COMPREHENSIVE ECOLOGICAL ASSESSMENT OF OOTY LAKE: A MULTI-DISCIPLINARY STUDY ON AVIFAUNAL DIVERSITY, WETLAND DYNAMICS, WATER QUALITY, MICROBIAL THREATS AND MAMMALIAN DIVERSITY

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Abstract: The ecological health and challenges encountered by Ooty Lake, a prominent wetland area in India, have been comprehensively investigated in this research article. A multi-faceted approach was employed, combining focal animal sampling, pH assessment, microbial testing, and mammal diversity assessment were carried out to provide a holistic understanding of the lake's ecosystem. Focal animal sampling revealed diverse avifaunal diversity and behaviour, that enriched the knowledge on avian ecology and their adaptability to changing conditions. pH assessment indicated slightly alkaline lake water, raising concerns for specific aquatic organisms, highlighting the need for comprehensive ecological analysis. Microbial testing discovered the presence of *Clostridium* bacteria, emphasizing the urgency of water treatment measures for wildlife and human health. The study also shed light on the presence of small mammals, including endangered species, underscoring the importance of conservation efforts for the entire ecosystem. Overall, this research calls for immediate action to safeguard Ooty Lake's to fragile equilibrium of life and serves as a model for comprehensive ecological research and conservation efforts in the wetland ecosystems.

Keywords: ecological assessment, Nilgiris, Ooty Lake, wetland dynamics, wildlife

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Introduction:

The water quality of Ooty Lake is a matter of growing concern, with various studies highlighting its unsuitability for drinking due to heavy metal pollution indices (Parthasarathy et al. 2021). This issue is exacerbated by the significant increase in human activity in the vicinity of the Lake, leading to noticeable alterations in pH, colour, taste, and odour of the water. The contamination of this area's lake is primarily attributed to residential waste, the use of pesticides and fertilizers by local farmers (Hussain et al. 2020), as well as encroachment and silt deposition, which are the primary contributors to the lake's degradation. Ooty Lake, with a maximum depth of 12 meters and an average depth of 6 meters (Rajamanickam and Nagan 2016), experiences heightened organic contamination during the summer months due to the discharge of domestic wastewater into the lake (Ilavarasan et al. 2016). Ooty Lake is dangerous for both people and animals because, during the winter, the lake's waste water is drained and the waste soil becomes stagnant.

Ooty Lake poses a risk to both people and animals because, when the lake's waste water is drained in the winter, the leftover soil becomes stagnant and mixes with the waste water. Therefore, Diptera has a role in the evolution of several human-harming bloodsucking insect species (Moinudheen and Samson 2022). To assess the presence of water-borne pathogens, including *Salmonella* spp., *Shigella* spp., *Vibrio* spp., *Escherichia coli*, and faecal streptococci, a bacteriological investigation was conducted in Ooty Lake using specific culture media (Prathibha et al. 2019). *Clostridium botulinum*, a bacterium thriving in oxygen-free environments and capable of forming spores, is commonly found in the muddy sediments of wetlands and within the digestive systems of aquatic birds and fish (Rocke 2006; Nol et al. 2004; Anza et al. 2014). Recent research has linked an avian botulism outbreak in Sambhar salt lake to the pathogenic effects of *Clostridium botulinum* (Monali and Singh 2023). Furthermore, it has been suggested that migrating birds could play a role in the spread of bacterial antibiotic resistance (Lin et al. 2020). *Clostridium botulinum* is responsible for limberneck also known as the Western duck sickness, thereby posing a threat to both free-ranging and domestically raised poultry, as well as wild birds (Logue in: Swayne D.E. 2013). In addition to degrading the water quality in wetlands, which negatively affects hydrophytes and animals directly or indirectly, heavy metal pollution also causes a loss in the range of many bird species, which reduces the biodiversity in wetlands (Zhang and Ma 2011). Lead (Pb), nickel (Ni), mercury (Hg), chromium (Cr), arsenic (As), copper (Cu), and zinc (Zn) have all been extensively researched due to their negative effects on the environment due to the toxicity (Espin et al. 2016; Pandiyan et al. 2022).

In light of these multifaceted challenges, it is crucial to comprehensively address the water quality and ecological health of Ooty Lake. The study undertook to assess the chemical and biological effects and aspects of contamination to safeguard the environment and health of the local community. Water birds require wetlands for many purposes like, breeding, nesting, raising their young, foraging, drinking water sources and social contact. In both the breeding and non-breeding seasons, a large diversity of water birds can be found on urban lakes, and many of them seem to prefer built shorelines based on a variety of behavioural patterns (Traut and Hostetler 2003). The water birds and wetland birds that use the water's surface for resting or foraging are impacted by man-made lakes. The use of the new inundation zones by birds for breeding in nearby habitats may have an impact on them directly or indirectly through changes in the local climate or groundwater patterns (Reitan and Thingstad 1999). Wetlands (rivers, lakes, bogs etc.), the world's biodiversity hotspots, provide habitat for life on Earth and are crucial to the

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preservation of biodiversity (Wu et al. 2019). Because of their geographical position, rest and recovery habitats and stopover locations are chosen and visited every year by migrating species (Tattoni and Ciolli 2019). The species richness in mammal outcasts were found to be greater in riparian than in higher altitude uplands (Falck et al. 2003; Hamilton et al. 2015).

