International Journal of Scientific Research and Engineering Development-– Volume 8 Issue 5, Sep-Oct 2025
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Ecological Assessment of Mula-Mutha River Through Physicochemical Indicators and Avian Diversity Across Seasons

Alsabha Ayaz Sayyed, Shoeb Ahmad, Sameen Gazikhan*
(Post Graduate Department of Zoology, AKI's Poona College of Arts, Science and Commerce, Camp, Pune – 411001, Maharashtra. Affiliated to Savitribai Phule Pune University, Pune- 411007, Maharashtra)
*Corresponding Author's Email: sameen.gazikhan@poonacollege.edu.in

----------**********----------

Abstract:

This study provides a detailed ecological assessment of the Mula-Mutha River, Pune, integrating physicochemical water quality parameters with avian diversity as bioindicators across three hydrological seasons—pre-monsoon, monsoon, and post-monsoon. Water samples collected from upstream to downstream sites were analyzed for pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity, nitrate, and phosphate concentrations. Simultaneous avian surveys using point count and direct observation methods were assessed through Shannon-Wiener and Simpson's diversity indices. Seasonal variations were significant: pre-monsoon exhibited low DO (5.1 mg/L) and high BOD (8.9 mg/L), indicating organic enrichment, while post-monsoon showed improved water quality (DO 7.5 mg/L; BOD 5.2 mg/L) due to hydrological recovery. Avian richness peaked in post-monsoon (55 species; H′ = 3.35) and was lowest during pre-monsoon (38 species; H′ = 2.71), strongly correlating positively with DO and negatively with BOD and phosphate levels. Dry-season proliferation of invasive macrophytes (Eichhornia crassipes, Pistia stratiotes) exacerbated hypoxia, reducing piscivorous bird activity. These findings confirm avian diversity as a robust bioindicator of river health and highlight the urgent need for pollution control and habitat restoration measures within the Mula-Mutha river at Pune urban area.

Keywords — Mula-Mutha River, Physicochemical Parameters, Avian Diversity, Bioindicators.

----------**********----------

I. INTRODUCTION

Rivers are critical components of freshwater ecosystems, serving as lifelines for civilizations and as dynamic habitats for a variety of organisms. They not only provide water for domestic, agricultural, and industrial needs but also sustain biodiversity along their banks [1]. The Mula-Mutha River, formed by the confluence of the Mula and Mutha in Pune, Maharashtra, ultimately drains into the Bhima, a tributary of the Krishna River, before reaching the Bay of Bengal. The Mula originates from Mulshi Dam, while the Mutha flows from Panshet via Khadakwasla Dam, converging at Shivajinagar's Sangam Bridge. Historically, this river system supported human settlements and ecological communities; however, in recent decades, it has exemplified the consequences of unchecked urbanization and industrialization.

Water quality in the Mula-Mutha has drastically deteriorated due to untreated sewage, industrial discharges, and solid waste. High Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), coupled with low Dissolved Oxygen (DO), reflect severe organic and chemical pollution [2]. A Report of Central Pollution Control Board indicate that in certain stretches, BOD exceeds 30 mg/L—ten times the permissible limit for bathing waters. Such degradation threatens aquatic biota and renders the river unsuitable for potable or recreational use [3].

The ecological consequences extend beyond water chemistry to biodiversity. Historically rich in

avifauna and riparian vegetation, the river has suffered dramatic biodiversity losses. Over the last 66 years, more than 200 plant species along the Mutha's riparian zone have disappeared, reducing nesting and foraging opportunities for birds [4]. Nevertheless, recent surveys and citizen science platforms continue to report over 100 bird species in the region, including the Ruddy Shelduck (*Tadorna ferruginea*), Black-headed Ibis (*Threskiornis melanocephalus*), and Black-winged Stilt (*Himantopus himantopus*), highlighting the river's continued ecological significance [5].

