study focuses on a key wetland site called Bhopar, along the Ulhas River estuary, which serves as a critical hotspot for wetland birds. Bhopar is famous as mini Bharatpur of Dombivli among the bird watchers and wildlife photographers This wetland provides essential habitats for a diverse array of avian species, including resident birds, resident breeding species, local migrants, and winter migrants, underscoring their ecological importance. This site is commonly visited for birdwatching and offers habitat for an array of bird species. According to the data on eBird (*https://ebird.org*), Dombivli has a record of over 294 birds *(Desai et al., 2020)* of which this birding hotspot at Bhopar has, so far, a record of over 119 different bird species. The study focuses on the wetlands and wetland birds at this site. However, these wetlands are increasingly threatened by anthropogenic pressures such as habitat fragmentation, encroachment, pollution, and other destructive activities (*Rathod, 2016*). These challenges have a direct impact on the sustainability of the wetlands and their ability to support avian life. As wetlands and their functions become more limited, the traditional belief of viewing wetlands as a free resource is being challenged more and more (*Rafiq, et. al., 2014)*. The distribution of birds shows a clear pattern of them moving to areas with higher human activity during seasons with harsh weather conditions. This helps them find food and shelter, reducing their energy expenditure *(Zhulenko et al., 2023).* To address this, it is important to quantify the ecosystem services these wetlands provide. Researchers can attempt to quantify ecosystem services by examining their benefits, such as encouraging physical activity, improving health, fostering resilience in human-nature interactions and conflicts, offering protection from extreme events, supporting biodiversity, and addressing future changes due to global temperature rise and climate change. This analysis can be conducted at a local level and integrated with data from state, national, ecozone, or global scales.

The current study examines the geographical locations, land use patterns, and bird diversity at these sites over the past three years. The changes in avian biodiversity not only reflect the health of the wetlands but also serve as indicators of the ecosystem's functionality at large. Quantifying ecosystem services through this perspective provides actionable insights for policymakers, helping in the development of strategies to preserve and restore these critical ecosystems amidst mounting environmental and developmental pressures.

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Materials and Methods:

Study Site 1: This key site in Dombivli is located at the east side, near the Ulhas River Estuary bordered with a creek and mangroves. The study location includes a variety of habitats: grasslands, shrublands, wetland marshes, mangroves, man-made wetlands and wooded areas.

Table 1: Details of Study Site

Study Site	Bhopar Grassland
Geographical coordinates	19º11’48” N 73º04’09” E
Area In Hectares	82.48
Wetland cover (including Creek area) In Hectares	22.32
Location	Dombivli East

(Name mentioned as per hotspots on eBird)

Figure 1.: Study Site: Bhopar Grasslands

(Source: Google Earth Images- March 2024, 300m)

1. **Methodology:**

This study is based on a combination of primary field observations and secondary data analysis to assess avian diversity and habitat changes at the study site.

Primary Data Collection:

Frequent site visits were conducted to document bird species and their habitat use. Observations were recorded systematically, noting species presence, abundance, and behavioural patterns. Additionally, the condition of habitats was assessed in real time to understand the ongoing ecological changes impacting the bird population.

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Secondary Data Integration:
To supplement field observations, secondary data was obtained from bird checklists uploaded by birdwatchers to the eBird application between 2021 and 2024. The widely recognized citizen science platform, eBird, allows bird enthusiasts to contribute observational data, which can be analysed for scientific research *(https://ebird.org)*.

Data Verification and Filtering:
Since citizen science data may occasionally include identification errors or unverified species reports, careful screening was performed to ensure data accuracy. Only confirmed species records were considered in this study, while ambiguous, misidentified, or unverified taxa were excluded. This approach helped minimize errors and maintain data reliability.

Habitat Analysis:
In addition to avian diversity data, Google Earth imagery was utilized to analyse the changes in habitats over time. Satellite images provided valuable insights into landscape alterations, wetland shrinkage, and the effects of human activities such as quarries as well as constructions on bird habitats.

Data Processing and Analysis:

The collected data was systematically organized and analysed using Excel spread sheets to track species diversity, population trends, and habitat associations. Comparative analysis of yearly observations helped identify patterns in species composition, including the decline of migratory birds and shifts in habitat usage.

Figure 2.: The images depict wetland sites utilized by local communities for cattle grazing and daily activities, serving as habitats for resident as well as migratory birds and influenced by tidal fluctuations. (Photographs by Samiksha Chavan)

Results and discussion:

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Bhopar features an extensive wetland area connected to the Ulhas River estuary, exhibiting tidal fluctuations. In addition to this, the plateau region contains several small natural wetlands as well as man-made wetlands formed due to quarry excavations. Observations indicate that these wetlands fill up during the rainy season and retain moisture for a few months afterward. However, these man-made wetlands are highly unstable, as they get eventually filled with mud up to the level of surrounding land and disappear in due course of time. These wetlands within the landscape, however, play a crucial role, not only in supporting a diverse avian population but also in sustaining local communities. Many people rely on these wetlands for fishing and other livelihood activities, while the arrival of migratory birds during the winter months draws visitors, contributing to ecotourism and raising awareness about wetland conservation.

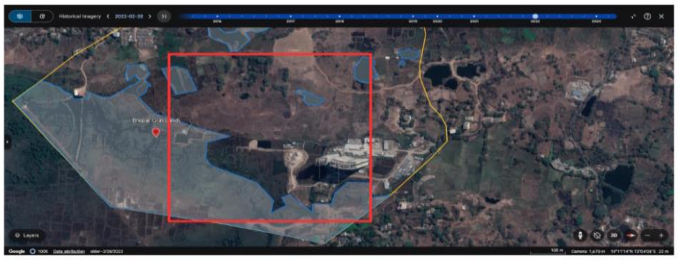
Figure 3.: Google Earth images depicting land modifications.

Images (a–d) illustrate the transformation of a wetland into a construction site.

Images (e–f) show changes in a plateau-area wetland, where quarry work, debris and mud deposition have led to its disappearance.

(Source: Google Earth Images)

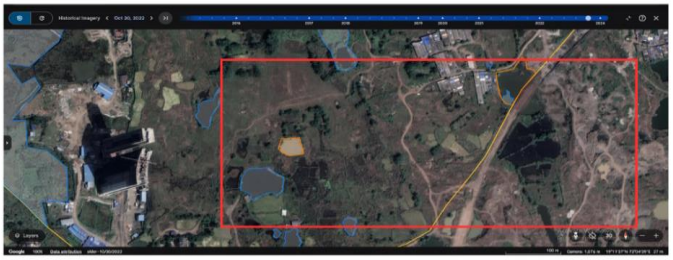
a. Jan. 2021, 100m



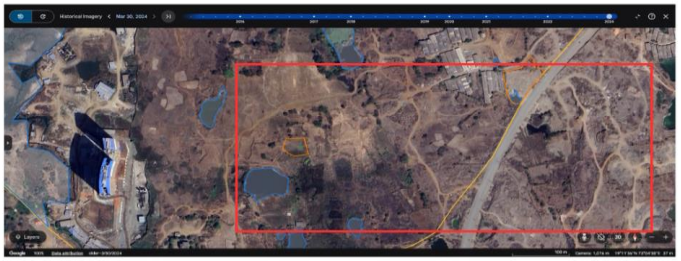
b. Feb. 2022, 100m

c. Oct. 2022, 100m

d. Current Status: Mar. 2024, 100m



e. Oct. 2022, 100m



f. March. 2024, 100m

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Table 2.: List of Bird Species observed at Study Site-Bhopar from 2021-2024.

SR. NO.	COMMON NAME	FAMILY	SCIENTIFIC NAME	MIGRATION STATUS
1	Lesser Whistling-Duck	*Anatidae 12*	*Dendrocygna javanica*	R
2	Greylag Goose		*Anser anser*	WM
3	Knob-billed Duck (Comb Duck)		*Sarkidiornis melenotos*	R
4	Ruddy Shelduck (Brahminy Duck)		*Tadorna ferruginea*	WM
5	Garganey		*Spatula querquedula*	WM
6	Northern Shoveler		*Spatula clypeata*	WM
7	Gadwall		*Mareca strepera*	WM
8	Eurasian Wigeon		*Mareca penelope*	WM
9	Indian Spot-billed Duck		*Anas poecilorhyncha*	R-BR
10	Northern Pintail		*Anas acuta*	WM
11	Green-winged Teal (Common Teal)		*Anas crecca*	WM
12	Cotton Pygmy-Goose (Cotton Teal)		*Nettapus coromandelianus*	R
13	Greater Flamingo	*Phoenicopteridae 2*	*Phoenicopterus roseus*	WM
14	Lesser Flamingo		*Phoenicopterus minor*	WM
15	Little Grebe	*Podicipedidae 1*	*Tachybaptus ruficollis*	R
16	Ruddy-breasted Crake	*Rallidae 5*	*Zapornia fusca*	R-BR
17	White-breasted Waterhen		*Amaurornis phoenicurus*	R-BR
18	Grey-headed Swamphen (Purple Swamphen)		*Porphyrio poliocephalus*	R-BR
19	Eurasian Moorhen		*Gallinula chloropus*	R

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SR. NO.	COMMON NAME	FAMILY	SCIENTIFIC NAME	MIGRATION STATUS
20	Eurasian Coot		*Fulica atra*	R
21	Painted Stork	*Ciconiidae 5*	*Mycteria leucocephala*	R
22	Asian Openbill		*Anastomus oscitans*	R
23	Black Stork		*Ciconia nigra*	WM
24	Asian Woolly-necked Stork		*Ciconia episcopus*	R
25	White Stork		*Ciconia ciconia*	WM
26	Cinnamon Bittern	*Ardeidae 10*	*Botaurus cinnamomeus*	R-BR
27	Black-crowned Night-Heron		*Nycticorax nycticorax*	R-BR
28	Striated Heron (Little Heron)		*Butorides striata*	R
29	Indian Pond-Heron		*Ardeola grayii*	R-BR
30	Eastern Cattle Egret		*Bubulcus ibis*	R-BR
31	Grey Heron		*Ardea cinerea*	R
32	Purple Heron		*Ardea purpurea*	R-BR
33	Great Egret		*Ardea alba*	R
34	Intermediate Egret		*Ardea intermedia*	R
35	Little Egret		*Egretta garzetta*	R
36	Black-headed Ibis	*Threskiornithidae 4*	*Threskiornis melanocephalus*	R
37	Eurasian Spoonbill		*Platalea leucorodia*	R
38	Red-naped Ibis (Indian Black Ibis)		*Pseudibis papillosa*	R
39	Glossy Ibis		*Plegadis falcinellus*	R
40	Little Cormorant	*Phalacrocoracidae 2*	*Microcarbo niger*	R

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SR. NO.	COMMON NAME	FAMILY	SCIENTIFIC NAME	MIGRATION STATUS
41	Indian Cormorant (Indian Shag)		*Phalacrocorax fuscicollis*	R
42	Oriental Darter	*Anhingidae 1*	*Anhinga melanogaster*	R
43	Pied Avocet	*Recurvirostridae 2*	*Recurvirostra avosetta*	WM
44	Black winged Stilt		*Himantopus himantopus*	R-BR
45	Pacific Golden Plover	*Charadriidae 5*	*Pluvialis fulva*	WM
46	Little Ringed Plover		*Thinornis dubius*	R-BR
47	Tibetan Sand-Plover (Lesser Sand-Plover)		*Anarhynchus atrifrons*	WM
48	Kentish Plover		*Anarhynchus alexandrinus*	WM
49	Red-wattled Lapwing		*Vanellus indicus*	R-BR
50	Pheasant-tailed Jacana	*Jacanidae 2*	*Hydrophasianus chirurgus*	R-BR
51	Bronze-winged Jacana		*Metopidius indicus*	R-BR
52	Greater Painted-Snipe	*Rostratulidae 1*	*Rostratula benghalensis*	R-BR
53	Black tailed Godwit	*Scolopacidae 14*	*Limosa limosa*	WM
54	Ruff		*Calidris pugnax*	WM
55	Temminck's Stint		*Calidris temminckii*	WM
56	Little Stint		*Calidris minuta*	WM
57	Common Snipe		*Gallinago gallinago*	WM
58	Jack Snipe		*Lymnocryptes minimus*	WM
59	Terek Sandpiper		*Xenus cinereus*	WM
60	Common Sandpiper		*Actitis hypoleucos*	WM
61	Green Sandpiper		*Tringa ochropus*	WM
62	Marsh Sandpiper		*Tringa stagnatilis*	WM

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SR. NO.	COMMON NAME	FAMILY	SCIENTIFIC NAME	MIGRATION STATUS
63	Wood Sandpiper		*Tringa glareola*	WM
64	Common Redshank		*Tringa totanus*	WM
65	Common Greenshank		*Tringa nebularia*	WM
66	Curlew Sandpiper		*Calidris ferruginea*	WM
67	Black-headed Gull	*Laridae 7*	*Chroicocephalus ridibundus*	WM
68	Brown-headed Gull		*Chroicocephalus brunnicephalus*	WM
69	Gull-billed Tern		*Gelochelidon nilotica*	WM
70	Caspian Tern		*Hydroprogne caspia*	WM
71	Whiskered Tern		*Chlidonias hybrida*	WM
72	River Tern		*Sterna aurantia*	WM
73	Common Tern		*Sterna hirundo*	WM
74	Common Kingfisher (Small Blue Kingfisher)	*Alcedinidae 3*	*Alcedo atthis*	R-BR
75	Pied Kingfisher		*Ceryle rudis*	R
76	White-throated Kingfisher		*Halcyon smyrnensis*	R
77	Wire-tailed Swallow	*Hirundinidae 1*	*Hirundo smithii*	R-BR
78	Western Marsh-Harrier	*Accipitridae 1*	*Circus aeruginosus*	WM
79	Western Yellow Wagtail (thunbergi)	*Motacillidae 5*	*Motacilla flava thunbergi*	WM
80	Grey Wagtail		*Motacilla cinerea*	WM
81	White-browed Wagtail (Large Pied Wagtail)		*Motacilla maderaspatensis*	WM
82	Citrine Wagtail		*Motacilla citreola*	WM
83	White Wagtail		*Motacilla alba*	WM

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Despite their ecological and social significance, these wetlands face serious threats due to unsustainable land-use practices and human-induced disturbances (*Rathod, 2016; SACON, 2016 and Mangroves Foundation Report, 2020*). Garbage dumping has become a major issue, with large heaps of waste frequently discarded in the area, some of which are burned, causing pollution and habitat degradation. Construction activities, including land reclamation, have led to the filling of marshy patches with mud, reducing the availability of suitable wetland habitats for birds (*Rathod, 2016*). (See Figure 6.) Additionally, quarrying operations have resulted in drastic modifications to the landscape, disrupting bird populations that once thrived in these areas. Cattle grazing further adds to habitat degradation, disturbing both feeding and nesting sites for wetland birds. Google Earth imagery from 2021 to 2024 reveals substantial habitat changes, indicating the progressive loss of wetlands due to these on-going anthropogenic pressures. Regular visitors, including bird watchers and nature conservationists, have expressed deep concern over these rapid changes, fearing the potential disappearance of critical wetland ecosystems in the near future.

These wetlands of Bhopar serve as an essential habitat for water birds and wetland-dependent species, with a total of 83 diverse bird species recorded between 2021 and 2024. This includes both resident breeding species that rely on the wetlands throughout the year and migratory species that visit seasonally, particularly during the winter months. The study incorporates secondary data from eBird checklists, which provide valuable insights into bird distribution patterns and species diversity. Observations are more frequent between January to May and September to December, while fewer records exist during the monsoon season (June to September), may be due to the unfavourable weather conditions for birdwatching. Additionally, the number of checklists uploaded each year varies, as some birders document morning sightings while others upload data from evening observations, affecting the consistency of the dataset.

Table 3: Frequency of species observed at Bhopar per Year.

Year	2021	2022	2023	2024
No. of Species observed	72	73	51	43
Percentage	86.7	87.9	61.4	51.8

Analysis of data using Excel spread sheets indicates a steady decline in both the diversity of wetland bird species (Table 3 and Figure 3). Between 2021 and 2024, a total of 82 wetland bird species from 19 different families were documented (see Table 2.). This decline correlates with on-going habitat modifications driven by anthropogenic activities, including construction of buildings, road development, grazing, and pollution, which have significantly impacted bird populations. The shrinking of marshes and wet grasslands has particularly affected available foraging areas. Additionally, these habitats face multiple threats such as water pollution from washing activities, garbage dumping, and encroachment due to construction projects (See Figure 6).

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Several migratory species, including the black stork, white stork, common tern, and greylag goose, have shown a noticeable decline in recorded sightings. This reduction is linked to habitat destruction, pollution, and reduction in the availability of food due to the environmental degradation. We believe that the sudden increase in bird species observed in 2022 was primarily due to the formation of man-made wetlands in abandoned quarries (khadan) (See Figure 4 and Figure 5). As small hillocks and plateaus were excavated, these wetlands emerged, creating crucial foraging and roosting habitats for various bird species, particularly those from the families *Ciconiidae* (storks), *Ardeidae* (herons and egrets), *Scolopacidae* (sandpipers and plovers), *Laridae* (gulls and terns), and *Motacillidae* (wagtails). These wetlands provided temporary refuge, abundant food sources, and undisturbed roosting sites, making them highly attractive to wetland-dependent birds.

Figure 4: Graphical representation of Table 3.

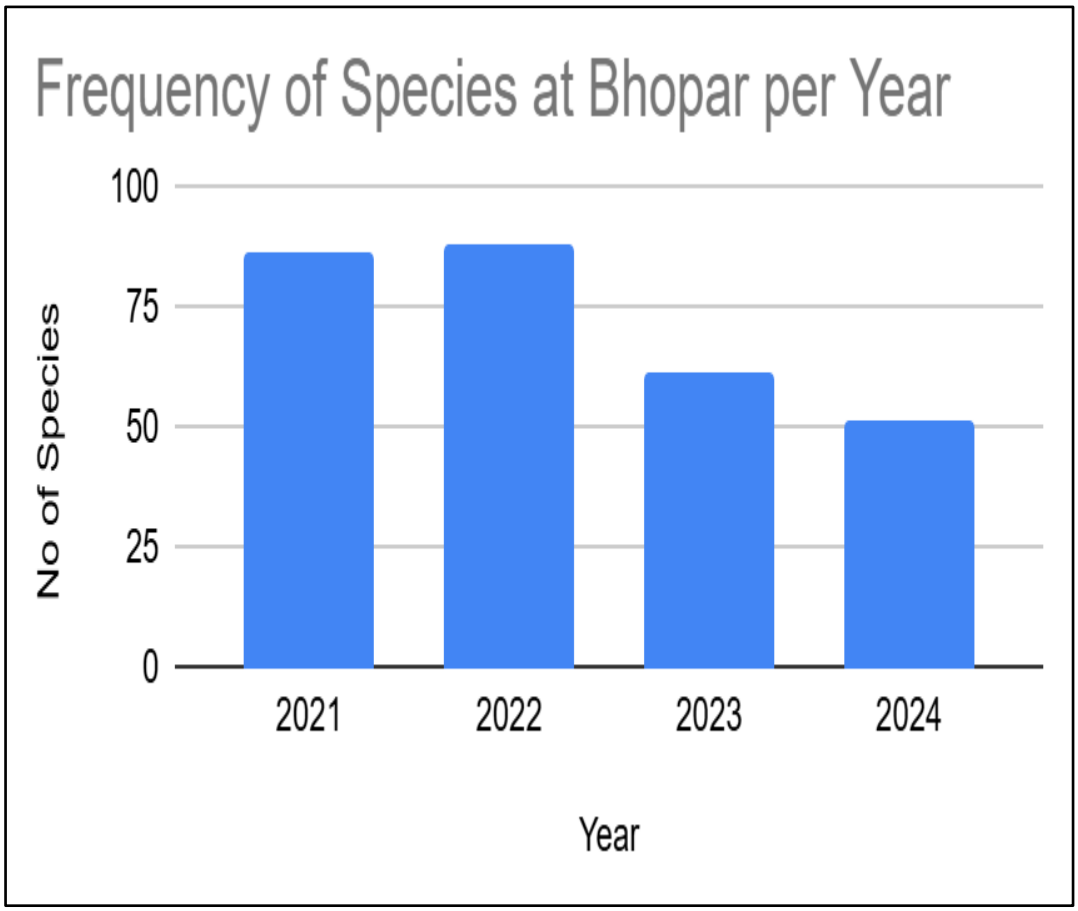

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Table 4.: Bird Species observed in various families over the years 2021-2024.

Family	2021	2022	2023	2024
Anatidae	11	8	6	4
Phoenicopteridae	2	1	0	1
Podicipedidae	1	1	1	0
Rallidae	5	4	3	4
Ciconiidae	3	5	3	3
Ardeidae	9	10	9	9
Threskiornithidae	4	4	4	4
Phalacrocoracidae	2	2	2	2
Anhingidae	1	1	1	0
Recurvirostridae	2	2	1	1
Charadriidae	4	4	3	1
Jacanidae	2	1	0	1
Rostratulidae	1	1	0	0
Scolopacidae	11	13	8	6
Laridae	5	6	1	1
Alcedinidae	3	3	3	3
Hirundinidae	1	1	1	1
Accipitridae	1	1	1	1
Motacillidae	4	5	4	1

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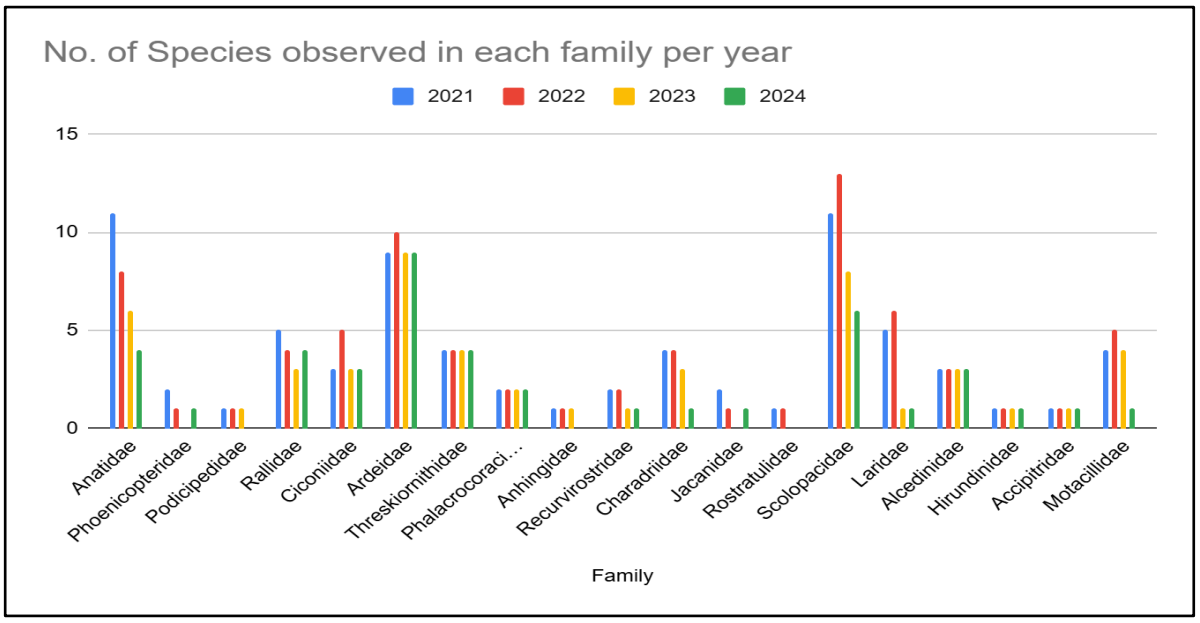
Figure 5.: Graphical Representation of Table 4.



Artificial wetlands play a crucial role as refuges for waterbirds, helping them to compensate for the loss of natural habitats by providing suitable feeding and nesting sites. Under favourable ecological conditions, these man-made wetlands can support diverse avian communities, often comparable to natural wetland systems (*Sebastián-González et al., 2015*). The significance of their conservation is particularly evident when they are maintained with minimal human disturbance. Wetlands in degraded landscapes have the potential to attract and sustain a variety of wetland bird species, highlighting their important role in avian conservation efforts (*Patil et al., 2023*). However, continuous habitat changes over time have led to the appearance and disappearance of these wetlands. While these man-made wetlands initially supported a wide range of bird species, their unstable nature caused fluctuations in bird populations. At present, these wetlands continue to provide foraging and nesting sites, but only for a limited number of species that have adapted to the changing conditions.

These wetlands are under constant threat from anthropogenic activities, with construction, garbage dumping, quarrying, cattle grazing, and pollution progressively altering the landscape and endangering their ecological stability. If these disturbances persist being unchecked, the wetlands may lose their ability to sustain even the remaining bird populations, leading to further disruptions in local biodiversity and essential ecosystem functions.

Conclusion:

As wetland ecosystems shrink and deteriorate, birds lose vital feeding and nesting sites, resulting in changes in species composition and decline in the population of each species. By combining direct field observations with structured citizen science data, this study offers a comprehensive understanding of the use of avian diversity as an indicator of the health of wetlands and of the ecological pressures affecting these wetlands. The findings highlight the urgent need for targeted conservation strategies, sustainable land-use practices, and community awareness programs to

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mitigate anthropogenic pressures and protect these fragile ecosystems before irreversible damage occurs.

The Ulhas River estuary and the other man-made wetlands of Bhopar play a crucial role in sustaining avian biodiversity and providing essential ecosystem services. However, rapid urbanization, pollution, and habitat degradation pose significant threats to their sustained survival. The decline in migratory species and alteration in bird populations emphasises the urgency of conservation efforts. Use of avian diversity as a research tool in determining the trends in the wetlands and would help in guiding the conservation practices. Understanding the dynamic interaction between avian diversity and ecological status of wetlands can help sustain the wetlands adjoining the villages and cities. They are sure to serve as edu-tourism and ecotourism sites and help in the developing a robust socio-economic-ecological paradigm.

Figure 6.: Showing Anthropogenic activities in wetland sites- Construction, grazing and habitat fragmentation.

(Photographs by Samiksha Chavan)

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Preliminary assessment of the status of 41 lakes in and around Thane city, Maharashtra, India

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Abstract: This study provides a preliminary assessment of 41 lakes located in and around Thane city, focusing on their water quality, biodiversity, facilities for sustainable tourism, local rituals, and public participation in conservation efforts. The research evaluates key water quality parameters such as colour, odour, presence of algae/water hyacinth, and aeration along with Biodiversity indicators studied include trees, insects, fish, reptiles, and birds. The study also examines facilities available for sustainable tourism such as walkways, food stalls, gardens, boating, dustbins, and surrounding walls. It also assesses the uncleared wastes left behind after rituals and the fish/bird feeding. The study also throws light on the community participation initiatives through the Maza Talao campaign.

We have categorized the lakes into three categories: Superior, Moderate, and Deteriorated, based on a 50-point evaluation scale. The study also highlights ongoing efforts in beautification and conservation of lakes in a view to improve ecological health and to promote sustainable tourism. The findings suggest a need for further action in enhancing the public awareness and engagement. It also recommends the reinforcement of the infrastructure to foster long-term lake conservation and sustainable tourism in the region.

Keywords - Conservation, Lake Biodiversity, Beautification, Sustainable tourism

Introduction: Thane, often referred to as the "City of Lakes," is home to several natural and man-made lakes that hold ecological, cultural, and recreational significance. None of these lakes are used as a source of drinking water but have a significant environmental and economic value (Pradhan & Latkar, 2008). Over the years, many of these lakes have undergone beautification and restoration efforts aimed at enhancing their aesthetic appeal. However, the effectiveness of these efforts for conservation of the lakes can only be determined through continuous monitoring and assessment to ensure that these water bodies remain protected and functional.

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Understanding the current status of lakes in and around Thane is crucial for their long-term sustainability. Rapid urbanization, industrial activities, and unregulated waste disposal have severely impacted these lakes, leading to deteriorating water quality, loss of biodiversity, and

ecosystem imbalances (Shirude et al., 2014). To safeguard these lakes, regular assessments are necessary to identify threats, track improvements, and guide conservation strategies.

For this purpose, the lakes are categorized into Superior, Moderate, and Deteriorated based on five key parameters:

1. Water Quality – Measuring pollution levels, oxygen content, and other chemical indicators.
2. Biodiversity – Assessing the presence of aquatic and surrounding terrestrial species.
3. Facilities for Sustainable Tourism – Evaluating eco-tourism potential and infrastructure.
4. Rituals – Understanding the impact of religious and cultural activities on lake health.
5. Public Participation – Examining community engagement in conservation efforts.

This study aims to provide a comprehensive assessment of 41 lakes in Thane using these criteria, ensuring that conservation efforts are well-apprised and sustainable. By integrating scientific studies and the public involvement, the present study seeks to contribute to effective urban lake management and long-term environmental protection.

Materials and Methods: This study assessed 41 lakes based on five key parameters: water quality, biodiversity, facilities for sustainable tourism, impact of rituals, and public participation. The methodology consisted of field-based observations, community interactions, and qualitative assessments, which were systematically converted into quantitative data using a structured 50-point scoring system. The scoring system assigned numerical values to each parameter based on its condition.

Founded on the cumulative scores, lakes were categorized into three groups: Superior (36–50 points), Moderate (21–35 points), and Deteriorated (1–20 points).

This classification framework provided an objective comparison of lakes, highlighting those requiring immediate conservation interventions.

The study was conducted over a period of one year, from December 2023 to December 2024. Each lake was visited once or twice per month to ensure a consistent evaluation.

To assess water quality, factors such as colour, odour, presence of floating garbage, algae, and aeration systems were recorded. Biodiversity assessments focused on documenting the presence of trees, insects, fish, reptiles, and birds through field observations. The facilities available for sustainable tourism were evaluated by recording the presence of walkways, benches, gardens, boating facilities, gym areas, food stalls, dustbins, toilets, and boundary walls. The impact of rituals was assessed through observations during Ganesh Visarjan, Chhath Puja, and Pitrupaksha. Interviews with local communities were also conducted to understand waste management practices

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during and after the rituals. Public participation was measured through awareness programs in schools, conducted lake visits, and student presentation in the My Lake Conference.

Water Quality		**Biodiversity**		**Facilities**		**Rituals**		**Public Participation**	
Colour	Bluish **+2** Greenish / Brownish **0**	Trees	**+2**	Walkway	**+1**	Ganesh Visarjan	**0**	Adoption	**+2**
				Benches	**+1**				
Odor	Yes **0** No **+2**	Insects	**+2**	Gym	**+1**	Chhath Puja	**0**	Lecture	**+2**
				Toilet	**+1**				
Floating garbage	No **+2**	Fishes	**+2**	Food stall	**+1**	Pitrupaksha	**0**	Visit	**+2**
				Garden	**+1**				
Algae / Water Hyacinth	No **+2**	Reptiles	**+2**	Boating	**+1**	Fish / bird feeding	**0**	Presentation	**+2**
				Dustbin	**+1**				
Aeration	Water filter / fountain / Floating Wetland **+2**	Birds	**+2**	Nirmalya kalash	**+1**	Others	**0**	Reporting	**+2**
				Wall	**+1**				

Table 1.1 Scoring System for all the Key Parameters and sub-parameters

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Category	Condition	Score Range
Category 1	Superior	36 and above
Category 2	Moderate	21 - 35
Category 3	Deteriorated	1 - 20

Table 1.2 Categories of Lake based on their total scores

Results and Discussions-

The assessment of 41 lakes in Thane city revealed significant variations in their ecological as well as social status. Based on the 50-point evaluation system, the lakes were categorized as Superior (36–50 points), Moderate (21–35 points), and Deteriorated (1–20 points). The study found that 5 lakes fell under the Superior category, indicating well-maintained water quality, biodiversity, tourism infrastructure, managed ritual waste, and strong public participation. 31 lakes were categorized as Moderate, requiring conservation interventions, while 5 lakes were found to be Deteriorated, showing severe environmental degradation and a lack of management efforts.

Understanding the Environmental State of Thane's Lakes

The five lakes (12.2%) that qualified as Superior lakes, demonstrated high water quality, strong biodiversity, effective infrastructure, and proactive conservation efforts. These lakes included Ghosale Lake (45 points), Ovala Lake (38 points), and Aagasan Talao (37 points). They exhibited minimal pollution, functional aeration systems, and claimed high levels of community participation. Their well-maintained ecosystems support native fish populations and diverse bird species.

In contrast, the majority of the lakes (31 out of 41, or 75.6%) fall under the Moderate category, indicating mixed environmental conditions. While these lakes retain some biodiversity and functional tourism infrastructure, they are increasingly vulnerable to pollution, encroachment, and habitat loss. Notable examples include Kachrali Lake (31 points), Bramhala Talao (28 points), and Kharegaon Lake (26 points), where declining water quality, unregulated religious rituals, and insufficient waste management were identified as key threats.

The remaining five lakes (12.2%) are categorized as Deteriorated, representing severely polluted and ecologically degraded systems. Diva Lake and Siddheshwar Lake (16 points each) emerged as the most degraded water bodies, exhibiting high turbidity, dominance of invasive species, and contaminated sediments. These lakes lack proper waste disposal mechanisms and have a little public engagement, leading to continued degradation.

This study serves as a baseline assessment of the current status of lakes in Tane city, identifying key challenges and potential conservation strategies. The findings highlight the need for continuous monitoring, improved waste management, eco-friendly infrastructure, and community-driven conservation efforts. While some lakes remain in relatively good condition, many require immediate intervention to prevent further decline in ecological as well as social status.

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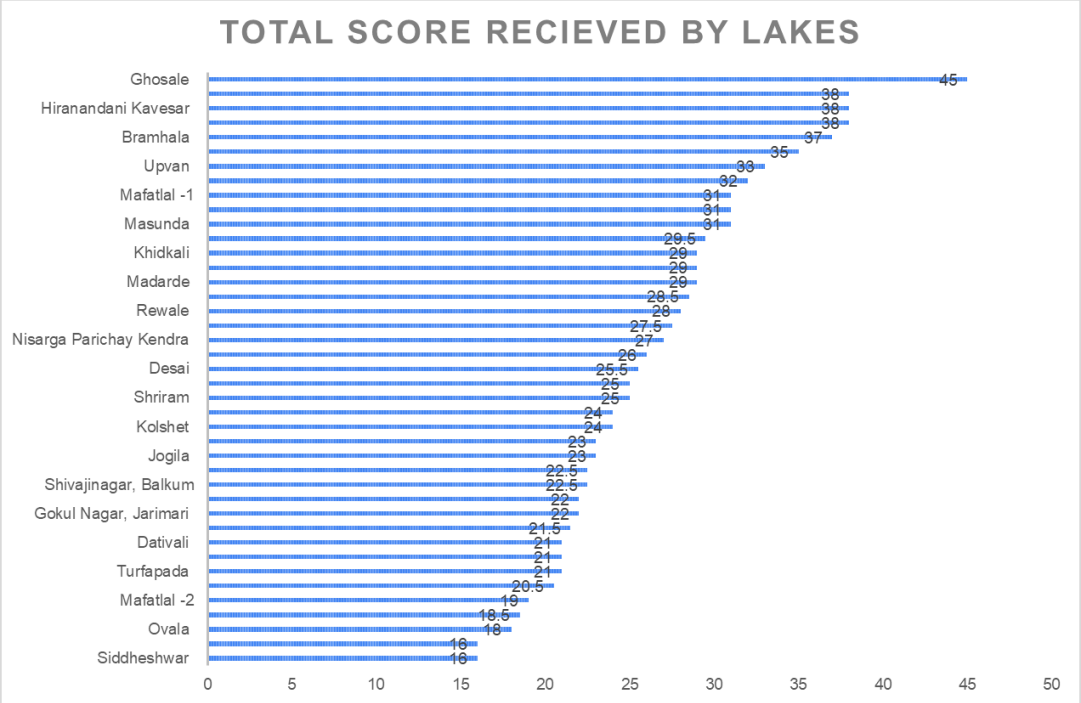

Fig 1.1 Total scores of all lakes- Ghosale Highest score and Siddheshwar and Ovala Lake showing lowest score

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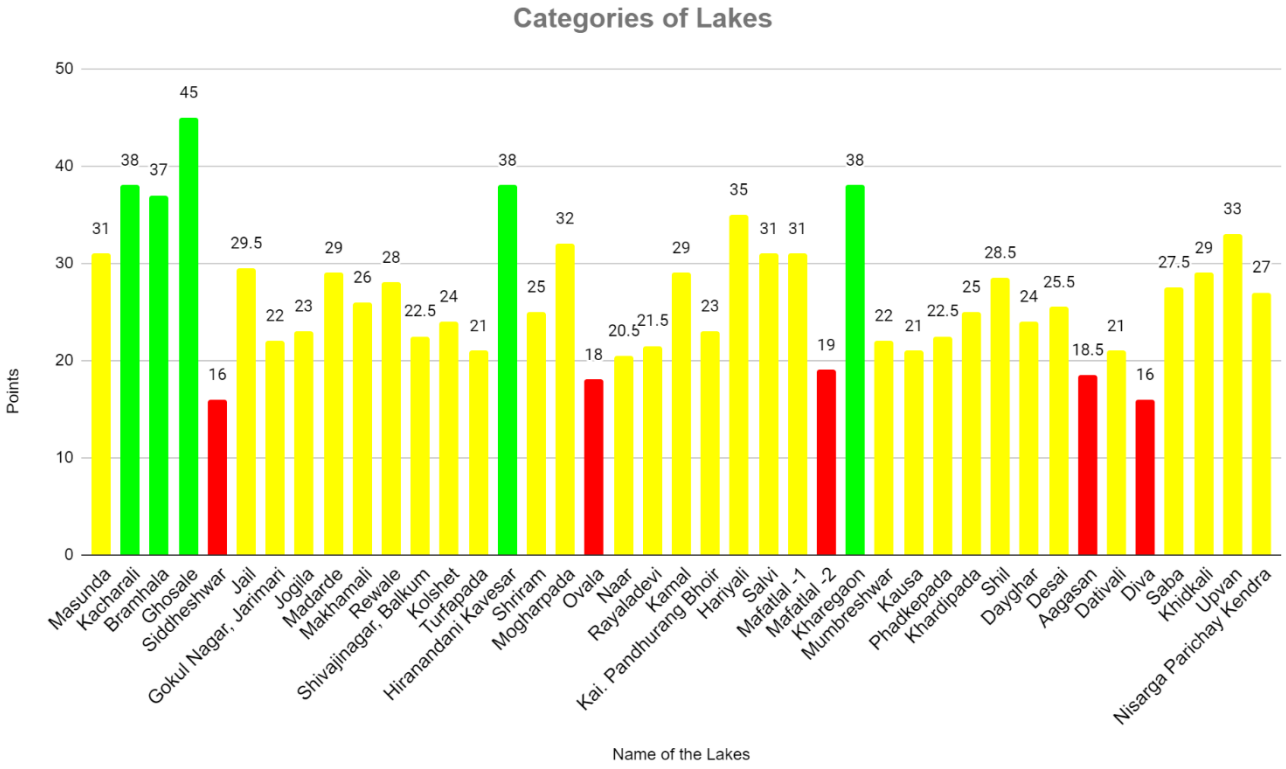

Fig 1.2 Total scores and accordingly categories of lakes indicating- 5 lakes Category1 (Superior Quality), 31 lakes Category 2 (Moderate Quality) and 5 lakes Category 3 (Inferior Quality)

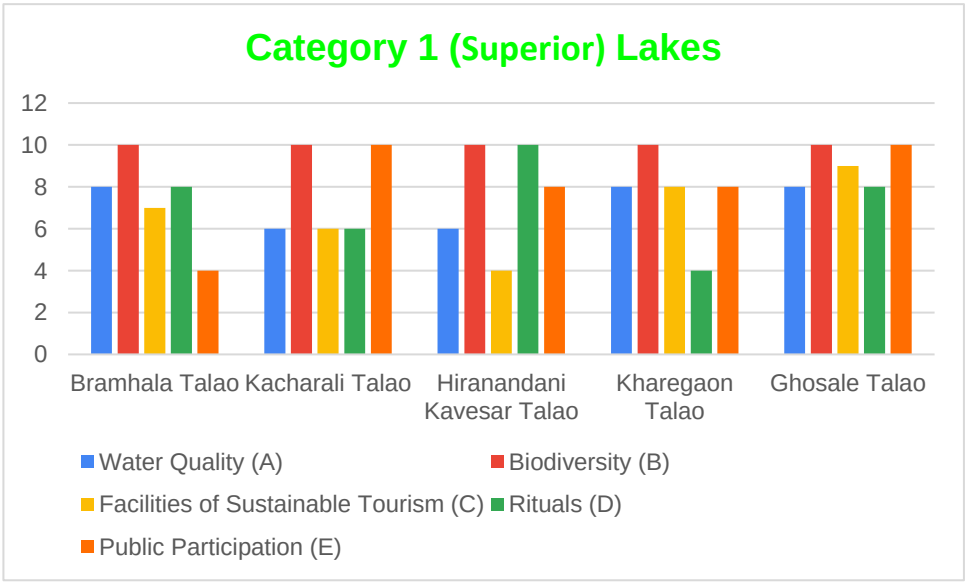

Fig 1.3 Category 1 Lakes

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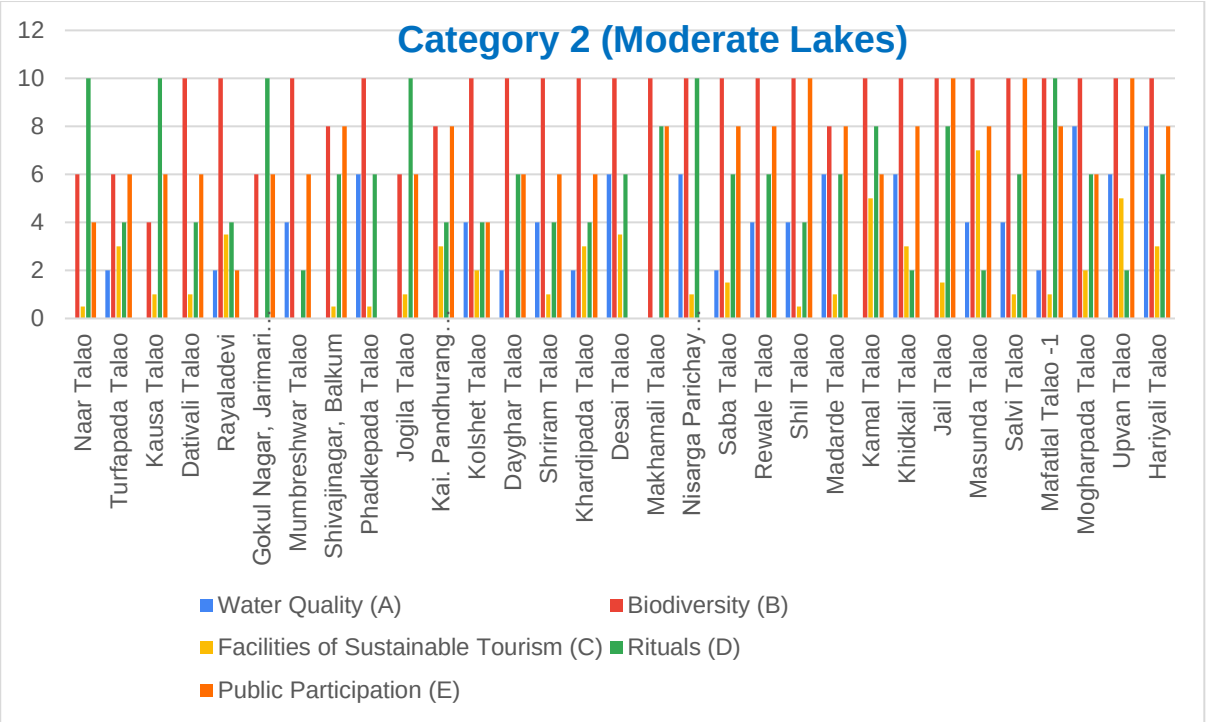

Fig 1.4 Category 2 Lakes

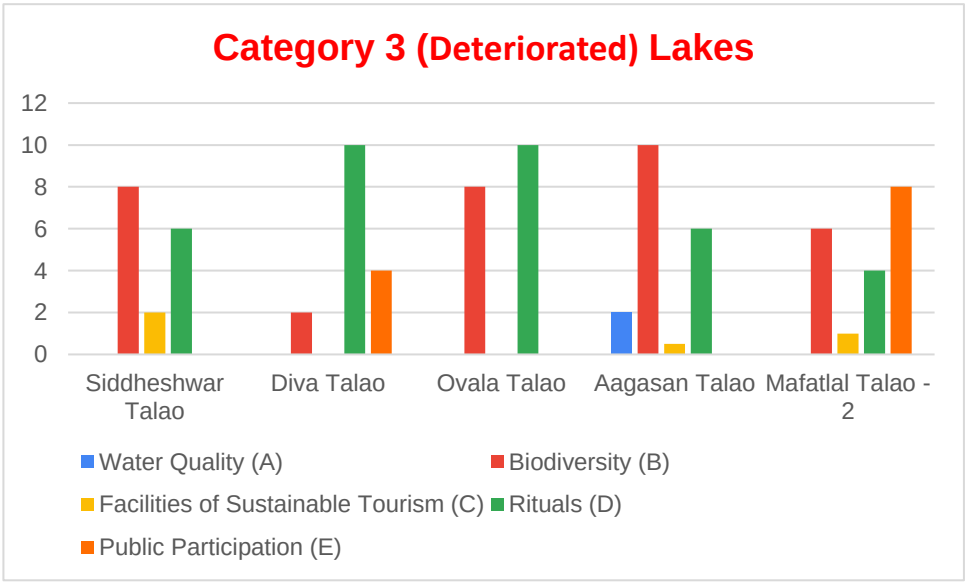

Fig 1.5 Category 3 Lakes

Parameter 1- Water Quality (Observation Based)

Water quality analysis identified elevated nutrient levels, organic pollution, and sediment accumulation as key issues affecting the lakes. Superior lakes exhibited high water clarity, minimal algal growth, and the presence of functional aeration systems, contributing to higher dissolved oxygen (DO) levels and improved aquatic ecosystem stability. On the other hand, moderate and

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deteriorated lakes showed reduced transparency, persistent odour, floating debris, and algal blooms, indicative of eutrophic conditions and declining ecology. The production of water hyacinth (Eichhornia crassipes) in several deteriorated lakes suggests excessive nutrient loading, likely driven by sewage inflows, surface runoff, and organic waste deposition. The absence of aeration systems and limited natural or constructed wetlands for biofiltration further intensifies hypoxic conditions, leading to fish mortality events.