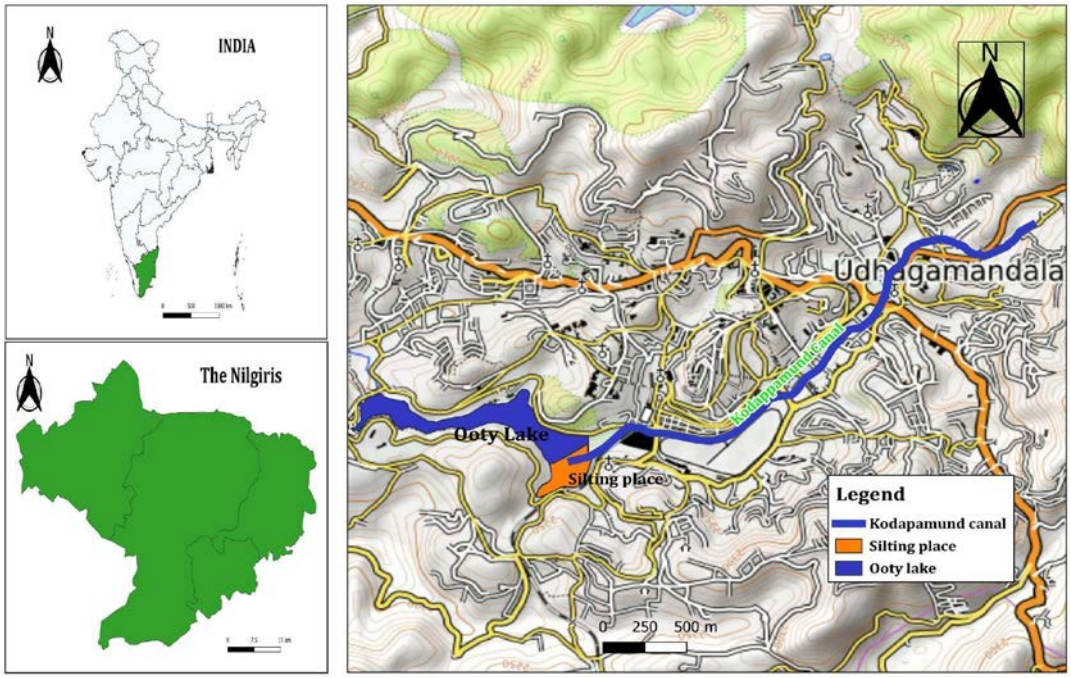
The study attempted to shed light on the detrimental effects of *Clostridium* bacteria on both avian and human populations, emphasizing the profound impact of siltation on biodiversity of Ooty Lake. This ecological issue is particularly pronounced during the winter and summer seasons when water levels experience a significant decline. The decline in the water level of the Kodappamund canal is a key factor exacerbating this problem, as it allows untreated wastewater to flow directly into Ooty Lake. Notably, Ooty Lake serves as a crucial habitat for migratory waterfowls, hosting these avian visitors for a substantial 6-7 months period. Unfortunately, the sources of sustenance for these migratory birds increasingly rely on the contaminated waters. These findings underscore the urgency of addressing siltation and wastewater management to safeguard both avian and human well-being while preserving the delicate balance of local ecosystems. Wetlands treated by wastewater provide water birds a great resource, but they are not risk-free. While wastewater treatment wetlands may have negative effects on water bird health owing to infections, heavy metals, chemical toxins, and human disturbance, water birds may also negatively affect the water treatment process and function as carriers of human illness (Murray and Hamilton 2010).

Present view of Ooty Lake

The Ooty Lake faces significant challenges due to the influx of water carrying a substantial load of sediment and waste materials. A pivotal source of this water is the Kodappamund canal, which originates from the pristine edge of Doddabetta peak. Ooty Lake gets silted due to excess silt mixed with water through Kodappamund canal (Fig. 1). However, as this water descends from its source, it encounters numerous houses and tourist cottages lining the canal's path, leading to the unfortunate practice of indiscriminate garbage dumping directly into the water.

This problem is exacerbated as the canal meanders through the Charing Cross area, a bustling tourist hub replete with shops and hostels. The contaminated water then flows onward, passing through the vital Ooty commercial road, a heavily trafficked region. Here too, the Kodappamund canal faces the deleterious effects of waste disposal from the adjacent houses and market areas. Finally, as the water reaches the water circulation area, it encounters further challenges, as this zone too is not in a proper condition. Regrettably, despite the passage of time, the Kodappamund canal remains plagued by noxious odors and unsightly pollution, underscoring the pressing need for effective remediation efforts in this critical waterway. Ooty Lake, located in the picturesque hill station of Ooty in India is a significant wetland lake area covering approximately 3.885 square kilometres. The lake serves as a vital habitat for a diverse range of bird species, with the entire lake area being utilized for bird counts, making it a crucial site for avian conservation. As a lake wetland, Ooty Lake primarily consists of water, encompassing about 80% of its total coverage, while the remaining 20% comprises dry land due to high silting. However, the lake has been experiencing a decline in water levels due to excessive silting, resulting in tidal conditions with drastically low water levels. The vegetation cover within the Ooty Lake area is approximately 30%, characterized by a combination of plants growing along the banks and submerged in water.

Figure no. 1 Kodapamund canal originates from the pristine edge of Doddabetta peak



The presence of sand silting and alligator weed contributes to the vegetation composition, with the remaining 70% of the wetland being open water. This lake wetland type retains water throughout the year, primarily sourced from nearby streams. While the wetland is not utilized for agricultural purposes, fishing activities are prevalent in Ooty Lake. Unfortunately, incidents of animal and bird poaching have been reported, particularly involving the use of nylon nets, posing a significant threat to the avian population. Recent surveys have documented the deaths of water birds, including the great cormorant, resulting from entanglement in these nets. Cattle grazing are observed within the wetland, potentially impacting the local bird species. Additionally, feral dogs pose a threat to the avian population in the area. Dogs occasionally enter bodies of water where they may harm water birds (Kramer 1986; Weston and Stankowich 2014). However, there is currently no presence of invasive alien plant species in Ooty Lake, although invasive alien animal species like mirror carp, leather carp, and common carp have been reported. Dr. Francis Day, in 1866, made pioneering strides in introducing fish to the Nilgiris by transforming the lake, previously home to only indigenous hill fish, with various low country varieties and Carnatic carp. In 1869, Mr. W. McIvor, the superintendent of the government garden, further enriched the lake's biodiversity by adding two types of tench, along with rudd, carp, goldfish, and silver eels (Francis 1908). The major threats faced by Ooty Lake as a wetland include pollution from domestic sewage, solid waste, sedimentation, and excessive tourism activities that disturb the birds. The noise pollution generated by tourists also could create an adverse impact on the avian population.