Recent fish kills caused by oxygen depletion demonstrate the close linkage between abiotic stressors and biotic integrity [6]. Birds dependent on aquatic prey, such as herons, cormorants, and kingfishers, are directly affected, often abandoning polluted stretches. Furthermore, decomposition of invasive water hyacinth (*Eichhornia crassipes*) biomass increases microbial loads and reduces oxygen levels, altering plankton and invertebrate diversity [7]. These shifts cascade through trophic levels, ultimately affecting insectivorous and piscivorous bird populations.

Given these challenges, comprehensive ecological assessments are vital. By correlating physicochemical parameters with avian diversity, alongside monitoring fish and microbial communities, a holistic understanding of the Mula-Mutha's ecosystem health can be achieved. Such integrated approaches are essential for formulating conservation and restoration strategies.

II. METHODOLOGY

The ecological assessment of the Mula-Mutha River was conducted using a combination of physicochemical water quality analysis and avian diversity monitoring across three seasons: pre-monsoon (March – May 2024), monsoon (June – September 2024), and post-monsoon (October – Novembe 2024). Sampling sites were selected along upstream, midstream, and downstream stretches form Khadakwasla dam, Z – bridge, Sangamwadi, Khadki Holkar bridge, Bund Garden, Kalyani Nagar, Kharadi gaon, Mundhwa to capture spatial variability. Water samples were collected following APHA guidelines [8] and analyzed for key indicators, including pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity, nitrate, and phosphate concentrations by using Water testing kit (LABTRONICS), which are widely recognized as indicators of aquatic health.

Avian surveys were carried out simultaneously using the point count method and direct visual observation with binoculars during early morning hours when bird activity is highest Bird species were identified using field guides prescribed by Grimmett *et al.,* [9] and diversity indices such as Shannon-Wiener and Simpson's index were applied to evaluate seasonal variations in community structure by following the method of Magurran [10].

III. RESULTS

Significant seasonal variation was observed in dissolved oxygen (DO), chemical oxygen (COD) demand**.** Turbidity also differed significantly across seasons, being highest during monsoon. Nitrate and phosphate showed seasonal decline, but variation was not significant. Bird species richness was positively correlated with dissolved oxygen and negatively correlated with biological oxygen demand (BOD) and phosphate. This suggests higher bird diversity in better-oxygenated, less polluted conditions.

Physicochemical results showed that pre-monsoon months were marked by low dissolved oxygen (5.1 mg/L), high biological oxygen demand (>8 mg/L), and elevated chemical oxygen demand (>40 mg/L), indicating organic pollution due to reduced flow and sewage discharge. In contrast, monsoon months showed improvement in dissolved oxygen (6.8 mg/L) and reduced organic load due to dilution, though turbidity spiked (29.6 NTU) from runoff. Post-monsoon exhibited the best water quality, with the highest dissolved oxygen (7.5 mg/L) and lowest biological oxygen demand and chemical oxygen demand (Table 1), suggesting recovery of the river system.

Table 1. Seasonal Variation in Physicochemical Parameters of Mula-Mutha River (Mean ± SD, n = 5 sites per season).

Parameter	Pre-Monsoon	Monsoon	Post-Monsoon	Seasonal Trend
pH	7.8 ± 0.2	7.2 ± 0.3	7.5 ± 0.2	Highest in pre-monsoon
Dissolved Oxygen (mg/L)	5.1 ± 0.7	6.8 ± 0.9	7.5 ± 1.1	Highest in post-monsoon
BOD (mg/L)	8.9 ± 1.2	6.4 ± 0.8	5.2 ± 0.7	Highest in pre-monsoon, lowest in post-monsoon
COD (mg/L)	42.3 ± 3.5	35.7 ± 2.8	30.1 ± 2.5	Decreasing trend towards post-monsoon
Turbidity (NTU)	16.8 ± 3.2	29.6 ± 5.1	12.4 ± 2.1	Peak during monsoon