Parameter 2- Biodiversity

Biodiversity assessments demonstrated a positive correlation between aquatic vegetation, shoreline stability, and species richness. Superior lakes supported a diverse collection of avifauna, including birds such as *Alcedo atthis* (common kingfisher), *Metopidius indicus* (bronze-winged jacana), and *Anastomus oscitans* (Asian openbill stork. Moderate lakes exhibited a decline in fish diversity and a reduced presence of bird species, suggesting a disruption in food web dynamics due to declining water quality and habitat fragmentation. In deteriorated lakes, fish deaths, absence of predatory bird species, and dominance of opportunistic taxa indicate an ecosystem shift towards low-resilience communities with reduced ecological function. The introduction of invasive species in several lakes further suggests biotic homogenization and competitive displacement of native fish populations.

Parameter 3- Facilities for Sustainable Tourism

The availability and condition of sustainable tourism infrastructure were found to influence both ecological health and community engagement. Superior lakes featured constructed walkways, and designated waste disposal units, facilitating both recreational activities and conservation efforts. In contrast, moderate lakes displayed inconsistent infrastructure maintenance, fragmented green spaces, and sporadic waste management practices, leading to localized pollution hotspots. Deteriorated lakes were characterized by a near-complete absence of visitor amenities, increased anthropogenic disturbances, and direct encroachments into banks of the lake, worsening shoreline erosion and habitat loss. The observed correlation between infrastructure maintenance and public participation highlights the role of urban planning and environmental stewardship in lake conservation.

Parameter 4- Rituals

Lakes with frequent ritual activities but lacking structured management showed significant sediment buildup, changing habitats and disrupting aquatic ecosystems. High turbidity levels reduced light penetration, affecting photosynthetic organisms and oxygen availability. The accumulation of idol fragments, floral waste, thermocol, and synthetic dyes was widespread, contributing to long-term pollution and potential heavy metal contamination from immersion materials. In contrast, lakes with designated immersion sites, waste collection systems, and regular clean-up efforts showed noticeably lower degradation, highlighting the role of community participation and regulatory measures in mitigating ritual-related pollution.

Parameter 5- Public Participation

Public participation exhibited a direct positive influence on lake health indicators. Superior lakes benefited from lake adoption programs, periodic clean-up drives, and active engagement of non-governmental organizations (NGOs) in conservation initiatives. Moderate lakes showed seasonal

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involvement from educational institutions and intermittent stakeholder interactions, which, although beneficial, lacked continuity. Deteriorated lakes exhibited minimal community-driven interventions, absence of structured monitoring programs, and limited policy enforcement, resulting in progressive environmental neglect. The findings underscore the importance of integrated governance frameworks that incorporate citizen science initiatives, participatory environmental monitoring, and legislative reinforcements to sustain long-term conservation outcomes.

Conclusion:

The study highlights that the conservation of Thane's lakes requires a long-term, science-driven, and community-supported approach. While some lakes exhibit good ecological health, many are at a risk due to pollution, unregulated rituals, poor waste management, and inadequate infrastructure developments that prioritize aesthetics over ecosystem stability. Continuous monitoring and proactive conservation are necessary to prevent further degradation.

Key Takeaways & Actionable Recommendations:

1) Lakes must be conserved and continuously monitored to track changes in water quality and biodiversity.
2) Water quality and biodiversity assessments should be conducted using scientific methods, integrating hydrological studies, bioindicator assessments, and pollution load tracking.
3) Rituals must be performed responsibly, ensuring controlled immersion zones, use of eco-friendly materials, and proper waste disposal.
4) Beautification should be nature-centric, not human-centric. The conservation efforts should focus on ecosystem restoration rather than artificial landscaping.
5) Public participation is crucial—more people should join the My Lake campaign to create public pressure against lake deterioration and push for stronger environmental policies.

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Research Papers and Review Articles: Group B

Degradation and Hydrodynamic Alterations in Creek

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The rapid urbanization and industrialization surrounding Thane Creek, an estuarine ecosystem south of Bombay harbor, have drastically altered its hydrodynamic and ecological balance over the past two decades. Thane Creek, characterized by its mangrove mudflats and bordered by industrial and residential zones, receives substantial discharges of untreated domestic waste water and industrial effluents. Additionally, anthropogenic activities such as sand dredging and reclamation of land under mangroves for infrastructure development have further compounded its environmental challenges.

This study presents an extensive evaluation of the hydrodynamics and water quality dynamics of Thane Creek, focusing on the impacts of anthropogenic interventions. Water and soil samples were collected from 28 locations across the creek and analyzed for the critical physicochemical parameters, including dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, temperature, nitrates, sulfates, phosphates, acidity, and alkalinity. The results indicate marked spatial and seasonal variations, highlighting higher contamination in upper reaches. Since 2000, observed trends include eutrophication, hypoxic zones, and sediment disruption, adversely affecting biodiversity and public health.

Integrated management strategies including wastewater treatment upgrades, mangrove restoration, reuse of treated water, and stringent effluent norms are recommended. The study offers insights for policymakers and ecologists to restore the creek's ecological balance.

Keywords: Hydrodynamics, Thane Creek, Water Quality, Eutrophication, Anthropogenic Impacts, Conservation Strategies

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1. Introduction:

Thane Creek, an important estuarine ecosystem in India, serves as a vital habitat for a diverse range of aquatic species, including fish, birds, and various plant species (*Kunte et al., 2014; Maharashtra Forest Department, 2021*). However, urbanization and industrialization in the surrounding areas have resulted in substantial environmental challenges. Pollution from domestic and industrial effluents, along with other human activities like sand dredging and mangrove clearing, have drastically altered the natural state of the creek (*Patil & Mhatre, 2019*). Seasonal changes, especially monsoon fluctuations, significantly influence the hydrodynamics and water quality.

The study in this paper compares water quality data collected before and after the monsoon season in 2024 to evaluate the seasonal effects on the hydrodynamics of the creek. The goal is to understand how the annual monsoonal variations influence the water quality and to identify any long-term environmental trends that have been emerging over the past few decades.

2. Materials and Methods:

2.1 Study Area:

Sampling was conducted in May 2024 (pre-monsoon) and December 2024 (post-monsoon) across 28 georeferenced locations in Thane Creek to ensure consistency and reliable temporal comparison.

2.2 Parameters Analyzed:

The research focuses on several key parameters that directly influence the creek's water quality and ecological health. The analyses were performed using standard method as per APHA (2005) guidelines. Each water quality parameter was measured in the laboratory following protocols listed in Standard Methods for the Examination of water and wastewater (*APHA, 21st Edition*).

1. **pH Levels:** pH is a key indicator of water's acidity or alkalinity, which can affect the solubility of nutrients and metals, and thus, the survival of aquatic life.
2. **Temperature (°C):** Water temperature influences the rate of biochemical reactions in the water and affects the distribution of species within the ecosystem.
3. **Conductivity (mS/m):** Conductivity is a measure of the number of dissolved ions in the water. Higher conductivity generally indicates higher levels of pollutants such as salts, heavy metals, and nutrients.
4. **Hardness (mg/L as $CaCO_3$):** This measures the levels of calcium and magnesium in the water, which can affect aquatic organisms' physiological functions.
5. **Acidity & Alkalinity (mg/L as $CaCO_3$):** These indicators reflect the water's buffering capacity, which is crucial for maintaining stable conditions in the ecosystem, especially in the face of pollution or environmental fluctuations.

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6. **Phosphates (mg/L):** Phosphates are often linked to nutrient pollution, particularly from agricultural runoff and wastewater, which can lead to eutrophication.
7. **Dissolved Oxygen (DO) (mg/L):** DO is crucial for the respiration of aquatic organisms. Low DO levels can indicate pollution or excess organic matter, leading to hypoxic or anoxic conditions.
8. **Chemical Oxygen Demand (COD) (mg/L):** COD reflects the amount of organic matter in the water, which can lead to oxygen depletion as it decomposes.

3. Results and Discussion:

Parameter	Pre-Monsoon Mean	Post-Monsoon Mean	% Change	Observation
pH	6.99	6.95	-0.57%	Minimal decrease, indicating stable water chemistry despite seasonal changes.
Temperature (°C)	32.75	26.36	-19.51%	Significant cooling due to the monsoon rains, which is typical in estuarine systems.
Conductivity (mS/m)	34.24	26.12	-23.71%	The reduction is due to dilution caused by increased water volume from rainfall.
Hardness (mg/L as $CaCO_3$)	2.05	1.50	-26.83%	Lower hardness values post-monsoon reflect reduced dissolved calcium and magnesium.
Acidity (mg/L as $CaCO_3$)	0.03	0.03	0%	No significant change in acidity, indicating stable pH regulation.
Alkalinity (mg/L as $CaCO_3$)	0.74	0.16	-78.38%	Alkalinity showed a significant reduction, indicating the loss of buffering capacity in the water.
Phosphates (mg/L)	20.60	21.15	+2.67%	A slight increase in phosphate levels, possibly due to urban or agricultural runoff.

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Dissolved Oxygen (DO) (mg/L)	1.86	1.48	-20.43%	The decrease in DO suggests a rise in organic matter decomposition, especially after the monsoon.
Chemical Oxygen Demand (COD) (mg/L)	8.58	6.91	-19.44%	The reduction indicates less organic pollution post-monsoon, likely due to dilution effects.

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Key Findings:

1. **Minimal pH Change:** The small decrease in pH indicates that the water's acidity remains relatively stable despite the monsoon's influence. pH stability is important for maintaining a healthy aquatic environment.
2. **Temperature Drop:** The significant decrease in water temperature after the monsoon is typical, as the rains cool down the water, impacting the metabolism and distribution of aquatic species.
3. **Conductivity and Hardness Reduction:** These reductions point to the dilution of dissolved ions due to the increased water volume from rainfall. This dilution can temporarily improve water quality, but it can also indicate that pollution levels might be higher in drier months.
4. **Alkalinity Loss:** A major decrease in alkalinity (78%) suggests that the water's ability to neutralize acids has diminished, which can affect aquatic life, particularly organisms that are sensitive to pH changes.
5. **Dissolved Oxygen Decline:** The decrease in DO suggests that after the monsoon, increased organic matter decomposition may have reduced oxygen levels, leading to hypoxic or anoxic conditions in certain areas.
6. **Phosphate Increase:** The minor increase in phosphates suggests that nutrient pollution, likely from runoff, is still present, which can lead to eutrophication and algal blooms.

4. Observations and Recommendations:

4.1 Observations:

The results demonstrate that monsoonal effects lead to significant dilution of chemical parameters, but also increased organic load and nutrient input. However, data from only two seasons cannot establish trends. For robust conclusions, tri-seasonal data collection (pre-monsoon, monsoon, and post-monsoon) across at least three years is necessary.

4.2 Recommendations:

1. **Strengthen Water Quality Monitoring:** Regular seasonal monitoring should be established to track ongoing changes in water quality and hydrodynamic conditions. This will help in identifying trends and assessing the effectiveness of mitigation measures.
2. **Manage Agricultural and Urban Runoff:** While urban runoff appears to be the major source of nutrient influx, some peri-urban areas may contribute agricultural runoff (MPCB Reports, 2022). However, more localized land-use studies are required. Regarding freshwater input, the creek currently receives mostly untreated domestic and industrial wastewater. If this is discontinued without alternative freshwater supplementation (e.g., stormwater harvesting or treated greywater), Thane Creek risks turning into a saline backwater system.

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3. **Improve Oxygenation Strategies:** Instead of artificial aeration, primary and secondary treatment of wastewater before discharge is the most sustainable approach. Upgrading treatment plants and implementing decentralized treatment near pollution hotspots are practical steps to improve DO levels naturally.
4. **Enhance Public Awareness and Policy Enforcement:** Educating the local community about pollution control and reinforcing the enforcement of water quality regulations will be crucial for maintaining water quality in the long term.
5. **Promote Ecosystem Conservation:** Protecting and restoring natural wetland areas and mangroves will enhance the water filtration process, reduce sedimentation, and increase ecosystem resilience.

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Current Status of Marshy Crocodiles of Bhitarkanika National Park

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Abstract: -

An important wetland habitat in Odisha, India's Bhitarkanika National Park has been designated a Ramsar site since 2002. Famous for its vast mangrove forests, this region is an essential home for various plants and animals, including the marshy crocodile (*Crocodylus porosus*). Because of conservation efforts, the saltwater crocodile population in the park has mostly recovered, particularly the Crocodile Conservation Project, which was started in 1975. 1,811 crocodiles were tallied in the yearly census held in January 2024, and there was a slight rise over 1,793 crocodiles counted in 2023. Despite these encouraging developments, habitat loss, climate change, and rising disputes between people and wildlife threaten the wetland environment, endangering biodiversity and local livelihood. To ensure the species' sustained presence in Bhitarkanika, such problems need to be addressed. In this review article, the present condition of saltwater crocodiles in Bhitarkanika National Park is referred to, the success of conservation initiatives is assessed and plans for maintaining and growing the crocodile population in this special ecosystem are discussed.

Keywords: - Bhitarkanika National Park, Marshy crocodiles, wetland, Ramsar site

Introduction:

Mangroves at Bhitarkanika. Orissa, August 19, 2002. 65,000 hectares. 20°39'N, 086°54'E. wildlife sanctuary. After 25 years of consistent conservation efforts, the location is now one of the most well-known wildlife sanctuaries and one of the best surviving mangrove forest areas on the Indian coast. With half a million turtles hatching there each year, the site's Gahirmatha beach is thought to be the largest known Olive Ridley Sea turtle nesting beach in the world. It also boasts the highest density of saltwater crocodiles in the nation, with about 700 *Crocodylus porosus*. In addition to being the primary nursery for brackish water and estuarine fish species on the East Coast, it serves as a key breeding and wintering location for numerous residents and migratory waterbirds. The extensive coastal woods, like many other mangrove areas, offer millions of people essential protection from tidal surges and destructive cyclones. Of India's 58 known species of mangroves, 55 are found in Bhitarkanika, which has a greater diversity of mangroves than the Sundarbans! Food, medicine, tannins, fuel wood, and building materials—especially fish and honey—have historically been harvested sustainably, but encroachment and population pressures could upset this balance. 1205 Ramsar site. [1] In Odisha, India's Bhitarkanika National Park, the marshy crocodile (*Crocodylus porosus)*. commonly referred to as the mugger crocodile, is a significant species. With its vast network of tidal rivers, mangrove swamps, and estuaries, Bhitarkanika—known for its abundant biodiversity—offers these crocodiles a special home. [2]

Importance of marshy crocodiles in the ecosystem

Prey species including fish, amphibians, and small mammals have their numbers controlled by marsh crocodiles. By doing this, overpopulation is avoided, which could result in ecological imbalances and resource depletion. In addition to being opportunistic feeders, they also scavenge carrion, which helps to keep the environment clean

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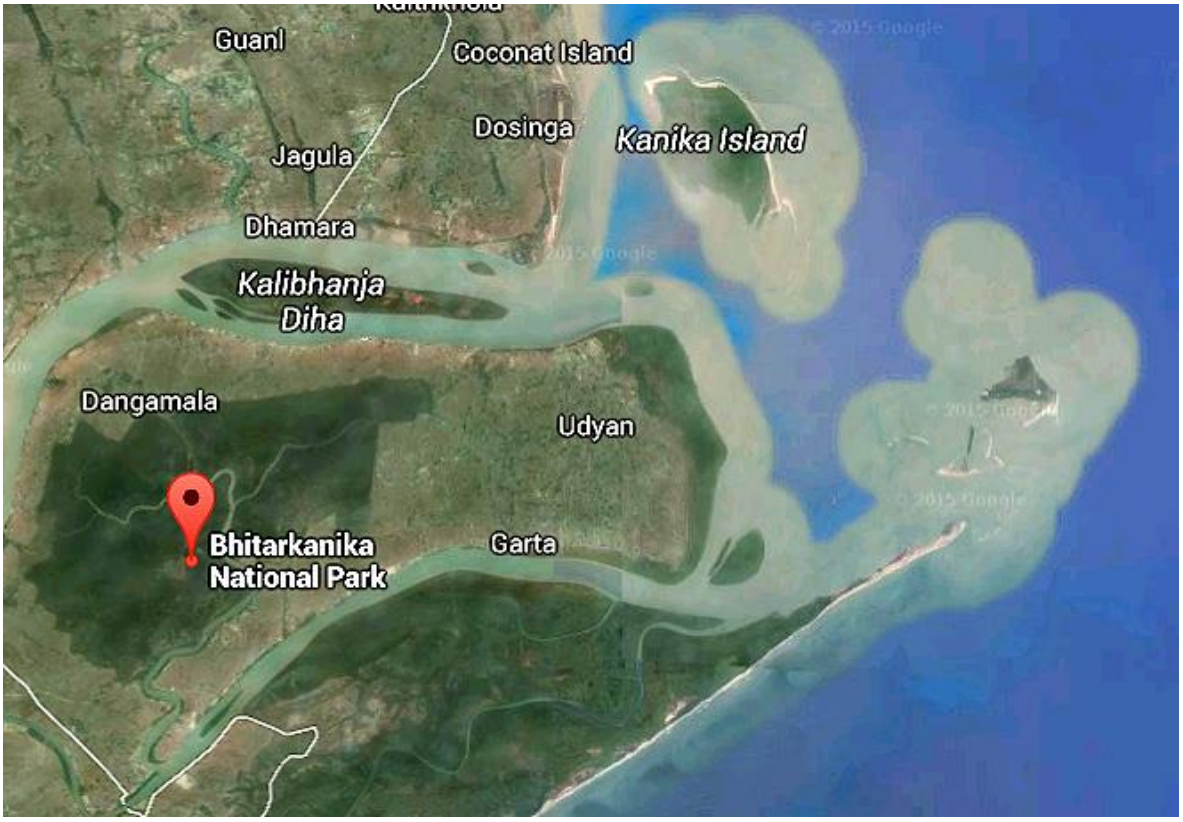
and stops the spread of illness. They aid in the cycling of nutrients in aquatic environments by eating decomposing materials. In marshes, marsh crocodiles dig "wallows" or burrows that hold water during dry spells. Many aquatic creatures, birds, and mammals find sanctuary in these waterholes, particularly during dry spells. A robust wetland habitat is indicated by healthy crocodile populations. Their existence is indicative of balanced biodiversity, plenty of prey, and high-quality water. Crocodiles can help spread seeds through their diet because the undigested seeds in their feces can sprout and spread, promoting vegetation regeneration. In many areas, crocodiles play a significant role in local customs and civilizations. They can also boost ecotourism, which incentivizes the preservation of wetlands. Young marsh crocodiles are a component of the greater food chain since they are prey to birds, big fish, and other predators.



https://www.musafirnamah.com/14-odisha-islands-to-get-facelift/

Conservation Implications:

Poaching, pollution, and habitat destruction are common threats to marsh crocodiles. These essential ecological functions may be disrupted by their loss, which could have a domino impact on biodiversity. Wetland ecosystems depend on the protection of marsh crocodiles and their habitats. [2,3] Evaluated the ecological contributions of marsh crocodiles (*Crocodylus porosus*) to the preservation of ecosystem stability and biodiversity. investigated how the animals contribute to wetland ecosystems as scavengers, apex predators, and ecosystem engineers. assessed how marsh crocodiles and other animals in their environment are interdependent. determined the present dangers facing marsh crocodile populations and their environments. offered evidence-based suggestions for sustainable wetland management and marsh crocodile protection. Cover the areas where marsh crocodiles are most common in South Asia, which includes India, Nepal, Pakistan, and Sri Lanka. To capture both historical and contemporary trends in research and conservation efforts, including works that were published within the last 30 years (1994–2024). Analyse ecological functions including wetland engineering,

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nutrient recycling, and predation. Examine the species' significance for sustaining biodiversity, controlling prey populations, and preserving wetland health. Threats like pollution, habitat loss, and conflict between humans and crocodiles should be addressed. Consult case studies, government reports, publications from conservation organizations, and peer-reviewed journal articles. Incorporate cultural, socioeconomic, and ecological elements into the preservation of marsh crocodiles.[4]

Study Area: The central region of Bhitarkanika Wildlife Sanctuary, located in the Kendrapara district of Orissa on India's east coast, is known as Bhitarkanika National Park. It is situated between 20° 33′ N and 20° 47' N latitude and 86° 48' E and 87° 03′ E longitude, covering an area of 145 square kilometers. In 1988, the Forest & Environment Department of the Government of Orissa declared it a National Park. This region's vegetation, which includes mangrove forests, coastal scrub, freshwater swamp forests, rivers, creeks, estuaries, accreted land, and mud flats, has a unique ecological, geomorphological, and biological background. Kendrapara district only makes up 180 sq. km or 4/16 of Orissa's 207 sq. km of mangrove cover (Forest Survey of India report, 2003).

https://www.jagranjosh.com/general-knowledge/bhitarkanika-wildlife-sanctuary-1441610397-1

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https://en.wikipedia.org/wiki/Bhitarkanika_National_Park#/media/File:Sunrise_at_Bhitarakanika.jpg

Climate: There are no distinct seasons in this region's tropical climate, which is warm and humid. The northeast monsoon from November to December and the southwest monsoon from May to September are the causes of rain. Cyclones occasionally occur in these regions. The majority of the 1000 mm of rainfall that falls on average occurs between June and October.

In May and January, the highest recorded temperature was 41°C, while the lowest was 9°C. Throughout the year, the mean relative humidity varies between 70% and 95%. The fine-grained silt or clay soils found in mangrove areas are the result of the Brahmani and Mahanadi rivers' deposition. During high tide, seawater frequently floods the earth. Mangrove roots in tidal creeks retain surface runoff water from all across the region, raising the substratum's level. The zonation of mangroves is primarily caused by a decrease in the time that soil is submerged under tidal water as the soil level rises from the creek towards the landmass. Mangrove vegetation turns into scrub vegetation as a result of the soil's altered composition and structure. [5]

Threats and Challenges:

Degradation of Habitat, Appropriate marshland habitats for crocodiles have been lost as a result of industrialization, agricultural growth, and coastal erosion. Furthermore, pollution has grown to be a serious environmental issue, particularly from chemical runoff and plastic trash. Conflict between Humans and Wildlife, As the number of crocodiles increases, so do contacts with people, especially in places where the animals enter human settlements to feed. These interactions frequently result in casualties on both sides and fuel local opposition to conservation initiatives. Despite a considerable decline, poaching remains a problem, particularly when crocodiles are targeted for their skins, which are highly sought-after on the illegal market. Although anti-poaching patrols have been bolstered, the illegal trade remains a menace. Eco-tourism has emerged as a crucial tactic to increase public awareness and provide funding for conservation. Wildlife lovers flock to Bhitarkanika

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National Park to see the remarkable number of marsh crocodiles as well as other species like the Indian python and migrating birds. The community has learned the value of preserving the marsh crocodile and its environment thanks in large part to local awareness campaigns.

Current Status of Marshy Crocodiles

Population trends and distribution

The coordinated conservation efforts, the marsh crocodile population in Bhitarkanika has steadily recovered over the last few decades. The park has put in place anti-poaching measures, habitat protection, and crocodile nest monitoring. With more than 1,000 individuals recorded in recent counts, the marsh crocodile population has grown, according to regular surveys carried out by the Odisha Forest Development Corporation (OFDC) and local wildlife officials. Bhitarkanika's mangrove forests and sizable tidal rivers offer these reptiles the perfect habitat, which aids in their development.

Conservation measures and policies in place

The Wildlife Protection Act of 1972, which forbids shooting and capture, is one of the protective legislations implemented by the Indian government that benefits Bhitarkanika's marsh crocodiles. To ensure the species survives, park officials also carry out yearly surveys, monitoring crocodile nests and hatchlings. Breeding areas receive particular attention and are meticulously shielded from human intervention. As an alternative source of income, ecotourism has been promoted and human-wildlife conflict has been lessened thanks to the local community's involvement in conservation efforts.

Threats to the Marshy Crocodile Population

Pollution: Rivers and creeks traverse Bhitarkanika get effluents from nearby industrial operations containing oil, heavy metals, and hazardous chemicals. This damages aquatic biodiversity, particularly crocodile prey bases, and deteriorates water quality. Excessive fertilizer and pesticide use in nearby agricultural regions cause pollution that seeps into the wetland. Algal blooms brought on by an excess of nutrients lower the water's oxygen content. Toxins affect crocodiles and other species by making their way up the food chain. Because Bhitarkanika is close to populated areas, plastic debris builds up in rivers and estuaries. Crocodiles frequently consume plastic or get tangled in it, which can cause harm or even death. The park's waterways are further contaminated by the uncontrolled disposal of sewage and domestic waste from neighboring cities and villages, endangering the health of the crocodiles and the aquatic ecosystem.

Water Management Issues

Water flow patterns have changed as a result of dams and irrigation projects on rivers like the Brahmani and Baitarani, which supply water to Bhitarkanika's wetlands. This affects the normal cycles of flooding that are essential for crocodile nesting and reproduction. Uncontrolled mining and upstream deforestation cause excessive silt deposition in rivers and estuaries, which lowers water depth and damages marsh crocodile nesting sites. Wetlands in Bhitarkanika are becoming more salinized as a result of rising sea levels and decreased freshwater inflow brought on by upstream irrigation and water extraction. Elevated salinity can alter the habitat of crocodiles and decrease the variety of their prey.[6,7] The park's wetland habitats have been divided by infrastructure projects such as roads, canals, and embankments, which restrict crocodile mobility and breeding grounds. Wetlands and riverbanks are destroyed by illegal settlements and agricultural practices in and around Bhitarkanika, which further reduces the amount of appropriate habitat for crocodiles.

Combined Effects in Bhitarkanika

The availability of prey, such as fish and crabs, decreases as a result of ecological deterioration brought on by pollution and problems with water management. loss of nesting locations due to disturbances in hydrological

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cycles and water quality. Crocodiles are more susceptible to illnesses and conflicts between people and nature.

Conservation Strategies and Management Efforts

In 2024, there was a slight rise in the number of saltwater or estuarine crocodiles (*Crocodylus porosus*) in and around Bhitarkanika National Park in Odisha. According to forest officials who conducted the yearly census, the park in the Kendrapara district is home to 1,811 crocodiles. There were 1,793 crocodiles last year. [8] To count estuarine crocodiles in all of the park's creeks and rivers as well as those close by, we organized 22 teams into 51 segments. The divisional forest officer of Bhitarkanika National Park, Sudarshan Gopinath Yadav, informed this reporter that the census was carried out between January 10–12, which was an appropriate time to count the animals because of the lunar cycle, the height of winter, and the exposure of over 50% of the mud banks. After West Bengal's Sundarbans, Bhitarkanika is India's second-largest mangrove forest. The Andaman and Nicobar Islands are the third of India's three saltwater crocodile strongholds, which are home to the largest reptiles in the world. Yadav went on to say that wildlife staff members oversaw the headcount drive. The Bhitarkanika river system, as well as countless creeks, water inlets, and nullahs, were covered by the enumerators with the help of certain herpetologists, including renowned crocodile researcher Sudhakar Kar, and educated local forest employees. 582 hatchlings (two feet in length), 387 yearlings (2–3 feet), 327 juveniles (3-6 feet), 167 sub-adults (6–8 feet long), and 348 adults (greater than 8 feet long) were all observed during the census, according to Kar. He noted that 345 adult reptiles, 388 yearlings, 325 juveniles, 166 sub-adults, and 569 hatchlings had been observed last year. [9]

Conservation Challenges and Recommendations

Laws governing pollution management are not strictly enforced in the neighbourhood. conflicting objectives between development and conservation initiatives. Residents are not sufficiently informed of marsh crocodiles' ecological significance. [10] Keep an eye on and manage agricultural and industrial runoff into rivers. Install systems for managing solid waste in neighboring villages. Control upstream dam operations to guarantee sufficient freshwater flow. Reforestation and soil conservation in upstream catchments can help prevent siltation. Improve nesting and basking locations by restoring wetlands and deteriorated riverbanks. [11] If natural habitats continue to deteriorate, provide artificial breeding grounds. Use ecotourism as a motivator to engage nearby communities in crocodile conservation initiatives.

Habitat Protection and Restoration

Increase the size of protected areas to incorporate vital habitats including places for breeding and sunbathing. Boost enforcement in protected areas to prevent poaching, illegal fishing, and encroachment. Repair damaged wetlands by lowering siltation and re-establishing hydrological cycles. Invasive plant species impact crocodile habitats; remove them. [12] Reforest riverbanks to enhance water quality and stop erosion. Strict laws should be put in place to lessen plastic, industrial, and agricultural pollution in crocodile habitats. Upstream of wetlands, locate effluent treatment facilities close to agricultural and industrial areas.

Sustainable Water Management: Control upstream dam operations and water diversion projects to ensure wetlands receive an adequate amount of freshwater inflow. [13] Create plans for the integrated management of water resources that strike a balance between development and conservation. Maintain the natural flood cycles that are necessary for crocodile nesting and reproduction.

Community Engagement and Awareness

Community-based Conservation Programs offering alternate sources of income (such as ecotourism or sustainable fishing methods), local communities can be involved in crocodile conservation. Through incentives and education, promote local care of wetlands. [14]

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Run educational initiatives to raise awareness of marsh crocodiles' ecological significance. By teaching people safe coexisting techniques, you can address the problems of human-crocodile conflict.

Research and Monitoring

Long-term Monitoring Programs Put in place initiatives to keep an eye on crocodile numbers, nesting locations, and habitat conditions. Utilise remote sensing and GIS to monitor habitat changes over time. Ecological Roles Research highlights the significance of marsh crocodiles in the preservation of biodiversity and examines their roles as apex predators and ecosystem engineers. Examine the effects of increasing salinity, changing rainfall patterns, and rising sea levels on crocodile habitats and behaviour. [15] To lessen direct conflicts, erect fencing or obstacles around important locations for human settlement and nesting. Create rapid response teams and early warning systems to address crocodile incidents in neighboring areas. Provide compensation plans to communities impacted by harm caused by crocodiles. Update and implement stronger legislation against poaching, pollution, and habitat degradation. Include national wetland and wildlife policies that prioritize crocodile protection. Work together with international organizations (such as the Ramsar Convention and IUCN) to support global conservation objectives. [16] Extend marsh crocodile breeding initiatives at zoological parks and sanctuaries. Reintroduce crocodiles to places where their numbers have decreased, making sure that the community is prepared and that the ecosystem is suitable. Create adaptable plans to lessen the effects of climate change, such as rising sea levels and shifting water supplies, on wetland ecosystems. Encourage the restoration of mangroves in coastal wetlands such as Bhitarkanika to serve as a buffer against the effects of climate change and to give crocodiles a place to live. Encourage environmentally friendly ecotourism to generate money for conservation projects and give local populations alternate sources of income. Create environmentally friendly ecotourism facilities that highlight marsh crocodiles and their environments. Exchange resources and best practices with global conservation organizations, such as the IUCN's Crocodile Specialist Group. [17] Take part in the Ramsar Convention's worldwide wetland protection initiatives.

Conclusion

Ultimately, due to successful conservation efforts, the marsh crocodile in Bhitarkanika National Park has made notable progress towards population recovery. Nonetheless, the species remains susceptible to several hazards, such as habitat degradation and conflicts between humans and wildlife. To preserve the fragile ecology that sustains this species, conservation efforts will need to address these issues through more protection, sustainable practices, and active community involvement.

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Comparative Analysis of Nutrient Components in Marine and Bay Fishes

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ABSTRACT: Fish belonging to the superclass Pisces of the subphylum Vertebrata have proven to be important food since ancient times. They are found in freshwater, saline waters, as well as ~~in~~ brackish waters. Along with the food industry, they have a huge role in fertilizers, animal feeds, and pharmaceutical industries. Fishes are classified into Osteichthyes and Chondrichthyes. Various micro- and macro-nutrients are abundantly present in fish. In the current study, some of the important nutrients were analyzed from two different fish species, which are *Lutjanus johnii* (marine fish) and *Mugil species.* (Bay fish). Proteins and carbohydrates were estimated from fish meat, lipids extracted from fish wastes, collagen from fish scales, and calcium phosphate from fish bones. The estimated parameters have been discussed in the light of current knowledge.

KEYWORDS: *Lutjanus johnii, Mugil species*, proteins, collagen, lipids, calcium phosphate.

INTRODUCTION: Fish belongs to Phylum: Chordata, Subphylum: Vertebrata, Superclass: Pisces. Fishes are aquatic, either marine or fresh water and herbivorous or carnivorous. They have a streamlined body which is differentiated into head, trunk and tail. Locomotion is carried out by fins and muscular tail. Exoskeleton is made up of scales or dermal plates. Pisces are further classified into Chondrichthyes and Osteichthyes depending on their endoskeleton (Kotpal, 2009 and Donald, 2012). The present study has been carried out on two species of fish i.e. *Lutjanus johnii* and *Mugil species.*

The global human population has been increasing rapidly and with increase in population the demand for food and nutrition has also increased. The proteins provided by the seafood have a significant contribution in food supply worldwide (Baksh *et al*., 2023). The continuously changing environmental and weather patterns have adverse effect on fish development and on planktons on which fish are directly dependent for food. Due to the frequent changes in temperatures, biological adaptations like alteration of growth patterns; shift in the distribution range and patterns of migration; prolonged or shortened growth period and infertility in fishes are observed (Huang *et al.*, 2021).

Various products use fish as raw material. These products have high quality, and longer shelf lives making them available throughout the year. Traditional fish preservation techniques, which are used in India include; Sun-drying, Smoking, Salting, Fermentation etc. (Valu *et al*., 2023). Fish products like fish liver oil, fish body oil, fish meal, surimi, fish sausages, canned fish, fish pickle and fish wafers have increased the economic value of various fishes. Besides these, fishing practices and aquaculture practices provide livelihood for many people. Fish as a raw material, is used in pharmaceuticals, cosmetics, agricultural, biomedical and textile industries besides food industry (Jimenez-Champi *et al*., 2024). Macro nutrients like proteins and fats are majorly present in fish along with micro nutrients like vitamins and minerals (Balami *et al*., 2019). Besides these, carbohydrates, fish protein concentrates, fish albumin, bioactive peptides, collagen, enzymes, calcium phosphates, fish fertilizers, antioxidants, isinglass/fish maw, gelatin, chitin and chitosan can also be obtained from fish and fish byproducts (Jimenez-Champi *et al*., 2024; Sarkar *et al*., 2023).

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Wetlands are classified into marine (coastal), estuarine (deltas, marshes, swamps), lacustrine (lakes), riverine (rivers and streams) and palustrine ecosystems (Cowardin *et al*., 1979). The varying topography of India supports various wetland ecosystems; study and preservation of such wetlands has proven to be important in the field of biodiversity and environment research (Bassi *et al*., 2014).

MATERIAL AND METHODS:

In the current study, the fishes *Lutjanus johnii* and *Mugil species* (Fishes of India, Day, Vol 1 and Food and Agriculture Organization of the United Nations) were used and all the fish raw material and byproduct was used for estimation of different nutrient factors. Proteins and carbohydrates were extracted from the fish meat; fish wastes were used for extraction of lipids, fish scales for isolation of collagen and dried fish bones were used for extraction of calcium phosphate. The estimated results were compared to observe the difference in the nutrient composition of two different species taken from different ecosystems.

Fish samples for marine fish (*Lutjanus johnii*) were purchased from local fish market Jogeshwari East in Mumbai (19.1355038, 72.8584535) and that of bay fish (*Mugil species*) were obtained from Panvel khadi (18.9904872, 73.1301535) through a local fisherman. From these two fish samples muscles, scales, endoskeleton, and other parts (head, fins, skin) were separated. Proteins and carbohydrates were estimated from the muscles of these fish, while lipids were isolated and estimated from fish waste. Calcium phosphate was obtained from the dried fish bones, and collagen was isolated from fish scales. All the chemicals were standardized according to the respective protocols.

The proteins were estimated using standard method of Folin- Lowry (Chang-Hui Shen, 2019), where the muscles were homogenised in phosphate buffer (pH 7) and used as sample. For the lipid extraction modified Kinsella method (Khoddami *et al*., 2009) was used, where chloroform and methanol were used as solvents for extraction. The lipid concentrations were estimated using phospho-vanillin method (Anschau *et al.*, 2017). To estimate carbohydrates in fish sample anthrone method was used (Layne, 1975).

Isolation of collagen from fish scales, involved immersion of samples first in alkaline solution for removal of non-collagen proteins followed by immersion in acidic solution for separation of collagen (Girsang *et al*., 2020). The solution obtained as a result was collagen which is water soluble. The further collagen characterisation was done by FTIR analysis.

Using dried fish bones as a raw material, calcium phosphate was obtained through acid treatment followed by precipitation by strong base i.e. ammonia (Ghuzaili *et al*., 2019). The weight of the resultant mixture was estimated to find percent composition of calcium phosphate in the bones.

OBSERVATIONS AND RESULTS:

	Concentration Of **protein**	Concentration Of **Lipids**	Concentration of **Carbohydrates**
Lujanus Johnii	37.14 mg/gm	16.3g%	6.5 mg/gm
Mugil species	34.761 mg/gm	9.975 g%	0.75 mg/gm

Table 1: Concentrations of proteins, lipids and carbohydrates in selected species

FTIR observations of Collagen:

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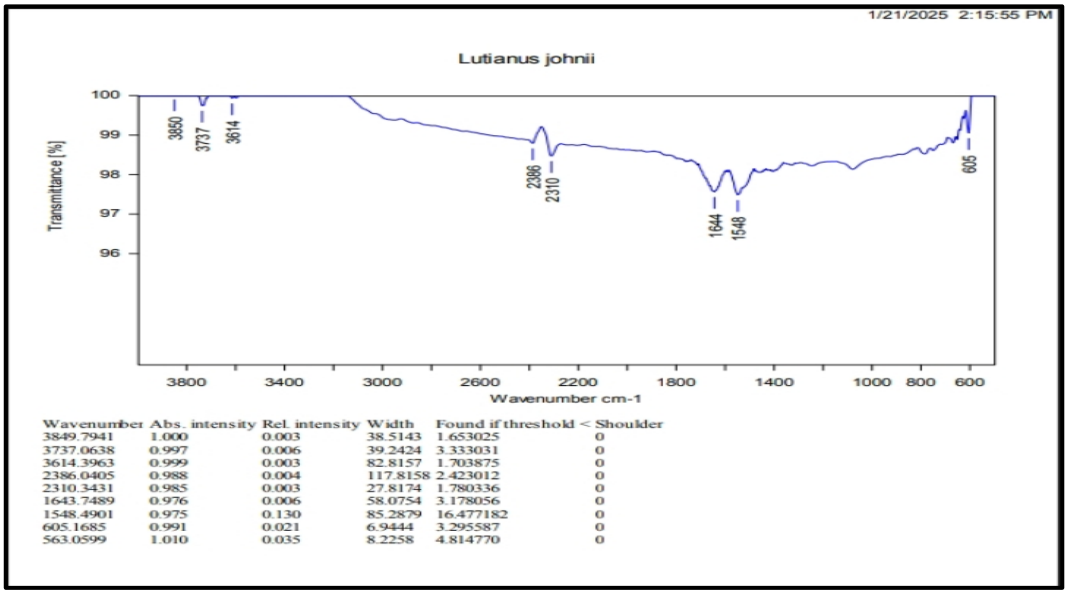
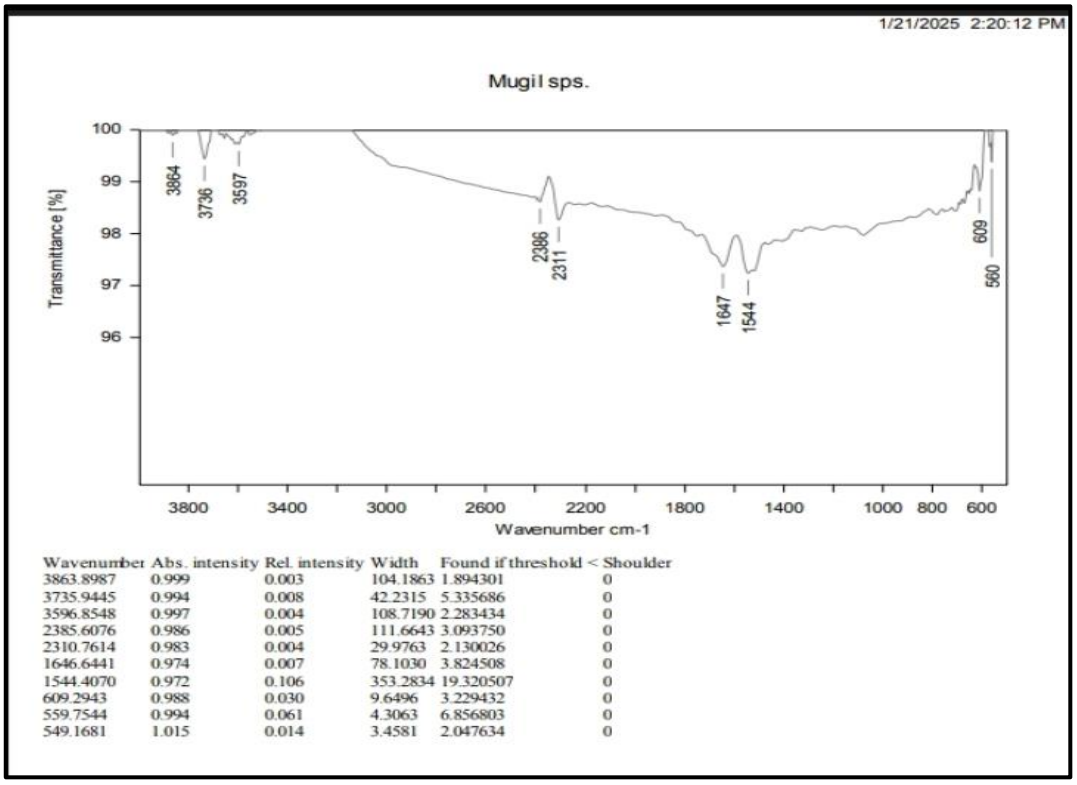


Wavenumber	Abs. intensity	Rel. intensity	Width	Found if threshold <	Shoulder
3849.7941	1.000	0.003	38.5143	1.653025	0
3737.0638	0.997	0.006	39.2424	3.333031	0
3614.3963	0.999	0.003	82.8157	1.703875	0
2386.0405	0.988	0.004	117.8158	2.423012	0
2310.3431	0.985	0.003	27.8174	1.780336	0
1643.7489	0.976	0.006	58.0754	3.178056	0
1548.4901	0.975	0.130	85.2879	16.477182	0
605.1685	0.991	0.021	6.9444	3.295587	0
563.0599	1.010	0.035	8.2258	4.814770	0

Figure 1: FTIR spectra of collagen isolated from *Lutjanus johnii*



Wavenumber	Abs. intensity	Rel. intensity	Width	Found if threshold <	Shoulder
3863.8987	0.999	0.003	104.1863	1.894301	0
3735.9445	0.994	0.008	42.2315	5.335686	0
3596.8548	0.997	0.004	108.7190	2.283434	0
2385.6076	0.986	0.005	111.6643	3.093750	0
2310.7614	0.983	0.004	29.9763	2.130026	0
1646.6441	0.974	0.007	78.1030	3.824508	0
1544.4070	0.972	0.106	353.2834	19.320507	0
609.2943	0.988	0.030	9.6496	3.229432	0
559.7544	0.994	0.061	4.3063	6.856803	0
549.1681	1.015	0.014	3.4581	2.047634	0

Figure 2: FTIR spectra of collagen isolated from *Mugil species.*

In both the above samples peaks in range:

3864-3750 which is the O-H bond stretching vibrations

3750-3587 indicates the Phenol bonds

2300-2400 indicates N-H/C-H bonds

1700-1600 indicates amide I bonds (Yang *et al*., 2020)

1570-1510 indicates amide II bonds (Yang *et al*., 2020)

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Amide and C-H bonds are present in the structure of collagen which indicates its presence in our fish scales samples.

Calcium phosphate:

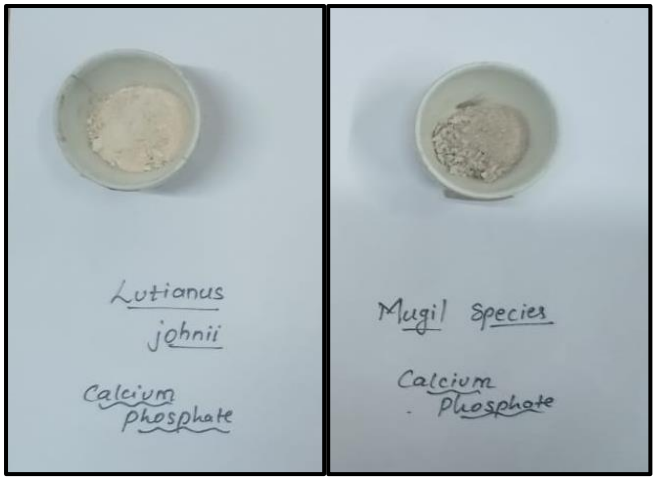
Initially 3 gm each of dried fish bones were utilized for Calcium phosphate extraction. The filtrate of bones and HCL forms white turbid precipitate when subjected to ammonia solution, the reaction taking place is as follows:

$$Ca(H_2PO_4)_2 + 2NH_3 \longrightarrow Ca(HPO_4) + (NH_4)2(HPO_4)$$

From the 3gms of initial dried bones the amount of calcium phosphate obtained after reaction:

In *Lutjanus johnii* – 2.738 gm

In *Mugil species*. - 1.145 gm



It was noticed that, *Lutjanus johnii* shows significantly more concentration of carbohydrates, lipids, proteins and calcium phosphate than *Mugil species*. This can be due to variations in their habit and habitat, age, stage of development, time of catch and majorly the species variations. Different species of fish show varied nutritional aspects.

DISCUSSIONS:

In 2023, Barua *et al*. conducted a study on stock assessment and population dynamics in the Bay of Bengal on *Lutjanus johnii*. Whitfield *et al*., 2012 provided a global assessment of flat-head mullet (*Mugil*), focusing on biology, genetics, ecology, and fisheries factors. Dibakar *et al*., 2024 conducted another study on the reproductive biology of migrants *Mugil cephalus* from the Narmada estuary on India's west coast. Although Byrd *et al*., 2020 conducted research on the nutritional composition of poorly assessed inland and marine fish species, the significance of this current work is that it is the first report of study on *Lutjanus johnii* and *Mugil species* from Maharashtra.

All the nutrient components extracted from the concerned fish species during the study can be used to determine the proper nutritional value of the fish species, and the study can be carried out for quantification of components from different species of fish to determine the meal (diet) plan for malnourished or ailing individuals. It may also help in the quantification of nutritional values of different fish products and to estimate which fish is best suited for which product. This study may help in the production of good-quality pet feed and fertilizers.

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A Study on Water Quality OF Mithi River, Mumbai

Presented By – Swarali Santosh Sawant.