Personal observations and interactions with relevant authorities have revealed the pressing issues faced by Ooty Lake and its ecosystem. Concerns were raised regarding the detrimental effects of dredging activities on migratory water birds, leading to discussions with the local administration. While they acknowledged the issues, they displayed limited interest in addressing the

situation. However, efforts have been made to conduct routine bird surveys every six months, along with pH and microbial testing. An assessment of the lake boundaries and water quality has also been undertaken, revealing high levels of pollution directly entering the lake. Local stakeholders, including tourists, have expressed their concern about the impact of reduced water levels on bird safety and the increasing trend of garbage disposal within the lake. The use of nylon nets for fishing has emerged as a significant threat to the bird population.

Materials and methods:

Study area and materials

The research study was conducted at Ooty Lake, 11.405156 N, 76.68896 E over the course of eight months, from October 2022 to the end of May 2023. Ooty Lake significant wetland lake area covers approximately 3.885 square kilometres. Approximate Elevation of this lake is 2.220 m ASL; average rainfall in year 1040.9 mm. The study aimed at assessing the water bird population dynamics and mammal diversity in the vicinity of Ooty Lake. To achieve the stated research objectives, various techniques were employed. Species were observed with Nikon Binocular and photographed by Nikon P900 camera 80 X Zooming lens. GPS locations were recorded with the help of Garmin GPS Location devices.

Point count Bird Survey and Bird Focal Sampling

On February 4, 2023, we conducted a point count bird survey via a boating excursion on Ooty Lake. The survey took place from 8:00am to 11:00am, during which we recorded avian species present in the area and estimated their abundance using established methodologies. Mobility and habit are examples of inherent traits of the focus species. Short observation intervals can be effective for quantifying the behaviour of the focus individual when utilizing either recording rule for animals that are very active or very mobile, like birds (Anciães and Prum 2008; Bosholn et al. 2016; Durães 2009). Focal animal sampling approach has benefitted in a number of studies. The foraging behaviour of jacana bird from Africa has been studied employing focal animal sampling with 10 minutes intervals (Ameha and Afework 2018). We conducted 22 observations of water birds during the study period, focusing on different species and their behaviours within the lake environment. These observations were carried out at regular intervals to capture seasonal variations. In the bird focal sampling we analyse percentage with cumulative percentage using PASS software (2022).

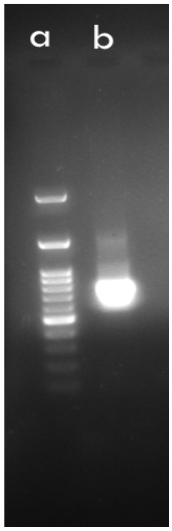
Mammal Observations

Throughout the study, continuous direct sighting and indirect evidence observations were made to document the diversity of mammals around the Ooty Lake. These observations were aimed at understanding the interactions between mammals and the lake ecosystem.

Water Ph Assessment and Microbial Analysis

In addition to avian and mammal observations, we conducted an assessment of the water quality of Ooty Lake. We measured the pH level of the lake water using an Elico pH meter to gauge its acidity or alkalinity. Additionally, we collected water samples from Ooty Lake to evaluate the presence of harmful microorganisms, specifically the potentially dangerous bacteria *Clostridium*. These samples were sent to a molecular laboratory for analysis. The image of the gel was recorded with the UV gel documentation system. A 100bp DNA ladder from Thermo was loaded parallel to PCR products as a size marker (Fig. 2), and the results were used to assess the potential risks associated with water quality for humans, animals, and birds, ensuring accuracy and reliability in the measurements.

Figure no. 2 (a) Marker (100bp), (b) sample



Results and discussion:

Focal animal sampling for water birds in Ooty Lake's silting region

The focal animal sampling data provides valuable insights into the behaviour and activities of various bird species observed in a specific location. The data reveals important information about the behaviours exhibited by each species during the specified time periods. Coots were observed throughout the day, with the initial observation starting at 08:50am and the final observation ending at 09:00am. They were primarily engaged in feeding, occasionally dipped and preened their feathers. No nesting behaviour was observed, but they were frequently observed flying, covering a distance of approximately 15 meters from the observation location. Little Grebes were closely monitored between 09:35am and 09:51am. They displayed a diverse range of behaviours, including feeding, dipping and preening. Additionally, their communication patterns were noted during this time. They were observed flying and floating, emphasizing their adaptability to both land and water habitats. Spot billed ducks were observed from 09:55am to 10:10am, covering a distance of 80 meters. These ducks exhibited a significant amount of feeding behaviour and also engaged in dipping and preening activities. This interaction between the ducks and other species adds an interesting ecological dimension to their behaviour. Eurasian Moorhens were observed at different intervals. During their sightings at 04:50pm to 05:05pm and 08:00am to 08:12am, they were predominantly engaged in feeding, with occasional dipping and preening. They were also observed flying, suggesting their ability to move between different areas. Overall, this focal animal sampling data provides valuable information for understanding the behaviours and ecological interactions of different bird species in the observed location. These insights contribute to a comprehensive understanding of avian ecology and can inform further research and conservation efforts in the area. The data presented in the frequency distribution table represents observations of bird species using focal animal sampling. The table shows the frequency, percent, valid percent, and cumulative percent for each species. The Common Coot is the most frequently observed species, accounting for one-third of the valid observations. Other species, such as the Eurasian Moorhen and Great Cormorant, have lower frequencies but contribute to the cumulative percent. The data provides a snapshot of bird species composition and their relative occurrence in the observation sample (Tab. 1).

Birds count

During winter, we conducted a bird count at Ooty Lake, recording 26 wetland bird species and a total of 602 individuals. The spot billed Duck (SBD) stands out with a substantial count of 221 individuals, indicating a significant population of local residents. Their preference for the study area suggests the availability of suitable habitats and resources. Conversely, the Lesser whistling Duck (LWD) and Pin-tailed Duck (PTD) exhibit lower counts of only 2 and 5 individuals, respectively, and are more likely to be

lower counts of only 2 and 5 individuals, respectively, and are more likely to be migratory species. The difference in counts between these species highlights variations in their abundance and migration patterns. The White-breasted Waterhen (WBWH), Common Moorhen (CM), and Coot (C) exhibit relatively higher counts of 42,37 and 58 individuals, respectively, indicating a sizable population of local residents.