Nitrate (mg/L)	7.2 ± 1.0	6.1 ± 0.8	5.4 ± 0.6	Decline from pre- to post-monsoon
Phosphate (mg/L)	2.8 ± 0.4	2.2 ± 0.3	1.9 ± 0.2	Decline from pre- to post-monsoon

Avian diversity followed a seasonal gradient, with species richness and diversity indices highest in post-monsoon (S = 55, H′ = 3.35), coinciding with improved water quality and arrival of migratory species such as Northern Shoveler, Common Teal, and Black-tailed Godwit. Monsoon months maintained moderate diversity (S = 42, H′ = 2.89), while pre-monsoon months had the lowest richness (S = 38, H′ = 2.71), reflecting the negative influence of eutrophication and macrophyte overgrowth (Table 2).

Table 2. Seasonal Variation in Avian Diversity Indices

Season	Species Richness (S)	Shannon-Wiener Index (H′)	Simpson's Diversity (1-D)
Pre-Monsoon	38	2.71	0.86
Monsoon	42	2.89	0.89
Post-Monsoon	55	3.35	0.93

Field surveys confirmed that summer (pre-monsoon) months showed dense mats of *Eichhornia crassipes* and *Pistia stratiotes*, associated with hypoxic conditions and fish mortality. These zones reduced foraging activity of piscivorous birds like Cormorants and Kingfishers. In contrast, winter months had sparse macrophyte cover, better dissolved oxygen, and higher bird presence, especially migratory ducks and waders.

Overall parameters of the results confirmed significant seasonal variation in key water quality parameters, while correlation tests established strong links between dissolved oxygen (DO) levels and bird richness. This supports the hypothesis that improved water quality enhances avian diversity, making migratory and resident birds effective bioindicators of riverine ecosystem health.

IV. DISCUSSION

The ecological assessment of the Mula-Mutha River highlights the strong influence of seasonal dynamics on water quality and avian diversity. Significant variation in dissolved oxygen (DO), chemical oxygen demand (COD), and turbidity was observed across the three seasons, while nitrate and phosphate showed a seasonal decline but were statistically non-significant. Such seasonal variability in Physicochemical parameters is consistent with findings from other Indian rivers, where monsoon-driven hydrological changes play a central role in shaping water quality [11, 12].

Low dissolved oxygen levels and high biological oxygen demand and chemical oxygen demand during the pre-monsoon season indicate organic pollution, likely due to reduced dilution capacity of the river and increased sewage inflow. Similar pre-monsoon oxygen depletion has been reported in the Yamuna and Sabarmati rivers, where untreated domestic wastewater leads to hypoxic conditions and fish mortality [13, 14]. The improvement in dissolved oxygen during the monsoon can be attributed to enhanced flow and aeration, although turbidity increases sharply due to sediment and runoff inputs. Post-monsoon recovery of water quality, reflected in elevated dissolved oxygen and reduced organic load, aligns with studies on seasonal self-purification capacity of rivers (Ravindra et al., 2019) [15].

Avian diversity exhibited a strong seasonal gradient, peaking during the post-monsoon season. Migratory birds such as *Anas crecca* and *Limosa limosa* coincided with improved water quality, supporting the hypothesis that avifauna respond sensitively to aquatic conditions [9, 16]. The positive correlation between bird species richness and DO, and the negative correlation with biological oxygen demand and phosphate, further emphasize the role of clean, oxygen-rich habitats in supporting bird communities. Comparable findings were reported by Surana *et al.*, [17] in Pune wetlands, where higher water quality promoted greater avian richness.

The proliferation of aquatic macrophytes during pre-monsoon, particularly *Eichhornia crassipes* and *Pistia stratiotes*, negatively affected aquatic fauna and piscivorous birds. Similar observations have been made in eutrophic wetlands of North India, where excessive macrophyte cover limited light penetration, created hypoxic zones, and reduced foraging efficiency of waterbirds [18]. Conversely, the sparse vegetation cover in winter facilitated improved fish activity, thereby attracting migratory ducks and waders.

