Impact of Pollution on Migratory Birds and Wetland Ecology: A Case Study of T.S. Chanakya Wetlands, Navi Mumbai, Maharashtra.

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***Abstract*— Wetlands serve as critical stopover habitats for migratory birds, offering food, shelter, and breeding grounds. The T.S. Chanakya Wetlands in Navi Mumbai, however, face increasing threats from urbanization, industrial discharge, and pollution. This research evaluates how water quality affects bird diversity and behavior through the examination of samples collected from three different locations —urban coastal, foraging and feeding, and creek-mangrove zones. Factors including cadmium, chromium, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and nitrates. nitrites, and pH were examined. Results revealed that cadmium and chromium exceeded permissible limits in mangrove and urban sites, while BOD and COD levels indicated heavy organic contamination. Such conditions reduce oxygen availability, alter aquatic food webs, and degrade foraging habitats. Field surveys recorded diverse species including flamingos, curlews, sandpipers, and gulls, with observable shifts in feeding and roosting behavior linked to pollution levels. The findings emphasize the urgent need for stricter pollution control, mangrove restoration, and sustainable urban planning to conserve wetland ecosystems and ensure the survival of migratory birds in urban landscapes.**

***Index Terms*— Wetlands, migratory birds, pollution, heavy metals, biodiversity, Navi Mumbai.**

I. INTRODUCTION

Wetlands are among the most productive and ecologically significant ecosystems on Earth, functioning as natural water filters, carbon sinks, and buffers against floods while supporting diverse flora and fauna. For migratory birds, wetlands serve as crucial stopover points, providing feeding, nesting, and roosting grounds during seasonal journeys across continents. These habitats enable birds to replenish energy reserves essential for long-distance migration, thus ensuring their survival and successful reproduction.

Despite their vital role in the ecosystem, wetlands around the globe are facing greater risks due to human activities like swift urban development, land-use change, industrial development, and climate variability. In India, urban wetlands face acute challenges due to habitat loss, pollution, and encroachment, leading to severe consequences for biodiversity. The Navi Mumbai region, located along India's western coastline, has witnessed large-scale reclamation, mangrove degradation, and contamination from untreated domestic and industrial effluents. These modifications have greatly impacted habitat quality, which in turn influences the distribution, behavior, and survival of migratory birds. The T.S. Chanakya Wetlands in Sea woods, Navi Mumbai, represent one such ecologically fragile yet vital habitat. Characterized by shallow water bodies, intertidal mudflats, and mangrove cover, these wetlands attract a wide variety of migratory species, including flamingos, curlews, and sandpipers. However, increasing heavy metal contamination, nutrient enrichment, and organic pollution have disrupted food availability, deteriorated water quality, and altered avian behavior. Studies indicate that bioaccumulation of cadmium and chromium in wetland ecosystems, coupled with high biochemical and chemical oxygen demand (BOD and COD), poses significant risks to bird health and ecological balance.

Given these challenges, there is an urgent need to assess the ecological status of urban wetlands and their role in sustaining migratory bird populations. This research concentrates on the T.S. Chanakya Wetlands to estimate the impact of pollution and water quality on avian diversity and behavior, while also highlighting the importance of conservation strategies for maintaining biodiversity within rapidly urbanizing landscapes.

II. MATERIAL AND METHODS

Study Area: The research was carried out at T.S. Chanakya Wetlands (Latitude 19.016607° N, Longitude 73.005905° E) located in Navi Mumbai, Maharashtra, India. The site is part of the Thane Creek ecosystem and is known for its rich avifauna, particularly migratory waterbirds. The wetland consists of shallow mudflats, areas of mangroves, and open water zones, which are essential for feeding and roosting.

Field Surveys: Birdwatching activities were conducted in the morning (06:30–10:00 hrs) and evening (16:30–19:00 hrs) sessions to capture peak feeding and roosting activity. Standard birdwatching tools, such as binoculars and high-resolution digital cameras, were utilized for recognizing species and documenting their behaviors. Field guides (Birds of the Indian Subcontinent by Grimmett et al.) and mobile applications (Merlin Bird ID, eBird, iNaturalist) aided in confirming identifications. Photographs were geotagged to map spatial distribution. Birds were categorized into waders, shorebirds, and waterfowl, and their foraging and roosting behavior was recorded.

Water Sampling and Analysis: Water samples were collected from three locations that reflect various habitat conditions:

1. Urban Coastal Site – influenced by human settlements and industrial activity.
2. Foraging and Feeding Site – shallow mudflats used by birds.
3. Creek and Mangrove Site – tidal mangrove ecosystem.