Table no. 1 The data provides a snapshot of bird species composition and their relative occurrence in the observation sample

Species Name	Frequency	Percent	Valid Percent	Cumulative Percent
coot	8	33.3	33.3	41.7
eurasian moorhen	2	8.3	8.3	50.0
great cormorant	2	8.3	8.3	58.3
grey heron	1	4.2	4.2	62.5
lesser whistling duck	1	4.2	4.2	66.7
little grebe	4	16.7	16.7	83.3
northern shoveler	2	8.3	8.3	91.7
spot billed duck	2	8.3	8.3	100.0

These species are well adapted to the study area and are likely to rely on the available resources for breeding and survival. Notably, the Coots also have three recorded nestings, emphasizing their successful breeding efforts within the local habitat. Several species, such as the White-browed Wagtail (WBWT), Grey Wagtail (GW), Green Sandpiper (GS), Wood Sandpiper (WS), Common Sandpiper (CS), Common Kingfisher (CKF), White-throated Kingfisher (WTKF), Little Grebe (LG), Cattle Egret (CE), and Great Cormorant (GC), exhibit moderate counts ranging from 12 to 33 individuals. These species are primarily categorized as local residents, indicating their preference for the study area as a year-round habitat. However, human anthropogenic activities in the region can exert significant effects, such as soil fertilisation, eutrophication, changes in terrestrial and aquatic vegetation, a loss of biodiversity, the spread of certain viruses, and alterations to food webs. Despite these potential challenges the Great Cormorant showcases a noteworthy count of 34 nesting, suggesting successful breeding and a stable local population (Fig. 3, Annexes). On the other hand, several species, such as the Grey Heron (GH), Northern Shoveler (NS), Garganey (GR), Little Egret (LE), Short-toed Snake Eagle (STSE), Common Buzzard (CB), and Besra (BS), exhibit lower counts ranging from 1 to 4 individuals.

These species are more likely to be winter migrants, with their presence in the study area indicating their temporary utilization of the habitat during winter seasons. The difference in counts between local residents and migratory species highlights the diverse ecological dynamics within the avian community (Fig. 4).

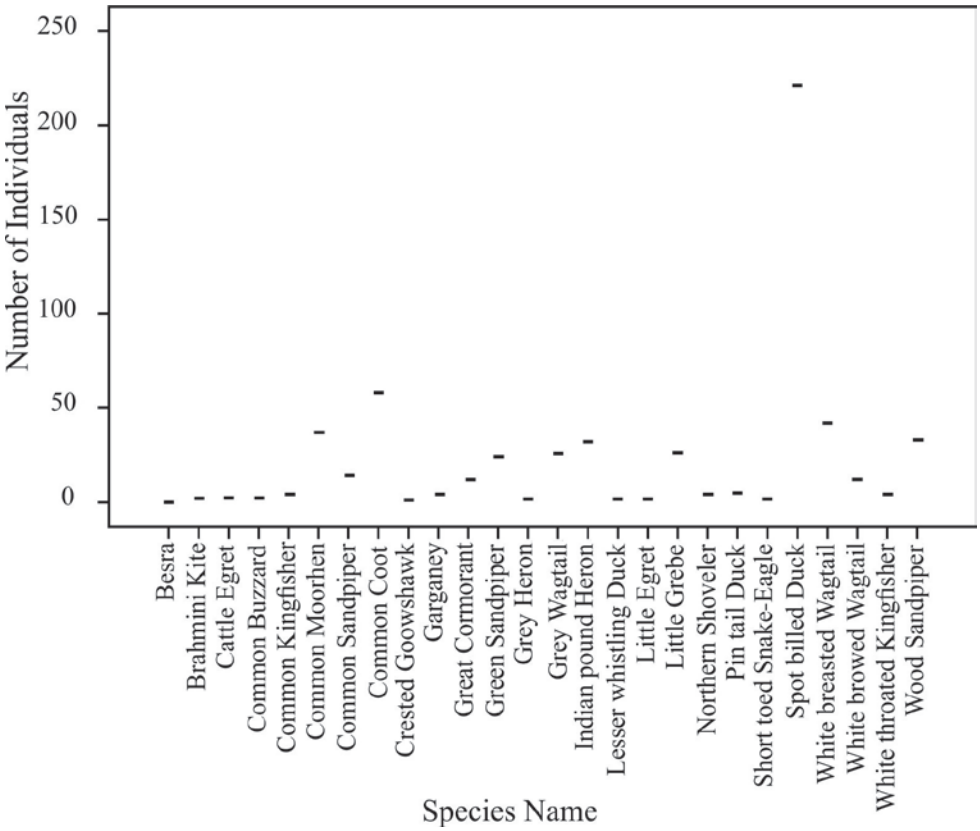
Overall, this profesional- level interpretation of the bird data provides comprehensive insights into the population sizes, nesting behaviours, and migration/local resident status of the observed species. These findings contribute to our understanding of the species composition, ecological interactions, and conservation needs within the study area. This migratory water birds visiting Ooty Lake for four consecutive years are Pin-tailed Duck (PTD), Garganey (GR), Northern Shoveler (NS), Wood Sandpiper (WS), Common Sandpiper (CS) and Green Sandpiper (GS) (Fig. 5, Annexes).

pH assessment

The pH values obtained from the pH test conducted in Kodappamund provide

interesting insights into the quality of the water in the area. Starting with the drainage channel water, the pH was measured to be 7.62. This value suggests that the water in the drainage channel is slightly alkaline, as pH values above 7 indicate alkalinity. Alkaline water can have implications for the ecosystem and aquatic life in the channel. Moving on to the water inside the lake, the pH was found to be 8.21. This measurement indicates that the lake water is more alkaline compared to the drainage channel water. Thus, the lake water is significantly more alkaline than the drainage channel water. A pH test result of 8.21 in the Ooty Lake suggests that the water is alkaline. While this pH level is slightly higher than the neutral range (pH 7), it is not significantly detrimental to the overall biodiversity of the lake. It is worth noting that certain aquatic organisms, such as frogs, might not be present in the lake due to factors other than pH, such as habitat suitability, predation, or water quality parameters beyond pH alone. However, the presence of fish indicates that the lake still supports aquatic life to a certain extent.