Project By – Ms. Deepali Gupta and Dr. Nisha Shah.

Abstract-

Mithi river is a river located at Salsette island in the heart of Mumbai. The river travels for 18 kilometres, starting from Vihar and Powai lakes and ending at Mahima Creek in the Arabian Sea. Prior to the 2005 floods, locals used the Mithi River for their daily duties, and little children played in the water, but the river's quality deteriorated due to various industrial effluents. The river water has grown exceedingly filthy and has degraded to the point where it is now deemed sewage. We conducted this study to find out the current water quality of the river by testing its parameters like; pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Solids (TS), Salinity and Chlorinity, Total Hardness, Chemical Oxygen Demand (COD). Water samples were collected from eight different sites with 1km – 1.5kms distance between every sampling site. The majority of the sampling sites were connected to industries, slums, and residential neighbourhoods, which dumped all of their sewage and other domestic and industrial trash directly into the river. After obtaining the results and studying them we concluded that majority of parameters exceeded normal limit most samples and the highest values were found in Bail Bazar-Kurla (S5), Air India Road-Kamani (S6) and Vakola nalla-Kalina (S8). These findings suggested that river water was significantly polluted and that the government should intervene immediately to clean it up and revive the original quality of the river.

Introduction-

The rivers have been important to man since history. But major anthropogenic activities like-industrialization, indiscriminate disposal of household waste, hospital waste and the degradation of pesticides and fertilizers has damaged the natural flow of the river [27]. The nutrients are normally there in the water because they are necessary for the health of the water system and to maintain its balance. However, the elimination of organic waste and untreated sewage has introduced excess nutrients which has ultimately led to endanger the water system [29].

The issue of water quality crumbling from depletion in dissolved oxygen to heavy metals has given cause for concern in most major cities in the state of Maharashtra in India, as well as in Mumbai. The

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Mithi river is one of the most important rivers in Mumbai city which flows through the core of the city. It covers a total distance of 15kms -18kms, before it reaches the Arabian Sea on the Mahim Creek, through the private and mechanical buildings of Saki Naka Powai, Kurla, Kalina, Vakola, Bandra-Kurla complex, Dharavi and Mahim [25] [34]. In the past the Mithi was not as dirtied as it is today, and around then it used to fill in as a vital tempest water deplete for Mumbai. However unlawful exercises like washing oily cans, dumping unauthorized hazardous waste along the river are also done [34]. It is estimated that the Mithi River receives about Five MLD (Million litres per day) domestic wastewaters from the Sakinaka area in Kurla to Chunabhatti, Mahim, neighboring barracks, traversed by several drains. Bio waste, sloppy and other wastes also have decreased the conveying limit of the Mithi River [29].

Due to these anthropogenic activities the physio-chemical properties of rivers are severely affected. The physio-chemical properties of water are very important for the ecosystem of the river and every parameter has its own importance [3]. pH is a parameter that shows how acidic or basic the water is, and also since pH can majorly be affected by chemicals it is very important parameter to indicate water quality [27]. Chemical Oxygen Demand is a very important water parameter as it provides a measure for assessing the impact of wastewater on the receiving environment [25]. Dissolved Oxygen is vital for fish and other aquatic organisms for surviving. Due to its influence on life in a body of water, it is an important parameter in the assessment of water quality. Biochemical oxygen demand provides measure for assessing the impact of wastewater on the receiving water body. The higher the BOD value, the more organic matter or food is available to the oxygen-consuming bacteria. Metals are dangerous to humans and also to the environment if they are present in exceeding limits in the water [34]. Total Solids & Total Suspended Solids are also an important measure in wastewater treatment and environmental health measures. Suspended matter absorbs light, increases water temperature, reduces oxygen content and creates an adverse environment for aquatic life [38]. Hardness of water indicates the amount of calcium and magnesium that is dissolved in the water. Hard water contains many dissolved minerals, mainly calcium and magnesium [25].

A sound biological community depends on physicochemical properties and biodiversity, monitoring waters at regular intervals in terms of physical-chemical and biological parameters are essential to control contamination. In the present investigation an attempt has been made to analyse Mithi river water to determine water quality and its utility in near future.

Materials and Methodology: -

Sample collection- Eight different sites of Mithi river were selected covering the entire river length,

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starting from the Vihar lake and each sampling site were at a 1.5-2 km distance from the other (Table-1).

Table -1: Descriptions of the Sampling Sites

Nos. of Sampling Station	**Name of the sampling station**	**Distance (in kms)**	**Altitudes**
S1	BEST Nagar (Vihar lake)	(Start point) 0	19.141522,72.894371
S2	Saki- Vihar Road	1.8	19.132807,72.896476
S3	Marol CHS- Road	4.7	19.109475,72.886980
S4	MTNL Road	5.9	19.100785,72.879497
S5	Bail-Bazar kurla	6.9	19.093838,72.878355
S6	Air-India Road (Kamani)	9.3	19.078903,72.876322
S7	BKC complex	10	19.071190,72.873178
S8	Vakola nalla (Kalina)	12	19.074600,72.847985

The water sampling was done on 3rd and 4th March, 2024 between 2pm to 5pm. For the collection of water samples clean one-liter plastic bottles were used. Before use, the bottles were rinsed 2-3 times with distilled water. The water was collected by tying a rope to both sides of the bottle and throwing towards the direction of the flow and collecting the surface water. pH, DO and BOD were performed within 48 hours of the sample collection. For the remaining tests the samples were stored at 4°C for further analysis.

Materials- All the glass wares used were washed thoroughly with distilled water, cleaned and dried before use. All the chemicals and reagents were Analytical Grade (AR). A blank trial was done to ensure the accuracy of every reagent. 1 liter plastic bottles were washed with distilled water and used for storing samples.

Methods- All the water analysis tests were performed in the Environmental Biotechnology Laboratory of Life Sciences in University of Mumbai. The pH test was conducted with the help of a simple pH meter. Total hardness was performed using complexometric titration by using 0.01M EDTA and Eriochrome Black-T as an indicator. Salinity and Chlorinity were performed using Silver Nitrate titration using 0.02N $AgNO_3$and Potassium Chromate as indicator. Total Solids test was performed using the standard evaporation method. COD was performed using

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Potassium Dichromate Open Reflux method by using 0.25N $K_2Cr_2O_7$ and Ferroin as indicator. Dissolved Oxygen and BOD both the tests were performed using Winkler's method with azide modification. (Environmental Protection Agency, 2001)

Results and Discussion-

Table -2: Water analysis of various sites of Mithi river

SAMPLES / Parameters	S1	S2	S3	S4	S5	S6	S7	S8
pH	6.0	6.2	6.40	6.20	5.40	6.80	6.60	5.85
Total Hardness (mg/L)	72.14	80.16	96.19	100.2	172.34	100.2	120.24	124.25
Salinity (ppm)	1.285	2.054	1.541	1.798	2.567	1.541	2.309	2.823
Chlorinity (mg/L)	0.71	1.14	0.86	0.99	1.43	0.86	1.28	1.57
Total Solids(mg/L)	1,000	600	600	1,800	2,800	1,200	800	600
COD (mg/L)	200	200	380	260	400	340	280	300
DO (mg/L)	2.84	Negli-Gible	Negli-gible	Negli-Gible	Negli-gible	Negli-gible	Negli-gible	1.4
BOD (mg/L)	0.9	Negli-Gible	Negli-gible	Negli-Gible	Negli-gible	Negli-gible	Negli-gible	Negli-gible

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After the collection the samples were bought to the lab to conduct the various water analysis tests as follows.

pH- The pH values were obtained in the range of (5.40-6.80) showing that the pH of the river is slightly acidic in nature due to the presence of excessive industrial effluents and other wastes. Where the lowest value 5.40 (being slightly acidic) was found out at S5 that is in Bail bazar Kurla and the highest value 6.80 as found at S6 at Air India road. The major reason of it is S5 being heavily populated with industries contributing wastes and effluents containing acidic mixtures as well as cement, concrete and mud. Whereas S6 is heavily polluted majorly with household sewage coming through the slums. From the results it can be said that the pH is slightly acidic as compared to the permissible limit i.e (6.5-8.5) [10]. A study of Mithi done in 2014 by More Rushikesh and Chaubal Sakshi, showed results of pH collected from National park, Goregaon, Jogeshwari and Bandra kalanagar as (6.75-7.17) being within the permissible limits [27]. Another study of mithi conducted in 2016 by Nagarsekar and Kakde showed the pH of the waters collected from Airport road, Safed pool, CST bridge and kalanagar as (6.18-7.63) which too was almost within the limits. [26]. This explains that the effect of point source pollutions, in this case specially the industrial effluents has increased and led to changes in the pH of the river.

Total Hardness-Total Hardness was found to be in the range of 72.14mg/L – 172.34mg/L. The highest value 172.34mg/L was observed in S5 i.e in Kurla and least value 72.14mg/L was observed in S1 i.e near Vihar lake. Water is supposed to have a Total Hardness of 75mg/L to 85 mg/L as $CaCO_3$ and a magnesium hardness of less than 40 mg/L $CaCO_3$ to minimize scaling at elevated temperature [44]. As compared to this, the results of total hardness observed in this study are very high ranging till 170mg/L, which is much higher than the normal limit. Only S1 and S2 were the sampling stations that showed total hardness of 72.144mg/L and 80.16mg/L, which is within the permissible level, rest all the remaining samples had hardness more than 85mg/L. The major reason of increase in hardness is the high release of the constituents of soap and detergents into the water due to residential use and the release of chemicals from the industries also pile up the contribution, to cause a rise in the hardness level. Similar results were seen in study of Mithi conducted in 2014 by More Rushikesh and Chaubal Sakshi which showed higher levels of total hardness (198mg/L-2452 mg/L) found in all the sampling points i.e National park, Goregaon, Jogeshwari and Bandra kalanagar in pre-monsoon as well as in post- monsoon [27]. Another physio-chemical study done of Powai lake showed high level of water hardness (92mg/L-100mg/L) [32]. These results indicate that the water can affect the aquatic system and is also not suitable for fishes as several fishes can only survive at a specific pH. It can also indirectly harm due to its action of affecting cystein residues in proteins, affecting prostetic groups as well as it

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binds to the DNA backbone. Thus, according to the previous studies and these results it can be said that the total hardness of mithi is more than that of the normal level and is rising in its levels.

Salinity and Chlorinity- Salinity was found to be in the range of 1.285mg/L to 2.823mg/L. Highest salinity was observed in the last sampling station, S8; which is Vakola nalla and the least salinity was found in the first sampling station S1 i.e near Vihar lake. Similar results were seen for Chlorinity. The results were found in the range of 0.71mg/L to 1.57mg/L which is lower than the normal value. Highest values observed at S8 and lowest values observed at S1. These are found in the river mainly due to the presence of sewage consisting components from water softeners, detergents, cleaners, liquid softeners, soaps and shampoos etc that eventually adds salt to the water. Seawater has a normal salinity of 30-35ppm, and its concentration changes seasonwise, where in summer it is the highest. A study conducted in August 2006 showed the low salinity occurance in mahim bay due to the mithi, where the overall salinity resulted was in the range of (1.0ppm-19ppm) [28]. Another study on Periyar river estuaries showed results of chlorinity as achieved above i.e (1.8006mg/L). Hence, the studies and the results suggest that the salinity and the chlorinity levels are lesser than the standard sea levels of it.

Total Solids- TS was found in the range of 600mg/L to 2,800mg/L. The permissible limit of Total solids is that it should not be more than 1000mg/L [38] and according to this study the range of TS found is more than 1000mg/L. The highest TS observed was in S4 and S5; 1,800 and 2,800 which is extremely high than the normal levels. Which is probably due to high residual and industrial wastes near those areas. S5 area is surrounded by many slums resulting in their continuous input of wastes into the river, which is a major reason for high amount of TS in that area. While evaluating the water quality of Mithi in 2016, More and Chaubal found similar results, i.e in all the seasons (summer, monsoon and winter) the TDS were more than the normal limit, (360mg/L-30,700mg/L) [25]. Similarly, in 2017, the analysis conducted by More and Chaubal showed exceeding measures of TDS i.e (259mg/L-30,6500mg/L) [26]. From the above information, we can infer that the levels of Total Solids of Mithi is greater than it should be in maximum of the sampling points.

Chemical Oxygen Demand- Observed Chemical Oxygen Demand (COD) of S1 and S2 were 200mg/L to 400 mg/L respectively whereas the highest was found at S5 (Bail bazar kurla). The permissible Chemical Oxygen Demand limit is that it should be not more than 200mg/L [33]. However, in this study the results were 200mg/L to 400mg/L. This showed that the COD in almost all the sampling stations is higher than the permissible values which ultimately leads to lowering of the Dissolved Oxygen.

The highest values of COD were found in sampling stations S3 – 380mg/L and S5 – 400mg/L and S6

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– 340mg/L. Among these sites. S3 is completely surrounded by industries and S5 and S6 are surrounded by industries and a dense population of slums and other residential areas which discharge sewage, and industrial effluents pollution to a very vulnerable state. Physio-chemical evaluation of mithi done by Shah and Bhave (2012) showed quite the same results as compared wherein the COD was found in the range of (498 mg/L -512mg/L) [37]. And the one conducted in 2014 by Singare et al., showed the results in the range of (100 mg/L - 350 mg/L), here the readings varied in different locations in different months [34]. Thus, the various previously performed studies and the current results show that the chemical oxygen demand is more in the Mithi river than the standard values and this ultimately leads to less Dissolved Oxygen.

Dissolved Oxygen- Dissolved oxygen is a very important parameter of water analysis and it was performed within 24 hours of collection of the water samples. The permissible limit for Dissolved oxygen is 5-6mg/L [27]. The results predicted that there was negligible dissolved oxygen present in samples S2, S3, S4, S5, S6 and S7. DO was observed only in S1 and S8 as wherein in S1 it was found to be 2.84mg/L and in S8 it was 1.4mg/L which is extremely low than the normal limit. The samples from S2 to S7 showed no reaction or color change on addition on Winkler's B reagent and starch, detecting negligible presence of dissolved oxygen in those water samples to react with. All the sampling stations from S2 - S8 are surrounded by different types of factories and industries and heavily populated residential and slum areas which add up the sewage and/or the industrial effluents into the water body, thus decreasing the level of Dissolved Oxygen to this level. And as mentioned above; the temperature plays a very important role in change in the concentration of DO, the solubility of oxygen decreases with increasing temperatures, which means that the warmer surface water requires less dissolved oxygen to achieve 100% air saturation than the cooler and deeper water. Thus, water at lower altitudes may contain more dissolved oxygen than water at higher altitudes. As this study was conducted during March afternoon which is summer season this can be another major reason for the decrease in the DO levels. The DO tests conducted during the study of mithi in 2016 by More and Chaubal showed negligible results in two of the four sample points and the other two showed a DO of (1.2mg/L-4mg/L) [25]. After that another study was performed in 2017 by them which again showed negligible results for DO in mithi in almost half of its sampling points and the rest showed DO in the range (1.1mg/L – 5MG/L) [26]. Therefore, as expressed above most of the studies and the performed results prove that the Dissolved Oxygen during the summer was next too negligible in almost whole of the mithi.

Biological Oxygen Demand- BOD incubation was done for 5 days at 27°C. However, Biological Oxygen Demand also showed negligible results in all almost all the samples except in S1 where the

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BOD measured was 0.9mg/L which is almost close to negligible. BOD should be less than 5mg/L in unpolluted rivers/waters and less than 20-30mg/L in polluted rivers, waters [27]. In the remaining samples, S2, S3, S4, S5, S6, S7 there was negligible amount of BOD observed. Since this study was conducted in the summer season, almost all the sample stations were badly affected by eutrophication at a very high level. Similarly due to the various anthropogenic activities, the excessive release of constituents like nitrogen and phosphorous into the mithi have caused the decrease in DO & BOD. Similar to the above achieved result the study on mithi conducted in summer 2016 mentioned above showed BOD only in the first sampling point which was 0.4mg/L and remaining points showed negligible BOD [25]. Another similar example can be seen in a study carried out during summer in 2017 which also showed BOD measures in a very low range (0.1mg/L- 1.0mg/L) in some sampling points whereas negligible BOD in the remaining sampling points [26]. Hence according to these findings and results it can be said that the Biological Oxygen Demand of mithi in summer was negligible due to lower DO.

So as per the total results, pH was found in the range of 5.50 - 6.86 showing a slight acidic raise of the pH in the river; Total Hardness was found in the range of 72.14(mg/L) - 124.25(mg/L) which exceeded the normal standards; Salinity in between 1.285(ppm) - 2.823 (ppm); Chlorinity was found in the range 0.71(mg/L)- 1.57(mg/L) which again showed diversion from the specific parameter standards that should be present in the river; Total Solids resulted in between 600(mg/L) – 2,800 (mg/L) which too were in very higher levels in water; COD ranged in between 200(mg/L) - 400(mg/L) showing high COD in some of the areas, DO was found only on two stations as 1.4(mg/L) on S8 and 2.84(mg/L) on S1 due to negligible presence of DO whereas BOD could only be seen on S1 as 0.9(mg/L).

Conclusion:

In the present study the results showed that the concentration levels of all the parameters were exceeding as compared to their respective permissible limits. Therefore, it can be concluded that Mithi river water is significantly contaminated due to various pollutants and thus, the water cannot be used for household or industrial purposes. Majority of the sampling stations in this study showed presence of industrial waste due to high levels of COD, Total hardness and Total solids. The excess pollution in the river has many negative effects on the health and hygiene of people who are living in and around areas near the river. Health threatening diseases like Typhoid, Cholera, Jaundice, Amoebiasis, Malaria, Paratyphoid Fever and Dysentery can occur. Presence of excess metals and other various chemicals and several petrochemicals in the river also eventually degrade the aquatic ecosystem as well as affect the human life around the river. Thus, this contribution of wastes by the industrial sector cannot go unrecognized. And the remaining percentage of waste is daily contributed by the residents that live in

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and around the river. It also damages ecologically the aquatic life of the river and ultimately of the Arabian Sea. This experimental data shows how critical the current situation of Mithi is, which can eventually be resolved by strict implementation of some major initiatives by the authorities and by the citizens.

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Promoting Sustainable Approaches for Carbon Sequestration in the Conservation and Restoration of Mangrove Forests

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Abstract

Mangrove forests are vital ecosystems recognized for their exceptional capacity to sequester carbon and combat climate change. The microbial communities inhabiting these ecosystems, especially bacteria, are integral to the carbon sequestration process through their roles in nutrient cycling, decomposition of organic matter, and storage of inorganic carbon. This review emphasizes the potential of mangrove ecosystems in Mumbai, which are under considerable pressure from urbanization and industrialization, to serve as natural carbon sinks. By examining specific bacterial examples, the review explores the mechanisms driving carbon sequestration and highlights sustainable strategies for conserving and restoring these crucial ecosystems.

Introduction

Mangrove forests are among the most productive ecosystems on Earth, thriving in the dynamic intertidal zones of tropical and subtropical regions. These unique ecosystems provide essential ecological services, including shoreline protection, biodiversity conservation, and water filtration, while acting as critical carbon sinks. Mangroves play an integral role in mitigating climate change by sequestering significant amounts of carbon in their biomass and sediments. Despite their importance, mangroves are under threat globally, with deforestation, pollution, and urban expansion contributing to their degradation (Kathiresan and Bingham, 2001). The mangrove forests of Mumbai, located along India's western coastline, face similar challenges. Their restoration and sustainable management are vital to preserving their ecological functions, particularly their carbon sequestration potential.

Mumbai's mangrove ecosystems, comprising species such as *Rhizophora mucronata*, *Avicennia marina*, and *Sonneratia alba*, cover approximately 66 square kilometers (Jagtap, 1991). These mangroves not only provide critical habitats for marine and terrestrial organisms but also serve as natural buffers against coastal erosion and flooding. However, rapid urbanization in Mumbai has resulted in significant mangrove loss, leading to adverse environmental consequences such as reduced biodiversity, increased vulnerability to storm

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surges, and a decline in carbon storage capacity (Chaudhuri and Choudhury, 1994). Addressing these challenges require innovative approaches that integrate ecological restoration with advanced scientific methods.

Carbon sequestration, the process of capturing and storing atmospheric carbon dioxide, is one of the most significant ecological functions of mangroves. This process occurs through the accumulation of organic carbon in mangrove biomass and sediments and the transformation of inorganic carbon into stable mineral forms. Recent studies highlight the pivotal role of microbial communities, particularly bacteria, in enhancing carbon sequestration in mangroves (Holguin et al., 2001). These microorganisms contribute to nutrient cycling, organic matter decomposition, and the stabilization of carbon compounds in sediments. For instance, bacteria such as *Bacillus altitudinis* produce enzymes like carbonic anhydrase, which catalyze the conversion of atmospheric CO_2 into calcium carbonate, a stable form of inorganic carbon (Bhattacharyya et al., 2014).

The mangroves of Mumbai present an opportunity to study and implement microbial-based carbon sequestration strategies. Despite being subjected to various anthropogenic pressures, these ecosystems have shown resilience, indicating their potential for restoration. Integrating microbial research into mangrove conservation practices can significantly enhance their carbon storage capacity while promoting biodiversity and ecosystem health. For instance, studies have demonstrated that nitrogen-fixing bacteria like *Marinobacterium mangrovicola*, commonly associated with mangrove roots, enhance plant growth by improving nitrogen availability in the rhizosphere (Lal et al., 2002). Such symbiotic relationships are crucial for the productivity and carbon sequestration potential of mangroves.

In addition to microbial interactions, mangrove sediments play a critical role in carbon storage. These sediments are characterized by low oxygen levels, which slow the decomposition of organic matter, resulting in the long-term storage of carbon. Sulfur-oxidizing bacteria, such as *Beggiatoa* species, further contribute to this process by creating anoxic conditions that inhibit microbial activity responsible for organic matter decomposition (Hinrichs and Boetius, 2002). Understanding these processes is essential for developing effective strategies to enhance carbon sequestration in mangrove ecosystems.

The conservation and restoration of Mumbai's mangroves require a multi-faceted approach that combines ecological restoration, community engagement, and policy integration. Hydrological restoration, for instance, can improve tidal flow and sediment deposition, creating favorable

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conditions for mangrove growth and microbial activity. Reforestation with native mangroves-species can enhance carbon storage while supporting biodiversity. Additionally, involving local communities in mangrove conservation efforts through awareness campaigns and alternative livelihood programs can reduce anthropogenic pressures and ensure the sustainability of restoration initiatives (Giri et al., 2011).

Policy integration is another critical aspect of mangrove conservation in Mumbai. Effective policies must prioritize the protection of mangrove ecosystems, regulate coastal development, and incentivize conservation practices. For instance, integrating microbial data into conservation strategies can highlight the role of bacteria in carbon sequestration and attract funding for restoration projects. International collaborations and funding mechanisms, such as carbon credit systems, can further support these efforts.

This review aims to provide an in-depth analysis of the role of bacteria in carbon sequestration within mangrove ecosystems, focusing on their application in the conservation and restoration of Mumbai's mangroves. The subsequent sections will explore the mechanisms of microbial carbon sequestration, the ecological functions of key bacterial species, and the challenges and opportunities associated with implementing microbial-based strategies in mangrove conservation. By synthesizing existing research and identifying knowledge gaps, this review seeks to contribute to the advancement of sustainable practices for the conservation and restoration of Mumbai's mangrove for

Literature Review

Mangrove Ecosystems: Structure and Function

Mangrove forests are unique coastal ecosystems that thrive in the intertidal zones of tropical and subtropical regions. They are characterized by a diverse assemblage of salt-tolerant plant species adapted to challenging environmental conditions, including fluctuating salinity, tidal inundation, and anaerobic soils. The structural complexity of mangrove vegetation, comprising various tree species, shrubs, and associated flora, provides critical habitats for a multitude of marine and terrestrial organisms, thereby supporting rich biodiversity (Kathiresan & Bingham, 2001).

Mangrove Species Diversity in Mumbai

Mumbai's coastline is adorned with a variety of mangrove species that contribute to the ecological stability and carbon dynamics of the region. Notable species include:

- Avicennia marina (Grey Mangrove): Dominant in Mumbai, this species exhibits high tolerance to salinity and pollution, making it prevalent in urbanized coastal areas (Jagtap, 1991).

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- Rhizophora mucronata (Red Mangrove): Known for its stilt roots, it plays a significant role in sediment stabilization and coastal protection.
- Sonneratia alba (Mangrove Apple): This species contributes to the structural diversity of mangrove forests and provides habitat for various fauna.
- Bruguiera cylindrica (Small-leafed Orange Mangrove): Although less dominant, it adds to the floristic diversity and resilience of the mangrove ecosystem.

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Species Name	Frequency of Occurrence	Locations
Avicennia marina	Common	Found across all locations
Avicennia marina var. acutissima Forma	Very common	Found across all locations
Avicennia officinalis	Common	Present in all locations except Bandra, Lokhandwala, Charkop, Gorai, Vikhroli, and Nerul
Dilivaria ilicifolia	Common	Present in all locations except Bandra and Lokhandwala
Rhizophora mucronata	Occasional	Present in Bandra, Malad, Elephanta, Versova
Rhizophora apiculata	Rare	Only found in cultivation
Sonneratia apetala	Common	Present in all locations
Sonneratia alba	Common	Found in all locations except Bandra, Elephanta Island, Manori, and few plants in Bandra
Ceriops tagel	Common	Present in all locations except Bandra
Brugueira cylindrica	Common	Found in all locations except Bandra
Lumnitzera racemosa	Rare	Present in Gorai, Charkop
Agiceras corniculatum	Common	Found in all locations except Bandra

Mangrove Species Diversity in Thane

1. **Avicennia marina**: A resilient mangrove species thriving in saline conditions, often forming dense stands in Thane Creek. Known for its tolerance to various environmental stresses such as high salinity and waterlogging.
2. **Sonneratia apetala**: This dominant mangrove species is found in the main channel of Thane Creek, thriving in areas with high water flow. It is characterized by its large, prominent flowers and its ability to tolerate waterlogged conditions.
3. **Bruguiera cylindrica**: Typically found in the higher tidal zones of Thane Creek, this mangrove species is adapted to thrive where tidal water reaches its farthest. Its aerial roots, which stabilize the sediment, are an important characteristic of the species.

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4. **Acanthus ilicifolius**: Located near the mainland where tidal waters reach their maximum, this species is recognized for its medicinal properties and its ability to grow in saline conditions. It plays a key role in stabilizing coastal ecosystems.
5. **Ceriops tagal**: A prominent mangrove species in Thane Creek, it thrives in muddy and saline waters. It is known for its ability to filter water and provide important habitat for marine life.
6. **Excoecaria agallocha**: Found in the tidal zones of Thane Creek, this species has distinctive, narrow leaves and is capable of thriving in brackish and salty waters. It is important for coastal stabilization and maintaining biodiversity.
7. **Aegiceras corniculatum**: This mangrove species is present in Thane Creek, often found in mudflats and tidal estuaries. It is known for its curved roots and contributes to the ecological health of the area by acting as a buffer against coastal erosion.
8. **Lumnitzera racemosa**: A rare species found in Gorai and Charkop, Lumnitzera racemosa thrives in brackish waters and plays a role in supporting coastal biodiversity. It features small white flowers and is adapted to high saline conditions.
9. **Rhizophora apiculata**: Present in Thane Creek, this mangrove species is known for its distinctive stilt roots and its role in providing habitat for marine organisms. It grows in the intertidal zone and is adapted to a wide range of salinities.
10. **Rhizophora mucronata**: Found in the tidal regions of Thane Creek, this species is characterized by its red-colored propagules and extensive aerial root system. It plays a crucial role in sediment stabilization and coastal protection.
11. **Salvadora persica**: A species that thrives in the brackish waters of Thane Creek, this plant is often found in the upper intertidal zone. It has significant ecological importance due to its role in stabilizing the shoreline and its medicinal uses.

Carbon Sequestration in Mangrove Ecosystems

Carbon sequestration refers to the process by which carbon dioxide (CO_2) is removed from the atmosphere and stored in a carbon pool, such as soils, oceans, or vegetation. This process plays a vital role in mitigating the impacts of climate change by reducing the concentration of greenhouse gases in the atmosphere. Carbon sequestration can occur through two primary mechanisms: biological and physical. Biological sequestration involves the absorption of CO_2 by plants and trees during photosynthesis, followed by its long-term storage in plant biomass, soils, or aquatic ecosystems. Physical sequestration, on the other hand, involves the capture of CO_2 in oceans or geological formations, such as underground rock layers or deep ocean basins

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(Mackenzie et al., 2019). The stored carbon in these reservoirs remains out of circulation for extended periods, making sequestration a crucial strategy for combating global warming.

In terrestrial ecosystems, plants such as trees and grasses absorb carbon during photosynthesis, with the carbon being stored in roots, stems, and leaves. The soil acts as an important carbon sink, with organic matter from decaying plants and animals contributing significantly to carbon storage. Forest ecosystems, including tropical forests, are among the most efficient carbon sinks due to their high biomass and extensive root systems. However, this carbon storage can be disrupted through activities like deforestation and land-use changes (Canadell & Raupach, 2008).Mangrove ecosystems, found in coastal regions, are highly productive and efficient at sequestering carbon, making them key players in the fight against climate change. Mangroves are unique in that they grow in saline, waterlogged soils, where other plant species may struggle to survive. These ecosystems are composed of various mangrove tree species, along with associated plants, and are highly efficient in capturing and storing carbon from both the atmosphere and surrounding waters (Alongi, 2014).

Photosynthetic Carbon Fixation

Mangrove plants absorb atmospheric CO_2 during photosynthesis, converting it into organic matter stored in their leaves, stems, and roots. This process contributes directly to the ecosystem's ability to store carbon in both aboveground and belowground biomass. As mangrove trees grow, they continuously fix carbon, playing an essential role in reducing atmospheric CO_2 levels (Donato et al., 2011).

Litter Production and Decomposition

Fallen leaves, branches, and other organic materials from mangrove trees contribute to the detrital pool, enriching the soil with organic matter. The decomposition of this litter by microbial communities within the waterlogged, anoxic soil leads to the formation of soil organic carbon (SOC). This process is slower in mangrove ecosystems due to anaerobic conditions, which significantly reduce the rate of decomposition and enhance carbon storage in the soil (Alongi, 2014).

Sediment Trapping and Accre

The complex root systems of mangroves trap sediments rich in organic matter, facilitating vertical accretion and long-term carbon storage in anaerobic soil conditions. The slow decomposition rates in these unique habitats allow the organic material to accumulate over time, contributing to the creation of carbon-rich soils. This mechanism enhances carbon sequestration by effectively storing large quantities of carbon in the sediments, which would

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otherwise be released into the atmosphere (Donato et al., 2011).

Mangrove forests sequester carbon through two main pathways: aboveground biomass and belowground storage. Aboveground biomass consists of the carbon stored in the trees, which absorb CO_2 through photosynthesis and store it in their trunks, branches, and leaves. However, it is the belowground carbon storage that sets mangroves apart from other ecosystems. Mangrove trees have extensive root systems that grow in waterlogged, anoxic soils. These anaerobic conditions prevent the rapid decomposition of organic material, allowing large amounts of carbon to be stored in the form of organic matter in the soil (Donato et al., 2011). The carbon stored in mangrove soils can remain sequestered for centuries, or even millennia, due to the slow decomposition rates in these unique habitats.

Mangrove ecosystems also play a significant role in reducing the release of CO_2 into the atmosphere by acting as a barrier to coastal erosion. They protect shorelines from storm surges, reduce sediment erosion, and enhance the deposition of organic material, thus promoting further carbon storage in the soil (McLeod et al., 2011). The ability of mangroves to sequester large amounts of carbon makes them critical components of global carbon cycles, with some studies estimating that mangrove forests store up to five times more carbon per unit area than tropical rainforests (Pendleton et al., 2012).

In addition to their direct carbon storage capabilities, mangroves have broader environmental benefits. They support rich biodiversity, provide nurseries for fish species, and protect coastal communities from the impacts of climate change, such as rising sea levels and extreme weather events. However, mangrove ecosystems are under threat due to coastal development, pollution, and climate change impacts. The destruction of mangrove forests not only results in the loss of vital carbon sinks but also releases large amounts of stored carbon back into the atmosphere, exacerbating climate change (Valiela et al., 2001).

Carbon sequestration in mangrove ecosystems is a powerful natural process that helps mitigate the effects of climate change by storing significant amounts of carbon both in the biomass and

The complex root systems of mangroves trap sediments rich in organic matter, facilitating vertical accretion and long-term carbon storage in anaerobic soil conditions. The slow decomposition rates in these unique habitats allow the organic material to accumulate over time, contributing to the creation of carbon-rich soils. This mechanism enhances carbon sequestration by effectively storing large quantities of carbon in the sediments, which would otherwise be released into the atmosphere (Donato et al., 2011).

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Mangrove forests sequester carbon through two main pathways: aboveground biomass and belowground storage. Aboveground biomass consists of the carbon stored in the trees, which absorb CO_2 through photosynthesis and store it in their trunks, branches, and leaves. However, it is the belowground carbon storage that sets mangroves apart from other ecosystems. Mangrove trees have extensive root systems that grow in waterlogged, anoxic soils. These anaerobic conditions prevent the rapid decomposition of organic material, allowing large amounts of carbon to be stored in the form of organic matter in the soil (Donato et al., 2011). The carbon stored in mangrove soils can remain sequestered for centuries, or even millennia, due to the slow decomposition rates in these unique habitats.

Mangrove ecosystems also play a significant role in reducing the release of CO_2 into the atmosphere by acting as a barrier to coastal erosion. They protect shorelines from storm surges, reduce sediment erosion, and enhance the deposition of organic material, thus promoting further carbon storage in the soil (McLeod et al., 2011). The ability of mangroves to sequester large amounts of carbon makes them critical components of global carbon cycles, with some studies estimating that mangrove forests store up to five times more carbon per unit area than tropical rainforests (Pendleton et al., 2012).

In addition to their direct carbon storage capabilities, mangroves have broader environmental benefits. They support rich biodiversity, provide nurseries for fish species, and protect coastal communities from the impacts of climate change, such as rising sea levels and extreme weather events. However, mangrove ecosystems are under threat due to coastal development, pollution, and climate change impacts. The destruction of mangrove forests not only results in the loss of vital carbon sinks but also releases large amounts of stored carbon back into the atmosphere, exacerbating climate change (Valiela et al., 2001).

Carbon sequestration in mangrove ecosystems is a powerful natural process that helps mitigate the effects of climate change by storing significant amounts of carbon both in the biomass and soil. Protecting and restoring these ecosystems is crucial for maintaining their role as carbon sinks and ensuring the health of coastal environments (Bastin et al., 2019).

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Carbon Storage in Mangrove Sediments

Mangrove sediments are vital carbon reservoirs due to their unique environmental conditions. These ecosystems are characterized by waterlogged, anoxic (low oxygen) conditions that inhibit the rapid decomposition of organic material. As a result, organic carbon accumulates in the sediments, with slower decomposition rates compared to other ecosystems. This accumulation allows mangrove sediments to store significantly larger amounts of carbon than terrestrial forests. Studies have shown that mangrove sediments can sequester up to ten times more carbon per unit area than land-based forests (Chaudhuri and Choudhury, 1994). This makes mangroves an important part of the global carbon cycle, acting as both a carbon sink and a long-term storage mechanism.

The carbon stored in mangrove sediments is derived from various sources, including the decomposition of plant litter, root biomass, and organic materials transported by tidal movements. Mangrove root systems play a crucial role in stabilizing the soil, enhancing sediment deposition, and further promoting carbon sequestration. The high content of organic material trapped in mangrove sediments contributes to the formation of soil organic carbon (SOC), which remains sequestered for extended periods due to the anoxic conditions that slow microbial decomposition (Giri et al., 2011).

In Mumbai, the mangrove ecosystem faces significant anthropogenic pressures, including urbanization, pollution, and reclamation activities. Despite these challenges, Mumbai's mangrove forests have shown resilience in retaining their carbon storage capacity. However, restoring degraded mangrove areas and protecting existing ecosystems are crucial for maintaining their role as carbon sinks. Hydrological restoration, which aims to restore natural tidal flows, can enhance sediment deposition, microbial activity, and ultimately, carbon sequestration in these vital ecosystems (Giri et al., 2011). Protecting mangroves is essential for sustaining their carbon storage potential and mitigating climate change.

Role of Microbial Communities in Carbon Sequestration

Microbial communities play a vital role in the carbon sequestration processes of mangrove ecosystems. These microorganisms facilitate the decomposition of organic matter, nutrient cycling, and the stabilization of carbon compounds in sediments. Among the diverse microbial

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populations, bacteria are particularly significant due to their metabolic activities, which directly influence carbon dynamics.

1. Bacillus altitudinis

   The bacterium *Bacillus altitudinis*, isolated from mangroves along India's western coastline, has demonstrated remarkable potential in carbon sequestration. This bacterium produces carbonic anhydrase, an enzyme that catalyzes the hydration of carbon dioxide into bicarbonate ions, which subsequently precipitate as calcium carbonate (calcite). This process not only reduces atmospheric CO_2 levels but also contributes to the long-term sequestration of inorganic carbon in mangrove sediments (Bhattacharyya et al., 2014). The presence of such bacteria underscores the importance of microbial diversity in enhancing the carbon storage potential of mangroves.

2. Marinobacterium mangrovicola

   Nitrogen-fixing bacteria like *Marinobacterium mangrovicola*, found in association with mangrove roots, are essential for supporting plant growth and maintaining ecosystem productivity. By increasing nitrogen availability in the rhizosphere, these bacteria enhance the photosynthetic efficiency of mangrove plants, leading to higher biomass production and carbon sequestration (Lal et al., 2002). This symbiotic relationship highlights the interconnectedness of microbial processes and plant physiology in carbon cycling.

3. Beggiatoa Species

   Sulfur-oxidizing bacteria such as *Beggiatoa* species are another critical component of mangrove microbial community. These bacteria thrive in the anoxic conditions of mangrove sediments and contribute to the sulfur cycle by oxidizing hydrogen sulfide to sulfate. This metabolic activity creates conditions that inhibit the decomposition of organic matter, thereby enhancing carbon storage in sediments (Hinrichs and Boetius, 2002). The role of *Beggiatoa* in maintaining the anoxic conditions necessary for carbon preservation underscores the importance of microbial activities in mangrove carbon dynamics.

4. Methanotrophic Bacteria

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Methanotrophic bacteria such as Methylobacterium extorquens, Methylomicrobium album, Methylobacterium tardum, Methyloscarcina fibrate, and Methylomonas methanica are a group of microorganisms that play a crucial role in reducing methane (CH_4) emissions, a potent greenhouse gas. These bacteria oxidize methane into less harmful compounds, such as carbon dioxide (CO_2), through a process known as methanotrophy. This process occurs primarily in anaerobic environments, such as the waterlogged sediments of mangrove ecosystems, where methane is produced by other microorganisms through the decomposition of organic material (Hinrichs & Boetius, 2002). In mangrove sediments, methanotrophic bacteria utilize methane as their primary carbon and energy source. By consuming methane, they help to mitigate the release of this greenhouse gas into the atmosphere, thus influencing carbon cycling within these ecosystems. The activity of these bacteria not only reduces methane emissions but also contributes to the carbon balance by converting methane into carbon dioxide, a less potent greenhouse gas.

Microbial-Based Restoration and Carbon Sequestration in Mangrove Ecosystems

Mangrove ecosystems are among the most productive and ecologically significant habitats on Earth, providing essential services such as coastal protection, biodiversity support, and carbon sequestration. However, these ecosystems are under threat due to anthropogenic pressures, including deforestation and pollution. Microbial-based restoration has emerged as a promising strategy for enhancing carbon sequestration in degraded mangrove ecosystems by utilizing the functional diversity of microbial communities. This approach not only restores mangrove habitats but also contributes to climate change mitigation by increasing carbon storage capacity.

1. Harnessing Microbial Diversity

Microbial communities play a pivotal role in maintaining the health and functionality of mangrove ecosystems. These microorganisms contribute to nutrient cycling, decomposition, and the stabilization of organic matter, all of which are crucial for carbon sequestration. Harnessing microbial diversity involves identifying and utilizing specific microbes that can enhance the natural processes of mangroves, especially carbon storage.

Studies have shown that inoculating degraded mangrove areas with beneficial microbes can significantly improve soil quality and promote plant growth. For example, Bacillus altitudinis and Marino bacterium mangrovicola are two bacterial species known to thrive in saline and anoxic conditions typical of mangrove environments (Räth et al., 2021). These bacteria enhance

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carbon sequestration by facilitating the breakdown of organic matter into stable forms, which are then stored in the soil. Moreover, such microbes can improve the resilience of mangrove plants to environmental stressors like salinity and waterlogging, further accelerating ecosystem recovery.

Another critical aspect of microbial-based restoration is the use of fungal species such as mycorrhizal fungi. These fungi establish symbiotic relationships with mangrove roots, improving nutrient uptake and increasing biomass production. Enhanced biomass leads to greater carbon fixation by plants, which eventually contributes to long-term carbon storage in both biomass and sediment.

2. Enhancing Soil Carbon Storage

Soils in mangrove ecosystems act as significant carbon sinks due to their ability to store organic carbon over extended periods. Microbial-based restoration can optimize this function by increasing the microbial activity in the soil. Beneficial microbes break down complex organic compounds into stable humic substances, which resist decomposition and remain in the soil for centuries (Alongi, 2014).

For instance, sulfate-reducing bacteria (SRB) are essential in anaerobic mangrove soils. These bacteria metabolize organic matter in the absence of oxygen, producing sulfides that combine with organic carbon to form stable compounds. This process not only stabilizes carbon but also reduces methane emissions, as SRB outcompete methanogens for substrates. The dual benefits of increased carbon storage and reduced greenhouse gas emissions highlight the importance of these microbes in mangrove restoration efforts.

3. Integrating Science with Policy

Effective implementation of microbial-based restoration strategies requires the integration of scientific research with policy frameworks. Policymakers and environmental managers need to recognize the role of microbial diversity in ecosystem restoration and develop incentives to promote microbial research and application.

One approach is to incorporate microbial restoration into carbon credit systems. By quantifying the carbon sequestration benefits of microbial inoculation in mangroves, project developers can generate carbon credits, which can then be traded in global markets (Fatoyinbo et al., 2021).

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This provides financial incentives for conservation efforts and encourages investment in microbial research.

Moreover, policies that support community-based mangrove restoration programs can benefit from integrating microbial techniques. For example, training local communities to use microbial inoculants in restoration projects can enhance the success rate of these initiatives. Additionally, governments can provide subsidies for microbial fertilizers and other restoration tools, making them more accessible to conservation practitioners.

4. Case Studies and Success Stories

Several projects have demonstrated the effectiveness of microbial-based restoration in enhancing carbon sequestration in mangroves. For instance, a study in Southeast Asia showed that inoculating degraded mangrove soils with a consortium of nitrogen-fixing bacteria significantly improved plant growth and soil carbon content (Giri et al., 2015). Similarly, projects in India have utilized mycorrhizal fungi to restore mangroves along degraded coastlines, resulting in increased biomass and carbon storage.

Strategies for Enhancing Carbon Sequestration in Mangrove Ecosystems

Mangrove ecosystems are renowned for their ability to sequester large amounts of carbon, both in their biomass and in the soil organic carbon (SOC) stored beneath their root systems. Enhancing carbon sequestration in these ecosystems is not only vital for mitigating climate change but also for supporting biodiversity, protecting coastlines, and sustaining local livelihoods. This document explores strategies to enhance carbon sequestration in mangrove ecosystems, particularly in the context of Mumbai's mangroves, while integrating references and detailed explanations.

Restoration Programs

Restoration of degraded mangrove habitats is a primary strategy for increasing carbon sequestration. Mangroves that have been cleared or degraded due to urban expansion, pollution, or natural calamities lose their capacity to store carbon effectively. Reforestation efforts using native mangrove species, such as *Avicennia marina*, can significantly increase the biomass and SOC pools. Studies have shown that restoration increases not only the density of vegetation but also the microbial activity in the soil, which is critical for long-term carbon storage (Spalding et al., 2014). Selecting native species ensures that the reforested areas are resilient to local environmental conditions and maintain ecological balance.

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Effective restoration programs should focus on:

1. Identifying degraded areas using satellite imagery and ground surveys.
2. Employing nursery-grown seedlings of native species to ensure high survival rates.
3. Regular monitoring and maintenance of restored areas to prevent further degradation.

These programs should also incorporate natural regeneration processes, which allow mangroves to recover autonomously in areas with favorable conditions. Natural regeneration is cost-effective and ensures genetic diversity in the restored mangroves (Lewis, 2005).

Pollution Control

Pollution is a major threat to the health and functionality of mangrove ecosystems. Industrial effluents, plastic waste, and untreated sewage discharge into coastal waters degrade the quality of water and soil, impeding the ability of mangroves to sequester carbon effectively. Contaminants can alter microbial communities in the soil, reducing their efficiency in carbon cycling (Alongi, 2012). Implementing stringent pollution control measures can mitigate these impacts and enhance the overall health of mangrove ecosystems.

Key pollution control strategies include:

- **Strengthening wastewater treatment infrastructure:** Treating industrial and domestic wastewater before it reaches coastal areas can reduce harmful pollutants.
- **Enforcing regulations:** Strict enforcement of environmental laws, such as penalties for illegal dumping, can discourage polluters.
- **Promoting sustainable waste management:** Encouraging recycling, reducing single-use plastics, and establishing coastal clean-up programs can minimize the waste entering mangrove areas.

Reducing pollution not only supports carbon sequestration but also enhances the broader ecological functions of mangroves, such as supporting fisheries and protecting against storm surges.

Community Engagement

Local communities are key stakeholders in the conservation and management of mangrove ecosystems. Educating communities about the ecological and economic benefits of mangroves

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can foster a sense of stewardship, leading to participatory conservation efforts. Community-led initiatives have been successful in many parts of the world, demonstrating that inclusive approaches are vital for the long-term sustainability of mangroves (Primavera et al., 2012).

Strategies to engage communities include:

- **Awareness campaigns:** Organizing workshops and educational programs to highlight the role of mangroves in climate mitigation, biodiversity conservation, and livelihood support.
- **Incentive-based conservation:** Introducing programs that provide financial incentives to communities for protecting and restoring mangrove areas, such as payment for ecosystem services (PES) schemes.
- **Promoting alternative livelihoods:** Supporting sustainable livelihoods, such as eco-tourism, crab farming, or honey production, can reduce pressure on mangroves for fuelwood or land conversion.

When communities are actively involved, they are more likely to take ownership of conservation initiatives, ensuring their success and sustainability.