Overall, the integration of Physicochemical and avian data demonstrates that avian diversity is a reliable bioindicator of river health. The strong correlations between water quality and bird richness support earlier ecological frameworks emphasizing birds as sentinels of ecosystem integrity [10, 19]. These findings underline the urgent need for

pollution management, especially controlling nutrient input and sewage discharge, to safeguard both aquatic biodiversity and migratory bird habitats along the Mula-Mutha River.

V. REFERENCES

[1] Indian Council of Medical Research (ICMR). (1975). *Manual of standards of quality for drinking water supplies*. New Delhi: ICMR.

[2] Jadhav, S., & Jadhav, A. (2017). Assessment of water quality of Mula-Mutha River, Pune. *International Journal of Environmental Sciences*, 7(3), 45–52.

[3] Central Pollution Control Board. (2022). *Water quality status of Indian rivers*. Government of India.

[4] Hindustan Times. (2024, February 12). *Pune's Mutha river loses 200 plant species in 66 years*. Hindustan Times.

[5] eBird. (2023). *Bird observations along Mula-Mutha River, Pune*. Cornell Lab of Ornithology. Retrieved from https://ebird.org

[6] Indian Express. (2024, January 8). *Fish kill in Mula-Mutha raises concerns over pollution levels*. Indian Express.

[7] Sawant, S., Patil, S., & Gawade, S. (2018). Impact of invasive water hyacinth (*Eichhornia crassipes*) on freshwater ecosystems. *Journal of Aquatic Biology & Fisheries*, 6(2), 23–31.

[8] APHA. (2017). *Standard methods for the examination of water and wastewater* (23rd ed.). American Public Health Association.

[9] Grimmett, R., Inskipp, C., & Inskipp, T. (2011). *Birds of the Indian Subcontinent* (2nd ed.). Oxford University Press.

[10] Magurran, A. E. (2004). *Measuring biological diversity*. Blackwell Publishing.

[11] Sharma, M. P., Kansal, A., & Tyagi, S. (2016). Water quality assessment of major rivers of India. *Environmental Monitoring and Assessment, 188*(4), 199.

[12] Singh, A., & Nautiyal, R. (2017). Seasonal changes in water quality of the Ganga River at Rishikesh. *Applied Water Science, 7*(4), 1893–1905. https://doi.org/10.1007/s13201-015-0369-6

[13] Kumar, A., & Chopra, A. K. (2012). Seasonal variation in physicochemical and microbiological characteristics of Yamuna River water at Kalpi, India. *Environmental Monitoring and Assessment, 184*(9), 5049–5063.

[14] Mishra, A. S., & Nautiyal, R. (2013). Impact of sewage pollution on ecology of rivers: A review. *Journal of Environmental Biology, 34*(2), 171–180.

[15] Ravindra, K., Kaushik, A., & Rani, N. (2019). Seasonal variations in water quality of rivers in Northern India. *Environmental Science and Pollution Research, 26*(15), 15208–15220.

[16] Mukherjee, S., Banerjee, S., & Chowdhury, S. (2020). Avian diversity in relation to water quality of wetlands in eastern India. *Wetlands Ecology and Management, 28*(4), 563–577.

[17] Surana, R., Gaikwad, S., & Jadhav, R. (2019). Avian diversity as indicators of ecosystem health: A study of Pune wetlands, India. *Journal of Ecology and the Natural Environment, 11*(6), 109–118.

[18] Patel, R., & Hussain, S. A. (2019). Impact of invasive aquatic plants on waterbird habitats: A case study from North India. *Aquatic Conservation: Marine and Freshwater Ecosystems, 29*(3), 371–383.

[19] Li, Y., Liu, J., Sun, Y., & Wang, X. (2019). Birds as bioindicators of wetland ecosystem health in China. *Ecological Indicators, 104*, 204–212.