Figure no. 4 Count of the Ooty Lake water birds



To comprehensively assess the impact on biodiversity, it is necessary to consider multiple factors and conduct a thorough ecological analysis of the Ooty Lake. Lastly, the pH of the filtered water was determined to be 7.10. This pH value is closer to neutral (pH 7), suggesting that the filtration process has successfully removed some of the alkaline components present in the water. Filtered water with a pH close to neutral is generally considered suitable for various purposes, such as drinking and irrigation. Overall, these pH measurements highlight variations in the

water quality between the drainage channel, lake, and filtered water.

When referring to water and waste water, alkalinity is defined as the ability of compounds within the water to absorb hydroxium (H+ 3O) and attain a specific pH value (4.3 to 14) (Subramani 2012). The alkalinity observed in both the drainage channel and lake water may have implications for the aquatic environment, while the closer-to-neutral pH of the filtered water indicates an effective purification process. Further analysis and monitoring of these water sources are necessary to fully understand their impact on the local ecosystem and ensure the provision of safe and suitable water resources.

Microbial testing of Ooty Lake

The presence of multiple peaks in the chromatogram indicating the presence of more than one type of DNA suggests the possibility of multiple species of *Clostridium* in the water sample. To confirm the identity of the sample, the obtained sequence data was searched in NCBI using the BLASTn tool. Despite the low scores due to the poor quality of the chromatogram, a hit for *Clostridium* sp. was obtained, confirming the presence of *Clostridium* in the water sample. We got amplification for the *Clostridium* sp. Primer based results confirmed the presence of *Clostridium* in the sample given (Tab. 2). The DNA sequence of *Clostridium* sp. was found to be closer to *Clostridium paraputrificum* with a similarity of 92.87 % identity (Tab. 3) which is validated as a hazardous species to human and animal (BIOTEC 2015).

Clostridium bacteria can be harmful to the biodiversity of Ooty Lake, and lack of assessment and implementation of water treatment at the management level poses a significant risk. Both birds and humans near the edges of the lake are at a high risk of exposure to this bacterium. Among the concerning factors affecting the lake's ecosystem, *Clostridium* bacteria have emerged as primary culprits, leading to a higher incidence of wild bird fatalities compared to other causes of avian mortality (Milton and Franson 1999). Additionally, flies can act as potential carriers of the bacteria, further increasing the risk of its spread. It is important for the government to take immediate action to address the issue of untreated drainage water entering the lake. Implementing proper water treatment measures and conducting regular assessments can help mitigate the risk posed by *Clostridium* bacteria to the lake's ecosystem and the health of both wildlife and humans.

Table no. 2 Amplification for the *Clostridium* sp., present

Primer name	Sequence
Clos58F	AAAGGAAGATTAATACCGCATAA
Clos780R	ATCTTGCGACCGTACTCCCC

Table no. 3 *Clostridium* sp. DNA sequence close to *Clostridium paraputrificum*

Sl. No	Sample Name	Sequence Length (bp)	Nearest Neighbour	E value	% Identity	Query coverage
1	Clost	706	*Clostridium paraputrificum*	0.0	92.87	97

Mammal observations

Ooty Lake's ecosystem is characterized by an intriguing interplay of excessive plants and trees, providing a thriving habitat for a multitude of small mammals. One of the most remarkable aspects of Ooty Lake's ecosystem is the abundance of small mammals, notably the jungle cat (*Felis chaus*) (Fig. 6) and the leopard cat (*Prionailurus bengalensis*) (Fig. 7). These felid species have found a secure niche amidst the lush vegetation that surrounds the lake. Their presence underscores the importance of preserving this unique ecosystem, which offers a vital haven for these elusive and often misunderstood feline creatures.

In addition to the charismatic cats, Ooty Lake is home to a variety of rodent species. The rodent species include Indian bush rat (*Golunda ellioti*), black rat (*Rattus rattus*), Asian highland shrew (*Suncus montanus*), and the Kelaarts long-clawed shrew (*Feroculus feroculus*) (Fig. 8), Indian crested porcupine (*Hystrix indica*) Indian giant squirrel (*Ratufa indica*) (Fig. 9), Nilgiri three striped palm squirrel (*Funambulus palmarum*) (Fig. 10) and Nilgiri striped squirrel (*Funambulus sublineatus*) (Fig. 11).

Among these, Kelaarts long clawed shrew (*Feroculus feroculus*) has an endangered status and Nilgiri striped squirrel (*Funambulus sublineatus*), sloth bear (*Melursus ursinus*), Indian leopard (*Panthera pardus fusca*), brown palm civet (*Paradoxurus jerdoni*), Nilgiri Langur (*Semnopithecus johnii*) (Fig. 12) and Wild Gaur (*Bos gaurus*) (Fig. 13) has a vulnerable status according to IUCN. All these rodent species are found in good numbers in the bushes of Ooty Lake. The study observed Indian grey mongoose (*Urva edwardsii*) (Fig. 14), wild pig (*Sus scrofa cristatus*) (Fig. 15) Barking Deer (*Muntiacus muntjak*) (Fig. 16), and Indian spotted chevrotain (*Moschiola indica*).