Research and Monitoring

Scientific research and regular monitoring are essential for understanding the dynamics of carbon sequestration in mangrove ecosystems. Mangroves vary in their carbon storage capacities depending on species composition, age, soil type, and environmental conditions. Comprehensive research can help identify high-carbon storage areas, assess the impact of restoration efforts, and adapt management strategies accordingly (Donato et al., 2011).

Research priorities should include:

1. **Quantifying carbon stocks:** Conducting field studies to measure aboveground biomass, belowground biomass, and SOC pools in different mangrove habitats.
2. **Understanding microbial dynamics:** Investigating the role of soil microbes in carbon cycling and identifying factors that enhance their efficiency.
3. **Evaluating restoration outcomes:** Monitoring restored areas to assess their carbon sequestration potential compared to natural mangroves.

Technologies such as remote sensing, GIS mapping, and carbon flux towers can facilitate large- scale

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monitoring and data collection. Additionally, collaborating with academic institutions and research organizations can bring in technical expertise and resources to support long-term studies.

Additional Strategies

In addition to the core strategies mentioned above, the following measures can further enhance carbon sequestration in mangrove ecosystems:

- **Promoting sustainable aquaculture:** Mangroves are often converted into aquaculture ponds, leading to significant carbon losses. Implementing sustainable aquaculture practices that integrate mangrove conservation can reduce these impacts.
- **Enhancing hydrological connectivity:** Restoring the natural flow of water in mangrove areas can improve soil aeration and nutrient availability, boosting carbon storage.
- **Establishing protected areas:** Designating mangrove forests as protected areas can prevent deforestation and degradation, ensuring their carbon sequestration potential is preserved.

Enhancing carbon sequestration in mangrove ecosystems requires a multi-faceted approach that combines restoration, pollution control, community engagement, and research. Each strategy complements the others, creating a holistic framework for conserving and enhancing these critical ecosystems. Implementing these strategies in Mumbai's mangroves can significantly contribute to climate change mitigation while supporting biodiversity and local livelihoods. By adopting such measures, policymakers, conservationists, and local communities can work together to safeguard the ecological and economic benefits of mangrove ecosystems for future generations.

Challenges in Mangrove Restoration

Mangrove ecosystems, renowned for their biodiversity and carbon sequestration potential, face significant challenges in restoration efforts. These challenges, particularly pronounced in urbanized regions like Mumbai, hinder the effective conservation and rehabilitation of these critical habitats. Below are key obstacles that complicate mangrove restoration initiatives:

1. Urbanization and Habitat Loss

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Rapid urban expansion and industrialization are among the leading causes of mangrove degradation. In Mumbai, large tracts of mangroves have been cleared to make way for infrastructure projects, land reclamation, and real estate development. This destruction not only reduces mangrove coverage but also disrupts their ecological functions, including their role in carbon sequestration. Habitat fragmentation caused by urbanization further limits the ability of mangroves to regenerate naturally, compounding the challenges of restoration (Chaudhuri and Choudhury, 1994).

2. Pollution and Environmental Degradation

Pollution is a significant impediment to mangrove restoration. Industrial discharge, untreated sewage, and plastic waste infiltrate mangrove ecosystems, impairing soil and water quality. These pollutants interfere with the microbial processes essential for nutrient cycling and organic matter decomposition, which are critical for mangrove health and growth. Heavy metals in sediments, a common problem in urban areas, can be toxic to both mangrove plants and the associated fauna, further hampering restoration efforts (Kathiresan and Bingham, 2001).

3. Hydrological Alterations

The natural hydrology of mangrove ecosystems is often disrupted by human activities, such as the construction of dams, embankments, and other coastal infrastructure. Altered tidal flows and water salinity levels can create unfavorable conditions for mangrove regeneration. Restoring hydrological balance is a complex and resource-intensive process, yet it is vital for successful mangrove restoration.

4. Lack of Awareness and Community Involvement

Public awareness about the ecological and socio-economic importance of mangroves remains limited, particularly in urbanized settings. Local communities often undervalue mangroves, viewing them as wastelands rather than critical ecosystems. This perception leads to unsustainable practices, such as overharvesting for fuelwood and illegal encroachments. Engaging local stakeholders and raising awareness about the benefits of mangroves—such as coastal protection and carbon sequestration—are essential for fostering community-led restoration initiatives (Giri et al., 2011).

5. Climate Change Impacts

Rising sea levels, extreme weather events, and shifting temperature patterns pose additional threats to mangrove ecosystems. Climate change can alter the salinity and sedimentation

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dynamics required for mangrove growth, making it harder to restore these habitats. Furthermore, frequent cyclones and storm surges can uproot newly planted saplings, setting back restoration efforts.

6. Limited Resources and Policy Gaps

Mangrove restoration projects often face resource constraints, including funding, expertise, and manpower. Additionally, policy frameworks governing mangrove conservation may lack enforcement mechanisms or fail to address the specific challenges of urban ecosystems. Collaborative efforts among government agencies, non-profits, and research institutions are needed to develop and implement effective restoration strategies.

7. Biophysical Challenges

Restoration projects often face biophysical challenges, such as selecting appropriate species and ensuring seedling survival. Planting unsuitable species or neglecting site-specific conditions can lead to high mortality rates. (Thuy et al.).

8. Socio-Economic Factors

Socio-economic factors, including funding constraints and competing land uses, pose significant challenges to mangrove restoration. Securing sustainable funding is often difficult, and restoration projects may depend on external donors with varying interests and timelines. Additionally, land use conflicts can arise when restoration areas overlap with agricultural or developmental interests. (Ngongolo et al.).

9. Policy and Regulatory Issues

Inadequate policy frameworks and lack of stringent regulatory actions can hinder restoration efforts. Without supportive policies and effective enforcement, conservation initiatives may fail to protect mangrove ecosystems from ongoing threats. Ensuring a future for mangroves requires forward-thinking approaches that anticipate challenges and create frameworks to overcome them (Shepard, C. et al).

10. Lack of standardized protocols and variability of environmental conditions

Despite its potential, microbial-based restoration faces several challenges. One significant hurdle is the lack of standardized protocols for identifying and applying beneficial microbes in mangrove ecosystems. Research is needed to establish guidelines for selecting microbial strains, determining optimal application methods, and monitoring their effectiveness.

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Another challenge is the variability of environmental conditions across different mangrove sites. Factors such as salinity, temperature, and nutrient availability can influence microbial activity, making it essential to tailor restoration strategies to site-specific conditions. Advances in metagenomics and bioinformatics can help overcome these challenges by providing detailed insights into microbial community dynamics under varying environmental conditions (Naidoo et al., 2020).

Furthermore, there is a need to address potential ecological risks associated with introducing non-native microbes into mangrove ecosystems. While beneficial in some contexts, non-native microbes may disrupt existing microbial communities or have unintended effects on other ecosystem components. Rigorous risk assessments and pilot studies should precede large-scale applications to mitigate these risks.

Conclusion and Future Directions

Mangrove forests in Mumbai are vital carbon sinks that mitigate climate change impacts through significant carbon sequestration in biomass and sediments. However, the ongoing challenges of urbanization, pollution, and habitat loss necessitate the exploration of future directions to sustain and enhance these ecosystems. Future efforts should focus on integrating advanced restoration techniques, such as employing native and resilient mangrove species like Avicennia marina var. acutissima and Sonneratia apetala, to maximize carbon storage capacity. Furthermore, implementing microbial research to harness the potential of nitrogen-fixing and sulfate-reducing bacteria could enhance soil organic carbon retention. Promoting community-driven conservation programs and leveraging technological tools like remote sensing for monitoring and management will also be critical. Through collaborative approaches that combine scientific research, policy development, and local involvement, Mumbai's mangroves can continue to thrive as pivotal carbon sinks and biodiversity reservoirs. The interplay between plant species and microbial communities underpins the efficiency of these ecosystems in storing carbon. However, anthropogenic pressures pose substantial threats to their integrity. Implementing sustainable management practices that encompass restoration, pollution mitigation, community involvement, and scientific research is imperative to preserve and enhance the carbon sequestration functions of Mumbai's mangroves.

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Impact of Climate Change On Wetland Ecosystem and its Restoration

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ABSTRACT

Climate change, a drastic transformation of the natural surroundings, affects wetlands directly or indirectly through factors such as the day-by-day increase in temperature, intensified rainfall, floods, and storms. Wetlands are fragile ecosystems playing a crucial role in providing numerous ecological services, including water purification, habitat provision for various organisms, and flood control.

This paper reviews the impact of climate change on wetlands and explores various restoration strategies aimed at mitigating its effects and enhancing wetland resilience. These strategies will help to develop effective conservation and restoration practices to preserve wetlands for future generations.

KEYWORDS: -CLIMATE CHANGE, WETLAND, RESTORATION, HYDROLOGY, VFCW

Methodology

This paper is based on the review of literature based on climate change and its impacts on wetlands and also restoration of its effects.

Introduction

Climate change critically affects wetlands, as increased temperatures can alter their hydrology, impacting water levels and the overall health of these ecosystems. It also disrupts precipitation patterns, raises sea levels, and elevates CO2 levels, all of which contribute to biodiversity loss. Different habitats require specific examination due to the varying stressors they face, necessitating tailored management strategies for restoration.

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This paper discusses the diverse ways in which climate change impacts wetlands and highlights the urgent need for effective restoration strategies to mitigate these effects. By understanding the challenges and opportunities associated with wetland conservation, we can work towards preserving these vital ecosystems for future generations.

Discussion

Climate change increases temperatures, shifts weather patterns, and leads to changes in the global distribution of pathogens, hosts, and disease reservoirs. A wetland study conducted in Thane Creek, Maharashtra, reported that the creek's boundaries have been encroached upon by rapid urbanization, which causes variability in extreme precipitation indices, leading to climatic oscillations, extreme rainfall, and flooding of the coastal wetlands (Shivakumar et al., 2024). Wetlands, as a vulnerable system, are affected by changes in the quality and quantity of water supply, as reported by Erwin (2008). The paper incorporates opinions, interpretations, and science-based arguments regarding different wetland systems such as the Sundarbans (Bangladesh and India), the Mekong River Delta (Vietnam), and Southern Ontario (Canada). It highlights that the successful long-term restoration and management of these systems depend on how effectively we respond to the effects of climate change.

Salimi S. et al. (2021) explored the various forms of environmental damage, including changes in water levels, water quality, and the transformation of wetlands from carbon sinks to carbon sources. The same authors emphasized the main causes, effects, and methodologies required for in-depth studies to maintain the natural balance.

In another study concerning the water quality of the Panchaganga River in Kolhapur, Joshi et al. (2024) identified wastewater as a significant threat to natural water systems, damaging ecological balance and aquatic environments. This research highlighted how wastewater not only harms aquatic ecosystems but also adversely impacts human society. The study further explored the efficiency of a vertical flow constructed wetland (VFCW) system in restoring the Panchaganga River, which passes through Kolhapur, Maharashtra, India. It provided parameters and treatment recommendations to address pollution in the river. Local wetland conservation, alongside global climate change efforts, is presented as an essential tool for stabilizing greenhouse gas concentrations in the atmosphere to prevent dangerous anthropogenic interference with the climate system (UNFCCC, 1992).

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While several authors have explained the effects and impacts of climate change on natural ecosystems, Goyette J. et al. (2023) proposed a science-based approach for regional wetland restoration programs. This approach, based on hydrological functions, utilized case studies on several sub-watersheds of a northern temperate basin in southeastern Canada. The restoration concept is designed to minimize the negative side effects of climate change on watershed hydrology.

In another review, Schuster L. et al. (2024) highlighted the potential of freshwater wetlands to serve as long-term carbon sinks. The ecological restoration of degraded wetlands is increasingly recognized as a valuable natural climate solution. The authors emphasized that conserving and protecting natural freshwater wetlands should take priority over restoration, ensuring that ecosystems remain undisturbed and play a significant role in climate change mitigation. The conservation and protection of natural freshwater wetlands should be prioritized over wetland restoration, while precautions should be taken to ensure that the ecosystem remains undisturbed and plays an important role in climate change mitigation. According to Spieles (2022), constructed wetlands and restored wetlands offer only partial wetland functions and services to degraded landscapes, whereas integrated constructed wetlands have greater potential to restore wetlands by reducing wastewater, supporting habitat development, and maintaining biodiversity to sustain ecosystem functions. As per Waltham et al. (2020), there is an urgent need to determine metrics and success indicators to assist restoration practitioners. Further research is required to identify common parameters or indicators to assess the restoration process of wetlands and preserve this fragile system for future generations.

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Impact of Anthropogenic Activities on Wetland Ecosystems:

A Comparative Study

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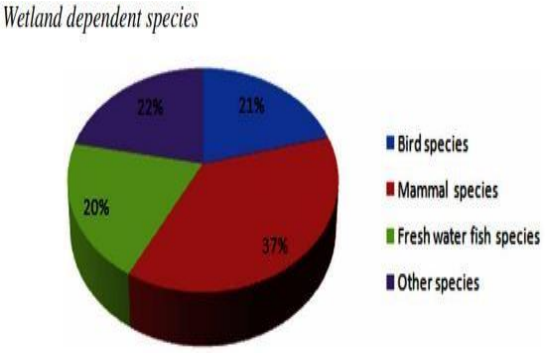
ABSTRACT:

Wetlands are ecosystems between terrestrial and aquatic environments, e.g. estuaries, mangroves, salt marshes etc. characterized by a water table near the surface or shallow water coverage, and exhibit significant diversity based on their genesis, geography, water regime, chemistry, dominant species, and soil characteristics. India hosts a diverse range of wetland ecosystems that offer essential ecological services and goods. However, these habitats are increasingly threatened by urbanization, industrialization, and agricultural intensification, resulting in a significant loss of area and a decline in their hydrological, economic, and ecological functions. Maharashtra alone has an estimated 1,014,522 hectares of wetlands, accounting for 3.30% of its geographic area, with prominent wetland areas in Mumbai suburban (24.87%), Mumbai urban (11.06%), and inland wetlands concentrated in Pune district (6.72%) due to numerous dams in the Western Ghats. Additionally, India is home to biodiverse mangroves, crucial marine wetlands that host various species like crustaceans, amphibians, reptiles, birds, and mammals, while playing a key role in protecting shorelines from erosion and extreme weather. Unfortunately, these mangroves are under threat from human activities. This review explores India's wetland wealth, focusing on bird species such as the Indian Skimmer, Pallas's Fish Eagle, and Sarus Crane, along with the impact of human interventions on their habitats [10,14,4].

Key words: Wetlands, mangroves, Indian Skimmer, Pallas's Fish Eagle, Sarus Crane

Introduction:

Wetlands, known as the 'kidney of the earth' and are vital ecosystems that regulate water and nutrient cycles [15]. India hosts diverse coastal and inland wetlands, including rivers, lakes, and reservoirs. These ecosystems support biodiversity, providing habitats for species like migratory birds and waterfowl [3,1]. Wetlands stabilize water tables, mitigate floods, and filter suspended solids and nutrients. They are critical for wildlife feeding, breeding, and refuge. Classified as marine, estuarine, lacustrine, riverine, and palustrine, wetlands are defined by their hydrological, ecological, and geological characteristics. [14].



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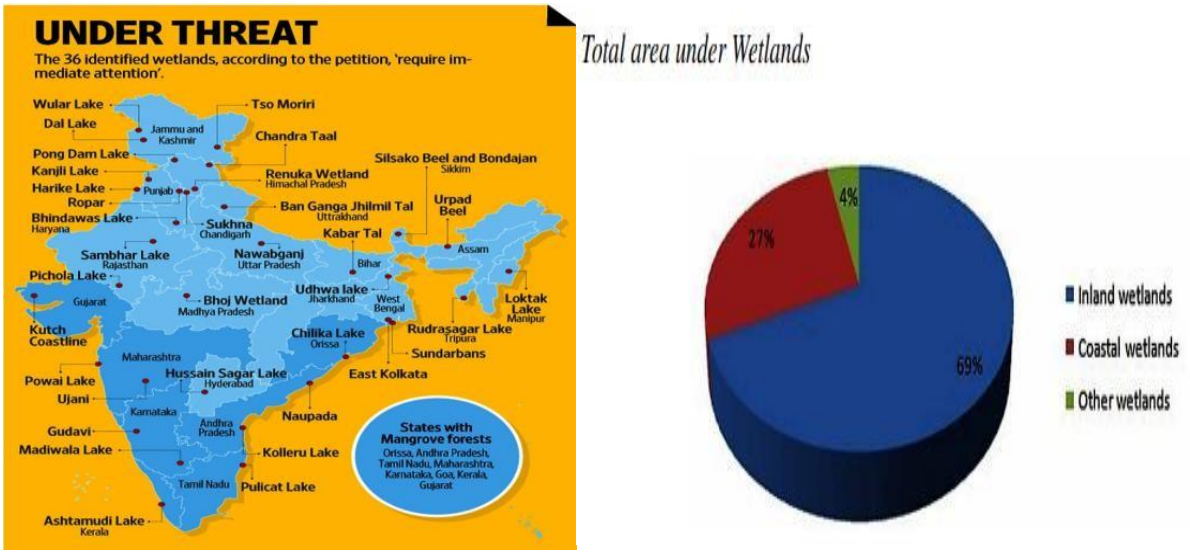
Current scenario of wetlands:

India's wetlands span 7.6 million hectares, with 3.6 million hectares of inland wetlands and 4 million hectares of coastal wetlands. Of the total, 1.5 million hectares are natural, 2.6 million are man-made, and 0.6 million hectares are mangrove vegetation. Wetland deterioration has accelerated due to population growth and resource demands. Inland wetlands have seen a 35% reduction in water spread area, with man-made types (49.5%) declining more than natural types (24%) due to irrigation pressures and evaporation losses. Coastal wetlands have declined by 16%, and India has lost 40% of its mangrove cover over the last century [13].

Out of the total area under wetlands, area under inland wetlands accounts for 69%, coastal wetlands 27%, and other wetlands (smaller than 2.25 ha) 4% [13].



Mangroves-a marine wetland:

Mangroves are halophytic plants adapted to saline and estuarine conditions. They thrive in sandy or muddy substrates (Alongi,2008). Globally, mangroves cover 14.79 million hectares across 113 countries, with only 6.9% under protection. In Maharashtra, natural regeneration increased mangrove covers by 4 km². Key species include *Rhizophora*, *Avicennia*, *Laguncularia*, and *Conocarpus*.

Hussain and Badola (2010) reported that mangroves dissipate wave energy, prevent erosion, and promote sediment deposition. Their roots filter pollutants, and decomposing organic matter supports marine food chains. They provide resources like honey, tannins, and fish for coastal communities.

Threats include natural hazards such as cyclones, grazing, barnacle infestations, and invasive weeds like *Acrostichum aureum*. Extensive anthropogenic activities like urbanization, deforestation, untreated waste disposal, and insect pests like timber borers also pose treat to mangroves. These factors have reported to reduce mangrove cover and biodiversity [2].

Overview of marine wetlands ecosystem:

Mangrove ecosystems support diverse organisms. Mangrove roots offer shelter and food, hosting crabs, conchs, and other crustaceans. The roots and branches provide nesting sites for seabirds like gulls, freshwater birds like herons, and species like Pallas's fish eagle. Bird droppings fertilize the swamp, while bees and insects serve as key food sources for tropical birds. Storks, ibises, and herons nest in tall trees, while smaller birds like kingfisher's roost in shrubs.

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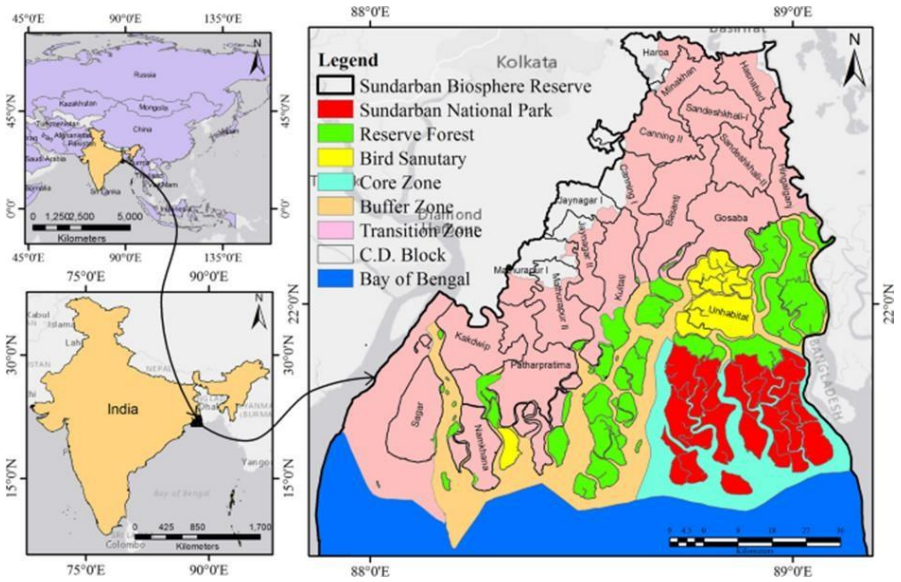
Fish such as rays, carp, eels, crabs, and shrimp inhabit the brackish waters, forming part of the food web. Reptiles and amphibians, including frogs, turtles, snakes like the Indian python, monitor lizards, and crocodiles, are abundant. Large reptiles prey on mammals like deer, boar, mongooses, and monkeys.

The Bengal tiger, an apex predator and endangered species, is the most iconic inhabitant of the Sundarbans. These tigers, weighing up to 220 kg, swim in swampy waters and climb trees. They occasionally attack humans, their only natural threat.

The current review focus on the three prominent bird species inhabiting mangrove wetlands of west coast – Mumbai coast. They are Indian Skimmer, Pallas's Fish Eagle, Sarus Crane



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INDIAN SKIMMER (*Rynchops albicollis*):

The Indian Skimmer (*Rynchops albicollis*) is listed as a vulnerable species because its population is undergoing a rapid decline due to widespread degradation and disturbance of lowland rivers and lakes. Indian Skimmer is confined to India, Pakistan and Bangladesh, where a large proportion of the population winters, principally in the Padma-Meghna delta, and to Myanmar. India holds the only known remaining breeding grounds for this species and National Chambal Sanctuary (NCS) is one among the very few locations in the country that hosts significant breeding populations of Indian Skimmer [6]. The population of Indian skimmers in India is estimated to be between 3,700 and 4,400 individuals. This is a significant decline from the 2001 estimate of 4,000–6,000 individuals.

As a fish-eating bird, the Indian skimmer helps regulate fish populations, ensuring balance within the aquatic ecosystem. By preying on smaller fish, it indirectly supports larger predatory fish by preventing overpopulation of small fish that compete for the same food resources.

The Indian Skimmer is not just a beautiful bird to observe; it also plays an essential role in the ecosystem. As a predator of small fish, it helps to keep the population of aquatic species balanced, contributing to the health of the river ecosystems it inhabits. Moreover, the bird's presence is an indicator of the overall health of freshwater bodies. When skimmers are found in large numbers, it suggests that the water quality is optimum, and fish populations are thriving [12].

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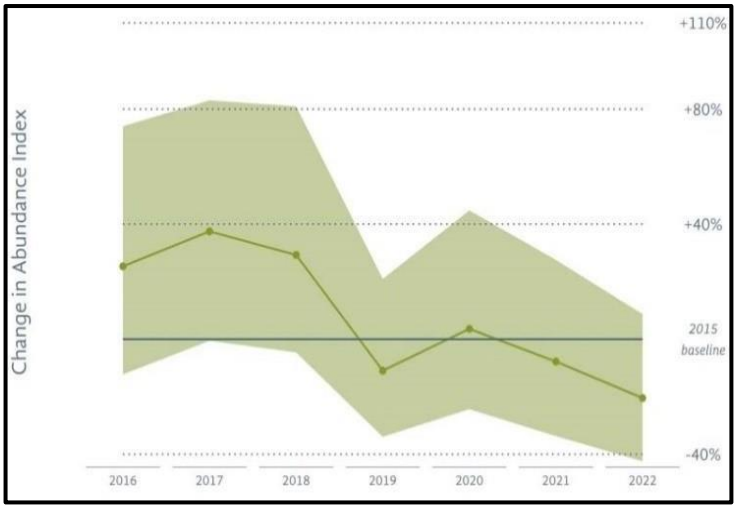
Population and biodiversity: Indian Skimmer [5]



PALLAS'S FISH EAGLE (*Haliaeetus leucoryphus*):

Pallas's fish eagle, (*Haliaeetus leucoryphus*), is listed as 'endangered'. Pallas's fish eagle is also known as Ring-tailed fishing eagle, is a large brownish eagle. The bird breeds from Central Asia, between the Caspian Sea and the Yellow Sea; Kazakhstan to Mongolia; west to east along foothills of Himalayas and the northern India. The Pallas's fish eagle lives in freshwater and marine wetlands, including lakes, rivers, estuaries, and coastal areas. The population of Pallas's fish eagles in India is estimated to be between 1,000 and 2,499 mature individuals and its population is declining.

Since Pallas fish eagle feeds on small birds, fishes, and amphibians, it makes sure that non other dominates the area. They mainly feed on sick and old animals. Hence, it makes the ecosystem healthier. In the ecosystems, eagles signify the well- being of a food chain. Declining in number of predators, indicates treat to the prey and overall food chain. By regulating prey populations, they create a balance that allows other species, including smaller predators and scavengers, to thrive. As partially migratory birds, they link wetland ecosystems across their range, promoting genetic diversity and connecting habitats critical for various other species.

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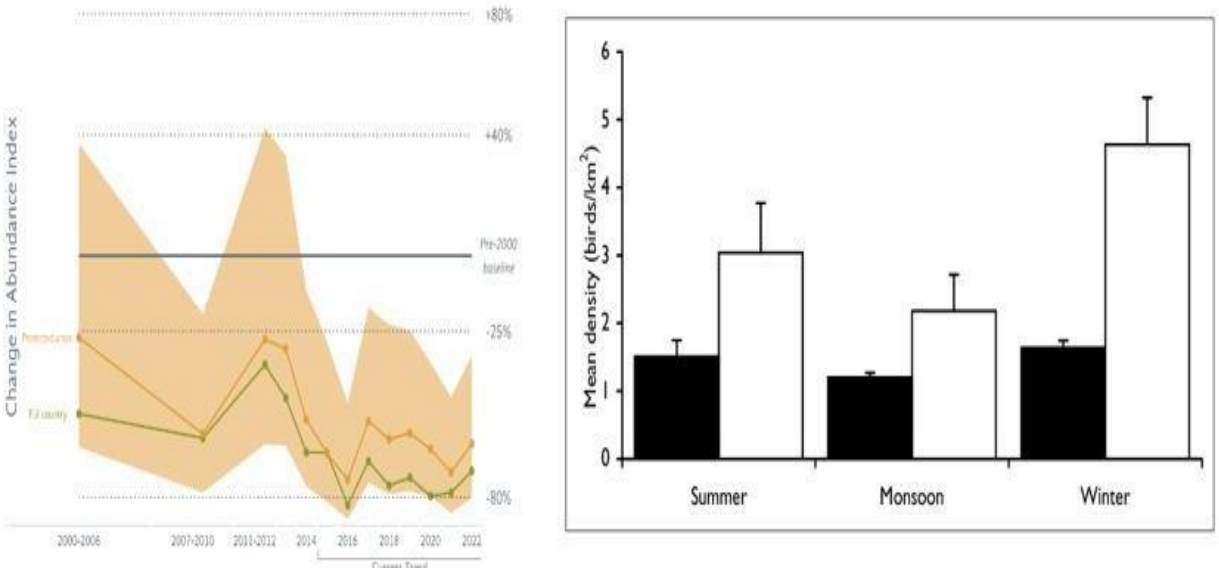

Population and biodiversity: Pallas's Fish Eagle [8]

SARUS CRANE (*Grus Antigone*):

The Indian Sarus Crane (*Grus antigone*), listed as 'Vulnerable' by the IUCN, has a declining population of around 19,918 in India. Historically widespread across northern and central India, including Bangladesh, these cranes inhabit wetlands such as marshes, lakes, and streams [13]. They are ecological indicators of healthy wetlands, feeding on aquatic plants, insects, small vertebrates, and invasive species like Mozambique tilapia, while also controlling pests, rodents, and invasive plants near farmlands [11].

Key threats include habitat loss from wetland drainage, sugarcane cultivation, and infrastructure development. Human activities such as hunting, egg theft, pesticide use, and electrocution further reduce populations. Flooding, a common occurrence, destroys nests and lowers nesting success. Sarus cranes are monogamous, returning to the same nesting sites annually, with reproductive success tied to habitat quality. Smaller, resource-rich territories improve nesting outcomes, while larger, low-quality territories require more energy for defence.

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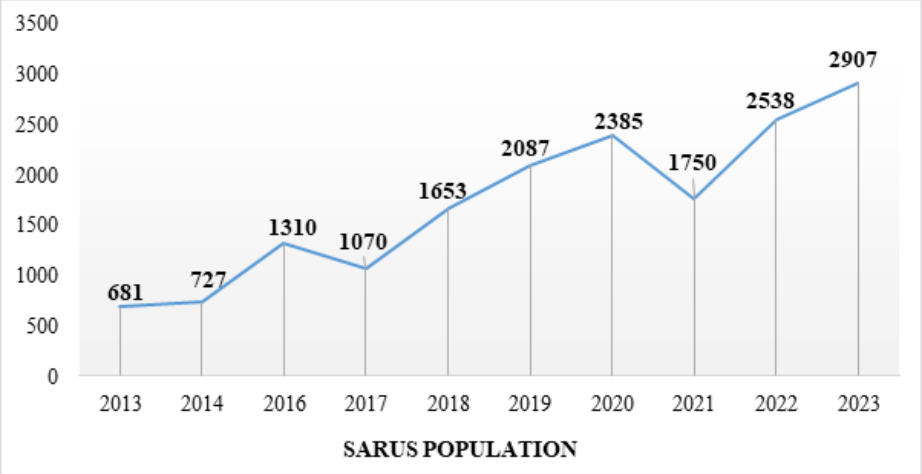

Population and biodiversity: Sarus Crane [9]

Discussion:

Wetlands are among the most vital ecosystems on Earth, yet they face significant degradation due to various human activities and a lack of awareness about their importance. Wetland loss is a critical issue, contributing to pollution, climate change, and the destruction of natural habitats, all of which severely impact the environment. Historically, insufficient attention to environmental conservation has exacerbated the decline of these ecosystems in several states, including Uttar Pradesh, West Bengal, Tamil Nadu, Gujarat, and Assam. To address this, it is essential to implement strict laws and regulations, enhance public awareness, and establish robust management and monitoring systems. Governments should prioritize wetland conservation through the development of comprehensive policies, dedicated research teams, and proactive strategies to mitigate the increasing pressures from climatic and anthropogenic factors. Urbanization has reclaimed wetlands, displacing birds that rely on them for nesting and feeding.

The current study shows relationship between effect of anthropogenic activities and its effect on bird species of west coast mangroves. The human intervention has seen to interfere with population of birds like Indian skimmers, Pallas's fish eagle & Sarus crane. Industrial waste and pollutants have degraded water quality, reducing food sources for species like the Indian Skimmer and Pallas's Fish Eagle. Agriculture has drained marshlands, destroying critical habitats for birds such as the Sarus Crane. Unregulated tourism has fragmented habitats and disrupted bird migration and breeding. These pressures are driving wetland bird populations to decline.

Conclusion:

Wetlands are vital ecosystems that support biodiversity and regulate the environment, yet they face rapid degradation due to human activities. Urbanization, industrial pollution, agriculture, and unregulated tourism have destroyed habitats and disrupted ecosystems, particularly impacting birds like the Indian Skimmer, Pallas's Fish Eagle, and Sarus Crane. These changes threaten biodiversity, and the ecological services wetlands provide, such as water filtration and climate regulation. Immediate action through strict conservation policies, sustainable management, and increased public awareness is essential to protect wetlands and the species that rely on them.

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Industrial Waste Water and Its Effects on Wetlands

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ABSTRACT

Industrialization has significantly impacted environmental health, particularly through the discharge of untreated or inadequately treated wastewater into natural ecosystems such as wetlands. Industrial effluents contain hazardous substances including chemicals, heavy metals, oils, pesticides, pharmaceuticals, and phenolic compounds, which contribute to the degradation of water quality, biodiversity loss, and ecosystem imbalance. Improper disposal of this wastewater can contaminate soil, air, and agricultural land, potentially entering the food chain and posing severe health risks to humans and animals. Waterborne diseases such as diarrhoea, typhoid, cholera, hepatitis, jaundice, and even cancer is linked to polluted water sources. Effluent Treatment Plants (ETPs) are critical in mitigating these environmental impacts. A well-structured ETP system supports environmental protection, ecological sustainability, and resource conservation by effectively managing industrial wastewater. The secondary treatment phase of ETPs plays a crucial role in degrading organic and inorganic pollutants through biological and chemical processes. Phenols and volatile organic compounds (VOCs), commonly found in industrial effluents, are treated using methods such as aerobic biological treatment, physical filtration, and chemical neutralization. This paper discusses the operational procedures of ETPs with a focus on the importance of secondary treatment in reducing pollutants. By ensuring proper treatment and disposal of industrial wastewater, organizations can minimize environmental risks and support sustainable development.

Keywords: Effluent Treatment Plant, Industrial Wastewater, Wetland Pollution, Phenolic Compounds, Environmental Sustainability

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INTRODUCTION

Industrial Waste Water has excessive hazardous contaminants that make it unsuitable for domestic use. Water pollution generally results from human activities, and the pollutants released, mostly come from the industrial dumps, sewage leakages, oil spillages, heavy metals, and chemical wastes. Industrial effluents originated from TTC-Pawane, MIDC Industrial area-Thane Belapur Road, are one of the major causes of irreversible damage to the ecosystem. Improper treatment and direct release of these hazardous effluents, has adverse effects on the health of not only the aquatic life but also those that are directly or indirectly dependent on these waterbodies. Under-treated effluents can also pollute air, land surface, soil etc. Casual disposal of industrial wastewater can cause serious damage to the quality of the crops produced and can reach the food chain. Waterborne diseases caused by water pollution are diarrhoea, typhoid, cholera, hepatitis, jaundice and cancer.

The operation of the secondary effluent treatment plant if adequately followed will lead all industrial units in TTC Industrial, Pawane MIDC area to prevent water pollution & will be helpful for Environmental Protection simultaneously it adopts a comprehensive approach toward environmental protection and sustainable development by integrating both technical and operational strategies aimed at minimizing ecological harm, conserving resources, and complying with regulatory frameworks. The Effective Wastewater Treatment remove harmful physical, chemical, and biological contaminants before discharging into wetlands. Zero Liquid Discharge (ZLD) system can reuse and recycle all treated water, will be helpful to avoid any discharge into natural water bodies. Effective Sludge Management can treat and dispose of sludge (e.g., for biogas or compost), minimizing land and water pollution. Modern technologies will encourage industries to replace hazardous chemicals with eco-friendly alternatives upstream.

Industrial sectors and their major water pollutants

Industry	Major water pollutants
Dye manufacturing	Copper, colour, salt, sulphides, formaldehydes
Paint manufacturing	Chromium, zinc, lead, volatile organic compounds (VOCs)
Textile	Iron, chromium, chlorinated compounds, urea, salts, hydrogen peroxide, high pH NaOH, surfactants
Pharmaceutical	Cadmium, nickel, phenolic compounds
Petrochemical	Petroleum hydrocarbons, phenolic compounds, nitrobenzene, alkanes, Chloro alkanes, high salt, *etc.*
Paper and pulp	Organic and chlorophenolic compounds, suspended solids, AOX, lignin, tannins, sterols, colours, biocides, *etc.*
Metal working	Perfluorooctane sulfonate (PFOS), ammonium nitrogen, cyanide, phenol, oil and grease

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Effects on wetland

The industries use raw materials, process them and produce finished products. Besides the finished products, a huge number of by-products are produced after processing, but the industrialists dump them into the environment. The gases are usually released into the atmosphere, while the liquids are discharged into aquatic bodies like sewers, canals, rivers or sea and solid wastes are dumped either on the land or in aquatic bodies. In all the cases, the air, water or land is polluted due to the dumping of wastes Industrial, wastewaters contribute greatly to water pollution. Particularly the untreated or partially treated wastewater can cause environmental pollution. High organic matter content can cause oxygen depletion, bad odour, and increased BOD while chemical pollution causes increase in chemical oxygen demand (COD), and total suspended solids (TSS). Adopting appropriate wastewater treatment technologies is necessary to minimize pollution.

Key impacts of industrial wastewater on wetlands are-

Direct toxicity:

Toxic chemicals in the wastewater can directly kill aquatic organisms & impacting the food chain.

Altered water chemistry:

Changes in pH, salinity, and dissolved oxygen levels due to industrial waste can stress wetland inhabitants and disrupt their physiological processes.

Eutrophication:

Excess nutrients like nitrogen and phosphorus from industrial wastewater can lead to excessive algal growth, which can eventually deplete oxygen levels in the water.

Sedimentation:

Industrial wastewater can carry large amounts of suspended solids that settle in the wetland, altering the habitat structure

Habitat destruction:

Significant pollution can drastically change the wetland's plant community, affecting the food sources and shelter available for wildlife.

Bioaccumulation:
Persistent pollutants like heavy metals can accumulate in wetland organisms through the food chain, posing risks to wildlife and human consumers.

Non-compliance of the statutory requirements and standards poses risks to wildlife and human consumers.

Habitat Loss and Degradation:

Vegetation Damage:

Polluted water can damage or kill wetland plants, which are essential for providing habitat and food for various species.

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Soil Contamination:

Industrial wastewater can contaminate wetland soils, making them unsuitable for plant growth and impacting the overall health of the wetland ecosystem.

Reduced Biodiversity:
The combined effects of water pollution and habitat degradation can lead to a decline in wetland biodiversity, with some species becoming extinct or migrating to other areas.
Impacts on Aquatic Life:

Fish and Invertebrate Mortality:

Exposure to toxic substances in industrial wastewater can cause fish and invertebrate populations to decline or even die.

Deformities and Diseases:

Industrial pollutants can cause deformities or diseases in aquatic organisms, further affecting their survival and reproduction.

Disrupted Food Webs:
The loss of wetland organisms can disrupt the entire food web.-
Other Impacts:

Human Health Risks:

Contaminated wetland water can pose risks to human health, as it can be a source of waterborne diseases and contamination of drinking water sources.

Economic Impacts:
Degradation of wetlands can lead to economic losses, such as reduced fisheries, tourism, and other ecosystem services that wetlands provide.

AIM:

1. To study and assess the adverse effects of industrial effluents discharged from industries in the TTC Industrial Area, Pawane MIDC, on nearby wetlands.

2. To enhance bacterial activity in the aeration tank of effluent treatment systems in order to reduce effluent load and lower key pollution parameters such as Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), aiming for compliance with the discharge standards set by the Maharashtra Pollution Control Board (MPCB) before release into wetland ecosystems.

OBJECTIVES:

1. To investigate the current status and effectiveness of primary and secondary effluent treatment processes used by industries in the TTC Industrial Area, Pawane MIDC, and examine their environmental implications due to inadequate or absent treatment.

2. To evaluate the efficiency of treatment processes at various stages within the Effluent Treatment Plants (ETPs).

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3. To monitor the quality of treated effluents for compliance with environmental discharge norms.

4. To assess the contribution and environmental impact of effluents from specific industries, particularly Darshan Chemicals and Aarti Labs.

5. To evaluate the performance of the existing secondary treatment systems and propose actionable strategies to enhance aerobic bacterial growth, ensuring improved effluent quality and sustainable environmental management.

This paper presentation summarizes the findings from a site visit to NGL Fine Chem Ltd., located in the TTC Industrial Area, Pawane MIDC. The purpose of the visit was to observe the effluent treatment processes, and its effects on TTC wetland and to assess compliance with environmental norms, and verify the effectiveness of effluent treatment practices in that area. This report outlines the procedures and outcomes of effluent sampling conducted throughout December 2024 at the First Effluent Treatment Facility. The primary objective was to monitor the quality of influent and treated effluent, ensuring compliance with environmental standards and identifying any anomalies in treatment performance.

Treatment of Pharmaceutical Industrial water

Inorganic & Organic compounds, VOC's Phenol and phenolic compounds are the most prominent chemical pollutants present in wastewaters released from industries. These pollutants can be treated by a number of methods .The inorganic & organic compounds can be removed by primary, secondary & tertiary treatment, while phenolic waste can be removed by electrochemical process. It uses electrons as the main reagent for destruction of the pollutants by direct or indirect oxidation processes. Ti/Pt and Ti/Pt Graphite, anodes are used.

Methodology of Effluent Treatment

At first Effluent, samples were collected daily throughout the month of December 2024. Samples were taken randomly from various treatment tanks before and after the treatment process. The sampling was conducted in accordance with standard procedures to ensure consistency additionally, treated effluent samples were collected near industrial units of Darshan Chemicals and Aarti Labs, prior to discharge to the CETP (Common Effluent Treatment Plant).

2. Sampling Methodology

Effluent samples were collected daily across the month of December 2024. To ensure representativeness and consistency, the sampling followed standard operating procedures aligned with regulatory guidelines.

Sampling Locations:

Influent and effluent points of various treatment tanks. Post-treatment discharge points near industrial units, specifically **Darshan Chemicals** and **Aarti Labs**, before their discharge into the Common Effluent Treatment Plant (CETP)

Sampling Technique:

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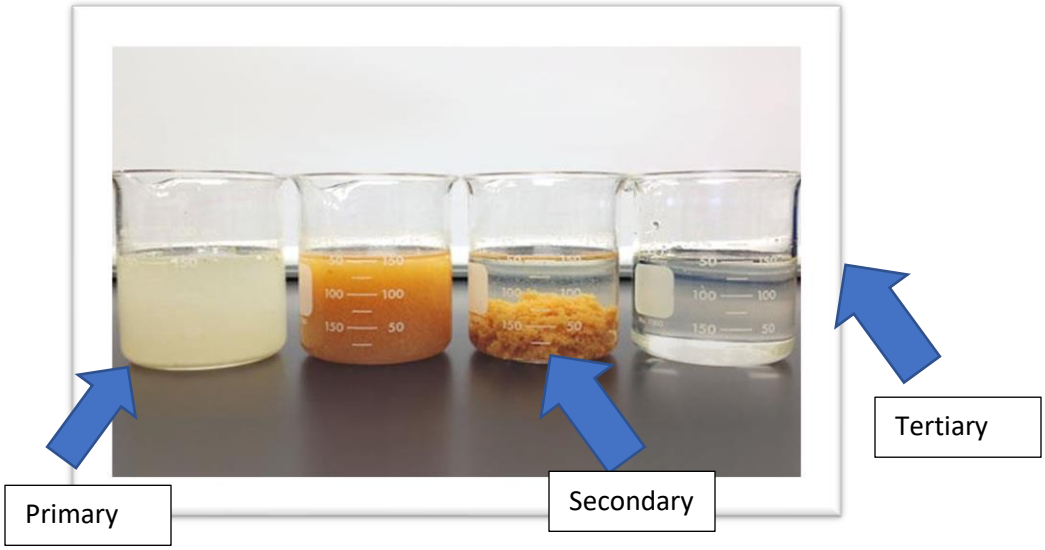
Random grab samples were taken from different stages of the treatment process to capture variation in composition. All samples were collected using sterilized containers and immediately preserved to prevent contamination or degradation of samples.

Effluent Process of Primary Treatment

1. Screening & pH Neutralization
2. Coagulation & Flocculation
3. Transfer of Supernatant in to MBBR Tank.



Treatment level in Effluent Treatment Plant

Primary Treatment for Raw Effluent consists of following equipment

1-Existing Collection Tank

2-Flash Mixer

3-Flocculator

4- Primary Settling Tank

Methodology of the Primary Treatment

The Raw effluent generated is collected in Existing Collection Tank by Gravity. Air grids are provided for equalization of flow. In Existing Collection Tank, pH of effluent is neutralized using Sulphuric Acid /HCL or by Soda lime /NaOH dosing. Retention time of effluent in Collection Tank is 8hrs. Neutralized effluent from existing Collection tank is pumped to Flash Mixer. In Flash mixer alum act as a coagulant, which enhances coagulation process. Retention time of effluent in Flash Mixer is 30 minutes. From Flash Mixer, effluent is overflowed into flocculator. In Flocculator, Polyelectrolyte dosing is done to accelerate

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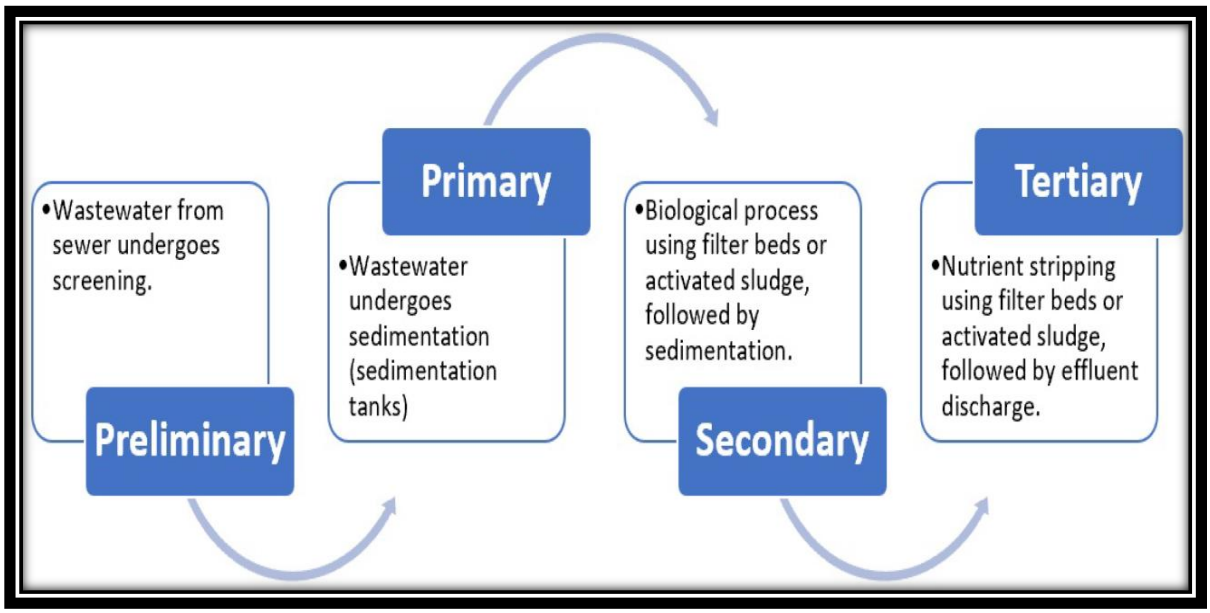
flocculation process. Retention time of effluent in Flocculator is 30 minutes. In Flash Mixer & Flocculator, agitator is provided for proper & uniform mixing.
From Flocculator, effluent is passed to Primary settling tank for Settling of heavy suspended solids. Settled sludge is drained out & send to as CHWTSDF for further treatment. Supernatant from primary settling tank is passed to MBBR Tank for biological destruction of effluent. Retention time of effluent in MBBR/Aeration Tank is 72 hrs.