Results and discussion:

The study provides a comprehensive overview of the ecological dynamics and challenges faced by Ooty Lake, a significant wetland area in India. The study employs a multi-faceted approach, combining focal animal sampling, pH assessment, microbial testing, and mammal diversity assessment to offer a holistic understanding of the lake's ecosystem. The focal animal sampling data reveals valuable insights into the behaviour of various bird species inhabiting Ooty Lake. It highlights the diverse range of behaviours exhibited by different species, including feeding, nesting, and interactions with other species. This information not only enriches our knowledge of avian ecology but also denotes the adaptability of these species to the lake's changing conditions. The discussion on pH assessment provides crucial information about water quality in the lake. The slightly alkaline nature of the lake water, as indicated by a pH of 8.21, is noted. While this pH level is not severely detrimental to the lake's biodiversity, it raises concerns about its potential impact on specific aquatic organisms. The discussion rightly emphasizes that a comprehensive ecological analysis is necessary to assess the overall impact on biodiversity.

The microbial testing results reveal the presence of *Clostridium* bacteria in the water sample, indicating potential risks to both wildlife and human health. This finding underscores the urgent need for proper water treatment measures to mitigate the spread of harmful bacteria. The discussion rightly points out the higher incidence of avian mortality linked to *Clostridium* bacteria, emphasizing the pressing need for government intervention to safeguard the lake's ecosystem and public health. The section on mammal diversity introduces an intriguing aspect of Ooty Lake's ecosystem by highlighting the presence of wild mammals, including jungle cats and other endangered rodent species. This inclusion adds depth to our understanding of the lake's biodiversity and emphasizes the importance of

conservation efforts, not only for charismatic megafauna but also for smaller, often overlooked inhabitants.

Strong Recommendation for Conservation:

1. Immediate Remediation Efforts
The study highlights the pressing need for immediate remediation efforts in the Kodappamund canal and the surrounding areas. Effective waste management and pollution control measures are essential to prevent further degradation of Ooty Lake.
2. Water Treatment
To mitigate the risks posed by *Clostridium* bacteria, it is imperative that the government implements proper water treatment measures. Regular assessments and purification of the lake water are essential to safeguard the ecosystem and public health.
3. Habitat Preservation
The study underscores the significance of preserving Ooty Lake as a vital wetland habitat. It is crucial to protect the lake from encroachment, habitat destruction, and pollution to ensure the survival of the diverse species that call it home.
4. Sustainable Tourism
Encourage sustainable tourism practices in the area to minimize disturbances to the avian population. Implementing regulations that promote responsible tourism and minimize noise pollution can greatly benefit the ecosystem.
5. Education and Awareness
Raise awareness among local communities, tourists, and policymakers about the ecological importance of Ooty Lake. Informed stakeholders are more likely to support conservation efforts and take steps to protect the lake.

Recommendations for more sustainable and bird-friendly de-silting methods:

1. Schedule de-silting during off season
Coordinate de-silting activities to take place during the off-season when migratory birds are not present, typically not during their breeding and roosting months. This minimizes disturbances to their habitat.
2. Use dredging machines
Replace manual digging with modern dredging machines. Dredging is a more controlled and environmentally friendly method for removing silt and sediment from the lake. It's less disruptive to the ecosystem and can be more efficient. The protection of fish spawning and nursery regions, waterfowl feeding areas, and other animal habitats must be taken into account in any macrophyte dredging strategy (Peterson 1982). This can help in retaining valuable nutrients and sediment while allowing cleaner water to flow back into the lake. The separated silt can be used for various purposes, such as fertilizing nearby lands.
3. Implement eco-friendly de-silting techniques
Investigate and implement eco-friendly de-silting methods that minimize damage to the surrounding environment. These may include techniques like hydraulic dredging, which can be more precise and less disruptive.
4. Regular maintenance
Develop a routine maintenance schedule for the lake to prevent excessive silt build-up. Regular monitoring and small-scale de-silting can be more cost-effective and less disruptive compared to infrequent, large-scale operations.
5. Habitat restoration
After de-silting, focus on habitat restoration. Plant native vegetation along the banks to provide shelter and foraging areas for birds. Create nesting sites, such as birdhouses or artificial islands, to compensate for any disruptions during de-silting.
6. Community engagement
Involve the local community and conservation organizations in lake management and de-silting efforts. This will help raise awareness and garner support for bird and habitat protection.
7. Environmental Impact Assessment
Conduct a thorough environmental impact assessment before initiating de-silting. This assessment should consider the potential

effects on the ecosystem and suggest mitigation measures.

8. Educational programs

Organize educational programs and workshops for locals and visitors to raise awareness about the importance of the lake's ecosystem and the need for sustainable desilting practices.

9. Government and NGO collaboration

Collaborate with governmental agencies and non-governmental organizations specializing in conservation and environmental protection to ensure that desilting efforts are in line with best practices.

By adopting these recommendations, Ooty Lake can be desilted in a more environmentally responsible and bird-friendly manner, while also considering cost-effectiveness and the long-term health of the ecosystem.

Ooty Lake-Recommendations for RAMSAR Site:

Ooty Lake is facing significant ecological challenges, and the research conducted provides valuable insights into the state of this wetland ecosystem. The findings presented in this article emphasize the need for conservation efforts and immediate action to address various ecological issues. Here we present some recommendations and criteria that could be considered for designating Ooty Lake as a Ramsar site, which is an internationally recognized designation for wetlands for international importance.

Nine criteria are notified for identifying wetlands of international importance, on this basis Ooty Lake matches with 3 Criterion for Ramsar site.

RAMSAR Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

This study underscores the remarkable significance of Ooty Lake and its surrounding wetlands by emphasizing the presence of endangered and threatened species. Notably, the Kelaarts long-clawed shrew (*Feroculus feroculus*) classified as IUCN-Endangered, finds refuge in this ecosystem. Additionally, the Nilgiri Langur (*Semnopithecus johnii*) and the Nilgiri striped squirrel (*Funambulus sublineatus*), both IUCN-Vulnerable species, thrive in this unique habitat. In accordance with Group-2 criteria, Ooty Lake and its wetlands undoubtedly meet the international standard for supporting vulnerable, endangered, and threatened species, contributing significantly to their conservation efforts. This highlights the imperative recognition of Ooty Lake as an internationally important wetland, ensuring the protection of these remarkable species and their fragile ecological communities.

RAMSAR Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

The wetlands surrounding Ooty Lake are abundant with *Juncus* species, indicating the rich and diverse flora in this unique ecosystem. This particular area boasts a significant population of jungle cat (*Felis chaus*) and the leopard cat (*Prionailurus bengalensis*), making it a thriving habitat for these elusive feline species. Notably, it serves as a vital breeding site for these cats, contributing to their conservation and the overall biodiversity of the region. Ooty Lake and its adjacent wetlands play a crucial role in preserving both plant and animal life. Under Group-2 Criteria 4 the plant species supports as an important habitat for the aforementioned mammal species which are at a critical stage in their life cycles.

RAMSAR Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

The Ooty Lake and its surrounding wetlands are home to a rich avian diversity, hosting five distinct species of waterfowl. Notably, the large cormorants have established a significant nesting colony, underscoring the ecological significance of this region. Moreover, the spot-billed duck

has chosen the wetlands around the lake as a nesting site, further emphasizing the area's importance for waterfowl. According to international criteria, a wetland is deemed of global importance when it consistently sustains at least 1% of a specific waterbird species or subspecies population. Ooty Lake undeniably meets this criterion, as it supports these diverse and thriving waterfowl populations, thus warranting recognition as an internationally important wetland for avian conservation and ecological significance.

Conclusions:

This research article offers a well-rounded exploration of Ooty Lake's ecosystem, addressing key ecological issues such as water quality, bacterial threats, and mammal diversity. It underscores the importance of preserving this unique habitat and calls for immediate action to mitigate threats and conserve the delicate balance of life in and around the lake. The interdisciplinary approach employed in this study serves as a model for comprehensive ecological research and conservation efforts in other wetland ecosystems. The silting area of Ooty Lake plays a crucial role as the breeding ground for numerous bird species, with migratory birds relying on this area for sustenance during a significant portion of the year. It also serves as their primary roosting place. However, the traditional approach to undertake desilting, which persists even as water levels recede, poses a severe threat to the avian habitats. The outdated technique involves the use of heavy machinery to excavate the silt, resulting in significant environmental disruption. Regrettably, more modern and ecologically friendly methods, such as dredging, have not been adopted. This not only drives up costs but also endangers the arrival of migratory birds to the region. It is imperative that we re-evaluate the desilting practices to safeguard both the avian population and the precious ecosystem of Ooty Lake. A small marshland area graces the left side of the path leading from the railway station to the Ooty Lake drainage zone. This humble wetland serves as a nesting ground for various avian species, including the graceful spot-bellied duck, the elusive water hen, and the common moorhen. Nestled amidst its reeds and waterways, the marshland is not only a haven for birds but also a domain inhabited by jungle cats. Amidst the vibrant ecosystem, the *Juncus inflexus* plant thrives, renowned for its remarkable ability to naturally purify the water, from moderate to colder climes, several species of the genus *Juncus* have the capacity to purify water and/or soil polluted with a variety of heavy metals and/or organics (Syranidou et al. 2017). This tranquil, biodiverse corner provides both shelter to wildlife and a lesson in the vital role nature plays in maintaining the balance of our environment.

The presence of these rodents highlights the critical need for conservation efforts to ensure their survival, as they play an integral role in maintaining the delicate balance of the ecosystem. The coexistence of both endangered and thriving species in the same ecosystem is a testament to the intricate web of life that thrives around Ooty Lake. It emphasizes the importance of holistic conservation measures that not only protect the charismatic megafauna but also safeguard the often-overlooked smaller inhabitants of this fragile ecosystem. Ooty Lake, with its rich biodiversity, is not just a haven for mammals; it is a sanctuary that fosters the harmonious existence of numerous species. As we delve deeper into the exploration of this captivating ecosystem, it becomes evident that Ooty Lake is not only a refuge for birds but also a safe haven for these remarkable mammals. Our research underscores the significance of preserving this natural wonder, and it serves as a clarion call for concerted efforts to protect and conserve the unique biodiversity that graces the shores of Ooty Lake for generations to come.

Rezumat:

EVALUAREA ECOLOGICĂ CUPRINZĂTOARE A LACULUI OOTY: UN STUDIU MULTIDISCIPLINAR PRIVIND DIVERSITATEA AVIFAUNISTICĂ, DINAMICA ZONELOR UMEDE, CALITATEA APEI, AMENINȚĂRILE MICROBIENE ȘI DIVERSITATEA MAMIFERELOR

Sănătatea ecologică și provocările cu care se confruntă lacul Ooty, o zonă umedă proeminentă din India, au fost investigate în detaliu în acest articol de cercetare. A fost utilizată o abordare multifațetată, combinând eșantionarea animalelor focale, evaluarea pH-ului, testele microbiene și evaluarea diversității mamiferelor pentru a oferi o înțelegere holistică a ecosistemului lacului. Eșantionarea animalelor focale a evidențiat o diversitate avifaunistică și comportamentală, care a îmbogățit cunoștințele privind ecologia aviară și adaptabilitatea acestora la condițiile în schimbare. Evaluarea pH-ului a indicat o apă a lacului ușor alcalină, ceea ce a ridicat probleme pentru anumite organisme acvatice, subliniind necesitatea unei analize ecologice complete. Testele microbiene au descoperit prezența bacteriei *Clostridium*, subliniind urgența măsurilor de tratare a apei pentru fauna sălbatică și sănătatea umană. De asemenea, studiul pune în lumină prezența mamiferelor mici, inclusiv a speciilor pe cale de dispariție, subliniind importanța eforturilor de conservare pentru întregul ecosistem. În general, această cercetare solicită măsuri imediate pentru a proteja echilibrul fragil al vieții din lacul Ooty și servește drept model pentru cercetarea ecologică completă și eforturile de conservare în ecosistemele zonelor umede.