Secondary Treatment Process consist of the following treatment.

1- MBBR tank /Aeration Tank.
2- Tube Settler
3- Sludge Tank



CHARACTERISTICS OF EFFLUENT IN PRIMARY, SECONDARY & TERTIARY TREATMENT

Methodology of Secondary Treatment

1-Retention of Effluent in Aeration Tank.
2-Development of Aerobic Bacteria
3-Transfer of Sludge recirculation in Tube settler & Aeration Tank.
4-To do analysis of bacterial growth.
5-Collection of bottom sludge in sludge tank and transfer of supernatant into the polishing tank for further tertiary treatment.
6-Sludge dewatering system (filter press)
7-ETP Analysis –observation of various activated sludge process parameters such as SVI, MLVSS, MLSS in the Aeration Tank (MBBR Tank).
8-Effluent parameter Analysis.

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The Moving Bed Biofilm Reactor (MBBR) technology is an attached growth biological treatment process based on a continuously operating, non-clogging biofilm reactor with low head loss, a high specific Biofilm surface area, and no requirement for backwashing.

The MBBR- The Moving Bed Biofilm Reactor is a complete mix, continuous flow through process, which is based on the biofilms principle that combines the benefits of both the activated sludge process and conventional fixed film systems. The basic principal of the moving bed process is the growth of the biomass on plastic supports that move in the biological reactor via agitation generated by aeration systems (aerobic reactors).

In Aeration Tank, concentration of MLSS i.e. Mixed Liquor Suspended Solids is maintained around 35-40% for efficient biological degradation of sewage. Sample of Aeration Tank is drawn once in a day for determination of MLSS of Aeration Tank. The stabilized Effluent from MBBR Tank then overflowed into Tube settler**.** Retention time of the effluent is 3-4 hrs. The arrested sludge is pumped back as sludge recirculation to the MBBR to maintain the growth of biomass in system and excess sludge is taken to the Sludge Tanks.

From Sludge, tank sludge generated is fed to Sludge Dewatering System. The Drained supernatant effluent from Tube settler is collected in Polishing Tank and later it is passed to Pressure Sand Filter & Active Carbon Filter for tertiary Treatment. Filter press along with feed pump is provided to separate the sludge from slurry. Sludge can be separate and dried out by blowing air, and filtered liquid is drained into the equalization chamber. Dried sludge can be disposed of to CHWTSDF after comprehensive test analysis.

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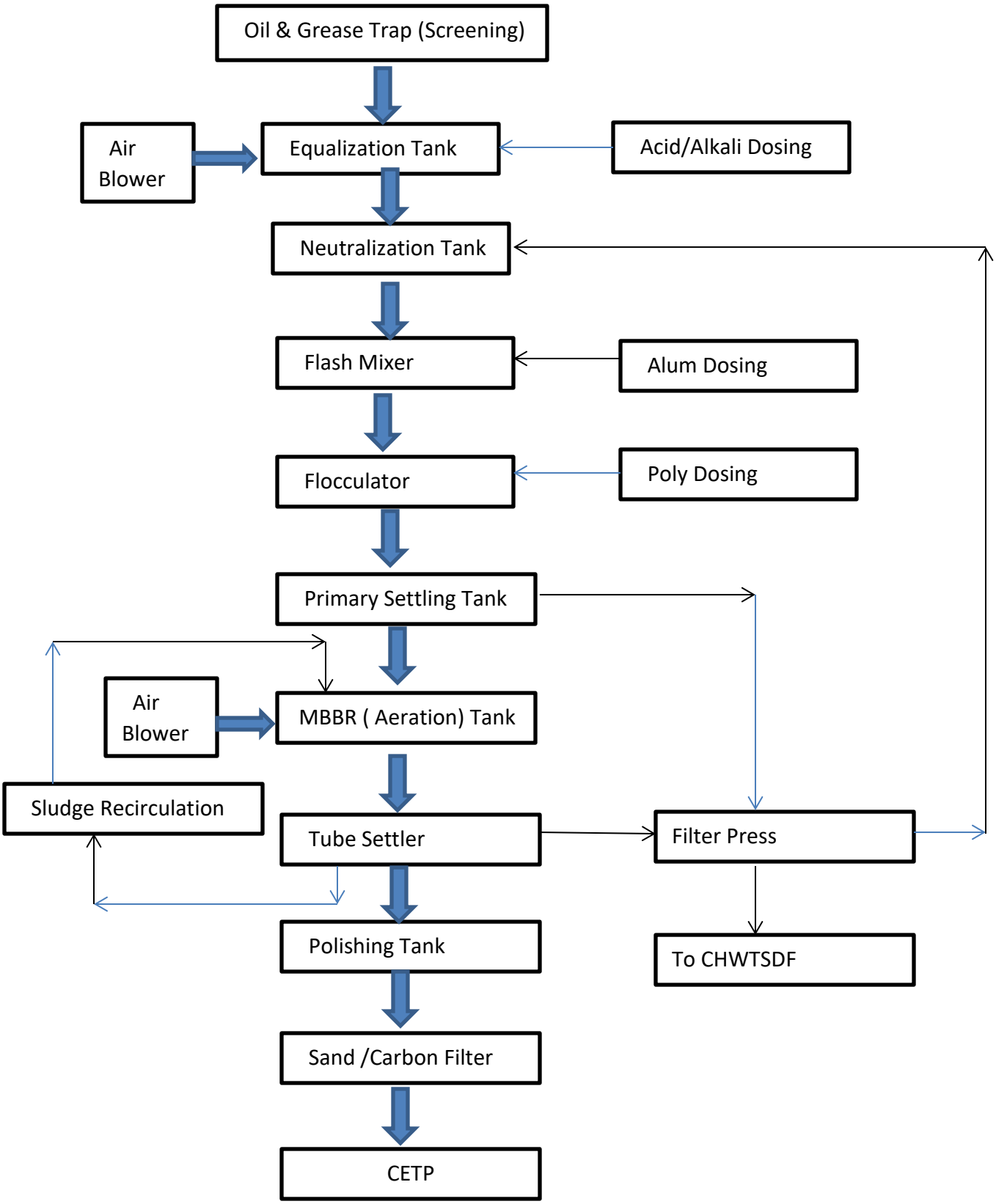
LOW COD EFFLUENT TREATMENT (COD <10000 mg/lit & TDS <4000 mg/lit)



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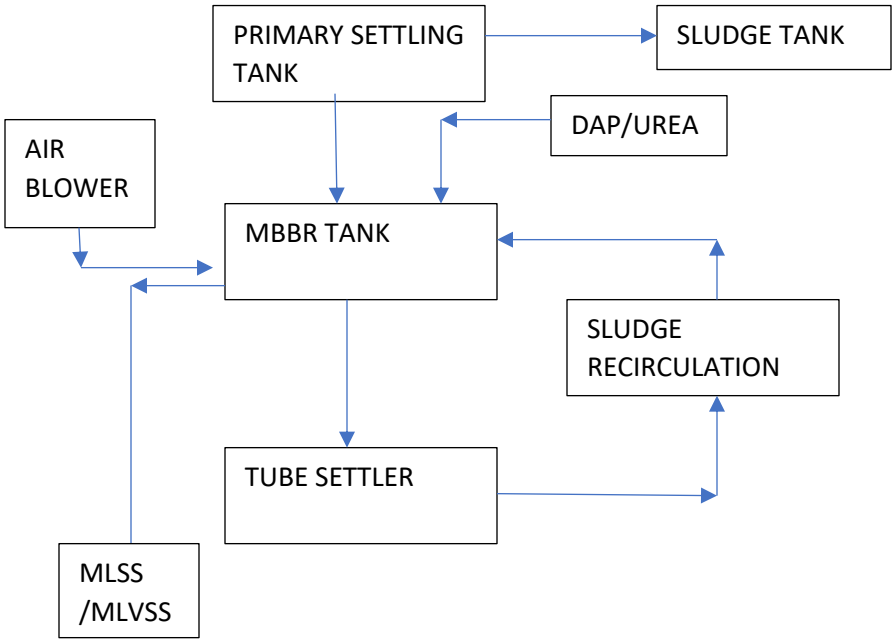
ETP-Process Flow Diagram of Secondary Treatment.



Observation:

The Inlet Parameters of influent are mentioned as under

Sr.No.	Parameter	Unit	Concentration
1	Flow	CMD	7.0
2	PH	-	2
3	Chemical Oxygen Demand	Mg/Lit	35000
4	Biological oxygen Demand, 3 day, 27 °c	Mg/Lit	3500
5	Total Dissolved Solids	Mg/Lit	25000
6	Total Suspended Solids	MG/Lit	4500
7	MLSS	Mg/Lit	--
8	MLVSS	MG/Lit	---
9	SVI	%	---

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From the above table it has been observed that effluent parameters before treatment are significantly on higher side, as the process is generating more discharge of solvent-based effluent containing organic hydrocarbon, which naturally increase the COD & BOD level of the effluent, and due to precipitated and acidic nature of effluent the PH and dissolved solids are also more.

Influent Characteristics: High variability in COD, BOD, and TSS levels was observed, consistent with fluctuating industrial activity.

Effluent Analysis after the Secondary Treatment at NGL Fine Chem Ltd.

S.N.	Parameter	Unit	Concentration
1	PH	-----	6.8-8.5
2	Chemical Oxygen Demand	Mg/Lit	78
3	Biological Oxygen Demand, 3 day, 27 °c	Mg/Lit	34
4	Total Dissolved Solids	Mg/Lit	558
5	Total Suspended Solids	MG/Lit	78
6	MLSS	Mg/Lit	4500
7	MLVSS	MG/Lit	3500
8	SVI	%	30-40%

Effluent Analysis after the Secondary Treatment

Based on the analysis of the above table, it is evident that the quality of treated water after secondary treatment is well within the permissible limits set by the Maharashtra Pollution Control Board (MPCB). The significant reduction in Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) levels indicates effective treatment of effluents, ensuring compliance with Central Pollution Control Board (CPCB) standards. Given the high pollution load typically associated with pharmaceutical industries—due to the diverse range of chemicals and solvents used—the company's Effluent Treatment Plant (ETP) has demonstrated efficient performance. This reflects the organization's commitment to environmental sustainability. Furthermore, the parameters related to bacterial growth in the aeration tank confirm that the concentration of aerobic bacteria is adequate for proper biological treatment, and the Sludge Volume Index (SVI), a key indicator of bacterial activity and sludge settling properties, falls within the normal range. Overall, the data supports that all treated effluent parameters follow regulatory norms, indicating effective environmental management by the company. For verification purposes, the analytical test results of the effluent are compared with online SCADA real time monitoring system, and no any major variations in test results were observed.

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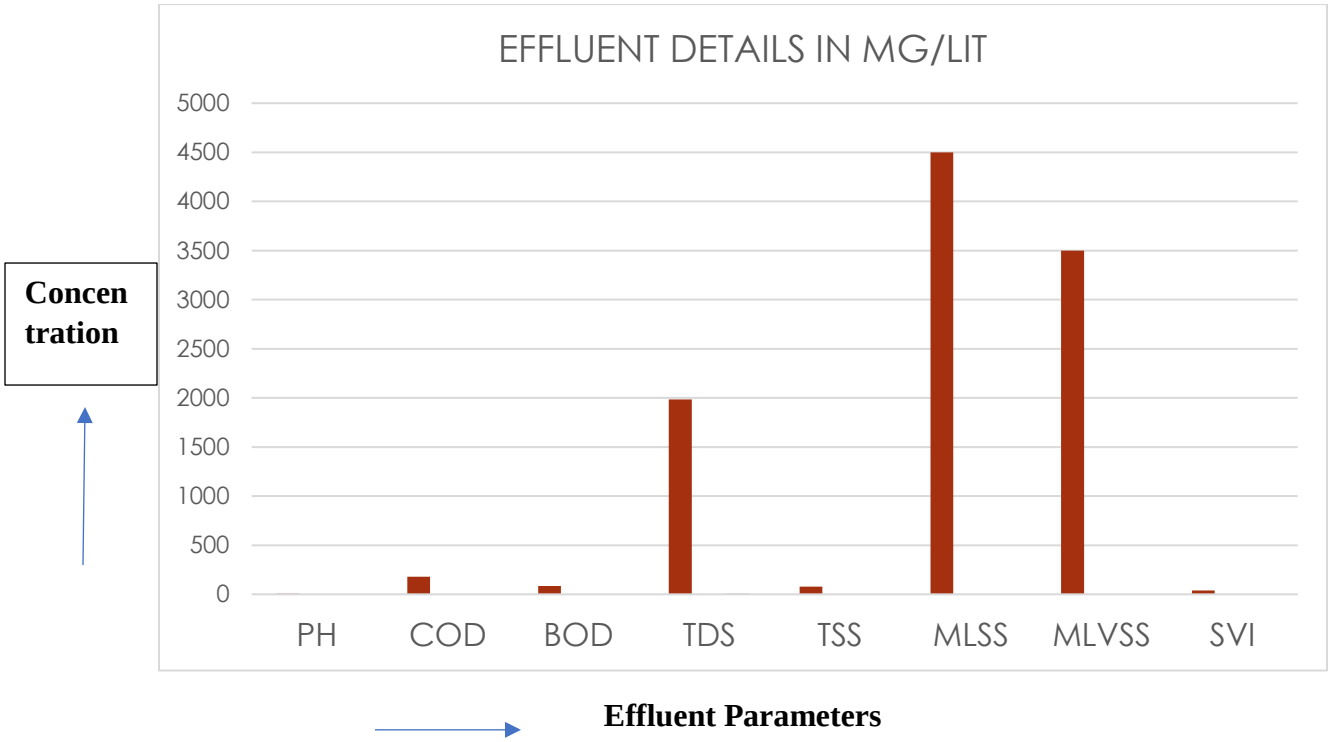
Graph 1. HISTOGRAM OF EFFLUENT PARAMETERS



Effluent Analysis of Surrounding Industries (Darshan Chemicals and Aarti Labs):
Sampling Location: Post treatment discharge point of Darshan chemicals & Aarti Labs -Effluent Drainage Nallah leading to CETP

Sampling Technique:

Random grab samples were taken from different stages of the treatment process to capture variation in composition. All samples were collected using sterilized containers and immediately preserved to prevent contamination or degradation of analytes.

S.N.	Parameter	Unit	Concentration
1	PH	-----	8.5
2	Chemical Oxygen Demand	Mg/Lit	227
3	Biological Oxygen Demand, 3 day, 27 °c	Mg/Lit	95
4	Total Dissolved Solids	Mg/Lit	1985

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5	Total Suspended Solids	MG/Lit	78
6	MLSS	Mg/Lit	Not Determined
7	MLVSS	MG/Lit	Not Determined
8	SVI	%	Not Determined

The effluent treatment system at NGL Fine Chem Ltd. was found to be well-structured and consistently operational, with daily sampling indicating stable performance and expected treatment outcomes. The quality of treated effluent met the regulatory standards, as verified through both manual testing and real-time online monitoring systems. Significant reductions in key pollutants—namely Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), and Total Suspended Solids (TSS)—were observed across various treatment stages, reflecting the efficiency of the process. Additionally, inspections of nearby industries, including Darshan Chemicals and Aarti Labs, revealed that their effluent discharge points showed no presence of harmful chemical residues, and all facilities appeared to comply with established treatment norms.

Results:

The observed data from both sampling and online monitoring systems were found to be accurate, consistent, and reliable. No evidence of untreated or hazardous discharge into the surrounding environment was detected during the inspection. Furthermore, the treated effluent from all assessed units remained within the permissible limits set by regulatory authorities and was being safely routed to the Common Effluent Treatment Plant (CETP) for final discharge.

Environmental Impact:

Based on comprehensive observations and test results, there is no indication of environmental degradation in the TTC Industrial Area or the adjacent Panje Wetland resulting from industrial effluent discharge. Industries such as NGL Fine Chem Ltd., Darshan Chemicals, and Aarti Labs have demonstrated effective management of their effluent treatment systems, thereby contributing positively to environmental protection and sustainable industrial practices.

Conclusion:
The site visit and effluent sampling conducted in December 2024 confirm that the effluent treatment processes within the TTC Industrial Area are being properly and efficiently executed. The observed industries are in compliance with environmental regulations, ensuring that no harmful discharges are entering the environment or threatening the ecologically sensitive Panje Wetland.

Conclusion & Suggestion:

Many industries demonstrate limited commitment toward proper effluent treatment and ensuring the safety of discharged wastewater, particularly in terms of discharge methods and compliance. One of the major barriers is the high capital investment required for setting up and maintaining efficient effluent

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treatment systems. A clear gap exists between theoretical understanding and practical implementation of treatment practices. Notably, only around 30% of industries have proactively adopted pre-treatment of effluent before discharging into water bodies, acknowledging their shared responsibility in environmental protection and sustainability. These findings highlight the urgent need for regular awareness programs focused on statutory compliance, best practices in effluent treatment, and the ecological importance of wetland conservation. Moreover, while several industries operate secondary effluent treatment systems, these are often run intermittently. Given the hazardous nature of high-organic-load effluents, there is a pressing need to enhance and stabilize the bacterial load in aeration tanks to improve treatment efficiency across all facilities.

Possible Cause /Troubleshooting	Necessary check and possible corrective actions
1-Under Aeration	1. Check the valves of blower and adjust the valve accordingly. 2. Check the air quality delivered by blower, in case the quantity is less than design; check the blower for any mechanical problem. In case of any mechanical problem, refer the blower manual for the maintenance. 3. Check for adequate mixing in Aeration tank. 4. Retention time to be increased.
2-Air Grid are damaged	In case the grid are damaged, it will result in excessive turbulence but low oxygen transfer. The corrective action should be taken for immediate repairing of the diffuser/grid.
3-High Inlet organic i.e. BOD/COD load	1. In case the BOD/COD load is higher than design, the same to be controlled prior to its treatment, the flow to the plant to be reduced to decrease the BOD/COD loading. Generally, solvents are causing more COD in the effluent level; hence, control is necessary before discharging any liquid solvent to ETP. 2. High COD & Low cod Segregation to be done
4-Septic odour in primary settling tank & tube settler	1- To install gas detection system to detect gases of hydrocarbons near tube settler. 2- To follow PM Schedule of cleaning of tank at regular interval. 3- To segregate hazardous waste such as ETP Sludge and to send to CHWTSDF at regular interval. 4- To neutralize the acidic ml itself in the reaction vessel before discharging and draining into the ETP

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ABBREVIATIONS

S.N	Name	Description
01	MT	Metric Tonne
02	EIA	Environmental Impact Assessment
03	MPCB	Maharashtra Pollution Control Board
04	ETP	Effluent Treatment Plant
05	COD	Chemical Oxygen Demand
06	BOD	Biological Oxygen Demand
07	TDS	Total Dissolved Solid
08	TSS	Total Suspended Solid
09	SS	Suspended Solid
10	MLVSS	Mixed Liquor Volatile Suspended Solid
11	MLSS	Mixed Liquor Suspended Solid
12	SVI	Sludge Volume Index
13	CHWTSDF	Common Hazardous Waste Treatment Storage Disposal Facility
14	MBBR	Mixed Bed Biofilm Reactor
15	CETP	Common Effluent Treatment Plant
16	LCOD	Low Chemical Oxygen Demand
17	HCOD	High Chemical Oxygen Demand
18	CMD	Cubic Meter per day
19	VOC	Volatile Organic Compound
20	MG/LIT	Miligram per Liter

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Wetlands-The Gateway Towards Conservation and Ecotourism

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ABSTRACT

Wetlands, which serve as transitional zones between land and water ecosystems, are among the most dynamic and productive environments on Earth. These ecosystems are vital for maintaining ecological balance and offer numerous economic and social benefits. As biodiversity hubs, wetlands provide indispensable services such as purifying water, controlling floods, and regulating climate. Beyond these functions, they offer significant potential for ecotourism, fostering sustainable environmental practices while supporting local economic development. This paper explores the various types and characteristics of wetland ecosystems, highlighting their global significance. It investigates the role of ecotourism within these areas, focusing on its activities, economic value, and community engagement, while addressing challenges like habitat degradation. Additionally, the review discusses conservation strategies designed to protect these vulnerable ecosystems and offers approaches for integrating ecotourism with environmental stewardship. By examining effective management methods, this study underscores the importance of wetlands in achieving sustainability goals. It concludes with strategies for harmonizing ecotourism and conservation to preserve wetlands as vital ecological and economic assets.

Key words- wetland, conservation, ecotourism, ecosystem services.

Introduction

A wetland defines as lands transitional between terrestrial and aquatic ecosystem. The water is often groundwater, seeping up from an aquifer or spring. A wetland's water can also come from a nearby river or lake. Seawater can also create wetlands, especially in coastal area that experience strong tides (Prasad et all, 2002). Wetlands are unique and vital ecosystems that occupy the transitional zone between land and water, exhibiting a fascinating blend of terrestrial and aquatic characteristics. These dynamic and diverse environments which includes marshes, swamps, bogs, fens and mangroves, among others provide a wide range of ecological, economic and social benefits. wetland supports an astonishing array of plant and animal species, many of which are found nowhere else on earth. They also play critical role in maintaining water quality, regulating the water cycle and mitigating the impact of climate change. Despite their importance, wetlands are facing unprecedented threats, including habitat destruction, pollution and climate change which underscore the need for concerted conservation and management efforts to protect these precious ecosystem (ramsar.org).

Types of wetlands

Wetlands are mainly categorized into four types which includes the Marshes, Swamps, Bogs and Fens.

1.Marshes

"Marshes are periodically saturated, flooded, or ponded with water and characterized by herbaceous (non-woody) vegetation adapted to wet soil condition." (Types of wetland, 2001) Marshes come in a wide variety of forms, from the Everglades to prairie potholes, from inland to coastal, freshwater to saltwater. Surface water provides the majority of the water for all kinds, while groundwater also supplies water to many

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marshes. The abundance of plant and animal life is caused by the abundance of nutrients and the generally neutral pH. We have divided marshes into two main groups: tidal and non-tidal.

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2. Swamps

Any marsh where woody plants predominate is called a swamp. Swamps come in a variety of forms, from the large bottomland hardwood forests found along the slow-moving rivers of the Southeast to the forested Red Maple (Acer rubrum) swamps of the Northeast. Saturated soils during the growing season and standing water at specific periods of the year are characteristics of swamps. Cypress (Taxodium spp.), Atlantic White Cedar (Chamaecyparis thyroids), and tulelo (Nyssa aquatica) are among the water-tolerant trees that thrive in the thick, black, nutrient-rich soils of swamps. Shrubs like buttonbush or smooth alder predominate in some marshes. Swamps are essential habitats for fish, birds, plants, and invertebrates including clams, crayfish, and freshwater shrimp. These environments are also essential to many rare species, including the endangered American Crocodile. Depending on the kind of vegetation they include, swamps can be classified into two main classes: shrub swamps and forest swamps.

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3. Bogs

Among the most unique types of wetlands found in North America are bogs. They are distinguished by acidic waters, spongy peat deposits, and a dense carpet of sphagnum moss covering the floor. Instead of runoff, groundwater, or streams, bogs get all or most of their water from precipitation. Bogs lack the nutrients required for plant growth as a result, and acid-forming peat mosses make this situation worse. One of the

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most unique types of wetlands in North America is bogs. Spongy peat deposits, acidic waters, and a dense carpet of sphagnum moss covering the floor are some of their distinguishing features. The majority of the water in bogs comes from precipitation, not runoff, groundwater, or streams. Because of this, bogs lack the nutrients required for plant growth, a situation that is made worse by acid-forming peat mosses. “These systems, whose only water source is rainwater are usually found in glaciated areas.” (Types of wetland, 2001). There are two types- Northen bogs & pocosins.

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4. Fens

Fens are peat-forming wetlands that get their nutrients from sources other than precipitation. Typically, these sources are upslope and come from groundwater movement and drainage from nearby mineral soils. Because they are more nutrient-rich and less acidic than bogs, fens are different. As a result, a far more varied plant and animal community may be supported by them. Wildflowers, rushes, sedges, and grasses frequently cover these systems. Parallel ridges of vegetation divided by less productive hollows are a defining feature of certain fens. These patterned fens generate ridges that are perpendicular to the direction of water movement downslope. Peat accumulation over time may cause the fen to become disconnected from its groundwater source. The fen may turn into a bog as a result of receiving fewer nutrients. Similar to bogs, fens are primarily a northern hemisphere phenomenon, found in parts of Canada, the Great Lakes region, the Rocky Mountains, and the northeastern United States. They are typically linked to short growing seasons and low temperatures, where high humidity and plenty of precipitation lead to an excess of moisture.

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Wetland an ecological hub

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Wetlands are often considered ecological hubs due to their rich biodiversity and critical role in supporting ecosystems. They serve as a habitat for a wide range of species, including birds, amphibians, fish, and plants, making them hotspots of biodiversity. Wetlands also act as natural water filters, improving water quality by trapping pollutants and sediments. Additionally, they provide essential ecosystem services like flood control, carbon storage, and groundwater recharge, contributing significantly to environmental stability. These unique characteristics make wetlands a cornerstone of ecological health and sustainability.

- **Wetland Biodiversity**

Wetland biodiversity is a cornerstone of ecological balance, showcasing an extraordinary array of plant and animal species uniquely adapted to this dynamic environment. Wetlands are home to an incredible variety of aquatic plants, fish, amphibians, birds, reptiles, and mammals, many of which are either endemic or endangered (worldwildlife.org). These ecosystems serve as critical breeding, feeding, and nesting grounds, ensuring the survival of species that are often highly specialized and dependent on wetland habitats for their lifecycle. For example, migratory birds like cranes rely on wetlands as stopover sites during their long journeys, while amphibians thrive in the moist conditions that wetlands provide. Additionally, wetlands such as mangroves, peatlands, and marshes are biodiversity hotspots, housing intricate food webs that sustain both predator and prey populations. This complexity ensures ecological balance by regulating species interactions and nutrient cycling (Denny P, 1994). The unique conditions of wetlands where land and water meet create a diverse range of microhabitats, from shallow waters to dense vegetation, each supporting different species. This habitat heterogeneity promotes high levels of biodiversity, fostering interactions among species and increasing ecosystem resilience. Wetlands also serve as nurseries for many fish and invertebrate species that are crucial for commercial and subsistence fisheries, making them economically valuable in addition to their ecological significance. Furthermore, by supporting keystone species, wetlands play a critical role in maintaining the stability of broader ecosystems, influencing the health of surrounding terrestrial and aquatic environments. However, this immense biodiversity is increasingly under threat due to habitat destruction, pollution, climate change, and invasive species, highlighting the urgent need for conservation efforts. Protecting wetland biodiversity is not only essential for the survival of countless species but also for the continued provision of ecosystem services that benefit humanity, from food security to water purification and climate regulation (Gibbs, 2001).

- **Wetland in climate regulation**

Wetlands play a crucial role in regulating the Earth's climate, acting as natural buffers against the impacts of climate change while contributing significantly to its mitigation. One of the most vital functions of wetlands in climate regulation is carbon sequestration. Wetlands such as peatlands, mangroves, and salt marshes are among the most efficient natural systems for storing carbon, as they accumulate organic material in waterlogged conditions where decomposition is slow. This process prevents vast amounts of carbon dioxide, a major greenhouse gas, from being released into the atmosphere. Peatlands alone store more carbon than all the world's forests combined, making their preservation critical in the fight against global warming. Wetlands also help regulate local and regional climates by influencing humidity and temperature. Their capacity to retain and release water creates a cooling effect in their surroundings, helping to moderate temperatures in nearby areas. Beyond carbon storage, wetlands act as natural defenses against the increasing severity of climate-related disasters. They play a pivotal role in flood control, acting like sponges that absorb excess water during heavy rains, thereby reducing the risk of downstream flooding. Similarly, during periods of drought, wetlands release stored water gradually, ensuring a steady supply and preventing water scarcity (Salimi et all 2021). Coastal wetlands such as mangroves provide additional climate-related benefits by protecting shorelines from storm surges and sea-level rise, which are becoming more frequent due to global warming. These ecosystems act as natural barriers, dissipating wave energy and minimizing erosion. Despite

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their critical role in climate regulation, wetlands are among the most threatened ecosystems on Earth, with large areas being drained or degraded for agriculture, urbanization, and industrial use. Protecting and restoring wetlands is essential not only for their biodiversity but also for their unparalleled ability to regulate the climate, provide resilience against extreme weather events, and ensure long-term environmental sustainability.

- **Ecosystem Services Provided by Wetlands**

Wetlands provide an array of ecosystem services that are vital for environmental health, human well-being, and economic stability. One of the most significant services they offer is water purification. Acting as natural filters, wetlands remove pollutants, sediments, and excess nutrients from water, improving water quality and protecting aquatic ecosystems (Mitsch et all 2015). This natural filtration reduces the burden on artificial water treatment systems, making wetlands an indispensable resource for clean and safe water. Additionally, wetlands facilitate groundwater recharge by allowing water to seep into aquifers, ensuring a sustainable supply of fresh water, especially in regions prone to water scarcity. These ecosystems are also crucial for flood control, as they act like sponges, absorbing and storing excess water during heavy rains and gradually releasing it, thereby reducing the risk of floods downstream. Similarly, during dry periods, wetlands retain and release water slowly, mitigating the effects of drought and ensuring water availability for surrounding communities.

Wetlands also support livelihoods and contribute to local economies by providing resources such as fish, shellfish, reeds, timber, and medicinal plants, which sustain millions of people globally (Mitsch et all 2015). Furthermore, they have immense cultural, spiritual, and recreational value. Many wetlands are sites of cultural heritage, offering opportunities for ecotourism, birdwatching, and recreational activities that attract visitors while supporting local economies. Coastal wetlands like mangroves play a critical role in protecting shorelines from erosion and storm surges by acting as natural barriers that absorb wave energy, safeguarding coastal communities from the impacts of climate change and extreme weather events. Additionally, wetlands are essential for biodiversity, serving as habitats for countless species of plants, animals, and microorganisms, many of which are unique to these environments. This biodiversity supports food webs and enhances ecosystem resilience. Despite their invaluable services, wetlands are under severe threat from human activities, emphasizing the urgent need for their conservation and restoration to ensure the continued provision of these critical ecosystem services

Ecotourism in wetland

Ecotourism in wetlands is a sustainable approach to tourism that highlights the ecological, cultural, and aesthetic significance of these unique ecosystems. It supports local livelihoods by generating income through eco-friendly tourism practices and educating visitors about the importance of wetlands in climate regulation, water purification, and wildlife habitat preservation. This balance of tourism and conservation helps protect these fragile ecosystems for future generations.

- **Benefits of wetland-based ecotourism**

Wetlands perform significant economic benefit to human society, including some economic services that no other ecosystem can provide, including certain types of water quality improvement, flood protection, shoreline erosion control, and opportunities for recreation and aesthetic appreciation and natural products for our use at no cost. (kour et all, 2021). One of the primary advantages is the promotion of sustainable conservation practices. By attracting visitors who value natural beauty and biodiversity, ecotourism

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generates funds that can be reinvested into the protection and restoration of wetlands, ensuring their long-term ecological health. This financial support often aids in the management of these fragile ecosystems, such as maintaining biodiversity, monitoring species, and controlling invasive species. Ecotourism also fosters environmental awareness among visitors, educating them about the critical role wetlands play in climate regulation, water purification, and biodiversity support. This increased awareness can inspire individuals and communities to actively participate in wetland conservation efforts. Additionally, ecotourism provides significant economic benefits to local communities by creating jobs and income-generating opportunities. Tour guides, local artisans, small businesses, and hospitality services all benefit from the influx of eco-conscious tourists, fostering economic growth in often rural or underserved areas.

Moreover, ecotourism helps preserve cultural heritage by promoting the traditional knowledge and practices of local communities that are closely tied to wetlands. It encourages the sharing of indigenous wisdom, rituals, and sustainable practices that have coexisted with these ecosystems for generations. These interactions not only provide cultural enrichment for visitors but also instil pride among local people, motivating them to protect their natural and cultural heritage. Wetland ecotourism can also act as a buffer against harmful land-use changes, such as agriculture or urbanization, by providing a profitable alternative that relies on keeping the ecosystem intact. Furthermore, it supports global efforts to combat climate change by emphasizing the importance of wetlands as carbon sinks and natural defences against climate-related disasters. While ecotourism in wetlands has immense potential, it must be carefully managed to prevent over-tourism, habitat degradation, and disruption of wildlife, ensuring that its benefits are truly sustainable for both the environment and the communities that depend on it.

- **Activities can perform in wetlands**

Wetlands offer a wide range of ecotourism activities that allow visitors to connect with nature, appreciate the beauty of these ecosystems, and contribute to their conservation. One of the most popular activities is birdwatching, as wetlands serve as critical habitats for a diverse array of resident and migratory bird species, making them a paradise for bird enthusiasts. Visitors can observe unique species such as cranes, herons, and flamingos, particularly during migratory seasons, fostering an appreciation for biodiversity. Another engaging activity is wildlife photography, as wetlands are home to a variety of animals, including amphibians, reptiles, fish, and mammals, offering opportunities to capture the beauty and diversity of these ecosystems. Guided nature walks and educational tours are also common, allowing visitors to explore the wetland landscape while learning about its ecological significance, biodiversity, and the challenges it faces. These tours often highlight the importance of wetlands in climate regulation, water purification, and supporting endangered species.

Water-based activities like canoeing, kayaking, and boat safaris provide a unique perspective of wetlands, enabling visitors to navigate through winding waterways, mangrove forests, or serene marshes while observing wildlife in its natural habitat. Fishing, when conducted sustainably, is another activity that allows tourists to engage with local traditions while understanding the importance of wetland ecosystems in supporting fisheries. Ecotourism in wetlands often includes cultural experiences, such as visiting nearby indigenous or local communities to learn about their traditional practices, crafts, and rituals that are closely tied to wetland resources. These interactions foster a deeper connection between visitors and the people who rely on wetlands for their livelihoods. Additionally, eco-conscious tourists can participate in volunteer activities, such as planting mangroves, removing invasive species, or joining clean-up drives, directly contributing to wetland restoration and conservation. Wetlands also provide opportunities for meditation, yoga, and other wellness activities, offering tranquil surroundings that promote mental well-being. By engaging in these diverse ecotourism activities, visitors not only enjoy unforgettable experiences but also support the protection and sustainable use of wetlands for future generations.

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- **Examples of Wetlands ecotourism**

1. Sundarbans Mangrove Forest (India and Bangladesh):

The Sundarbans Mangrove Forest, spanning India and Bangladesh, is one of the largest and most significant wetland ecosystems in the world, renowned for its rich biodiversity, unique mangrove habitat, and critical role in climate regulation. Designated as a UNESCO World Heritage Site, the Sundarbans cover approximately 10,000 square kilometres and serve as the largest contiguous mangrove forest globally. This vast and dynamic wetland is home to the iconic and endangered Royal Bengal Tiger, which has adapted to a semi-aquatic lifestyle, making it one of the most elusive and unique tiger populations in the world. The Sundarbans also support a diverse array of wildlife, including estuarine crocodiles, Gangetic dolphins, Indian pythons, spotted deer, and various species of otters and monkeys. Additionally, the region is a haven for birdwatchers, with species such as the masked finfoot, kingfishers, egrets, and the rare spoon-billed sandpiper thriving in this complex ecosystem. Beyond its biodiversity, the Sundarbans act as a natural barrier, protecting coastal communities from cyclones, storm surges, and erosion, making their conservation a matter of both ecological and human importance (Ghosh et all, 2015).

Ecotourism in the Sundarbans provides a sustainable means of promoting conservation while offering visitors a chance to experience the beauty and uniqueness of this mangrove ecosystem. One of the most popular activities is boat safaris, where tourists navigate through the intricate network of tidal waterways, observing the dense mangrove vegetation and spotting wildlife along the shores. Birdwatching is another key attraction, with guided tours helping visitors identify rare and migratory birds that frequent the wetlands. Sundarbans ecotourism also includes visits to conservation centers, such as crocodile breeding farms and tiger rehabilitation programs, where travelers can learn about efforts to protect endangered species. Cultural tourism plays a significant role as well, with visitors engaging with local fishing and honey-collecting communities, gaining insight into their sustainable traditional practices (Ghosh et al, 2015). The region also hosts eco-lodges and nature camps that emphasize responsible tourism, minimizing environmental impact while educating guests on the importance of wetland conservation.

The impact of ecotourism in the Sundarbans has been significant, both in terms of conservation and local socio-economic development. Revenue generated from tourism helps fund conservation programs, including anti-poaching patrols, habitat restoration, and mangrove plantation initiatives that strengthen coastal resilience against climate change. Additionally, ecotourism provides alternative livelihoods for local communities, reducing their dependence on resource extraction, such as illegal fishing or deforestation, which can threaten the ecosystem. Many local guides, boat operators, and hospitality staff are now employed in the tourism sector, fostering a sense of environmental stewardship within the community. However, the Sundarbans face ongoing challenges, including rising sea levels, increased frequency of cyclones, and human-wildlife conflicts, particularly in areas where tigers and humans compete for space. Sustainable ecotourism, combined with strong conservation policies and community involvement, remains crucial in ensuring the long-term protection of this extraordinary wetland. By balancing tourism with conservation, the Sundarbans continue to serve as a model for wetland ecotourism, demonstrating how economic growth and environmental preservation can go hand in hand.

2.Okavango Delta (Botswana):

The Okavango Delta in Botswana is one of the world's most renowned wetland ecotourism and conservation sites, offering a unique and pristine environment teeming with biodiversity. Recognized as a UNESCO World Heritage Site, this inland delta is formed by seasonal floodwaters from the Okavango River, creating a lush oasis in the middle of the arid Kalahari Desert. The delta supports a diverse array of flora and fauna, including large populations of elephants, hippos, crocodiles, and rare species such as the African wild dog and sitatunga antelope (McCarthy et all, 1998). It also serves as a crucial habitat for over 400 bird species,

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making it a prime destination for birdwatchers. The Okavango Delta is not only an ecological marvel but also an essential lifeline for both wildlife and local communities, making its conservation and sustainable ecotourism practices vital for long-term environmental protection.

Tourism in the Okavango Delta is carefully managed to ensure minimal environmental impact while maximizing visitor experiences. Popular ecotourism activities include mokoro (traditional dugout canoe) safaris, which allow tourists to glide silently through the delta's waterways and get up close to wildlife without disturbing the natural balance. Guided walking safaris provide an intimate exploration of the landscape, where visitors can learn about the delicate ecosystem, track animals, and understand the significance of conservation efforts. Game drives offer opportunities to witness the Big Five—lion, leopard, elephant, rhino, and buffalo—in their natural habitat. Birdwatching is another major attraction, with species like the African fish eagle, Pel's fishing owl, and various kingfishers thriving in the wetland environment. Additionally, cultural tourism allows visitors to engage with local communities, such as the indigenous San people, who share their traditional knowledge of the land, sustainable hunting techniques, and folklore about the delta's significance.

The conservation impact of ecotourism in the Okavango Delta has been significant, as responsible tourism generates revenue that directly funds conservation programs and anti-poaching initiatives. Many lodges and safari operators follow strict eco-friendly practices, such as using solar energy, reducing plastic waste, and supporting local conservation projects. The presence of tourism also helps deter illegal hunting and habitat destruction, as local communities benefit financially from protecting wildlife rather than exploiting it. Furthermore, ecotourism provides employment opportunities, empowering local populations and fostering a sense of stewardship over the delta. However, balancing conservation with increasing tourist numbers remains a challenge, requiring continued efforts to ensure that ecotourism remains sustainable. Overall, the Okavango Delta stands as a model for wetland conservation and ecotourism, demonstrating how responsible tourism can contribute to both economic development and environmental preservation.

Integrating conservation and ecotourism in wetland

Integrating ecotourism and conservation in wetlands is a sustainable approach that ensures the protection of these valuable ecosystems while supporting local communities and providing economic benefits. This integration focuses on balancing tourism activities with efforts to preserve the natural environment and biodiversity.

- **Challenges in integrating conservation and ecotourism**

Integrating conservation and ecotourism in wetland areas presents several complex challenges that need to be addressed carefully to ensure the sustainability of both environmental protection and tourism activities. One of the foremost challenges is the issue of overuse and over-tourism, which can severely degrade wetland ecosystems if not managed properly. Wetlands are fragile and sensitive environments that can be easily disturbed by large numbers of visitors. The presence of tourists, particularly in areas that are not carefully regulated, can lead to soil compaction, vegetation trampling, pollution, and disturbance to wildlife, especially during critical breeding or migratory periods (Pemberton et all, 2005) . These impacts can undermine the very qualities that make the wetlands attractive to tourists in the first place, creating a vicious cycle of degradation. Furthermore, the growth of tourism can often outpace the development of necessary infrastructure, which may exacerbate the environmental strain. In many wetland regions, the lack of adequate infrastructure to manage increasing visitor numbers, such as proper pathways, waste management systems, and visitor facilities, can lead to pollution, littering, and environmental degradation. Without well-planned infrastructure that minimizes ecological footprints, tourism can easily cross the threshold of sustainability. Another significant challenge is the conflicting interests of various stakeholders involved in the management

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of wetland areas. Local communities, for example, might prioritize short-term economic benefits derived from ecotourism or extractive practices like fishing or farming, while conservationists focus on long-term environmental preservation. These differing priorities can lead to tensions, making it difficult to find common ground for sustainable management. Additionally, government policies may not always align with the needs of both conservation and tourism, as political pressures or economic incentives may prioritize development over environmental protection. Invasive species represent another serious threat to wetlands, especially in areas where tourism activities bring in non-native plants, animals, or pathogens. These species can outcompete native flora and fauna, disrupt the ecological balance, and damage the integrity of wetland habitats. Without strict regulations and monitoring, tourism can inadvertently contribute to the spread of invasive species, complicating conservation efforts. Moreover, the lack of awareness and education among tourists can exacerbate environmental issues. Many visitors may not be aware of the delicate nature of wetlands or may engage in harmful behaviours such as straying off designated paths, disturbing wildlife, or polluting the environment. Without robust education and outreach programs, tourists may unintentionally damage the very ecosystems they have come to appreciate. Furthermore, the financial sustainability of conservation efforts combined with ecotourism can be a major hurdle. Although ecotourism has the potential to generate revenue for conservation activities, the financial model is often unpredictable, and there may be insufficient funds for long-term monitoring, habitat restoration, or protection of critical wetland areas. Many ecotourism initiatives are also reliant on seasonal fluctuations in visitor numbers, which can create financial instability for both conservation programs and local communities. Climate change poses an additional threat, as rising sea levels, shifting weather patterns, and increased temperatures can dramatically alter wetland ecosystems (Salimi et all 2021). These changes may reduce the effectiveness of conservation efforts or create new challenges in managing visitor access and activities. For example, some wetlands may experience changes in water levels that affect the habitat of migratory species, forcing ecotourism operators to adjust their offerings or even close parts of the area to visitors. Lastly, the lack of effective governance and coordination among stakeholders can hinder the integration of conservation and ecotourism. Wetland areas often span multiple jurisdictions, making it difficult to implement cohesive policies that address both tourism and conservation. Fragmented governance structures can lead to inconsistent regulations, lack of enforcement, and insufficient coordination between tourism operators, local communities, government agencies, and conservation organizations, all of which are critical for the sustainable management of wetland areas. Without a unified approach, efforts to integrate conservation and ecotourism may falter, leaving wetlands vulnerable to degradation. Addressing these challenges requires a multifaceted approach that includes strict regulations, effective infrastructure, education, stakeholder collaboration, and adaptive management to ensure that both conservation and tourism thrive in harmony.

- **Strategies for Integrating conservation and ecotourism**

To successfully integrate conservation and ecotourism in wetland areas, a combination of sustainable management practices, community engagement, education, and strategic planning is essential. One of the first strategies is the establishment of a comprehensive management plan that balances the environmental, social, and economic needs of the area. This plan should be based on thorough research and data collection about the wetland's biodiversity, hydrology, and current tourism trends (Acharya et al, 2009). It should also account for the carrying capacity of the wetland, ensuring that tourism numbers are limited to levels that do not threaten the ecosystem's health. Zoning within the wetland can help designate protected areas where tourism is restricted, while other zones may be allocated for low-impact ecotourism activities. This kind of spatial management prevents the overuse of sensitive areas and helps protect critical habitats for species that depend on wetlands for breeding, feeding, and shelter. Another key strategy is community involvement and empowerment. Local communities are often the first line of defense in conserving wetland areas, and their participation is critical for the success of ecotourism projects. By involving local residents in the planning, decision-making, and management processes, it's possible to ensure that they benefit economically from ecotourism while also fostering a sense of stewardship and responsibility toward the environment. Providing

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training in sustainable tourism practices, hospitality, and guiding can create new livelihoods and incentivize conservation efforts. Moreover, fostering environmental education for both tourists and local communities plays a pivotal role in the integration of conservation with ecotourism. Educating tourists on the ecological significance of wetlands, as well as the potential negative impacts of their actions, can promote responsible behaviour such as staying on designated trails, avoiding littering, and respecting wildlife. Informational programs, nature walks, and visitor centres with exhibits can help visitors understand the value of wetlands and how they contribute to ecosystem services like water purification, carbon sequestration, and flood mitigation. In addition to this, collaborative partnerships between government agencies, non-governmental organizations (NGOs), conservationists, and tourism operators are essential for effective wetland conservation. These stakeholders must work together to create policies, regulations, and incentives that encourage sustainable tourism practices while ensuring the long-term health of the wetland ecosystem. Collaborative research efforts can help identify areas where tourism may be having a negative impact, while also uncovering innovative solutions for sustainable tourism. Another important strategy is monitoring and adaptive management, which allows managers to track the effects of tourism on wetland ecosystems and make adjustments as needed (wetland-initiative.org) . Regular environmental assessments and visitor behaviour monitoring can help identify emerging issues, such as habitat degradation, the introduction of invasive species, or increased pollution, and take corrective action before these issues become severe. This approach is dynamic and flexible, ensuring that both conservation and tourism objectives can be met over time. Additionally, implementing eco-certification programs and sustainable tourism certifications can further incentivize responsible ecotourism practices. These programs encourage operators to meet specific sustainability standards and help tourists make informed choices when selecting ecotourism destinations. Finally, fostering alternative income sources for local communities, such as through handicrafts, sustainable agriculture, or eco-friendly fishing practices, can reduce the pressure on wetlands and allow communities to rely on non-exploitative resources. When properly managed, these integrated strategies not only protect the wetland ecosystem but also promote the sustainable development of ecotourism as a tool for long-term conservation.

Future prospect

The future of wetland ecotourism, integrated with conservation, presents a transformative opportunity for global environmental sustainability and community development. With increasing awareness of the vital role wetlands play in biodiversity preservation, climate regulation, and ecosystem services, wetland ecotourism is poised to become a cornerstone of sustainable tourism (Ramsar.org). As travelers prioritize eco-friendly experiences, wetlands offer unique attractions such as birdwatching, guided nature tours, and cultural heritage exploration, all of which can support conservation efforts when managed responsibly. Advancements in technology, including smart monitoring systems and eco-friendly infrastructure, will further enhance the sustainability of ecotourism activities while minimizing ecological footprints. Local communities stand to benefit significantly from this integration, as they gain access to economic opportunities, skill development, and cultural preservation. Revenue generated from ecotourism can be reinvested into wetland restoration, species protection, and climate resilience projects, ensuring the long-term health of these ecosystems. Furthermore, global policies and collaborations, such as the Ramsar Convention, will continue to promote wetlands as key components of biodiversity and climate strategies. By aligning ecotourism with conservation goals, wetland destinations can evolve into living examples of how humans and nature can coexist harmoniously, creating lasting environmental, social, and economic benefits for future generations.

Conclusion

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Wetlands are invaluable ecosystems that serve as biodiversity hotspots, natural climate regulators, and providers of essential ecosystem services. Wetland-based ecotourism offers a sustainable pathway to conserve these fragile habitats while generating economic and social benefits. By promoting environmental awareness, engaging local communities, and adopting eco-friendly practices, ecotourism can harmonize human activities with conservation efforts. However, challenges such as habitat degradation, lack of funding, and poor management must be addressed through effective policies, innovative solutions, and collaborative approaches. With the growing demand for sustainable travel, the future of wetland ecotourism holds immense potential to contribute to global conservation goals and foster a deeper connection between people and nature. Ensuring that ecotourism is practiced responsibly will secure the long-term protection of wetlands and their irreplaceable benefits for future generations.

https://images.app.goo.gl/RsFFZkoRwogzY1Hx5

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Only Abstracts: Group A

Insights into Water Quality and Meiofauna Dynamics of Ulhas River wetland: A Conservative Approach

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Abstract:

The study aims to explore the water quality and meiofauna dynamics of the Ulhas River wetland, employing a conservative approach to assess the ecological health of this vital ecosystem. The research investigates key water quality parameters such as pH, dissolved oxygen, turbidity, COD and BOD levels, alongside the distribution patterns of meiofauna communities. By monitoring seasonal variations of 3 months for 2 selected sites and anthropogenic influences, this study seeks to provide a comprehensive understanding of how water quality affects meiofauna populations and their role in maintaining the wetland's ecological balance. The findings emphasize the importance of sustainable management practices to preserve the biodiversity and functional integrity of the Ulhas River wetland, highlighting the critical need for conservation efforts to mitigate the impacts of pollution and climate change.

Keywords: Ulhas River wetland, pollution, water quality monitoring, environmental impact, Meiofauna, sustainable practices

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Only Abstracts: Group B

Conserving Saltpans: A Key to Biodiversity and Sustainable Livelihoods

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ABSTRACT: Saltpans are vital coastal ecosystems, home to diverse species of birds, aquatic life, halophilic microorganisms, microflora and microfauna. In Mumbai, key sites like Naigaon, Mulund, and Bhandup provide critical habitats for migratory birds and play a significant role in local livelihoods through salt production. Despite their importance, these ecosystems face severe threats from urbanization, pollution, and climate change.

This review highlights the ecological value of saltpans from Mumbai, focusing on their biodiversity, role in nutrient cycling, and socio-economic significance. It also emphasizes the urgent need for sustainable conservation strategies to protect these habitats from further degradation and ensure their long-term survival. By integrating ecological and economic considerations, saltpans can be preserved as both a natural and socio-economic asset.

Keywords: Saltpans, wetland, ecosystem, migratory birds, habitat, biodiversity, sustainable livelihood

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Marine Litter on Mahim Causeway Beach, India: An Assessment of Their Abundance and Pollution Indices.

Meha Patil, Smruti Patel and Anil Avhad*

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Abstract:

The problem of marine litter is increasing along the Indian coast. For conducting a baseline study to identify and assess the abundance, clean-coast index (CCI), and plastics abundance index (PAI) of marine litter was calculated on Mahim causeway beach of Mumbai, India. A total of 280 marine litter items were collected and classified into 30 groups along the beach.

From the results, plastics were the most abundant items (38.57 %) followed by cloth (22.5 %), along with foam (5%) and others (33.92 %). The average CCI value (6) indicates that the beach is moderately clean; however, the PAI average value (> 8) indicates 'very high abundance'. This study provides an interpretive framework for further plastic pollution assessment, which could lead to a better marine litter management on Indian beaches.

Key words: CCI, PAI, marine litter

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The Green Solution of Fruit Peel Wastes as Bio Adsorbent for Heavy Metal Remediation

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Abstract:

The study investigates the potential of fruit waste, in both powdered and bead forms, as a biosorbent for lead removal from contaminated solutions. Utilizing commonly discarded fruit peels, the research presents an eco-friendly and cost-effective method for heavy metal remediation. Experimental findings reveal that lemon waste powder demonstrated the highest lead removal efficiency, achieving up to 99.69% at 100 ppm after 48 hours. At 50 ppm, lemon waste exhibited the highest adsorption for 24 hours, while chiku waste performed best at 48 hours. In bead form, orange waste showed superior lead removal across all intervals, except for 48 hours at 100 ppm, where apple waste was most effective. The high adsorption efficiency is attributed to the pectin, cellulose, and lignin content in fruit peels, which enhance biosorption capacity. Additionally, fruit waste powders proved to be more convenient and effective than whole plant materials for application in wastewater treatment. The study underscores the environmental and economic benefits of repurposing fruit waste, offering a sustainable alternative for lead remediation. Future research should focus on optimizing biosorption techniques and scaling up the application for large-scale wastewater treatment.

Keywords: Biosorption, Fruit Waste, Lead Removal, Wastewater Treatment, Sustainability

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Seasonal Physiochemical Analysis of Thane Creek

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Abstract

Thane Creek is a significant estuarine ecosystem near Mumbai, India, supporting diverse aquatic life. However, increasing industrialization and urbanization have impacted on its ecological health. This study focuses on the seasonal physiochemical analysis of water and sediment samples collected from different locations in Thane Creek during pre-monsoon and post-monsoon seasons. Various water quality parameters, including pH, temperature, nitrate-nitrite levels, total dissolved solids (TDS), and organic matter content, Salinity, Oil & Grease were analysed to assess seasonal variations. The findings revealed significant changes in water quality after the monsoon, indicating a dilution effect on pollutants. The study highlights the interplay of natural and anthropogenic factors affecting the creek's health and emphasizes the need for sustainable management practices. The results provide a baseline for long-term monitoring and conservation strategies to protect this sensitive estuarine environment.

Keywords -Thane Creek, estuarine ecosystem, water quality, sediment analysis, seasonal variation.

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Scope of Ecotourism in The Conservation of Biodiversity

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Abstract:

Ecotourism is considered as sustainable tourism. It is the most efficient way to reduce stress in the environment by involving local community. The main motive of ecotourism is to promote local culture, employment and conservation initiatives. In India, many states are moving towards the way of eco-friendly tourism and Maharashtra is not staying back. Maharashtra is rich with varied biodiversity ranging from forests, wetland, and grassland to coast and evergreen forest. Wetlands were earlier unnoticed and unexplored, but now it is getting limelight due to many reasons. Many waders, aquatic birds, reptiles, amphibians, mammals, etc. shelters in the wetland ecosystem. Various wildlife sanctuaries and national parks, already have all trained and well-educated resource persons; but some local communities who are blessed with abundant biodiversity lack organisation and sufficient funds for ecotourism. Mangrove foundation is funding for the ecotourism of Mangrove conservation and local community like Swamini self-help group in Sindhudurg is actively involved in mangrove safaris and providing homestays, while in Nandur Madhameshwar Forest department is leading this initiative. Ecotourism helps in conservation and awareness both, as people face positive as well as negative impacts on the environment and interacts with the local community.

Keywords: Ecotourism, Wetland, Community, Maharashtra, Mangroves.

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Posters: Group A

Habitat features influence oviposition site selection in the Indian Goldenback frog *Indosylvirana indica* in the Western Ghats of India

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2. The Niche- Malnad Farm Stay, Sirsi

3. Centre for Ecological Science, Indian Institute of Science, Bangalore

Abstract:

Oviposition site selection can influence offspring survival and can thus affect adult fitness. Although oviposition site selection has important conservation implication, what factors influence oviposition site selection in many species of amphibians remain unknown. Here, we investigate whether habitat and microhabitat features influence oviposition site selection in *Indosylvirana indica*, a stream-dwelling ranid frog that is endemic to the central Western Ghats of India. We tested for non-random selection of oviposition sites by sampling three streams in Sirsi taluk of Uttara Kannada district, Karnataka and comparing the habitat and microhabitat features of 64 plots with egg clutches and 58 plots without egg clutches. We show that *I. indica* preferentially select sites in the stream adjacent to forested patches compared to plantations or agricultural fields. We also show that some factors such as water depth, distance from the stream edge and water temperature has a significant effect on oviposition sites selections, while other factors such as water velocity, canopy cover and substrate composition did not have any significant effect. Overall, we show that oviposition site selection in *I. indica* is non-random and females prefer to lay eggs in warmer shallow waters away from the stream margins in regions of the stream adjacent to forested areas.

Keywords: Western ghat, goldenback frog, habitat, oviposition

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Influence of Habitat Features on the Oviposition site selection of the Indian Golden-backed frog

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[3] Centre for Ecological Sciences, Indian Institute of Science, Bangalore.

Question: What are the habitat and microhabitat factors influencing oviposition site selection of Indian Golden-backed frog (*Indosylvirana indica)*?

Conceptual Background

- Amphibian diversity in the Western Ghats: Home to 90% endemic species and one of the highest concentrations of threatened amphibians globally, yet their ecology and breeding behavior are under-documented.
- Indian Golden-backed frog: *Indosylviranaindica*is a member of the Ranidaefamily. It inhabits moist evergreen and semi-evergreen forests, along with grasslands and marshes of western ghats.
- Knowledge Gap: Understanding oviposition site selection is crucial, as poor choices can significantly impact species population and overall fitness.
- Egg Clutch Survival: Depends heavily on female's choice of oviposition sites.
- Conservation Implications: Critical for species conservation amid the amphibian crisis.

Fig 1. Study Species

Fig 2. Life cycle of frog

Study area

- Study Location: Near Bekkanjaddi village, Sirsi, Uttara Kannada district, Karnataka, India.
- Study Sites: Local stream originating near Bekkanjaddi, passing through Moist deciduous forest.
- Study Focus: Visual encounter surveys of *Indosylvirana indica* egg clutches.

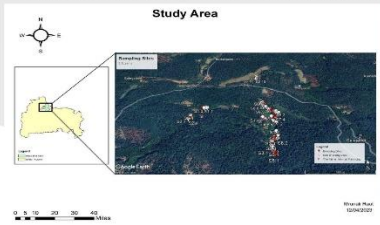
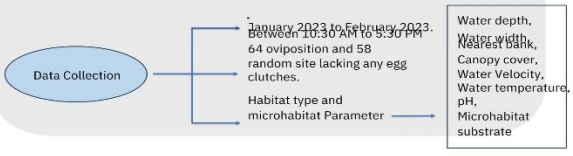


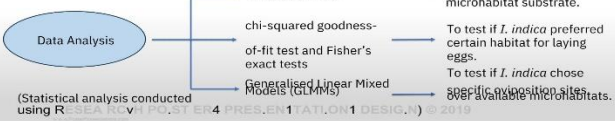
Fig 4. The map of survey sites in near Bekkanjaddi Village

Fig 5. Study site

Methods

Aim: to examine which habitat and microhabitat features are associated with oviposition site selection in *I. indica*





(Statistical analysis conducted using R version 4.1.1 (RESEARCH OTTOSITTER PRESENTATION DESIGN) © 2019

Results

- Habitat selection: *Indosylvirana indica* preferred oviposition sites at stream margins within moist deciduous forests over other habitat types.
- Oviposition site selection: Strongly influenced by water depth, distance from the stream edge, and water temperature.
- *Indosylviranaindica*prefers laying clutches in shallow, warmer areas near the middle of streams.

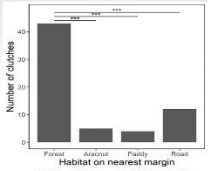


Fig 6. Habitat in the nearest margin of oviposition site

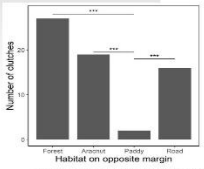


Fig 7. Habitat in the opposite margin of oviposition site

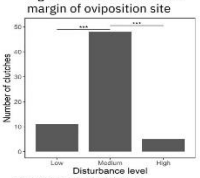


Fig 8. Level of Habitat disturbance in the oviposition sites

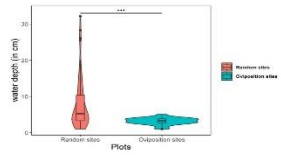


Fig 8. Relationship between site selection and water depth

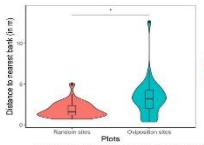


Fig 10. Distance from nearest bank

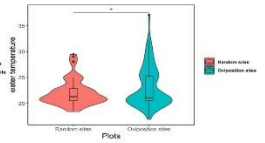


Fig 11. Relationship between site selection and Water temperature

Conclusion

- Breeding Period: The post-monsoon months, especially January, are ideal for the breeding and reproduction of *Indosylviranaindica.*
- Oviposition Site Selection: Within-stream oviposition sites are associated with specific water parameters.
- Conservation Implications: Preserving moist deciduous forests is crucial for the conservation of *Indosylviranaindica.*

Future scope

Further studies are needed to determine the water parameters that favor successful hatching a survival of *Indosylvirana indica.*

Acknowledgement

I express my gratitude to Priti Hebbarfor her support and suggestions in designing the study. I also appreciate the hospitality of the staff at The Niche-MalnadFarm Stay during the study period. Special thanks to ShivonaBhojwani for her valuable insights and to Nikhil Modakfor his assistance with ImageJ analyses. I am thankful to Naman Hegde and Shubham Soni for their field assistance, as well as to HarikrishnanS and Swathi C S and Swathikpadhyfor their valuable suggestions and help in designing this poster.

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Assessment of Environmental Impact of Kamwari River Pollution on Communities in Bhiwandi, Maharashtra, India.

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Abstract:

Water resources have been connected to human well-being, with riverine ecosystems serving as crucial sources for diverse human activities. Over past few decades, increasing human population, improper waste management, and rapid industrialization have adversely impacted water quality at global level. The current study was carried out for evaluating the impact of Kamwari River pollution on the local community in Bhiwandi. Questionnaire survey was used to assess community knowledge, historical and present water usage, perceptions of pollution and its causes, the environmental, health, and occupational impacts on the community. The survey revealed significant decline in water quality, with 88% of respondents acknowledging the pollution in river. In the past, river water was being used for drinking, swimming, fishing, irrigation, etc. However, current usage has declined from 56% to 34%, primarily due to deteriorated water quality. The primary sources of pollution according to the surveyed population were industrial effluents (94%), domestic sewage (54%), and waste dumping (40%). 84% of respondents reporting adverse effects on health, environment, and livelihoods highlighting severity of impact of pollution. Furthermore, 94% of respondents emphasized that efforts taken for pollution abatement are inadequate. Proper treatment of industrial effluents and domestic sewage, proper waste management and community driven efforts are needed for safeguarding ecological health of Kamwari River.

Keywords: Kamwari River, Pollution, Community impact, questionnaire survey

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Assessment of Environmental Impact of Kamwari River Pollution Communities in Bhiwandi, Maharashtra, India

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AIM To study the impact of pollution of Kamwari River on local communities in and around Bhiwandi.

INTRODUCTION

Rivers are known to provide various ecological services to mankind ranging from fresh water for domestic purposes, food resources to acting as a drainage system for surface water during Monsoon. Overcrowding in cities coupled with industrialization, gave birth to the problem of waste management in cities. Mismanagement of solid waste and waste water negatively affected river water quality. Major rivers around the world have become polluted owing to the discharge of untreated domestic sewage and industrial effluents. Kamwari River in Bhiwandi taluka is also on the verge of being biologically dead due to the continuous addition of pollutants through varied anthropogenic sources. The increased pollution levels have detrimental impact on the lives of the local people living in and around the river stretch in Bhiwandi.

STUDY AREA

Kamwari River originates near the foot hills of Tungareshwar Wildlife Sanctuary near Depoli (19°24'58.03"N 73°03' 02. 80"E.) in Bhiwandi Taluka. The river runs across Bhiwandi taluka for about 34 km. For the resent study, questionnaire survey was conducted in and around Bhiwandi along the study stretch which accounted for 24 kms.

Image 1: Satellite map of Study area

MATERIALS AND METHOD

- The questionnaire survey was carried out among the local communities (60 individuals) that were observed near the river bank along the study stretch
- A random sampling technique was used to select people to be surveyed
- Responses recorded using semi-quantitative scales and categorized into Excel for analysis.

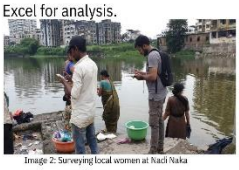

Image 2: Surveying local women at Nadi Naka

Image 3: Solid waste pollution in Kamwarinear Nadi-Naka

OBSERVATION and RESULT

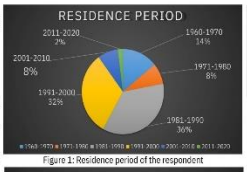

Figure 1: Residence period of the respondent

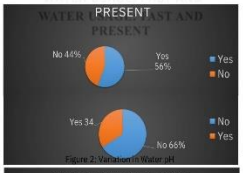

Figure 2: Variation in Water pH

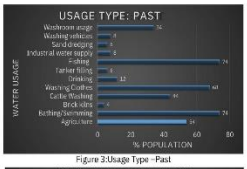

Figure 3:Usage Type –Past

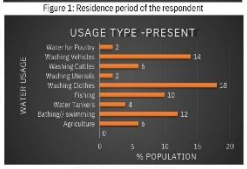

Figure 4:Usage type-Present

Figure 5:Water Quality Rating

Figure 6: Reason for Pollution

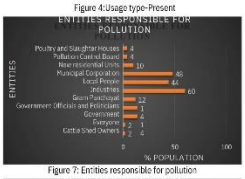

Figure 7: Entities responsible for pollution

Figure 8:Impacts due to pollution

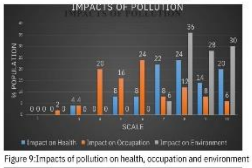

Figure 9:Impacts of pollution on health, occupation and environment

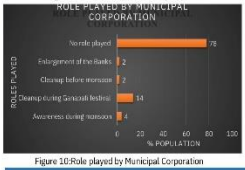

Figure 10:Role played by Municipal Corporation

Figure 11:Responsibility to keep check on pollution

Figure 12:Strategies for pollution prevention

CONCLUSION

- The survey responses revealed a decline in water quality over a period with significant changes observed by long-term residents.
- Community perceptions confirmed pollution of the river, with industrial effluents, domestic sewage, and dumping of waste identified as major contributors
- Many respondents recognized the impacts of pollution on health, the environment, and livelihoods as severe, emphasizing the urgent need for effective mitigation measures.
- Feedback on government efforts to tackle pollution was largely negative, indicating minimal action taken to restore the riverine ecosystem.

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Impact of Industrial Pollution on Water Quality in Bhiwandi's Aquatic Ecosystems: A Comparative Study

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Abstract:

Rivers and lakes serve as crucial sources of livelihood for surrounding communities. However, increasing urbanization and industrialization have led to the emergence of environmental contaminants, particularly heavy metals, which pose significant threats to both human health and aquatic ecosystems. Industrial discharge is a major contributor to heavy metal pollution, and the extent of accumulation in water bodies largely depends on the effectiveness of wastewater treatment processes. Heavy metal contamination adversely impacts aquatic flora and fauna, leading to biomagnification and subsequent risks to human health. This study investigates the presence of heavy metals in key water bodies of Bhiwandi, namely the Kamwari River, Varala Lake, and Diwanshah Lake. Findings indicate that water samples from the Kamwari River contain significantly higher concentrations of copper, lead, and iron compared to those from Varala and Diwanshah lakes. The elevated levels observed in the Kamwari River can be attributed to increased anthropogenic activities in the vicinity, highlighting the need for enhanced pollution management strategies in the region.

Keywords: Heavy metal contamination, aquatic pollution, Kamwari River, Varala Lake, Diwanshah Lake, industrial discharge, biomagnification, water quality assessment, anthropogenic impact.

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IMPACT OF INDUSTRIAL POLLUTION ON WATER QUALITY IN BHIWANDI'S AQUATIC ECOSYSTEMS: A COMPARATIVE STUDY

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ABSTRACT

Rivers and lakes serve as crucial sources of livelihood for surrounding communities. However, increasing urbanization and industrialization have led to the emergence of environmental contaminants, particularly heavy metals, which pose significant threats to both human health and aquatic ecosystems. Industrial discharge is a major contributor to heavy metal pollution, and the extent of accumulation in water bodies largely depends on the effectiveness of wastewater treatment processes. Heavy metal contamination adversely impacts aquatic flora and fauna, leading to biomagnification and subsequent risks to human health. This study investigates the presence of heavy metals in key water bodies of Bhiwandi, namely the Kamwari River, Varala Lake, and Diwanshah Lake. Findings indicate that water samples from the Kamwari River contain significantly higher concentrations of copper, lead, and iron compared to those from Varala and Diwanshah lakes. The elevated levels observed in the Kamwari River can be attributed to increased anthropogenic activities in the vicinity, highlighting the need for enhanced pollution management strategies in the region.

Keywords:
Heavy metal contamination, aquatic pollution, Kamwari River, Varala Lake, Diwanshah Lake, industrial discharge, biomagnification, water quality assessment, anthropogenic impact..

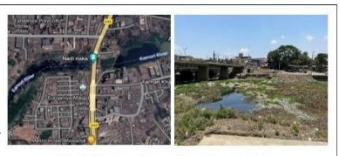

Fig. No. 1: Location of Kamwari River, Maharashtra, India

Fig. No. 2: Location of Varala lake, Maharashtra, India

Fig. No. 3: Location of Diwanshah Lake, Maharashtra, India

INTRODUCTION

1.Heavy Metal Pollution in Water: Aquatic ecosystems are the ultimate recipients of various water pollutants, including heavy metals, which have reached alarming levels worldwide due to industrial and anthropogenic activities.

2.Sources of Heavy Metals: Heavy metals originate from industries, sewage, hospital waste, and recreational activities, as well as natural sources like rock leaching, airborne dust, and vegetation.

3.Toxicity of Heavy Metals: Metals such as arsenic, lead, cadmium, mercury, and chromium are highly toxic even in trace amounts, and their accumulation in water bodies poses serious environmental and health risks.

4.Industrial Growth in Bhiwandi: Bhiwandi, known for its textile and power loom industries, relies heavily on water, leading to significant industrial effluent discharge and increasing water pollution concerns.

5.Pollution in Major Water Bodies: The Kamwari River, once a thriving commercial waterway, is now heavily polluted due to industrialization, while Varala Devi and Diwanshah Lakes face contamination from sewage, domestic waste, and religious activities.

6.Water Quality Assessment: This study focuses on testing the physico-chemical parameters of Kamwari River, Varala Devi Lake, and Diwanshah Lake to evaluate the extent of water pollution in Bhiwandi.

MATERIALS AND METHODOLOGY

•Study Area: Study sites were selected near pollution-prone catchmentareas(Figures1-3). •Sample Collection: Water samples were taken from Kamwari River (S1), Varala Lake (S2), and Diwanshah Lake (S3) using avoid clean containers. •Analysis: Physical parameters (pH, odor, color, temperature) and heavy metal concentrations (Cu, Pb, Fe) were analyzed using the colorimetricmethodfollowingstandardprocedures[8].

OBSERVATION AND RESULT

Physical Parameters for Water Quality Testing

Sr. No.	Parameter	Kamwari River (S1)	Varala Lake (S2)	Diwanshah Lake (S3)
1	pH	8.23	7.28	7.39
2	Odor	Foul	Foul	Slightly pungent
3	Color	Brownish gray	Brownish green	Brownish green
4	Temperature	29°C	28°C	28°C

Table 1: Physical Parameters of Water Samples

Key Observations

•pH: Kamwari River (8.23) shows higher alkalinity, possibly due to pollution disrupting the carbonate equilibrium.

•Temperature Ranges from 28°C to 29°C , affecting microbial activity and aquatic ecosystems.

•Color & Odor : All samples indicate pollution—Kamwari and Varala Lakes emit a foul smell while Diwanshah Lake has a slightly pungent odor, suggesting contamination. These findings highlight significant water quality concerns in Bhiwandi's water bodies.

Chemical Parameters for Water Quality Testing: Heavy Metal Estimation

The analysis indicates that heavy metal concentrations in Kamwari River, Varala Lake, and Diwanshah Lake exceed acceptable limits, posing potential risks to aquatic ecosystems. •Heavy Metal Contamination: Elevated levels of metals such as copper (Cu), lead (Pb), and iron (Fe) may impact water quality and aquatic life. •Environmental Impact: Excessive heavy metals can disrupt ecological balance, harming aquatic organisms and making the water unsafe for consumption or recreational use.

Sr. No	Parameter	Unit	Standard limits as per WHO guidelines (mg/L)	Result: Kamwari river (Sample 1)	Result: Varala Lake (Sample 2)	Result: Diwanshah Lake (Sample 3)
1	Copper (Cu)	mg/L	2.0 mg/L	16.07 ± 0. 43	13.07 ± 0. 68	9.72 ± 0.11
2	Lead (Pb)	mg/L	0.01 mg/L	5.02 ± 0. 22	2.83 ± 0. 08	3.4 ± 0. 10
3	Iron (Fe)	mg/L	3.0 mg/L	4.43 ± 0. 16	4.43 ± 0. 16	3.32 ± 0. 10

Table No. 2: Concentration of heavy metals in the tested samples.

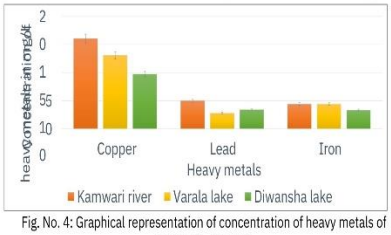

Fig. No. 4: Graphical representation of concentration of heavy metals of Sample 1, 2 and 3

Heavy Metal Contamination in Water Samples

1.Copper (Cu): Essential in small amounts but toxic in excess. Highest concentration in Kamwari River (16.07 mg/L), followed by Varala Lake (13.07 mg/L) and Diwanshah Lake (9.72 mg/L). High levels may cause toxicity in humans and aquatic life. 2.Lead (Pb): A hazardous pollutant affecting neurological and organ health. Detected highest in Kamwari River (5.02 mg/L), with lower levels in Varala (3.4 mg/L) and Diwanshah (2.83 mg/L), requiring urgent pollution control. 3.Iron (Fe): Excessive levels impact water quality. Kamwari and Varala Lakes (4.43 mg/L) show higher iron content than Diwanshah Lake (3.32 mg/L), indicating possible contamination from natural or human activities.

CONCLUSION

This study analyzed water samples from Kamwari River, Varala Lake, and Diwanshah Lake, revealing elevated levels of copper, lead, and iron beyond WHO limits, posing risks to human health and aquatic life.

•Kamwari River had the highest metal concentrations, making its water unsafe for domestic use.

•Heavy metal accumulation in fish raises concerns about bioaccumulation and human consumption risks.

•Urgent action is needed to monitor pollution, regulate industrial discharge, and adopt sustainable management practices to protect water quality and ecosystems.

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Posters: Group B

1. Extract of butterfly caterpillar frass: A novel bio-pesticide

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Use of chemical pesticides has been on rise in recent years as a result of which their concentrations are increasing in wetlands. They not only harm beneficial organisms like pollinators, soil biota but also their runoffs into natural water bodies pose great threat to aquatic flora and fauna both micro and macro. There have been studies on serious negative effects on avi-fauna like migratory birds. Taking into consideration these issues related to chemical pesticides we have come up with a novel bio-pesticide. One of the by-products of insect rearing is the faecal matter (frass). The study is to evaluate the effect of frass as a biopesticide on pests like Spider mites and Aphids. Currently, caterpillars of *Tirumala limniace*, *Danaus chrysippus*, *Graphium agamemnon*, *Papilio polytes* and *Ariadne merione* are selected. These caterpillars are multivoltine and with a relatively shorter life span. Around 15-20 days are required for a caterpillar to change into the next stage (pupal) giving sufficient time for frass collection. Frass can be easily collected and it can be used as biopesticide, soil enricher, manure by farmers. Therefore, we can conduce whether frass shows positive or negative effects, which will open opportunities for promoting butterfly conservation and sustainable agriculture.

Keywords: - Wetlands, Chemical pesticides, Frass, Butterfly caterpillars

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Extract of butterfly caterpillar frass: A novel bio-pesticide

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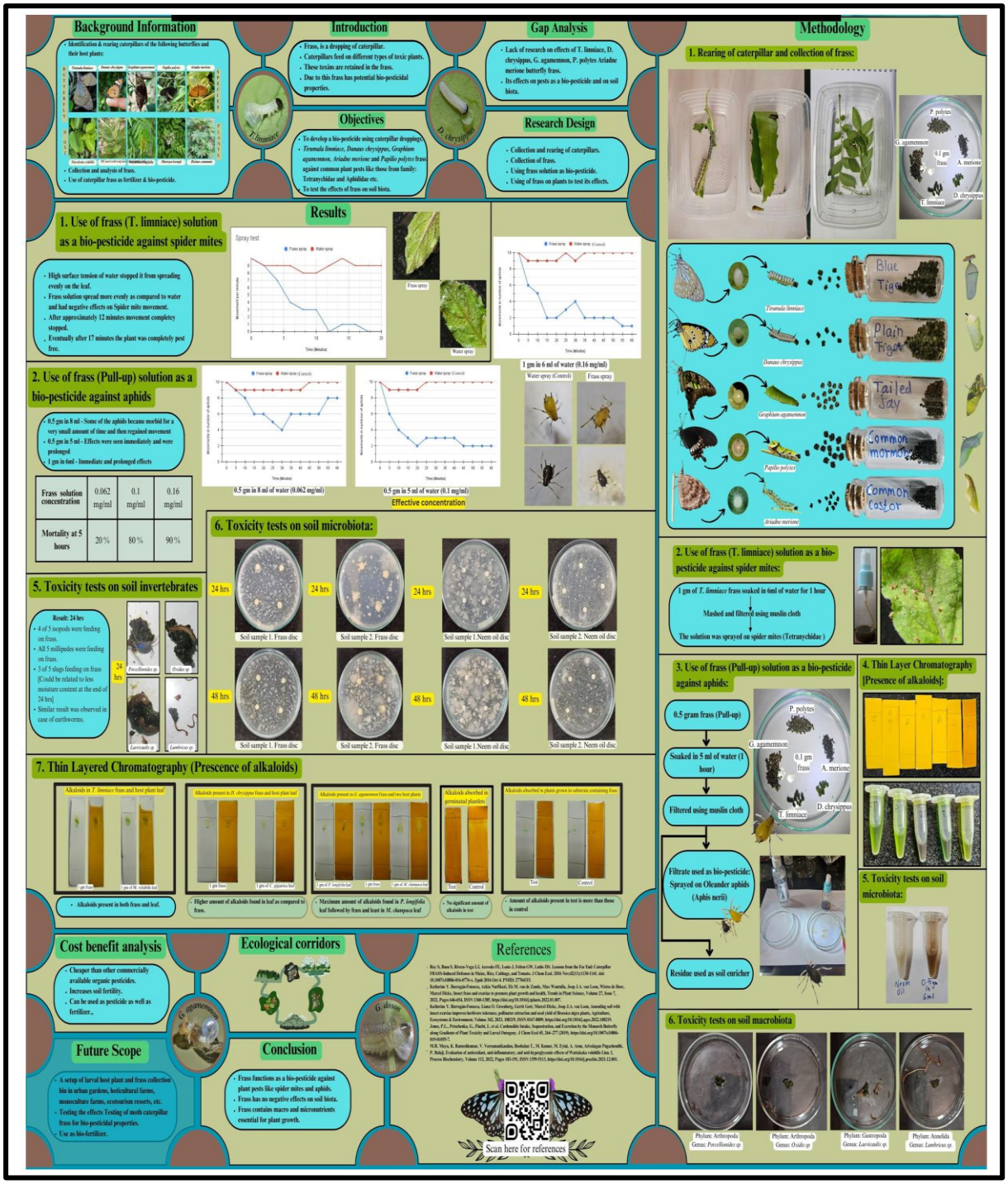

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2. Use of Microbial Biosurfactants to curb biofilms

Anushka Borole, Jagruti Mahadik, Vaishnavi Mane, Sachin Rajagopalan

Department of Microbiology, Ramnarain Ruia Autonomous College

ABSTRACT

Biosurfactants are amphiphilic molecules that exhibit strong surface and emulsifying activities produced by different microorganisms for facilitating nutrient transport. Biosurfactants inhibit the formation of biofilms by inhibiting the quorum sensing mechanism and eradicate the pre-formed biofilms by emulsifying the exopolysaccharide secreted extracellularly by the biofilm-forming organisms which act by lowering their surface tension. In this study, the goal was to screen marine water samples from various locations and screen them for organisms that show the ability to produce biosurfactants. The primary screening procedures included drop collapse test, oil spreading assay, and CTAB methylene blue agar screening and testing the hemolytic properties of the isolates. One of the isolates showed promising results in these tests, which later was identified as *Pseudomonas fluorescens.* Mass production of the biosurfactant was carried out followed by extraction of the biosurfactant by methanol-chloroform solvent extraction procedure. Further, this extract was screened by *Chromobacterium violaceum* based anti-quorum sensing assay. Biofilm inhibition and eradication assay was performed for *Staphylococcus aureus* and *Pseudomonas aeruginosa* biofilms and it was found that the extract exhibited 80% inhibition potential for both the biofilms.

Keywords: Biosurfactants, exopolysaccharide, anti-quorum sensing, inhibition, eradication

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USE OF MICROBIAL BIOSURFACTANTS TO CURB BIOFILMS

Anushka Borole, Jagruti Mahadik,Vaishnavi Mane, Sachin Rajagopalan

Department of Microbiology, Ramnarain Ruia Autonomous College

Introduction :

- Biofilms are complex communities of various microorganisms produced using certain matrices composed of polysaccharides. About 40-80% of bacterial cells on earth form biofilms.
- Bioprospecting is the utilization of biodiversity for their genetic resources for production of certain viable products. Microbial bioprospecting can be one of the aids to look at for the inhibition of the biofilm formation.
- For the formation of biofilm the planktonic cells communicate through the mechanism of quorum sensing. Quorum sensing has its role in metabolic activities of cells involved in the biofilm formed along with increasing its virulence. Hence quorum sensing can be inhibited by disabling it using small molecules- biosurfactants known to be quorum sensing inhibitors becomes a strategy to prevent virulence.
- Biofilms formed by *Pseudomonas aeruginosa* and *Staphylococcus aureus* is used to examine the biosurfactant obtained due to its associations with certain infection and it's resistance towards antibiotics. 96 well plates and Crystal Violet assays of the biofilm of these species are done to study their biofilm forming ability by measuring their absorbance using spectrometry.

Materials & Methods :

• Sample Collection, Enrichment and Isolation :

Marine water samples were collected from 7 locations along the Kokan and Mumbai belt, and soil samples were collected from garages and petrol pumps. Media used: Tryptic soy broth, ISP 1 & 2 (International Streptomyces Project medium), Casein starch broth medium supplemented with crude oil.
Total Strains isolated = 114
All the strains were characterized for their gram nature and morphology.

• Screening to check activity of Biosurfactants :

To screen the samples further for their activity they were tested using Drop Collapse assay and Oil Spreading assay which were used as preliminary tests for selection of strains.

Drop Collapse : In a microtitre well plate ;
well coated with oil + culture suspension supernatant → Oil Drop Flattens

Oil Spreading : In a petri plate ;
Base layer of water + crude oil layer + culture suspension supernatant → Spreading medium on the surface of oil layer

Hemolysis : To check if the organism can lyse RBC's or not by spot inoculating the culture on Blood Agar Plates.

Methylene blue CTAB Agar : It is a Direct Screening method to check for biosurfactant producing organisms done by spot inoculating the culture on CTAB Methylene blue agar plate.

• Mass Production and Extraction :

The culture was subjected for bulk production in the same medium
↓
Medium centrifuged
↓
Supernatant subjected to Methanol and Chloroform (2:1 ratio) extraction method.

• Anti-Quorum Sensing Assay :

The extract of biosurfactant obtained is further analyzed for anti-quorum sensing activity using *Chromobacterium violaceum* and here the zone with no pigment indicates anti-quorum sensing activity shown by the sample.

• Minimum Biofilm Inhibitory Concentration Assay & Minimum Biofilm Eradication Concentration Assay :

This was done in 96 well plates using 2 well known biofilm producing culture of *P.aeruginosa* and *S.aureus*. Well contained :
Media + Agent/Extract + Culture (Incubate for 24-48 hrs) → Inhibition of biofilm
Media + Culture (Incubate for 24 hours) + Agent/Extract → Eradication of biofilm

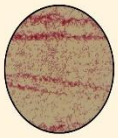
Results :

Out of all the total strains, the **Isolate G2** isolated from the water sample enriched in ISP 2 medium from Girgaon Chowpatty gave promising results and further quantitative analysis was done for the same.

1.Enrichment & Isolation :

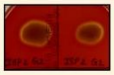
Enrichment of the Marine water samples in ISP2 medium

Isolation of the isolate G2 on Tryptic soy agar medium



Gram Staining of G2 isolate **(Gram-negative short rods)** 1000x magnification

2. Primary Screening :



Hemolysis test for isolate G2 showing Beta Hemolysis

Drop Collapse Assay of the G2 broth in ISP2 medium showing positive result due to collapse of the oil drop.

CTAB Agar Assay of G2 isolate giving a tinge of Bluish color on CTAB agar

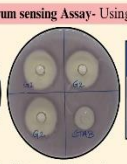
Oil spreading assay of isolate G2 medium broth spreading the oil layer on distilled water.

3. Mass production and extraction of biosurfactant

Mass production was done in the ISP2 medium
Extraction by methanol-chloroform method to extract the biosurfactant produced by the isolate G2

4. Anti-quorum sensing Assay- Using *Chromobacterium violaceum*

Extract of *B. subtilis* - Standard biosurfactant producer.

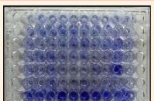


Extract of the isolate G2

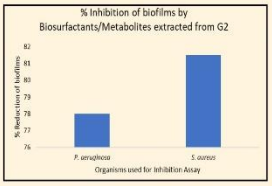
Sample	Zone Diameter (mm)
G2 biosurfactant	23
BS biosurfactant	21.5
10% CTAB	16

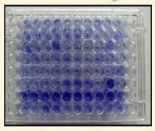
Extracted biosurfactant from G2 giving greater zone size than standards.

5. Minimum Biofilm Inhibitory Concentration Assay



Inhibition Assay of *Pseudomonas aeruginosa*

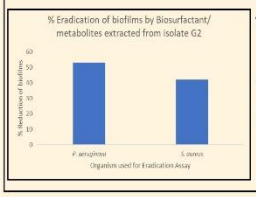




Inhibition Assay of *Staphylococcus aureus*

The biosurfactant extracted from G2 inhibited the biofilm formation of *Pseudomonas aeruginosa* up to78 % and of *Staphylococcus aureus* up to 81.5 %.

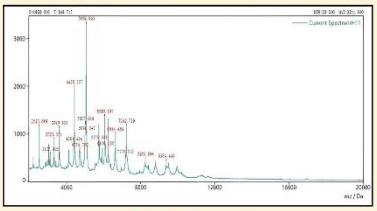
6. Minimum Biofilm Eradication Concentration Assay



The extracted biosurfactant from G2 eradicated the biofilm formed by *Pseudomonas aeruginosa* up to 53% whereas biofilms formed by *Staphylococcus aureus* up to 42%.

Strain Identification Analysis :

Mass Spectrum: *Pseudomonas fluorescens*



Identification Result

Sr No.	Customer Sample ID	Score Value	Organism Identified by MALDI-TOF system
1	G2	9.332	*Pseudomonas fluorescens*

Conclusion :

- The potential Biosurfactant producer i.e. the isolate G2 is identified as *Pseudomonas fluorescens* by using the MALDI TOF analysis system.
- The biosurfactant extracted demonstrated significant inhibition against *P. aeruginosa* and *S. aureus*, with G2 reducing up to 78% and 81.5% reduction respectively.
- In eradication assays, G2-derived biosurfactants effectively disrupted pre-formed biofilms, with efficacy of 53% against *P. aeruginosa* and 42% against *S. aureus.*
- These findings highlight the potential of the isolate G2 as promising antibiofilm agents, particularly for *S. aureus* and *P. aeruginosa* infections, and suggest that biosurfactants from G2 could serve as effective biofilm disruptors.

Future Prospects :

- The most effective isolate will be used for production of the biosurfactant, the agent will be characterized and its production will be optimized.
- The efficacy of the agent will be studied in flow and static system and will be imaged and quantified.
- Biosurfactants can be made available in the form of a ready-to-use formulation or can be coated on medical devices, and surfaces where biofilm growth has to be inhibited. This formulation can be further scaled up for large-scale production of the finished product.
- Further, HPLC can be performed for the identification, analysis and applications of the biosurfactant.

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3. Biomedical Waste Awareness: A Step Towards Wetland Revival

Sayyed Aisha, Ansari Mehwish, Shaikh Namra and Asba Ansari.

Department of Environmental Science, VPM's B.N. Bandodkar College of Science (Autonomous), Thane 400601

Abstract:

This study, titled "Biomedical Waste Awareness: A Step Towards Wetland Revival," aims to evaluate the knowledge, attitudes, and practices (KAP) of biomedical waste management among healthcare professionals and students. Conducted over three months with 103 participants, the study highlights gaps in awareness and compliance, with an emphasis on the adverse effects of biomedical waste on wetlands. Results show that while participants demonstrated adequate knowledge about biomedical waste, practical implementation of proper disposal methods remained insufficient. The study concludes that enhancing awareness, strengthening regulations, and promoting sustainable waste management practices are essential steps toward mitigating wetland degradation and ensuring ecological conservation.

Keyword: Biomedical waste, Awareness Survey, Management

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BIOMEDICAL WASTE AWARENESS: A STEP TOWARDS WETLAND REVIVAL

Sayyed Aisha , Ansari Mehwish , Shaikh Namra and Asba Ansari.
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ABSTRACT

This study, titled "Biomedical Waste Awareness: A Step Towards Wetland Revival," aims to evaluate the knowledge, attitudes, and practices (KAP) of biomedical waste management among healthcare professionals and students. Conducted over three months with 103 participants, the study highlights gaps in awareness and compliance, with an emphasis on the adverse effects of biomedical waste on wetlands. Results show that while participants demonstrated adequate knowledge about biomedical waste, practical implementation of proper disposal methods remained insufficient. The study concludes that enhancing awareness, strengthening regulations, and promoting sustainable waste management practices are essential steps toward mitigating wetland degradation and ensuring ecological conservation.
Keyword: Biomedical waste, Awareness Survey, Management

INTRODUCTION

Biomedical waste management is a critical issue that directly impacts environmental health, public safety, and ecological balance. As healthcare facilities generate significant quantities of biomedical waste, improper disposal poses risks of contamination, infectious disease transmission, and environmental degradation. A major concern is the detrimental effect of biomedical waste on wetland ecosystems, which play a vital role in maintaining ecological stability. Wetlands act as natural water filters and biodiversity hubs, but are increasingly threatened by biomedical waste pollution. Addressing awareness about biomedical waste management among healthcare professionals and the public is a crucial step toward reviving and protecting wetlands from further harm.

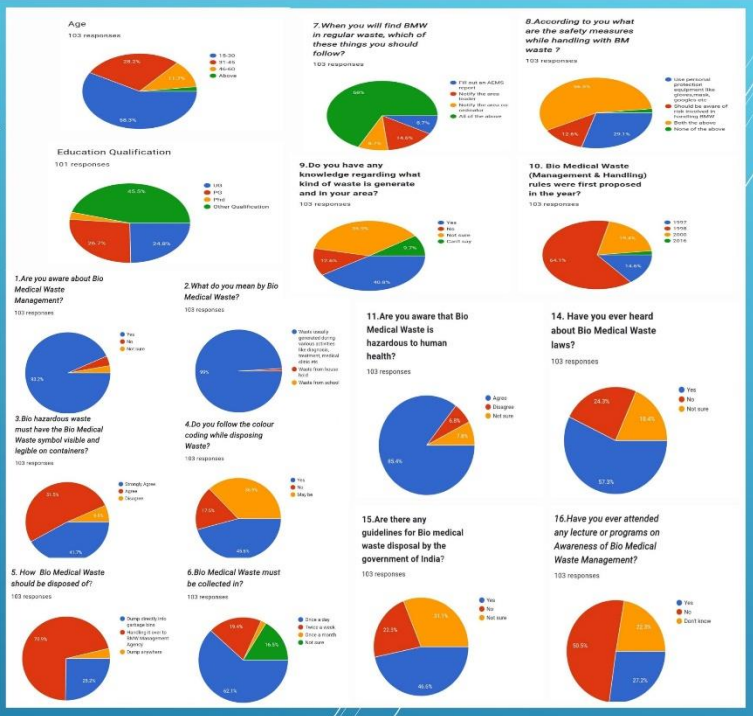
METHODOLOGY

Study Design: A cross-sectional study conducted over three months.
Study Sample Size: A total of 103 participants, including 27 males and 76 females from healthcare facilities and educational institutions.
Study Tool: A structured questionnaire consisting of 16 questions divided into three sections: 1. Knowledge assessment (6 questions with Yes/No/Not Sure responses). 2. Attitude evaluation (4 questions with Agree/Disagree options). 3. Practices and awareness about disposal methods, safety measures, and environmental impact (6 questions). Data Analysis: The data were analyzed using graphical representation to identify knowledge gaps and evaluate responses concerning biomedical waste disposal and its impact on wetlands.