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Annexes:

Figure no. 3 Great cormorant (*Phalacrocorax carbo*) nesting site in inside Ooty Lake

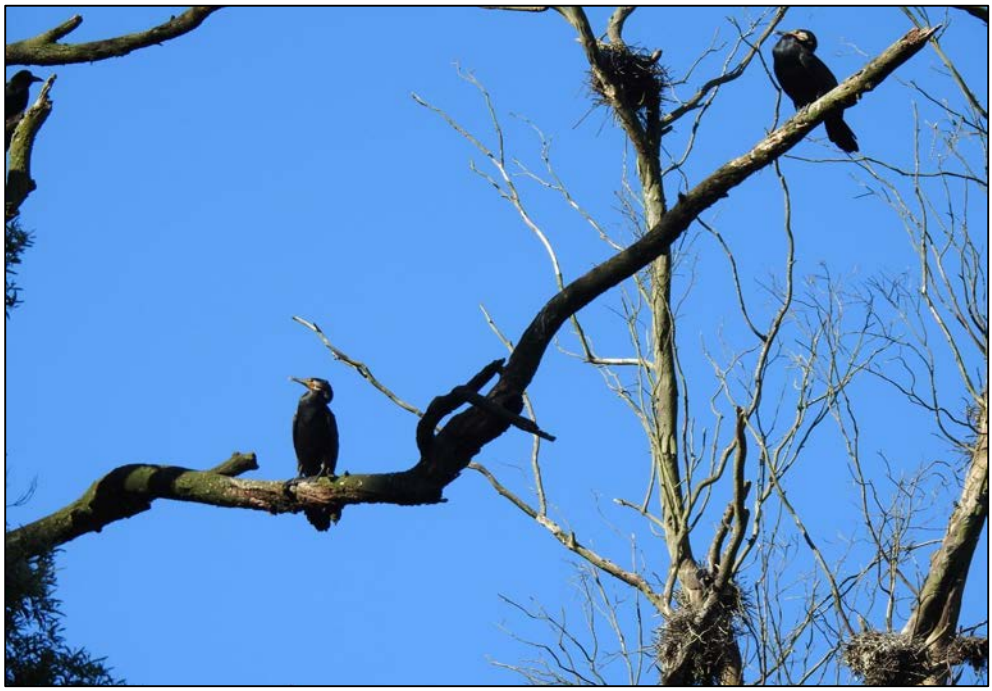

Figure no. 5 Migratory water birds visiting Ooty Lake for four consecutive years (a) Pin-tailed Duck (PTD), (b) Garganey (GR), (c) Northern Shoveler (NS), (d) Wood Sandpiper (WS), (e) Common Sandpiper (CS), (f) Green Sandpiper (GS)

a.


b.


c.


d.


e.

f.

Figure no. 6 Abundance of jungle cat (*Felis chaus*) in Ooty Lake

Figure no. 7 Leopard cat (*Prionailurus bengalensis*)

Figure no. 8 Kelaart`s long clawed shrew (*Feroculus feroculus*) IUCN - Endangered

Figure no. 9 Indian giant squirrel (*Ratufa indica*)

Figure no. 10 Nilgiri three striped palm squirrel (*Funambulus palmarum*)

Figure no. 11 Nilgiri striped squirrel (*Funambulus sublineatus*) IUCN – Vulnerable

Figure no. 12 The Nilgiri langur (*Semnopithecus johnii*) IUCN - Vulnerable

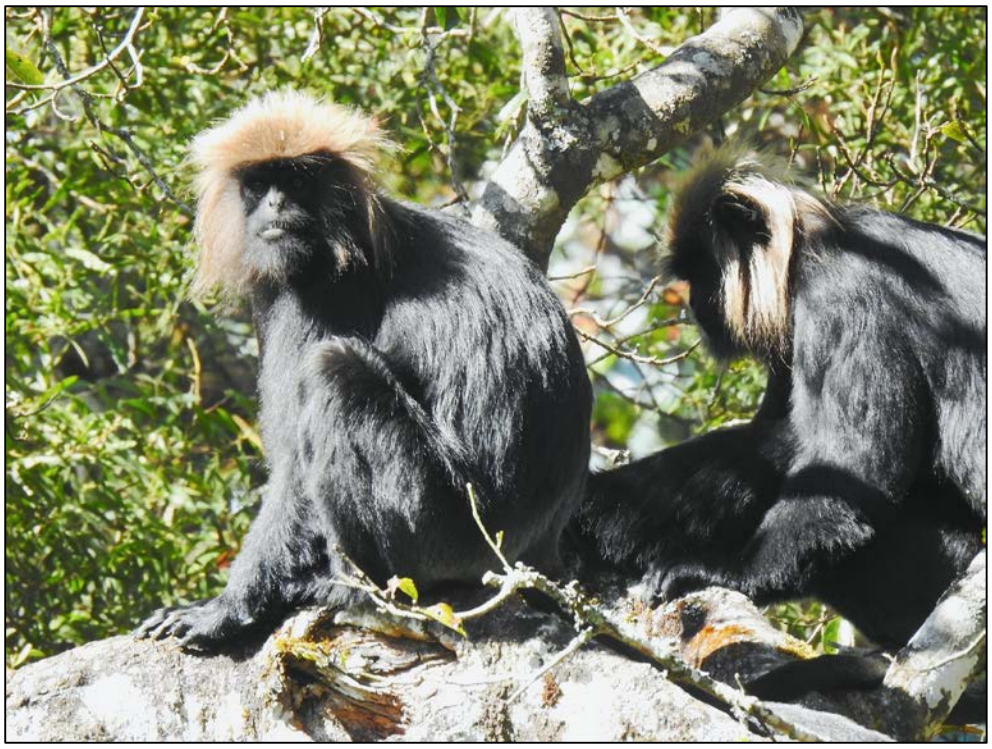

Figure no. 13 Wild Gaur (*Bos gaurus*)

Figure no. 14 Indian grey mongoose (*Urva edwardsii*)

Figure no. 15 Ooty Lake abundance of Indian boar (*Sus scrofa cristatus*)

Figure no. 16 Barking Deer (*Muntiacus muntjak*)