Fig 1: Khadipar Creek, Bhiwandi

Fig 2: Kamvari River, Bhiwandi

OBSERVATIONS AND RESULTS



DISCUSSION

The study revealed that while 93% of participants were aware that biomedical waste is generated and 99% could define it correctly, there were significant gaps in practical knowledge and disposal practices. While 41.7% agreed and 51.5% strongly agreed that biohazard symbols should be visible on containers, only 45.5% followed the color-coding system for waste disposal, and 70.9% thought it could simply be dumped in regular garbage. Additionally, only 46% were aware of the legal regulations for biomedical waste disposal, and 27.2% had attended any educational programs on the topic. These findings highlight the need for improved training and awareness campaigns to bridge these knowledge gaps and ensure safe, responsible biomedical waste management, protecting both public health and the environment.

CONCLUSION

- Biomedical waste awareness is a crucial step toward wetland revival and environmental conservation.
  Proper disposal practices, supported by public awareness, technological innovations, and strict regulatory frameworks, are essential to mitigate the impact of biomedical waste on ecosystems.
- The study underscores the importance of integrating waste management education into healthcare curricula and promoting community involvement in wetland restoration efforts.
- By prioritizing sustainable waste management, we can ensure a healthier environment and protect wetlands for future generations.

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4. Study of Molluscan Shells in Priyadarshini Park Beach, Mumbai

Mitali Pote, Sanjana Gunjal and Gayathri N.

Department of Zoology, MES's The D.G Ruparel College of Arts, Science and Commerce, Mahim, Mumbai-400016

Abstract:

Mollusca is the second most diverse animal phylum with over 100,000 species. The phylum includes many well-known organisms including clams, mussels, snails, squids and octopuses. Mumbai's once pristine shoreline is slowly polluted with plastic and other debris, which can harm the marine environment and ocean species. Invertebrate shells are good bioindicators of environmental pollutants. They exhibit physical changes in their color, structure and shape, in addition to the variation in their chemical composition due to accumulation of heavy metals. The aim of the study is to survey the molluscan shells and along the Priyadarshini park beach shore for over a period of four months and make a record of the same. This can serve as a baseline data for continuous monitoring of the region over a period of time.

Keywords: Bioindicator, Marine environment, Pollution

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Introduction

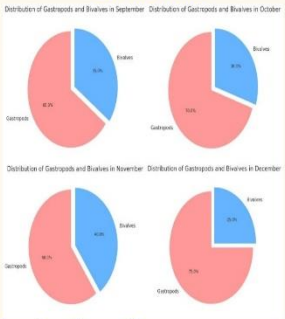
Biodiversity is essential for the processes that support all life on Earth, including humans. The intertidal zone, commonly known as the littoral zone, is the area between land and sea that is covered by water at high tide but not during low tide. It is part of the coast which is highly variable, and one of the diverse areas providing shelter to several intertidal fauna such as crustaceans, polychaetes, amphipods and molluscs. Ever increasing human population, habitat destruction and pollution along the Mumbai coast are some of the major threats to molluscan fauna.

This study focuses on the Molluscan biodiversity in the intertidal zone of the Priyadarshini Park Beach, Mumbai to identify the different types of molluscan species present in the intertidal zone and assessment of water sample provide us information about the quality of water

Methods And Materials

- Location of study: Priyadarshini Park Beach, Mumbai
- Beach walk and survey of the Molluscs was carried out during lowest lowtide on monthly basis from September 2024 to December 2024
- Photography of Molluscan species was done by mobile cameras
- Identification of species by using "Sea Shells of India" by Deepak Apte
- Water sample collection and estimation of Silicates, Phosphates and pH using standard procedures

Observation



Molluscan Shells

Result and Conclusion

- The species found abundantly in September month was Semiricinula tissoti and in October month was Littorina littorea. The dominant species seen in November month was *Lajonkairia lajonkairii* and in December month was *Gafrarium divaricatum.*
- Amount of Silicates present is 195µg/L, concentration of Phosphates is 130mg/L and pH is 6.5. The observed Gastropods species were ranging
- from 65% to 75% and Bivalves from 25% to 40% As the area of study was a rocky patch, many live organisms were attached to the substratum
- Rocky shores are home to diverse organisms, including molluscs. Variation in water parameters can affect their growth, reproduction and
- survival Rocky shores are highly productive zones and checking water parameters helps assess the extent of pollution and its impact on the local habitat. Monitoring water parameters is vital for understanding the
- health, productivity and sustainability of rocky shore ecosystems and for implementing measures to preserve these biologically rich habitats.

Sample collection and Estimation

Parameters	Observed Value
Silicates	195 µg/L
Phosphate	130 mg/L
pH Value	6.5

References

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- "Sea Shells of India" book by Deepak Apte
- https://www.researchgate.net/publication/371303644_Molluscan_Biodiversity_of_Juhu_Mumbai_Maharashtrax

Acknowledgement

We express our gratitude to our principal Dr. Dilip Maske and our Head of Zoology Department, Mr. Nitin Wasnik for providing us with the opportunity and encouraging us to complete this study. We also wish to acknowledge our laboratory staff for their assistance. Lastly, we thank our classmates Rajeev and Rishabh for helping us in our study.

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5. Assessing the Water Quality of Three Urban Lakes in Thane: A Baseline Study

Nandini Pandey, Virashree Churi and Sumaiyya Zainul Islam

Department of Environmental Science, VPM's B.N. Bandodkar College of Science (Autonomous), Thane 400601

Abstract:

This study presents a comprehensive analysis of the water quality of Kasarvadavali Lake, Owala Lake, and Kavesar Lake, aiming to assess its suitability for various uses and to identify potential environmental concerns. Sampling was conducted at multiple locations within the lake. Covering parameters such as Physical and Chemical Parameters. The results were analyzed using standard methods. Overall, the findings provide valuable insights into the current state of Kasarvadavali lake, Owala lake, and Kavesar lake, highlighting areas of concern and potential strategies for its preservation and management.

Keywords: Lakes of Thane, water quality, Conservation and Management

ISBN 978-81-926582-1-6

ASSESSING THE WATER QUALITY OF THREE URBAN LAKES IN THANE: A BASELINE STUDY

NandiniPandey, VirashreeChuriandSumaiyyaZainulIslam

Department of Environmental Science, VPM's B.N. BandodkarCollege of Science (Autonomous), Thane 400601

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Keywords: Lakes of Thane, water quality, Conservation and Management

Introduction:

Lakes and wetlands support biodiversity, regulate climate, and provide essential resources. Healthy lakes sustain wetlands, which filter pollutants, prevent floods, and support life. However, pollution, overuse, and climate change threaten these ecosystems. Monitoring water quality (pH, DO, nutrients,TSS&TDS)andreducingrunoffare crucialforconservation.

Objective:

This study assesses the physico-chemical characteristics of Kasarvadavli, Kavesar, and Davale Lakes to evaluate their water quality for fishing, irrigation, and recreation. It identifies pollution sources from anthropogenic activities like washing and idol immersion, monitors aquatic biodiversity threats, and explores the lakes' roles in groundwater recharge, flood mitigation, and carbon sequestration. Emphasizing their ecological significance as urban wetlands, the research highlights the need for regular monitoring, pollution control, and community involvement to ensure sustainableuse andconservationforfuturegenerations.

Study Areas:

Kasarvadavali Lake: Supports biodiversity but faces pollution; restoration efforts include cleanups and tree plantations. Mogharpada Davale Lake: Historic lake affected by waste dumping; improved conditions need further restoration. Kavesar Lake: Urban lake under TMC restoration, with a lotus-filled section enhancing its scenic value. Anthropogenic Threats: Ram Mandir Lake: Polluted by religious rituals. Kavesar Lake: Littering from recreation. Mogharpada Davale Lake: Affected by washing and waste disposal. Sustainable practices, community efforts, and regular monitoring are vital for preserving these lakes and wetlands for future generations.

Fig 1: Ram Mandir Kasarvadavli lake

Fig 2: Mogharpada Davale lake

Fig 3: Kavesar lake

Methodology:

pH: Measuredon-siteusingapHpen.

Temperature:Measuredbyimmersingathermometerinthesamplefor10seconds.

Color: Determinedbydirectvisualobservation.

TSS: InitialweightofWhatmanfilterpaperrecorded,5mlsamplefiltered,dried,andweighed.

TDS: Sampleevaporatedinanovenusinganevaporatingdish;weightrecordedpost-drying.

TS (Total Solids): CalculatedbyaddingTSSandTDS.

Alkalinity: Titrated with 0.1N H_2SO_4 using phenolphthalein and methyl orange indicators.
Acidity: Measured using methyl orange and titration with 0.005N NaOH.
DO: Determined using Winkler's method and titration with 0.025N $Na_2S_2O_3$.
BOD: Performed using Winkler's method, with initial and final readings recorded after 3 days of incubation.

Observation and Result:

Water Quality Parameters of Lakes					
Sr. No.	Parameter	Kasarvadavali Lake	Davale Lake	KavesarLake	Permissible Limit set by CPCB & BIS
1	Temperature (°C)	21	21	20	10–20 (Ideal for freshwater life)
2	Color	Greenish	Greenish	Greenish Blue	–
3	pH	7.5	8.0	7.3	6.5–9.5
4	Acidity	0	0	0	–
5	Alkalinity	0	0	0	–
6	Chloride (mg/l)	65.32	42.6	69.58	1–250
7	Dissolved Oxygen (DO) (mg/l)	5	3	4	4–6
8	BiologicalOxygen Demand (BOD) (mg/l)	0	1	2	<5
9	Total Dissolved Solids (TDS) (mg/l)	458	264	302	<500

Table :- Physico-chemical parameters for evaluating water quality in lakes

Conclusion:

When comparing the water quality parameters of Kasarvadavali, Davale, and Kavesar Lakes with the permissible limits, it is observed that the lakes are not highly polluted at present. Most parameters, including pH, chloride, BOD, and TDS, fall within acceptable limits, indicating relatively good water quality. However, some concerns, such as the low dissolved oxygen (DO) in Davale Lake and the greenish coloration in Kasarvadavali and Davale Lakes, suggest early signs of organic pollution and algal growth.If proper precautions are not taken, such as controlling nutrient runoff, preventing waste discharge, and maintaining proper aeration, the water quality may deteriorate over time. This could lead to exceeding permissible limits, resulting in severe pollution and harm to aquatic ecosystem. Therefore, timely conservation efforts and regular monitoring are essential to ensure the long-term health of these lakes.

Environmental Significance:

- Biodiversity: Lakes support aquatic species, ensuring ecosystem balance.
- Groundwater Recharge: Vital for replenishing water tables.
- Climate Regulation: Moderate local climates.
- Water Purification: Naturally filter pollutants.
- CarbonSequestration:AbsorbCO_2,mitigatingclimatechange.ImpactofLakeConservationonWetlands
- Habitat Protection: Preserves wetland ecosystems.
- Pollution Control: Reduces eutrophication in wetlands.
- Flood Mitigation: Acts as reservoirs to protect wetlands.
- Enhanced Ecosystem Services: Boosts purification and sediment trapping.

Conserving lakes ensures wetland health, biodiversity, and ecosystem sustainability for future generations

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6. Exploring the abundance and migration of Black-tailed Godwits wintering in Thane Creek (Ramsar Site), Indian West Coast

Authors: Pranay Khadanga, Sameer Bajaru, Mrugank Prabhu and Rahul Khot

Abstract:

Black-tailed Godwit (BTG) is widely distributed across the Palearctic, breeding from Iceland to western Russia and wintering in Europe, Africa, Asia, and Australasia by traveling through different flyways. There are numerous studies on BTG migration being conducted in the African-Eurasian Flyways and the East Asian-Australasian Flyways. However, information on the Central Asian Flyway (CAF) is limited even though around 150,000 godwits winter in South Asia. Moreover, the alarming decline in the global population of BTG has created an urgency for understanding their population trend and migratory patterns to aid their conservation. This study explores the migration routes of BTGs using a small (3.5 gm) solar-powered Global Positioning System (GPS) radio transmitter, as well as their general population trend, using transect count data from 2018 to 2023 collected from Thane Creek, Maharashtra, India. The preliminary findings suggest that the overall population of BTG wintering in Thane Creek has increased gradually, but the results should be used cautiously as surveys did not cover the whole wintering period of the godwit in 2019–20 and 2020–21 due to COVID. The satellite telemetry has shown that the tagged BTG flew to Southwestern Siberia and back, revealing critical information about staging, stopover, and breeding sites. These findings would provide baseline data for further investigations on population dynamics and migration of BTG— particularly in the CAF— which eventually helps in taking appropriate actions to conserve the species.

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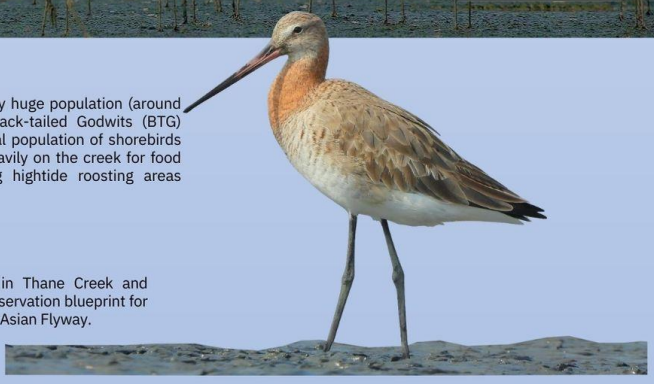
Pranay Khadanga, Sameer Bajaru, Mrugank Prabhu & Rahul Khot
Bombay Natural History Society, India

INTRODUCTION

- Thane Creek (Ramsar site) hosts a significantly huge population (around 1,15,000) of migratory birds every year. Black-tailed Godwits (BTG) constitute approximately 7 percent of the total population of shorebirds wintering at Thane Creek. These birds rely heavily on the creek for food supply and take refuge at the surrounding hightide roosting areas throughout the non-breeding season.



AIMS

We aim to explore the population dynamics of BTG in Thane Creek and understand their complete migratory route to create a conservation blueprint for Godwits arriving on the West Coast of India via the Central Asian Flyway.

METHODS

Determined Sampling units/Transects using Occupancy modelling and likelihood-based methodology.

The population of BTG was estimated using block and total count methods 2018-2023.

80 BTGs were captured and marked at hightide roosting sites simultaneously.

A BTG (Ring No. C-55730, Flag 5J4) was tagged with a solar-powered GPS radio transmitter on April 2022.

Data was downloaded using a base station attached to a laptop and hand-held Yagi antenna.

Data from Milsar's Telemetry Data Manager software were processed for analysis and visualisation using the move' package in R 4.2.1.

RESULTS & DISCUSSIONS

- Our preliminary findings suggest that the overall population of BTG wintering in Thane Creek has increased gradually, but the results should be used cautiously as surveys did not cover the whole wintering period of the godwit in 2019–20 and 2020–21 due to COVID.
- The study suggests that godwits wintering in India, mainly along the west coast, are migrating to Siberia, crossing Central Asia's deserts and mountains, using wetlands and rivers as stopover sites.
- In contrast, they have few short stopovers throughout their southward journey and fly directly over mountains and deserts before reaching their wintering grounds.

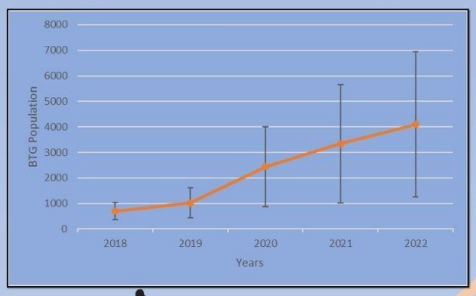


Fig. 1 Mean BTG population estimated from 2018-2022

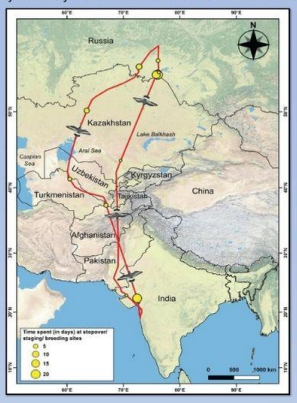


Fig. 2 Migration track of a Black-tailed Godwit between wintering (India) and breeding (Siberia) grounds. Yellow-filled circles represent stopover/staging/breeding sites; their sizes show the number of days spent at the sites.
Base Map: ESRI Physical; Coordinate Reference System: WGS84; Prepared in QGIS 2.18.1

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ACKNOWLEDGEMENT

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7. Biocultural Perspective of Pond Biomass Harvesting: Lessons from Prabalmachi in Panvel tehsil of Raigad district

Dewasi Pravin Kanaram and Lawhale Aditya Narayan

VPM S K.G. Joshi College of Arts and N.G. Bedekar College of Commerce (AUTONOMOUS) Chendani Bunder Road, Thane - 400601

Abstract –

Sahyadri is the local name of the northern part of a Western ghat in Maharashtra. Irregular topography with high rainfall and immense biodiversity in fauna and flora many of them endemic to the region responsible for the existence of diverse and unique cultural identity.

Biocultural is the study of how biological and cultural factors affect human behaviour. This research considers local Bio Manure of ponds and waterbodies at Prabalmachi and its relation with people. Pond biomass refers to the total amount of living matter, including plants, animals, and microorganisms, present in a pond ecosystem.

The research consists of a mixed-methods to understand man-environment relationship, approach, combining ethnographic observations, interviews and Surveys on Water bodies consisting Organic Manure. The findings highlight the importance of manure in maintaining soil fertility, supporting biodiversity, and fostering community resilience.

KEY WORDS – Biocultural, Biomanure, Pond Biomass

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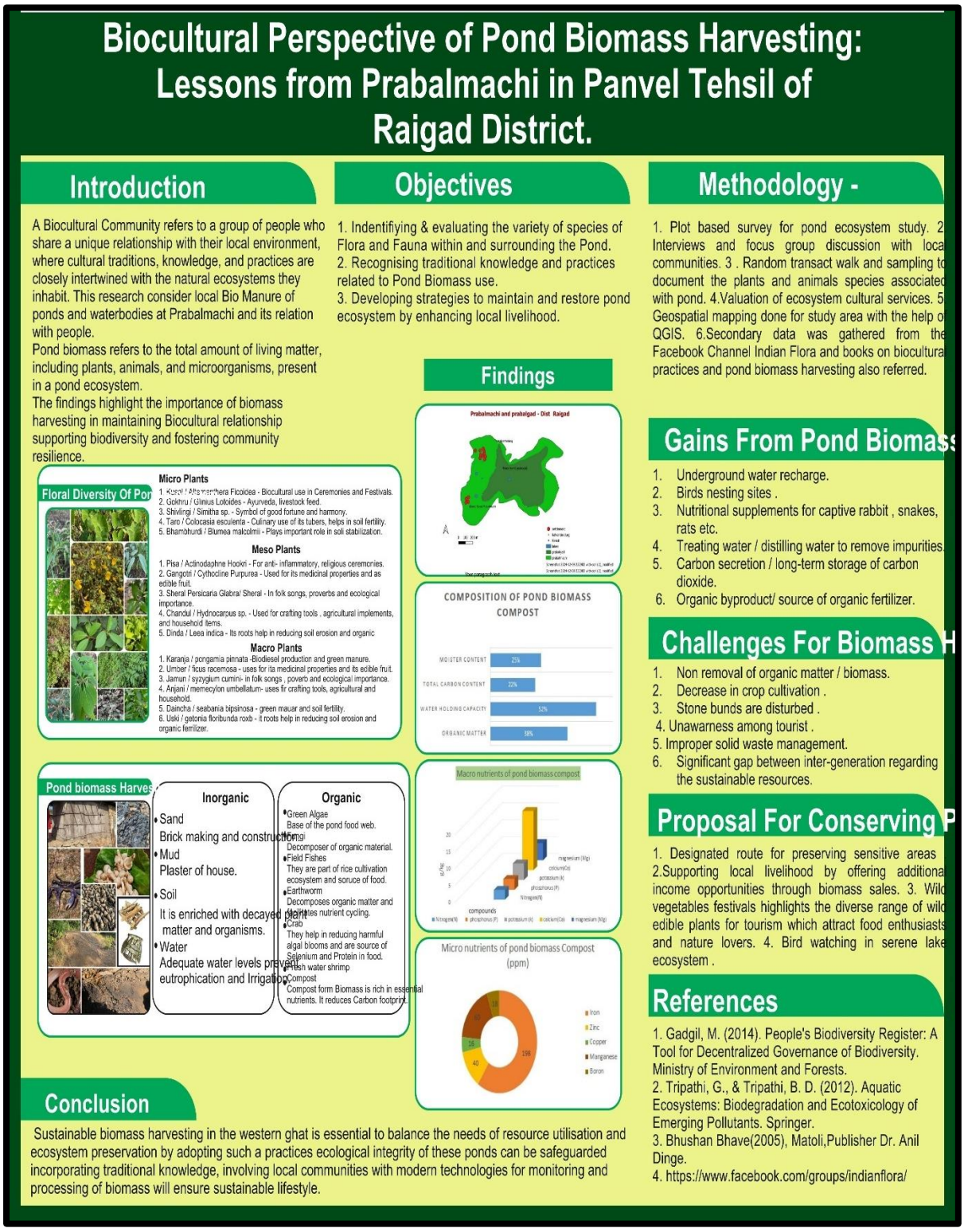
Dewasi Pravin Kanaram, Lawhale Aditya Narayan



ISBN 978-81-926582-1-6

Survey of Molluscan Shells in Juhu Beach, Mumbai

Rajeev Gawde, Rishabh Jha and Gayathri N.

Department of Zoology, MES's The D.G Ruparel College of Arts, Science and Commerce, Mahim, Mumbai-400016

ABSTRACT

Earth provides basic resources such as food, medicine, and clean air for human good. By conserving biodiversity from extinction an ecological balance is maintained which is vital for sustainable development of the world and in combating climate change effect. Due to widespread occurrence ecological diversity and ability to bio accumulate pollutants, molluscan and foraminiferan shells are often used as bio-indicator of marine pollution. Additionally, the reaction to pollutants offer insight into potential ecosystem risk and human health concern related to consuming contaminated sea food. In this study, a survey of molluscan shells has been conducted for a period of four months from September to December 2024 at Juhu Beach. The observations were then compared to the existing data available in order to understand the currently scenario.

KEYWORDS: Juhu Beach, Bio-indicator, Pollutants, Molluscan Diversity

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Introduction

Molluscs represent a part of marine ecosystems that may give information about environmental conditions, types of habitat, and seasonal variations. This study considers the distribution of molluscs on Juhu Beach during four monthly periods with a specific emphasis on gastropods and bivalves. The data represent the number of various molluscs species observed in the area during these months and has been categorized and presented

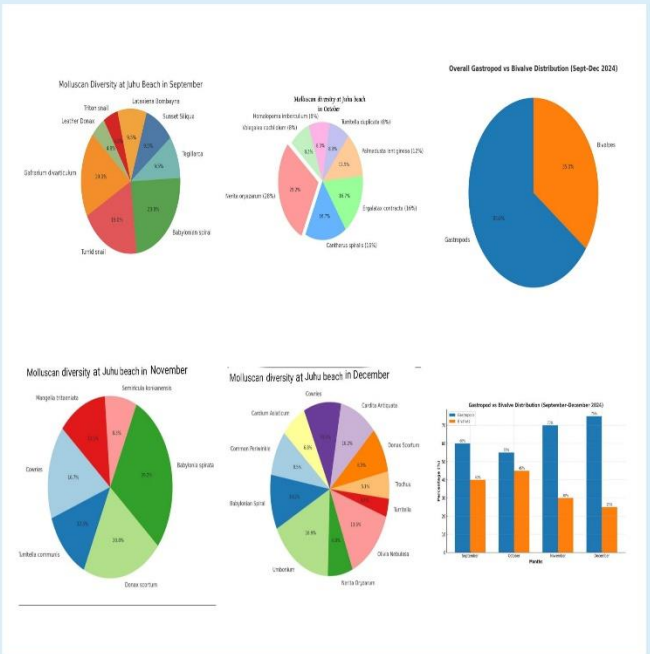
Juhu Beach | Turricula Javana | Babylonia Spirata | Cardiata Bicolor | Monodonta Vermicula | Gyrineum Natator | Common Periwinkle

Methods & Materials

Location of study: Juhu Chowpatty Beach, Mumbai• Beach walk and survey of the Molluscs was carried out on monthly basis from September to December.• Photography of Molluscan species was done by mobile cameras.• Use of the book "Sea Shells of India" by Deepak Apte to identify different species of Molluscs.•Standard procedures were carried out for the assessment.

Result and Discussion

Significant variations in species distribution was Observed each month The abundant species in September were *Tegillarca*, *Gafrarium divariculum*, and *Sunset Siliqua*, while *Homalopoma imberculum*, *Paradilla patruelis*, and *Turritella* duplicata were in abundance in October. In November showed *Semiricula konkanensis*, *Babylonia spirata*, and, finally, *Cowries* were largely found in December included *Cowries*, *Cardita antiquata*, and *Babylonian Spirals*. Gastropods were abundant and bivalves made up the remaining 25%. a sizable quantity of collected shells were broken and bleached, thus giving an indication of possible environmental stress or some form of influence by humans on the molluscan population.



Conclusion

During the study, it was revealed that Gastropods were much more diverse than bivalves at Juhu Beach from September to December 2024. Changes in the distribution of species could be related to seasonal differences with respect to environmental or anthropogenic stresses. This calls for immediate conservation efforts for molluscs and for ensuring a continuing healthy ecology at Juhu Beach.

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Wetlands in Mumbai And Navi-mumbai Challenges, Conservation and Opportunities

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Abstract:

Wetlands in Mumbai and Navi-mumbai are vital ecosystems that provide critical services such as flood control, water purification, carbon sequestration, and biodiversity conservation. These ecosystems, including mangroves, marshes, salt pans, act as buffers, protecting urban areas from flooding and supporting ecological balance amidst rapid urbanization. However, these wetlands face challenges. The lack of strict enforcement of environmental regulations and limited public awareness further exacerbate these threats. Despite these challenges, there are opportunities for conservation. Strengthening legal frameworks, fostering community participation, and adopting technology for monitoring and restoration can safeguard these ecosystems. The panje wetland must be declare as part of Thane flamingo sanctuary because the birds from sanctuary uses panje wetland as high tide roosting area and also to avoid land reclamation. Integrating wetlands into urban planning, promoting eco-tourism, and encouraging collaboration among government agencies, NGOs, and local communities can also support their sustainable management. Building of ecological corridor between panje wetland and thane creek flamingo sanctuary. This poster investigates the ecological importance of wetlands in Mumbai, Navi Mumbai, and Vasai, highlighting opportunities for their conservation and long-term sustainability. To make vasai creek less pollutant certain species of plants can be planted like (*Avecennia marina, sonnertia alba* and *ceriops tagal*)

Keywords: Wetlands, Ecological Importance, Conservation, Opportunities

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WETLANDS IN MUMBAI AND NAVI-MUMBAI:CHALLENGES, CONSERVATION AND OPPORTUNITIES

Name: Rushabhkumar Agawane Guide: Dr. Nisha Shah Institution Name: University Of Mumbai [Department of life sciences]

wetlands

❖Wetlands are transitional areas between uplands and deepwater environments. They can be covered by salt, fresh, or brackish water.
❖It functions as its own distinct ecosystem
❖Wetlands are home to a variety of aquatic and terrestrial species. They also provide important habitats for wildlife like marine annelids crustaceans fishes and birds

Opportunities

- Habitat restoration
- Green infrastructure
- Ecological park
- Advanced Sewage treatment
- Community awareness
- Soil restoration
- Eco-tourism
- Mangrove restoration
- Strengthening MPCB ACT

Ecological importance of wetlands

- Wetland undertakes ecological processes i.e water and carbon cycles.
- They provide habitats and support diverse range of biodiversity.
- They are also called as habitat nursery

Panje wetland

One of the Last Remaining Wetlands in Navi Mumbai

- Panje Wetland is among the few remaining natural wetlands in the region
- Preserving this wetland is crucial for the survival of local wildlife and biodiversity.

Threats to the Wetland

- Infrastructure Projects
- Illegal Encroachments

Vasai creek

Serious Threats to Vasai Creek

- **Urbanization**
  Rapid expansion of urban areas near the creek is encroaching on its natural habitat.
- **Industrial Pollution**
  Industrial effluents and untreated sewage are being discharged into the creek
- **Threat to Aquatic Life**
  The deterioration of water quality puts aquatic life at risk, including fish and other marine organisms.

Mumbai wetlands { mahim-sewri}

Threats to Mahim Creek and Sewri Creek

- **Plastic Pollution**
  Both creeks suffer from large amounts of plastic waste and other non-biodegradable materials being dumped directly into the water.
- **Shipping and Marine Traffic**
  Heavy traffic and shipping activities lead to water heavy maritime contamination and the risk of oil spills.

Major wetlands

- Mumbai [mahim-sewri]
- Vasai creek
- Panje wetland

- Mumbai, a city with a high population density, is home to a diverse range of wetlands, such as creeks, mangroves, lakes, mudflats, and marshes.
- Vasai Creek, situated in the western part of Mumbai, India, is a vital estuarine ecosystem that provides essential ecological services.
- Panje wetland is situated to the west of Dongri and Panje villages.

Threats to wetlands

- Population growth
- Land filling and dumping activities
- Urbanization
- Water quality Issues
- waste management

LONGTERM SOLUTIONS

- ❖ Reducing heavy metal deposition in Vasai creek
- ❖ Penalties for Violating the EPA Act Industries found violating the act should face penalties under Section 5
- ❖ For habitat restoration, seagrass beds using specific fast growing species *Halophila ovalis*
- ❖ Mangrove reforestration some plants can also be planted like *(Avecennia marina,sonnertia alba, ceriops tagal)*
- ❖ Establishment of a linear ecological corridor between Panje Wetland and Thane Creek Flamingo Sanctuary
- ❖ Aims to enhance habitat connectivity, support avian biodiversity, and facilitate the movement
- ❖ Green infrastructure should be prioritized in Mumbai's wetland areas, with collaborative efforts

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Conserving Estuaries: The Nexus of Life and Livelihood

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Abstract

Estuarine ecosystems, where freshwater and seawater converge, are among the Earth's most productive and vital habitats. These areas are essential for biodiversity preservation and play a significant role in global food security. They sustain a wide array of marine species, act as critical breeding and nursery grounds for commercially important fish, and support the livelihoods of millions of people living in coastal regions. However, these ecosystems face severe threats from pollution, overfishing, habitat destruction, and the impacts of climate change, all of which contribute to the loss of biodiversity and the degradation of ecosystem services. To safeguard these valuable systems, it is crucial to implement robust conservation measures such as mangrove restoration, pollution management, sustainable resource utilization, and effective policy enforcement. Protecting estuarine habitats is vital to ensure the continued health of these ecosystems and to secure food sources for future generations.

Keywords – Estuarine systems, biodiversity conservation, food security, coastal communities, pollution, overfishing, habitat degradation.

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CONSERVING ESTUARIES : THE NEXUS OF LIFE AND LIVELIHOOD

SUBIKSHA YADAVI [1], RAHMI RANJAN [1], MRS SANIKA GUPTE [1]

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Estuarine ecosystems, where freshwater and seawater converge, are among the Earth's most productive and vital habitats. These areas are essential for biodiversity preservation and play significant role in global food security. They sustain a wide array of marine species, act as critical breeding and nursery grounds for commercially important fish, and support the livelihood of millions of people living in coastal regions. However, these ecosystems face severe threats from pollution, overfishing, habitat destruction, and the impacts of climate change, all of whic contribute to the loss of biodiversity and the degradation of ecosystem services. To safeguard these valuable systems, it is crucial to implement robust conservation measures such a mangrove restoration, pollution management, sustainable resource utilization, and effective policy enforcement. Protecting estuarine habitats is vital to ensure the continued health of thes ecosystems and to secure food sources for future generations. Keywords – Estuarine systems, biodiversity conservation, food security, coastal communities, pollution, overfishing, habita degradation.

INTRODUCTION

- Estuaries are coastal water bodies where rivers meet the sea, creating brackish ecosystems.
- India has 14 major estuarine ecosystems, critical for biodiversity and food security.
- They provide breeding grounds for 75% of commercial fish species.
- Support livelihoods of over 4 million coastal communities in India.

MAJOR ESTUARINE SYSTEMS IN INDIA

- Sundarbans (West Bengal)
- Chilika Lake (Odisha)
- Godavari Estuary (AndhraPradesh)
- Mahanadi Estuary (Odisha)
- Hooghly-Matla Estuary (West Bengal)

ROLE IN FOOD SECURITY

Major Source of Protein, Employment & Economy
Supports Agriculture

THREATS TO ESTUARINE ECOSYSTEMS

Pollution, Habitat Destruction, Overfishing, Climate Change
Invasive Species

CONCLUSION

Healthy estuarine systems ensure biodiversity and food security.

Conservation today sustains future livelihoods.

Collaborative efforts are vital to protecting these ecosystems.

CONSERVATION STRATEGIES

- Community Participation
- Pollution Control
- Restoration Projects
- Policy and Enforcement

Act now before it's too late!

Conservation is not an option—it's a responsibility!

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Impact of Pollution on Avifaunal Diversity: A Study of Three LAKES IN Thane

Swapnali Korade*, Athrav charan, Aditya Mhatre
V.P. M's B.N. Bandodkar College of Science (Autonomous), Thane (W)- 400601

Abstract:

This study looks at how pollution affects bird diversity in three lakes of Thane, viz. Naar, Mogharpada, and Kavesar-along Ghodbunder Road. Over two months (January to March 2024), we observed 37 bird species from 10 groups and 24 families using a simple point count method. The cleanest lake, Kavesar, had the most bird species (25), showing a clear link between cleaner lakes and higher bird diversity. On the other hand, pollution, urbanization, and constant construction have taken a toll on natural habitats, giving invasive species like pigeons an advantage while making it harder for native birds to survive. This study highlights the importance of reducing pollution and protecting natural habitats to support bird populations in urban areas. Thorough research is needed to understand all the factors affecting bird diversity in these lakes.

Keywords: Avifaunal diversity, Naar lake, Mogharpada lake, Kavesar lake, pollution, urbanization.

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IMPACT OF POLLUTION ON AVIFAUNAL DIVERSITY: A STUDY OF THREE LAKES IN THANE

Swapnali Korade, Athrav chavan, Aditya Mhatre*
V.P.M's B.N. Bandodkar College of Science (Autonomous), Thane (W)- 400601

ABSTRACT

Abstract: This study looks at how pollution affects bird diversity in three lakes of Thane, viz. Naar, Mogharpada, and Kavesar—along Ghodbunder Road. Over two months (January to March 2024), we observed 37 bird species from 10 groups and 24 families using a simple point count method. The cleanest lake, Kavesar, had the most bird species (25), showing a clear link between cleaner lakes and higher bird diversity. On the other hand, pollution, urbanization, and constant construction have taken a toll on natural habitats, giving invasive species like pigeons an advantage while making it harder for native birds to survive. This study highlights the importance of reducing pollution and protecting natural habitats to support bird populations in urban areas. Thorough research is needed to understand all the factors affecting bird diversity in these lakes.

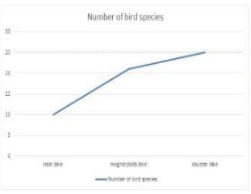
Keywords: Avifaunal diversity, Naar lake, Mogharpada lake, Kavesar lake, pollution, urbanization.

RESULTS

- We observed presence of green algae which is the indication of pollution.
- A total of 37 bird species, representing 24 families, were observed across the three lakes.
- Kavesar Lake had the highest number of bird species due to its cleaner environment, while Naar Lake had the lowest.
- Naar Lake recorded 10 bird species, Mogharpada Lake had 21 species, and Kavesar Lake had the highest count, with 21 species.
- Passeriformes had the greatest representation among bird species.
- House crow, house sparrow, and rock pigeon were the most abundant species in the lake region.
- Several species were not seen in the area due to deforestation, pollution, and human settlements.

INTRODUCTION

- Lakes are important ecosystems that supported various forms of plants, animals, and microorganisms.
- Birds are diverse creatures found from tropical rainforests to polar regions and also helped in pollination.
- Naar Lake, located in Ovala, was polluted, as observed visually.
- Mogharpada Lake, also in Ovala, was disturbed by anthropogenic activities.
- Kavesar Lake, located in Hiranandani Estate, was less polluted and had been used as a picnic spot in recent times.



METHODOLOGY

STUDY AREA

LAKE ARE AS FOLLOWS :

- Lake 1: Naar lake, Owala.
- Lake 2:Mogharpada lake, Owala.
- Lake 3: Kavesar lake, Hiranandani Estate.

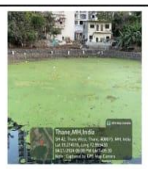
FIELD METHOD - Point count method
IDENTIFICATION using -
Merlin Bird ID by cornell Lab app used for identifying the birds with vocalization.
EQUIPMENT -
SKYCANDLE Phone Lens 18X Zoom HD with Tripod for Phones silver is the lens used for focusing and capturing the pictures of birds.

DISCUSSION

- Number of rock pigeons are increasing also occurs competition for resources like food and nesting sites, potential spread of diseases, and nuisance in urban areas due to excessive droppings and noise.
- Many of the native species are disturbed with the rock pigeon.
- Anthropogenic activities create many disturbtions too diversification of birds where many native species are exhausted by invasive species.
- Clean lakes provide a healthier ecosystem ,offering abundant food sources and suitable habitats for various bird species
- Corvidae and passeridae are the families of birds adapt with the local environment

CONCLUSION

- Study reveals the impact of the condition of lakes towards the bird diversity.
- Documentation of 37 species of birds, across 24 families are observed within the lake area.
- Urgent conservation efforts required to address threats from pollution, habitat loss and human settlements and to reduce the pollutants effect on lake.
- Lake also provide a significant ecological role ,make a strong efforts to conserve the lakes which provides habitat to the various types of birds.


Nar Lake


Mogharpada Lake


Kavesar Lake


SKYCANDLE Phone Lens 18X Zoom HD

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Water Quality Assessment of Thane and Kalher Creeks: Indicators for Wetland Conservation and Management

Vandana Khude, Yogini Ghegad, Shruti Shinde and Tejal Parmar
Department of Environmental Science, VPM's B.N. Bandodkar College of Science (Autonomous), Thane 400601

Abstract:

Degradation of natural resources is a major environmental issue the world is currently facing. Human activities and alterations made by reclamation have had an adverse effect on their ecology. Regular studies of the hydrological parameters are essential for this purpose, as they can assess the status of pollution and help in deciding the mitigation strategies. The reason behind selecting Kalher Creek and Thane Creek is to check the sustainability of the urban creek from the residential and industrial area. This study aims to know the concentration of some properties in creek water through chemical and physical analysis of the water and its impact on human and animal health. In existing research different chemical parameters have been studied which shows the current quality of water. A high value of chloride content in Kalher Creek and the water quality of Thane Creek studies have shown that the creek has low dissolved oxygen. So, such conditions degrade the quality of water.

Keywords: Water Quality, Thane and Kalher Creek, Pollution

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WATER QUALITY ASSESSMENT OF THANE AND KALHER CREEKS: INDICATORS FOR WETLAND CONSERVATION AND MANAGEMENT

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Department of Environmental Science, VPM's B.N. Bandodkar College of Science (Autonomous), Thane 400601

ABSTRACT

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INTRODUCTION

Water Quality can be defined as the chemical, physical and biological characteristics of water, usually in respect to its suitability for a designated use. Water can be used for recreation, drinking, fisheries, agriculture or industry. Each of these designated uses has different defined chemical, physical and biological standards necessary to fulfil the respective purpose. For example, there are stringent standards for water to be used for drinking or swimming compared to that used in agriculture or industry. After many years of research, water quality standards are put in place to ensure the suitability of efficient use of water for a designated purpose. Water quality analysis is to measure the required parameters of water, Water quality analysis is required mainly for monitoring purposes.

MATERIALS AND METHODOLOGY

Area of study

The reason behind selecting this particular location from Kalher and Thane Creek is to check the sustainability of the urban Creek site from the residential and industrial area.

This study aims to know the concentration of some properties in Creek water through chemical and physical analysis of the water and it's impact on human and animal health.

Figure 1.Kalher Creek.

Figure 2.Thane Creek.

METHODOLOGY

Sample Collection: Plastic bottles of 1.0 L were used to collect the grab water samples from location kalher reti bundar kalher creek site and chendani koliwada, Thane Creek, Maharashtra. The samples were collected in the period of February 2024. Methodology : The sample was analysed for the following chemical water quality parameters. pH: Measured using a pH pen. TSS: Initial weight of Whatman filter paper recorded, 5ml sample filtered, dried, and weighed. TDS: Sample evaporated in an oven using an evaporating dish; weight recorded post-drying. TS (Total Solids): Calculated by adding TSS and TDS. DO: Determined using Winkler's method and titration with 0.025N $Na_2S_2O_3$. Chlorine : Chlorine was determined by Iodometric method. BOD: Performed using Winkler's method, with initial and final readings recorded after 3 days of incubation. Alkalinity: Titrated with 0.1N H_2SO_4 using phenolphthalein and methyl orange indicators. Acidity: Measured using methyl orange and titration with 0.005N NaOH. Temperature: Measured by immersing a thermometer in the sample for 10 seconds. Color: Determined by direct visual observation.

OBSERVATION AND RESULTS

Parameters	Thane Creek	Kalher Creek	Permissible Limits set by CPCB guidelines
Physical Parameters			
pH	8	7.9	6.5 to 8.5
TDS	454 mg/L	310 mg/L	<500 mg/L
TSS	250 mg/L	14.3 mg/L	<50 mg/L
Color	Brownish	Blackish brown	_
Temperature	28°C	27°C	_
Chemical Parameters			
DO	3.2 mg/L	9.09 mg/L	>6 mg/L
BOD	16.1 mg/L	4.5 mg/L	<5 mg/L
Chlorine	14.1 mg/L	106.5 mg/L	10 to 20 mg/L
Acidity	0	0	_
Alkalinity	0	0	_

Table 1.Water quality parameters of Thane and Kalher Creek.

DISCUSSION

pH is an important parameter in evaluating the acid-base balance of water. It is also the indicator of acidic or alkaline condition of water status. WHO has recommended a maximum permissible limit of pH from 6.5 to 8.5.

Chlorine is used in water treatment plants, Chloride is present in natural water in the form of Sodium, Calcium and Magnesium salts. CI is widely distributed in natural water and is present in almost all surface waters, but the content varies widely from 10 to 20 mg/L in river water to 19,000 mg/L in seawater.

DO is considered to be one of the most important parameters of water quality in streams, rivers and lakes. It is a key test of water. The higher the concentration of dissolved oxygen, the better the water quality. The actual amount of dissolved oxygen varies depending on pressure, temperature and salinity of the water. TDS include dissolved minerals and salts in the water. As a result, TDS is often closely related to conductivity, salinity, alkalinity, and hardness measures. Most freshwater fish and bugs cannot tolerate high TDS because they are not adapted to saline water like marine fish are.

The Biochemical Oxygen Demand (BOD) values for Thane Creek (16.1 mg/L) and Kalher Creek (4.5 mg/L) indicate significant differences in their water quality.

Thane Creek's BOD value of 16.1 mg/L suggests high levels of organic pollution, which can lead to depleted dissolved oxygen levels, harming aquatic life. and In contrast, Kalher Creek's BOD value of 4.5 mg/L indicates relatively better water quality, with lower levels of organic pollution.

CONCLUSION

The main goal of the research was to assess the suitability of the Creek for recreational activities such as fishing, diving and boating to ensure the safety of users of the facility. In existing research different chemical parameters has been studied which shows the current quality of water. A high value of chlorine content in Kalher creek water. So such conditions degrade the quality of water. This creek is used for fishing purposes hence the presence of higher values of Chlorine content water became salty in test.

In Thane Creek Dissolved Oxygen (DO) level of 3.2 mg/L in Thane Creek indicates moderately polluted water, suggesting some level of organic pollution and potential stress on aquatic life.

The anthropogenic (human-influenced) changes to coastal environments may take many forms: creation or stabilization of inlets, consequently exacerbating the problems of coastal erosion and expanding algae and coastal hypoxia.

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Identification and Quantification of Intangible Benefits of Mangrove Ecosystem Services in West Coast of Ratnagiri District

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Abstract

The mangrove ecosystem provide various intangibles benefits to the local community. However, these benefits are undervalued. A study was conducted to determine WTP for conservation of mangroves and relative importance of identified intangible benefits of mangrove ecosystem services. The primary data was collected from 140 households through face-to-face interview using a structured questionnaire. Secondary data was sourced from various research articles, theses, books, newspapers, bulletins, reports. The Contingent valuation method was applied to estimate the Willingness to Pay (WTP) for the conservation of mangroves. The result showed that majority nearly 64 % of respondents are willing to pay for the conservation. The estimated overall average WTP for the conservation of mangroves was found to be Rs.77.64 per month. Total twenty intangible benefits were identified by the respondents. Top five ranked services were Protection from storm and flood, followed by breeding ground for fishes, control soil erosion, give scenic view to the village and tourism and recreation.

Keywords: Mangroves, Contingent valuation method, Willingness to pay

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Identification and quantification of intangible benefits of mangrove ecosystem services in west Coast of ratnagiri district

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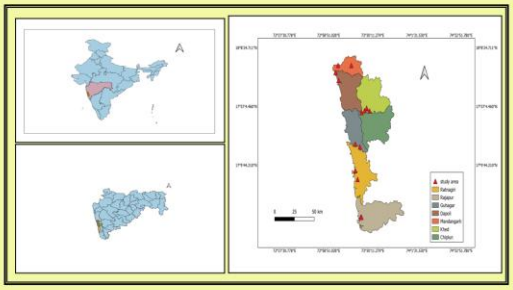
INTRODUCTION

Mangrove is a tropical woody evergreen tree or forest belonging to the genus Rhizophora (Mugade and Sapkale, 2014) that flourish in muddy, low-oxygen soils characterized by high salinity, significant tidal fluctuations, strong winds, and elevated temperatures, typically found at the land-water interface in tropical and subtropical regions. The terms "mangle" and "mangue" are commonly used in American, Spanish, and Portuguese contexts to denote trees and shrubs belonging to the genus Rhizophora (Singh et al., 2012).

MATERIAL AND METHODS

- **Study area :** Ratnagiri- Mandangad, Dapoli, Khed, Chiplun, Guhagar, Ratnagiri and Rajapur
- **Sample size :** 7 taluka x 2 villages x 10 households =140
- **Period:** Aug-Sep
- **Methodology :** Contingent valuation method , structured questionnaire, Face to face interview.
- **Stakeholders :** Farmer, fisherman, BPL/landless-labour, Student/education and Employee

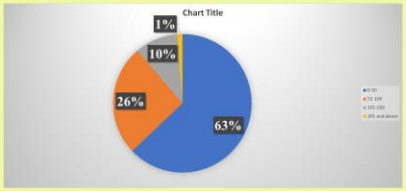


2.1 Study area

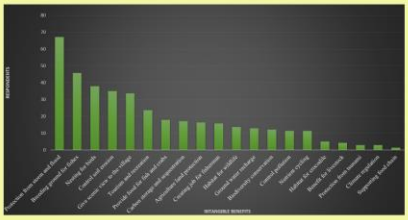
2.2. Surveyed individuals

RESULTS AND DISCUSSION

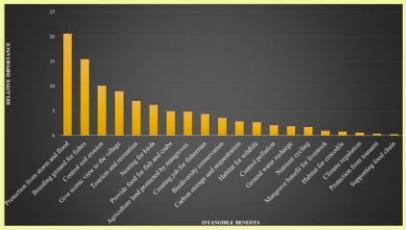
Willingness to pay



Identified intangible benefits



Relative importance of intangible benefits



CONCLUSION

The present study concluded that the overall mean willingness to pay (WTP) for mangrove conservation was Rs. 77.64 per month per household. Total twenty intangible benefits were identified by the respondents. Top five ranked services were Protection from storm and flood, followed by breeding ground for fishes, control soil erosion, give scenic view to the village and tourism and recreation.

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Bhandup Pumping Station: An Emerging Eco-Tourism Hub for Bird Enthusiast

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Shruti Rajesh Parab (sparab834@gmail.com)
Ms. Sanika gupte

Bhandup Pumping Station, located in the northeastern suburbs of Mumbai, has emerged as a significant eco-tourism hub for bird enthusiasts. Nestled near the Thane Creek Flamingo Sanctuary, this area offers a unique blend of natural and urban landscapes, attracting a diverse range of avian species. It serves as a crucial habitat for migratory birds, including the iconic Greater Flamingos, along with other waterfowl and waders. The site's proximity to the mangroves and its serene environment make it an ideal destination for birdwatchers, photographers, and nature lovers amidst the metro city. Recent efforts to promote eco-tourism in the area have included the development of bird-watching trails, guided tours, and awareness campaigns about the conservation of this fragile ecosystem. This poster presentation highlights the ecological significance of Bhandup Pumping Station, the biodiversity it supports, and its potential as a model for sustainable eco-tourism in urban settings. By balancing tourism and conservation, the site not only provides a unique experience for visitors but also plays a pivotal role in preserving biodiversity and raising awareness about the importance of mangrove ecosystem.

Keywords: Bhandup Pumping Station, Eco-tourism, creek, Flamingos.

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Bhandup pumping station
An emerging eco-tourism hub for Bird enthusiast

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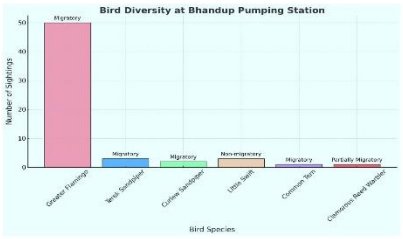
ABSTRACT

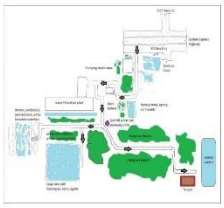
Bhandup Pumping Station, located in the northeastern suburbs of Mumbai, has emerged as a significant eco-tourism hub for bird enthusiasts. Nestled near the Thane Creek Flamingo Sanctuary, this area offers a unique blend of natural and urban landscapes, attracting a diverse range of avian species. It serves as a crucial habitat for migratory birds, including the iconic Greater Flamingos, along with other waterfowl and waders .The site's proximity to the mangroves and its serene environment make it an ideal destination for birdwatchers, photographers, and nature lovers admistthe metro city . Recent efforts to promote eco-tourism in the area have included the development of bird-watching trails, guided tours, and awareness campaigns about the conservation of this fragile ecosystem . This poster presentation highlights the ecological significance of Bhandup Pumping Station, the biodiversity it supports, and its potential as a model for sustainable eco-tourism in urban settings. By balancing tourism and conservation, the site not only provides a unique experience for visitors but also plays a pivotal role in preserving biodiversity and raising awareness about the importance of mangrove ecosystem

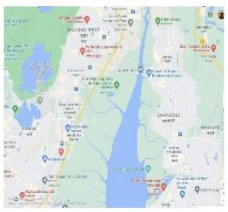
Keywords: Bhandup Pumping Station ,Eco-tourism , creek, Flamingos..



eBird. "Greater Flamingo." eBird, Cornell Lab of Ornithology https://ebird.org/species/grefla3/L2930709.

The best time for birdwatching is from October to March, when migratory species arrive from colder regions.

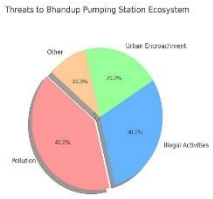




Why Bhandup is Emerging as an Eco-Tourism Hub

1. **Proximity to Mumbai –Easily accessible for urban nature lovers.**
2. **Rich Biodiversity –Home to marine, freshwater, and terrestrial ecosystems, supporting diverse**
3. **Photography & Research–Ideal for wildlife photography and ecological studies.**
4. **Sustainable Tourism –Authorities and local organizations promote responsible tourism and conservation.**

Eco-Tourism Attractions: Guided birdwatching tours, photography, nature walk



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Conclusion -*"Bhandup Pumping Station is a unique blend of urban development and nature. With responsible tourism, community efforts, and sustained conservation, it can continue to inspire biodiversity protection and environmental awareness."*

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Wetlands and Tourism

Mariyambi Salim Khan

Rizvi college of arts science and commerce. Bandra west

Abstract:

Wetlands are area of land that are saturated with water either permanently or seasonally. They support plants and animals and provide important benefits like filtering water habitat for wildlife and regulating water flows. Additionally, they support recreational and tourism activities collectively known as ecosystem services. There shows migration of numerous bird species and the rich plant diversity within wetlands which is the important effective biodiversity conservation initiatives. The connection between humans and nature makes upper major segment of tourism. Ecotourism brings together fauna, flora, tourists and local communities and contributes to both positive and negative effects on each other. Wetlands are facing with environmental degradation due to lack of awareness among local communities. Wetlands provides considerable environmental benefits to the region as well as being unique natural attractions which has also strengthen ecotourism. Thus, this study presents survey for the development of sustainable wetland tourism.

Keywords: wetlands, tourism, environmental benefits

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Survey of wetlands along western regions of Mumbai for stainable Beach Tourism

Mariyambi Salim Khan ; Rizvi college of Arts, Science and Commerce. Bandra west

Abstract: Wetlands are area of land that are saturated with water either permanently or seasonally. They support plants and animals and provide important benefits like filtering water habitat for wildlife and regulating water flows. Additionally, they support recreational and tourism activities collectively known as ecosystem services. There shows migration of numerous bird species and the rich plant diversity within wetlands which is the important effective biodiversity conservation initiatives. The connection between humans and nature makes upper major segment of tourism. Ecotourism brings together fauna, flora, tourists and local communities and contributes to both positive and negative effects on each other. Wetlands are facing with environmental degradation due to lack of awareness among local communities. Wetlands provides considerable environmental benefits to the region as well as being unique natural attractions which has also strengthen ecotourism. Thus, this study presents survey for the development of sustainable wetland tourism.

INTRODUCTION: Wetlands plays a vital role in ecosystem that support rich biodiversity, now a day's wetlands are facing unprecedented threats because of ecotourism. Mumbai's famous wetlands Juhu beach and Versova beach are the favourite spot for many tourists. These beaches have thriving habitats for many birds and marine life. But in present these animals are under pressure because of human activities which are been held on beaches. The growing popularity of ecotourism in the areas has raised concerns about the impacts on these fragile ecosystems. While ecotourism can generate economic benefits and promote conservation awareness, it also poses significant risks,including habitat disruption, pollution and disturbance of wildlife.

Objective: As ecotourism continues to grow in these areas it is essential to adopt sustainable and responsible practices that balance human interests with the long-term conservation of these vital ecosystem.

Method and methodology: The survey was been done in this study to know the impacts of ecotourism on wetlands on Juhu beach and Versova beach. In the survey tourists were interviewed from different places.

CONCLUSION: The survey on wetlands and tourism shows that while tourism can cause negative impacts such as pollution, overcrowding, habitat distribution of many marine lifes as well as to the migrating birds. Which can cause imbalance in the food chain. Which is not good for our ecosystem. There are positive impact like benefits in economy by tourism. Wetlands are very important to conserve for future.

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Wetland Tourism and Conservation: Bhigwan A case study

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Abstract: -

The Bhigwan Bird Sanctuary is appropriately known as Maharashtra's Bharatpur since it is home to hundreds of migratory and resident birds. It is located in Maharashtra's backwaters of the Ujani dam and is a well-known birdwatching location. Wildlife photographers and other bird watchers will find paradise there. It includes geographical elements such as a forest, waterfalls, wildlife, birds, butterflies, water bodies, and a lovely environment with great weather. Despite efforts to designate Bhigwan as a Protected Area, industrial development plans have left unprotected. Rising tourism has brought both benefits and challenges, with local fisherfolk adapting as birdwatching guides and conservations tourism. Initiatives by locals and NGOs have fostered community involvement, education, and research, making Bhigwan a model for ecotourism and wetland conservation.

Keywords: - wetland conservation, tourism.

ISBN 978-81-926582-1-6

WETLAND TOURISM AND CONSERVATION: BHIGWAN A CASE STUDY

Whiskered Tern

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(Empowered Autonomous Status), Ghatkopar MS India
Email I'd of presenter- singhaman2719@gmail.com ,
nishabaghel137@gmail.com

Black-eared Kite

Abstract :-
The **Bhigwan Bird Sanctuary** is appropriately known as **Maharashtra's Bharatpur** since it is home to hundreds of migratory and resident birds. It is located at Maharashtra's backwaters of the **Ujjani dam** and is a well-known birdwatching location. Wildlife photographers and other bird watchers will find paradise there. It includes geographical elements such as a forest, waterfalls, wildlife, birds, butterflies, water bodies, and a lovely environment with great weather.. Despite efforts to designate Bhigwan as a Protected Area, **industrial development** plans have left unprotected. Rising tourism has brought **both benefits and challenges**, with local fisherfolk adapting as birdwatching guides and conservations tourism. Initiatives by locals and NGOs have fostered community involvement, education, and research, making Bhigwan a model for **ecotourism** and **wetland conservation**.
Keywords **:- wetland conservation, tourism**.

INTRODUCTION

In **Maharashtra**, India, **Bhigwan** is a town that borders the districts of Pune, Ahmednagar, and Solapur. The **backwater** of **the River Bhima** is where Bhigwan is located. Commonly referred to as **Bhigwan Bird Sanctuary** also known as **Maharashtra's Bharatpur**, this backwater serves as the reservoir for the **Ujani Dam**, which was constructed downstream on the river. Both **migratory and year-round bird** species can be found in the man-made marsh and the fields and farms that surround it.

ECOTOURIS

With an emphasis on ecotourism, efforts are made to develop Bhigwan as a bird sanctuary. Creating financial incentives for conservation involves enlisting the help of local communities to host and guide bird watchers. Birdwatching especially Flamingos and many migratory birds, is the main reason people are attracted to Bhigwan.

- **Early days-**
  - Initially, many guides were fisherman catching Tilapia in the Ujjani backwaters.
- **Shift to Bird Guiding-**
  - Birdwatchers and photographers began to hire fisherman for boat rides.
  - Fisherman gained knowledge about bird by the birdwatchers or self-educated themselves.
  - And this was the reason for their transition from fisherman to full time bird guiding.
- **Current Scenario-**
  - These guides now own homestays in Kumbhargaon village, providing facilities to tourist.
  - This also provide employment opportunities. Local youths are trained for bird identification and guiding.

This is how ecotourism has not only provided knowledge for tourist but an opportunity for local transforming livelihoods.

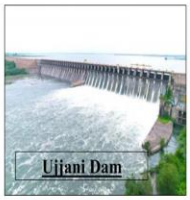
CONSERVATION

The need for conservation of Bhigwan bird sanctuary is due to several reasons mainly.

- **Tourism related Pollution-** Littering, plastic bottles and wastes.
- **Environmental damage from illegal sand mining-** Destruction of small islands where the bird nests.

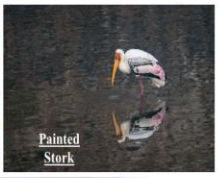
- Efforts made to conserve-
  - Community-Led initiatives.
  - Pollution control measures.
  - Protection of Bird Habitats.
  - Fighting against illegal sand mining.
  - Sustainable Tourism Development.

Bhigwan Bird Sanctuary



Ujjani Dam

Egyptian Vulture



Painted Stork

Boat Safari

Camping

CONCLUSION

- Home to migratory and resident bird species.
- Conservation efforts being made by local communities and unofficial authorities.
- Promote ecotourism.
- Aiding to economy.

Pheasant-tailed Jacana

Little Cormorant

Little Egret

Eurasian Marsh Harrier

Eurasian Curlew

Greater Flamingo

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Avifaunal Survey of Wetlands Around Thane: A Sustainable Tourism Initiative

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Abstract:

Wetlands are vital for avian biodiversity, providing essential habitats for various species. This study examines bird diversity at three wetland sites around Thane: VPM College Campus, Bhandup Pumping Station, and Tansa Lake. A total of 37 species were recorded at VPM, 42 species at Bhandup, and 68 species at Tansa Lake. Tansa Lake's higher diversity is due to minimal human disturbance and lower pollution. While urban areas face human impacts, they still support birdlife, thanks to nearby wetlands and green spaces. These findings emphasize the importance of wetland conservation and the role of eco-tourism, including nature trails and activities, in promoting public engagement. Cleanliness drives further contribute to preserving these ecosystems for future generations.

Keywords: Wetlands, Tansa lake, eco- tourism, Bhandup pumping station, VPM's college campus, Thane.

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Avifaunal survey of wetlands around Thane: A sustainable tourism initiative

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ABSTRACT

Wetlands are vital for avian biodiversity, providing essential habitats for various species. This study examines bird diversity at three wetland sites around Thane: VPM College Campus, Bhandup Pumping Station, and Tansa Lake. A total of 37 species were recorded at VPM, 42 species at Bhandup, and 68 species at Tansa Lake. Tansa Lake's higher diversity is due to minimal human disturbance and lower pollution. While urban areas face human impacts, they still support birdlife, thanks to nearby wetlands and green spaces. These findings emphasize the importance of wetland conservation and the role of eco-tourism, including nature trails and activities, in promoting public engagement. Cleanliness drives further contribute to preserving these ecosystems for future generations.

Keywords: Wetlands, Tansa lake, eco- tourism, Bhandup pumping station, VPM's college campus, Thane.

INTRODUCTION

- Wetlands are vital for bird diversity, conservation, and ecotourism.
- This study examines bird diversity at three wetland-associated sites near Thane:
- Site 1: VPM's college campus (plantations, butterfly garden, Thane Creek proximity)
- Site 2: Bhandup pumping station (mangrove vegetation)
- Site 3: Tansa Lake (tropical moist deciduous forests and wetlands)
- The study's goals include:
- Identifying ecotourism hotspots
- Promoting wetland ecosystem conservation
- Providing a baseline for monitoring tourism impacts on bird populations
- Supporting sustainable tourism initiatives

METHODOLOGY

- **Study Area:**
- VPM College campus, Thane.
- Bhandup pumping station.
- Tansa lake.

- **Methods:**
- Opportunistic sampling
- Observations made visually and supported with photography.
- Equipment used: Field guides and Techno camon 19 Pro 5G phone for photography.
- Bird identification based on field guide and merlin bird id app, inaturalist app and e bird. (Birds of the Indian Subcontinent)

VPM COLLEGE CAMPUS TANSA LAKE BHANDUP PUMPING STATION

RESULTS AND DISSCUSION

- Recorded 37 birds in VPM college campus Recorded 42
- birds in Bhandup pumping station Recorded 68 birds in
- Tansa lake. Total 106 species observed From 40
- different families Most species were found in Tansa lake
- as there is very less human disturbance and less
- pollution. Least species were found in VPM college campus, as there is human disturbance but due to
- presence of creek near by and plantation bird are present. The Sylviidae family has the highest representation with 3-4 species.
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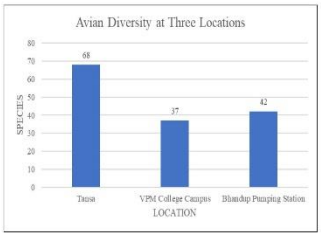
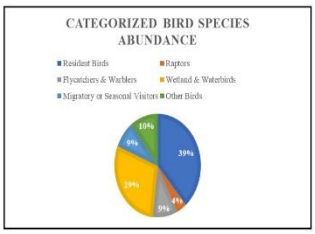
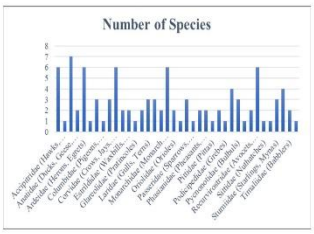


BAR GRAPH SHOWING AVIAN DIVERSITY A THREE LOCATION



PAI CHART SHOWING CATEGORIZED BIRD SPECIES ABUNDANCE



BAR GRAPH SHOWING NUMBER OF SPECCIES

CONCLUSION

This survey highlights the strong link between habitat quality and bird diversity. Tansa Lake, with minimal human disturbance, supported t highest bird diversity, emphasizing the value of undisturbed wetlands. In contrast, VPM College Campus and Bhandup Pumping Station, despite human impact, sustained diverse bird life due to wetlands and vegetation. These findings highlight the potential for sustainable tourism that fosters both conservation and public engagement. To support conservation, we propose nature trails, student birding sessions, and creative activities like stone and leaf paintings to promote nature appreciation. Birding tourism at Tansa Lake can provide local employment, while eco-friendly boating, community-led bird monitoring, habitat restoration, and sustainable infrastructure like boardwalks and observation towers can further strengthen conservation efforts and enhance visitor experiences.

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Abstract

Comparing Ecosystem Services of Major Wetlands in Pune City

Pradeep Mane
DES's Fergusson College (Autonomous) Pune; M. Sc. Environmental Science

Abstract:

Wetlands are invaluable ecosystems that provide a wide array of services, contributing significantly to environmental sustainability and human well-being. This study evaluates and compares the ecosystem services offered by five major wetlands in Pune City—Khadakwasla Lake, Pashan Lake, Katraj Lake, Lakaki Lake, and Jambhulwadi Lake. The assessment focuses on provisioning services (e.g., food, fresh water, and biochemical products), regulating services (e.g., climate regulation, pollution control, and natural hazard mitigation), supporting services (e.g., biodiversity conservation, soil formation, and pollination), and cultural services (e.g., recreation and aesthetic value).

Field surveys were conducted to gather data on these services, with observations highlighting key variations in service delivery across the wetlands. This research holds significant importance as Pune's wetlands face increasing anthropogenic pressures such as urban expansion and pollution. By identifying the strengths and vulnerabilities of these wetlands, the study aims to provide actionable insights to policymakers and stakeholders for the sustainable management and conservation of these critical ecosystems.

The findings will serve as a foundation for fostering awareness and developing targeted strategies to enhance the ecological and socio-economic benefits derived from wetlands, ensuring their longevity and resilience in the face of environmental challenges.

Key words: Pune wetland, Pashan Lake, Katraj lake, Lakaki Lake, Jambhulwadi lake

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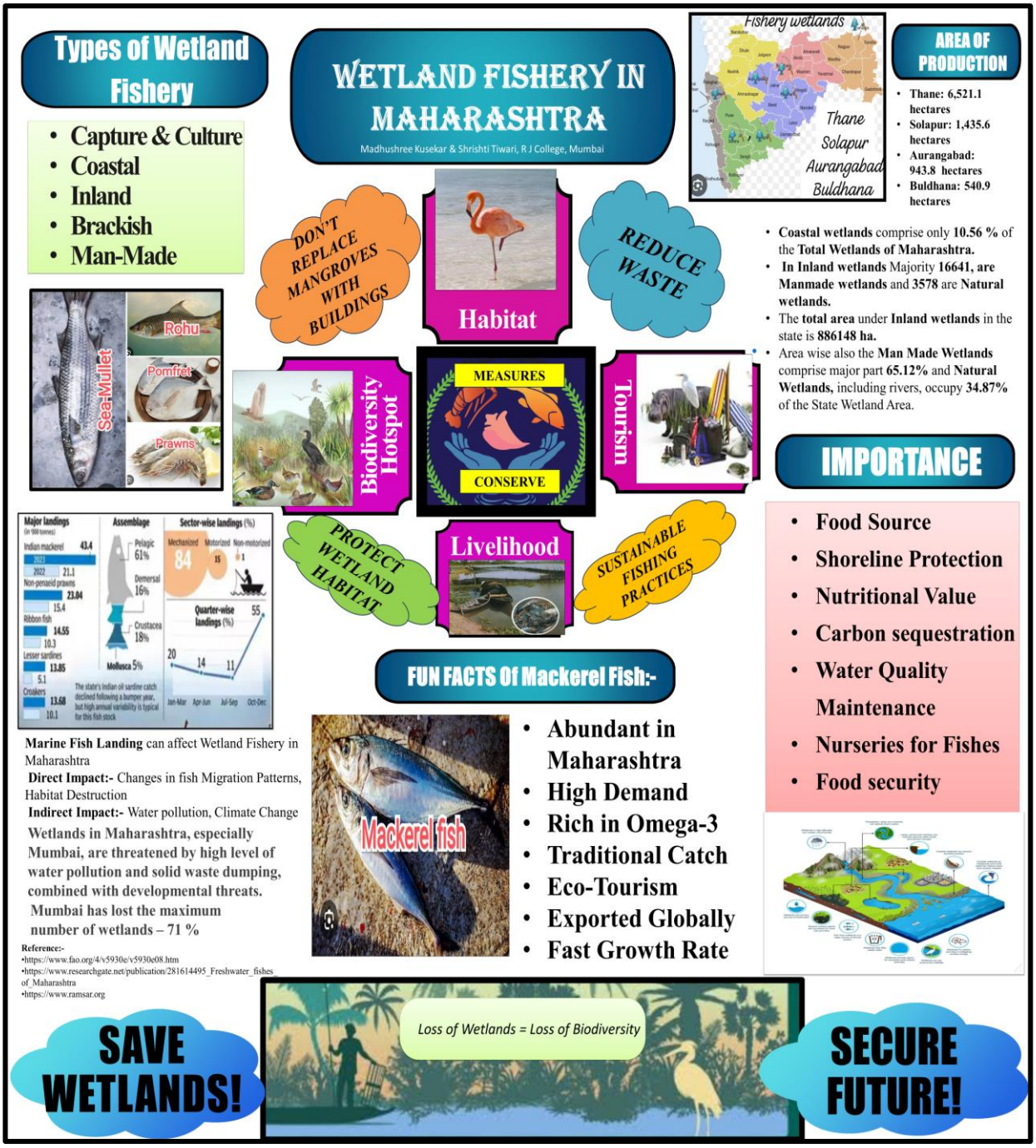
Posters

1. Wetland Fishery in Maharashtra

Madhushree Kusekar & Shrishti Tiwari, R J College, Mumbai



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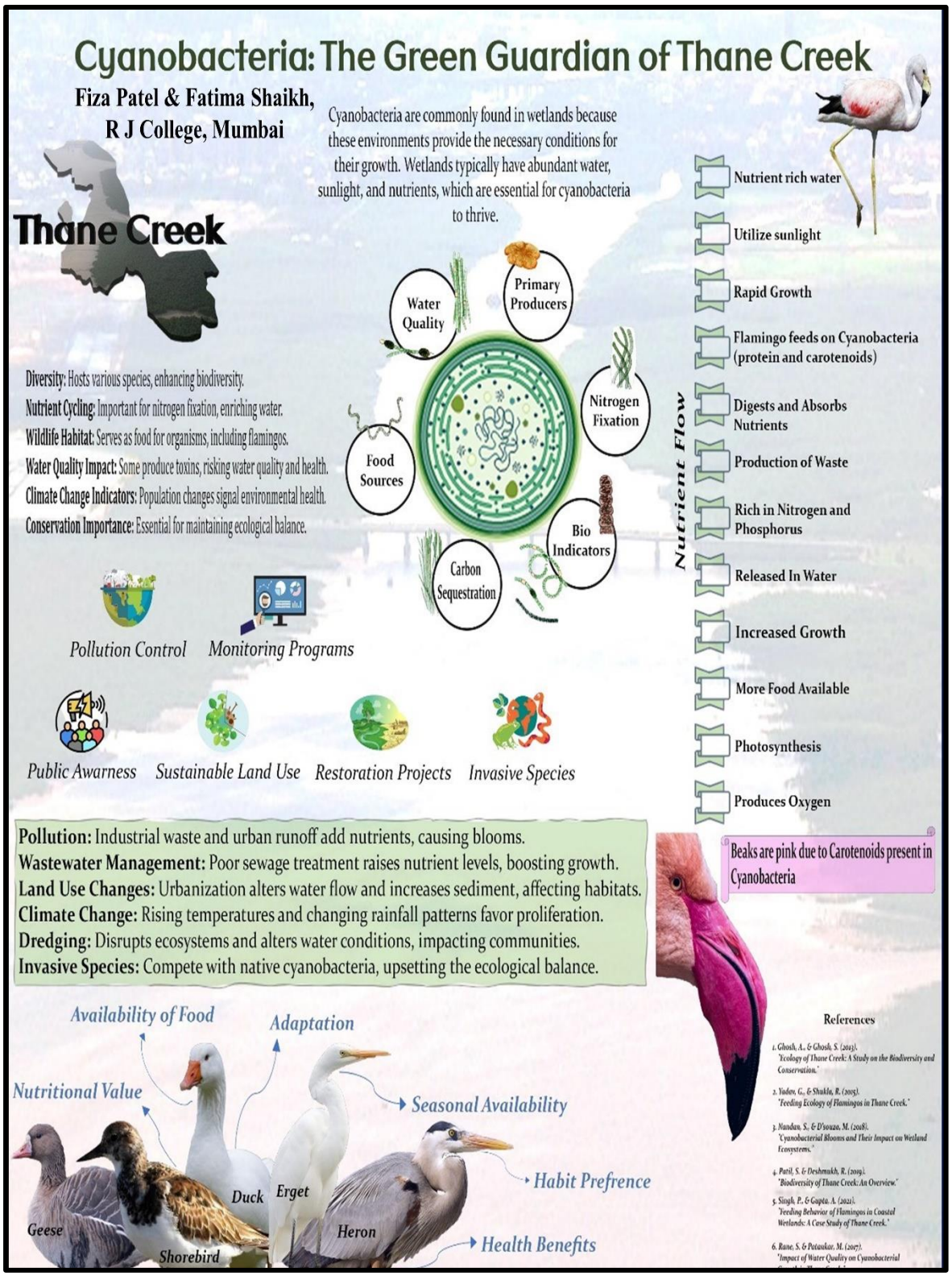
2. Cyanobacteria: The Green Guardian of Thane Creek

Fiza Patel and Fatima Shaikh, R J College, Mumbai



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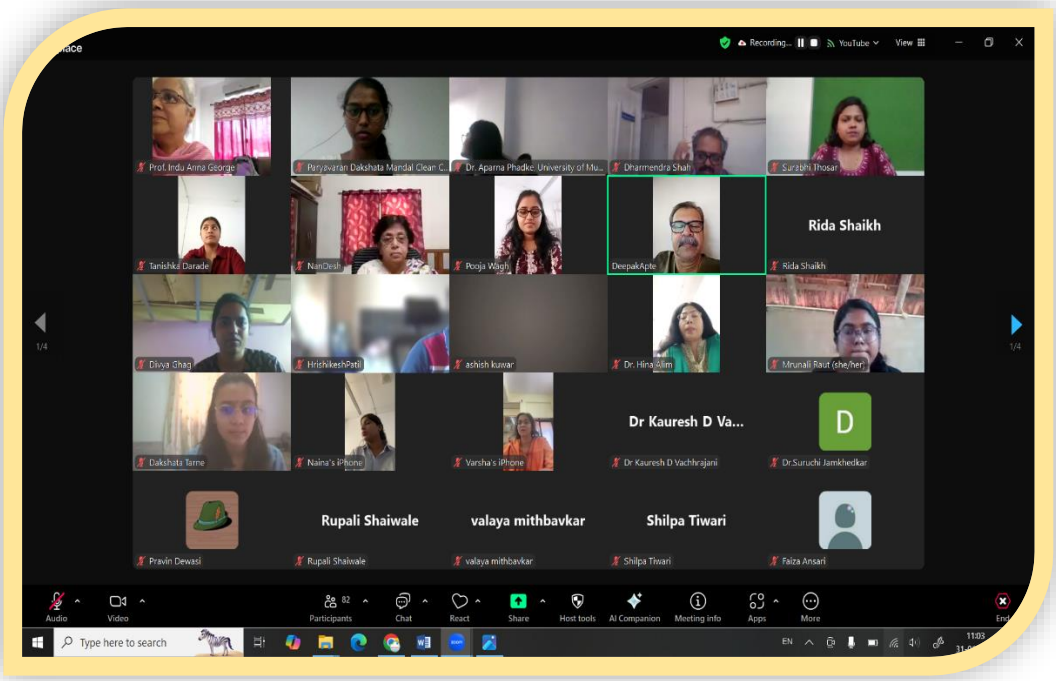
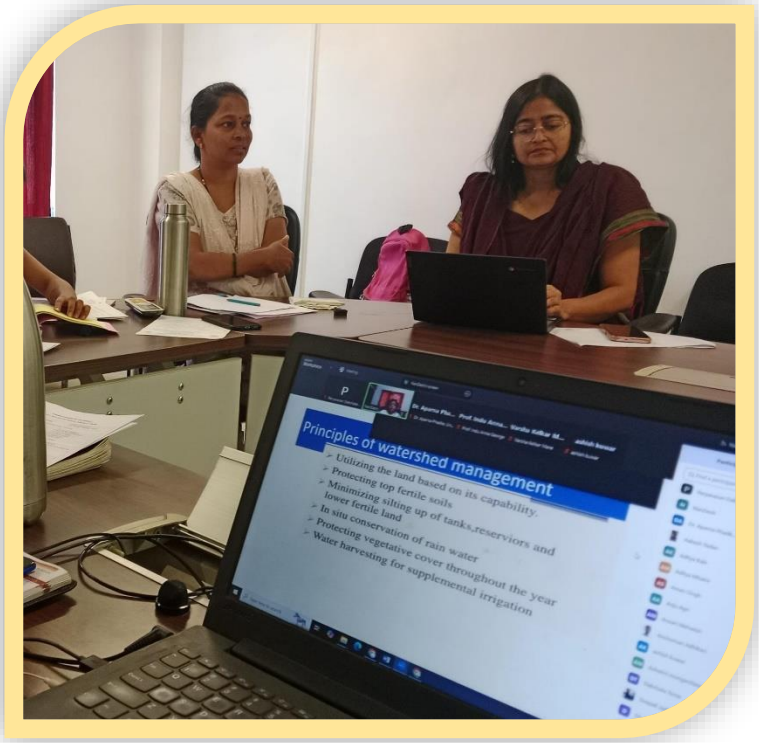
PHOTOGRAPHS



Day 1 Online mode: National Conference on World Wetlands Day 2025



Day 1 Online mode: Dr Aparna Phadke explaining the theme.

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Felicitation of Hon' Vice Chancellor Dr. Ravindra Kulkarni by Dr. Mansi Joshi, President of Paryavaran Dakshata Mandal.

Address by Hon' VC of University of Mumbai

Dr. Ravindra Kulkarni

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Dr. Prasad Karnik, Founder of Clean Creek Movement enlightened the students on current status of Thane Creek

Dr. Mansi Joshi, President of Paryavaran Dakshata Mandal

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Ms. Dhanashree Bagade from Mangrove Foundation explained role of MF in conservation of wetlands.

Convenor's Address by Dr. P. G. Kale

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Keynote Address by Dr. Ritesh Kumar, Director, Wetlands International South Asia

Participants engrossed in proceeding of the conference

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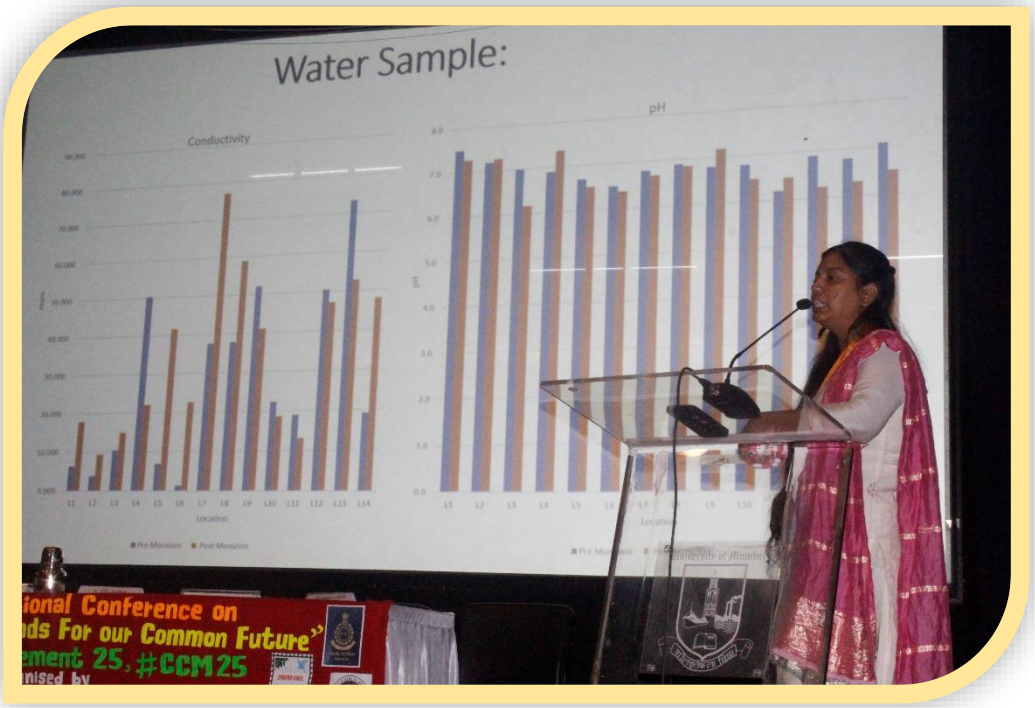

Research Paper Participants delivering PPT presentation

Poster Presentation judging by Dr. Deepali Bhide and Dr. Prasad Karnik

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Students of Achiever's College, Kalyan performing street play at Valedictory Session

Dr. Sanjay Joshi delivering concluding remark.

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Participant receiving the prize from ATBS president Mr. Pravin Nayak.

Participant receiving the prize from PDM president Dr. Mansi Joshi.

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Participants accepting the prizes at the conference.

Hon' VC Dr. Kulkarni along with Mr. Ghule, Dr. Karnik, Dr. Kale and students of UoM visited Green Shopee stall at the conference.

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Group Photo of all the participants at the University of Mumbai

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#Clean Creek Movement 2025

Summary of the National Conference Organized by

Paryavaran Dakshata Mandal Thane and University of Mumbai

In collaboration with

Association of Teachers in Biological Sciences (ATBS), Mangrove & Marine Biodiversity Conservation Foundation of Maharashtra, Keshav Srushti and Enviro-Vigil

On occasion of World Wetlands Day 2025

"Protecting Wetlands for Our Common Future"

Day and Dates: Friday, 31st January 2025 (Online Mode) & Saturday, 1st February 2025 (Offline Mode)

Following is an exhaustive report of the actual conference.

Proceedings of Day One, Friday, 31st January 2025:

On this day, the conference was held online at the Vidyanagari, Kalina Campus, University of Mumbai. Inaugural session started with India's national anthem, followed by Maharashtra song and then the University of Mumbai song as per the tradition.

Inaugural speech was delivered online by Hon. Vice Chancellor of Univ. of Mumbai, Dr. Ravindra Kulkarni. He appreciated the initiative taken by Paryavaran Dakshata Mandal for taking efforts to organize such national conference in collaboration with the University of Mumbai foe second consecutive year. Kalina campus has a large water body which attracts many species of migratory aquatic birds. He mentioned the importance of this water body in his speech. He further spoke about various initiatives taken by the University specially by the Dept. of Geography and Life Science for taking efforts to make Vidyanagari campus carbon neutral. He appreciated initiatives being taken by the concerned teachers and students to make the campus plastic free. Campus also has a rain water harvesting system and waste management activities.

Convener's address was delivered by Dr. Aparana Phadake, Head, Dept. of Geography. She gave a brief introduction of theme for this year's World Wetlands day. The objective of having such conference is to inculcate the research attitude and aptitude among the students in general and make them aware about depleting conditions of wetland ecosystems. This year the organizers received overwhelming response from all over India from the students and research scholars.

Key Note Address: This speech was delivered by an eminent oceanographer a hard-core researcher, author and photographer Dr. Deepak Apte. He is former Director of Bombay Natural History Society. Currently he is working as a Managing Director of Srushti Conservation Foundation. He started his presentation with origin of Earth, the prevailing conditions of that time and how the human interventions have added to the climate change in the present-day scenario. He also spoke

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about changing coastlines due to developmental activities and expressed his concern that the climate change is going to aggravate the conditions further if proper measures are not taken.

After his speech, Dr. Nisha Shaha from the Dept. of Life Sciences, Univ. of Mumbai offered vote of thanks marking the end of the inaugural session.

Lead Lectures related to subthemes of the conference:

Theme for WWD 2025 was **"Protecting Wetlands for Our Common Future"** as declared by the Ramsar Secretariate. Under this theme, there were four sub-themes. As a part of this conference, we decided to invite eminent scientists and researchers to deliver a special talk related to these sub-themes.

First lead lecture was delivered by marine zoologist Dr. Nandini Deshmukh, her topic was Watershed Management and River Rejuvenation. She explained various aspects of watershed management and spoke about watershed management programme in the state of Maharashtra. She spoke about role of National Bank for Agricultural and Rural Development (NABARD) having iys own watershed management programme. She further elaborated upon Integrated watershed management programme, Drought prone area programme (DPAP) community-based watershed development projects etc. She mentioned about the farmer's livelihood project by World Vision, India in the Vidarbha region of Maharashtra. Dr. Deshmukh further highlighted a case study in which, farm production increased two to four times with improved agricultural income by 50% to 100% because of effective implementation of watershed management programme. Then she elaborated upon mapping of wetlands. Moving on further, she explained various approaches to river rejuvenation and conservation programme. She mentioned holistic riverscape approach, policy kevel interventions, riverine and riparian wildlife management, wetland management etc. She also mentioned that Ministry of Environment, Forests & Climate Change (MoEFCC), Govt. of India has shortlisted 30 major rivers in India for rejuvenation and has allocated funds worth INR 19000 crores.

This lead lecture was followed by online presentations by the researchers.

Second Lead Lecture was delivered by Dr. Kauresh Vachharajani, Professor of Zoology (Retired) M. S. University, Baroda (Gujarat, India) and expert in Coastal Invertebrate Biodiversity. His topic was "Conservation of Estuarine Systems for Food Security". He explained how the estuarine ecosystems are getting degraded due to very high sedimentation rate and pollutant load as the pollutants are being circulated in the upper layers of the continental shelf. He gave emphasis upon multidisciplinary approach for conservation of these very important and precious ecosystems. He also spoke about the marine organisms, and especially the coastal invertebrate species which are under stress due to pollution.

Third Lead Lecture was delivered by Dr. Aparna Phadake from Geography Department, University of Mumbai. Her topic was "Ecosystem Services provided by the Wetlands". She presented data collected from the studies on the wetland that is present inside Kalina campus. Her focus was more upon tangible and intangible benefits from wetlands. She also described provisioning, regulatory, supporting and recreational services provided by the wetlands.

Fourth Lead Lecture was on "Wetlands and Ecotourism", delivered by Dr. Purushottam Kale, retired Professor and Head Zoology Dept. R. J. College, Ghatkopar, Mumbai. He mentioned that

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tourism is very important and contributes to the GDP of our country. At the same time, he explained how this tourism is causing stress on the rare or spectacular species, and is causing habitat loss and fragmentation thus threatening the existence of animals and plants. However, if wetlands are used for responsible tourism with the strict rules and regulations for the tourists so that no harm is caused to the ecosystem, such tourism will provide immense benefits like increased income for the locals, spreading awareness and literacy about wetland conservation.

These lead lectures were part of the technical sessions and were followed by paper and poster presentations by the respective participants.

Proceedings of Day Two, Saturday, 1st February 2025:

On this day, the conference was held offline at the Green Technology Auditorium, Kalina Campus, University of Mumbai. Inaugural session started with India's national anthem, followed by Maharashtra song and then the University of Mumbai song as per the tradition.

Convener of the conference, Dr. P. G. Kale. welcomed the audience and explained the objective of organizing this conference. He took overview of the clean creek movement and various activities which were conducted by Paryavaran Dakshata Mandal throughout the year. He then went ahead and elaborated upon proceedings for the day. Hon. Chief Minister of Maharashtra Shri Devendra Fadnavis had sent his best wishes for the conference in the form of a message. Dr. Kale read this message before ending his speech.

Convener's address was followed by brief introduction to the activities of Paryavaran Dakshata Mandal and Enviro-Vigil by Dr. Manasi Joshi, President, Paryavaran Dakshata Mandal.

After this, Mr. Pravin Nayak from R. J. College explained various activities carried out by Association of Teachers in Biological Sciences (ATBS) through a PowerPoint presentation. This is a national level organization of the teachers who are engaged in teaching and research in Botany, Zoology, Life Sciences and various other allied disciplines related to Biological Sciences. This organization offers membership to the teachers and even the students. It helps students to prepare for different competitive exams like International Biology Olympiad etc.

This was followed by a presentation on Mangrove Foundation by Ms. Dhanashri Bagade. Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra (Mangrove Foundation) is an Autonomous Body under the Revenue & Forests Department, Government of Maharashtra. Mangrove Foundation works towards the conservation and monitoring of mangroves and coastal biodiversity. The Foundation also supports the implementation of various livelihood activities under the 'Mangrove Conservation and Livelihood Generation Scheme' of Govt. of Maharashtra. In addition, the Foundation conducts capacity-building prog. for various stakeholders. Dr. Bagade highlighted all such important activities and initiatives that have been undertaken by Mangrove Foundation. Her speech marked the end of the inaugural session.

After Ms. Dhanashri Bagade's speech, Dr. Nisha Shaha from the Dept. of Life Sciences, Univ. of Mumbai offered vote of thanks marking the end of the inaugural session.

After a brief break, inaugural session was followed by beginning of the technical sessions. This was initiated by a keynote address by Dr. Ritesh Kumar, Director, Wetlands International, South Asia.

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He started his presentation with historical perspective about wetlands in India, pre-and post-independence. Then he spoke about Ramsar Convention, Development of specific legislation for wetlands by the Ministry of Environment, Forests and Climate Change, Govt. of India. He also mentioned that India is one of the pioneering countries having satellite mapping of the wetlands. He then spoke about degradation of natural wetlands, sectoral changes, integrated wetland management, small scale projects for wetland conservation being taken by Wetlands International etc.

Technical sessions comprised poster and paper presentation competitions. For this, the participants were divided into Group A comprising teachers and research scholars and Group B comprising undergraduate and postgraduate students.

We received an overwhelming response from students and teachers. All in all, total 1150 students got connected to clean creek movement this year. Around 180 participants registered for actual conference on 31st Jan. 25 and 1st Feb. 25. Following is a break up of participants for competitions

For the conference:

Papers: Group A: 6 (Online 1), Group B: 15 (Online 1)

Posters: Group A: 5 (Online 2), Group B: 24 (Online 3)

No. of Attendee: 53

No. of participants for poster: 54

No. of participants for Paper: 40

Details of the allied activities conducted throughout the year are presented in the following table.

Sr. No.	Program	Topic	Month / Date	Venue	No. of participants
1.	Pre-conference Workshop-1	Research Guidelines on Wetlands by Dr. P. G. Kale	11th May 2024	At R. J. College, Ghatkopar	70
2.	Pre-conference Workshop-2	Research Guidelines on Wetlands & Mapping of wetlands by Dr. Sanjay Joshi & Dr. Aparna Phadake	4th Sept. 2024	University of Mumbai, Kalina Campus	70
3.	Late Dr. Untawale Memorial Lecture	Status of Mangroves IN India by Dr. Sanjay Deshmukh	18th Oct. 2024	SIES college, Nerul	250
4.	Late Dr. Kodarkar memorial lecture	By Dr. Umesh Mundlye	1st Oct. 2024	BNN College, Bhiwandi	200

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5.	Late Dr. Gokhale memorial Lecture	On Thane Creek by Dr. Rathod	12th Dec. 2024	B. N. Bandodkar College, Thane.	160
6.	Photography Competition	Manmade Wetlands, Diversity in Wetlands, Stakeholders of Wetlands	02th Jan. 2025	Online Platform	50
7.	Short Film / Documentary Competition	Manmade Wetlands, Diversity in Wetlands, Stakeholders of Wetlands	02th Jan. 2025	Online Platform	7 films
8.	Creative Placard Competition	Wetlands Conservation, Pros and Cons of Ecotourism, Aesthetics of Wetlands	02th Jan. 2025	Online Platform	15
9.	Street play Competition (Final Round)	Wetlands Conservation (पाणथळ भूमीचे संवर्धन), Wetlands and Ecotourism (पाणथळ भूमी आणि निसर्गसहल), Significance of Wetlands (पाणथळभूमीचे महत्व)	11th Dec. 2024	At B. K. Birla College, Kalyan in coordination with NSS, Director office, Churchgate under Mumbai University	14 teams from Thane District = 150 students
10.	National Conference	Protecting wetlands for our common future	31st Jan. (Online mode) and 01st Feb. 2025 (Offline mode)	Mumbai University, Kalina Campus	180

Total no. of participants in above program: 1330

Valedictory Session:

The Valedictory Session was chaired by Hon' Vice- Chancellor Dr. Ravindra Kulkarni along with Dr. Mansi Joshi, President of Paryavaran Dakshata Mandal, Mr. Hrishikesh Rane from Mangrove Foundation and Dr. P. G. Kale, Convener of the conference. In the beginning of Valedictory session, a street play on Importance of Wetlands Conservation was presented by NSS students of Achievers Night College, Kalyan. It was appreciated by all. The best Documentary film, the best photograph and the best poster were screened for all the audience. Dr. Sanjay Joshi spoke about the social aspects of Clean Creek Movement and overall proceedings of 2 Days National Conference on the

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occasion of World Wetlands Day. Dr. Aparna Phadake from Geography Dept. of University of Mumbai announced the winners of Documentary Competition, Photography competition, Poster Competition followed by Best Poster and Best Paper in group A & B respectively. The delegates on the dais felicitated the prize winners. This was followed by vote of thanks by Ms. Rupali Shaiwale. The conference ended with 'Vande Mataram'.

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