Samples were collected in pre-cleaned polyethylene bottles, preserved at 4°C, and transported to the laboratory. In-situ parameters such as pH and temperature were recorded immediately. The quality of water was assessed in accordance with established protocols (USEPA, 1994).

a. **Heavy Metal Analysis**: Cadmium and chromium concentrations were measured by using acid digestion followed by spectrophotometric methods.

b. **Biochemical Oxygen Demand (BOD):** Measured using the Winkler titration method. Water samples were incubated at 20°C for five days, and dissolved oxygen (DO) levels were recorded before and after incubation.

c. **Chemical Oxygen Demand (COD**): Determined using potassium dichromate digestion in acidic medium, followed by titration with ferrous ammonium sulfate.

d. **Nitrates and Nitrites**: Measured using UV-Vis spectrophotometry with sulphanilamide and NED reagents.

e. pH: Recorded using a calibrated digital pH meter.

Data Analysis: To assess pollution levels, water quality parameters were compared against standard permissible limits. Bird diversity and abundance were analyzed with respect to habitat conditions and water quality variations. Birds behavioral observations were correlated with environmental stressors such as pollution, human disturbance, and habitat degradation.

III. Observations

Water quality and avifaunal observations were recorded across three distinct sites within the T.S. Chanakya Wetlands: An Urban Coastal Site, a Foraging and Feeding Site, and a Creek–Mangrove Site. The analysis revealed considerable variation in pollution levels and habitat suitability, which directly influenced the distribution and behavior of migratory birds.

Heavy Metals: Cadmium was absent at the Foraging and Feeding Site (Table 1, Fig. 1) (0.0 µg/100 mL) but exceeded permissible limits at the Creek–Mangrove Site (9.5 µg/100 mL) and Urban Coastal Site (11.0 µg/100 mL), suggesting contamination from industrial effluents and domestic waste. Chromium levels were detected to exceed the established standard limit. The levels of chromium were observed to exceed the established standard limit (50.0 µg/100 mL) at all sites, with the highest levels (>100 µg/100 mL) recorded at the Creek–Mangrove and Urban Coastal Sites, indicating severe heavy metal pollution.

BOD and DO: The Foraging and Feeding Site recorded moderate organic pollution with a BOD of 4.20 mg/L and DO declining from 8.40 mg/L to 4.20 mg/L. The Creek–Mangrove Site showed a higher BOD of 4.95 mg/L, reflecting reduced water quality. The Urban Coastal Site exhibited the most severe organic pollution, with DO dropping from 10.80 mg/L to 1.50 mg/L, and BOD reaching 10.30 mg/L, far exceeding permissible limits. (Table 2)

COD: COD values followed a similar trend. The Foraging and Feeding Site remained within acceptable limits (234.3 mg/L), whereas the Creek–Mangrove Site (407.4 mg/L) and the Urban Coastal Site (573.9 mg/L) showed heavy organic and inorganic pollution, pointing to untreated sewage and industrial discharge. (Table 2)

Nutrients: Nitrate levels remained within permissible limits at all sites (3.70–7.70 mg/L). However, nitrite levels exceeded safe limits (1.37 mg/L) at the Creek–Mangrove Site, indicating contamination from organic waste and wastewater inputs. The Urban Coastal Site showed comparatively lower nitrate and nitrite levels, likely due to tidal dilution. Nitrate and nitrite concentrations are summarized in Table 3.

pH: pH values at different locations varied from slightly acidic to neutral, creating conditions that are typically favorable for aquatic organisms but vulnerable to stress due to rising pollution levels.

Avifaunal Records: Field observations confirmed the presence of diverse migratory species, including Greater Flamingo (Phoenicopterus roseus), Lesser Flamingo (Phoenicopterus minor), Eurasian Curlew (Numenius arquata), Common Redshank (Tringa totanus), Curlew Sandpiper (Calidris ferruginea), Slender-billed Gull (Chroicocephalus genei), Lesser Sand Plover (Charadrius mongolus), Marsh Sandpiper (Tringa stagnatilis), and Common Greenshank (Tringa nebularia). Birds were typically seen searching for food in shallow mudflats and regions with lower pollution levels. Behavioral patterns included filter feeding by flamingos, V-shaped flight formations, and communal roosting. However, in high-disturbance zones such as the Urban Coastal Site, birds displayed reduced foraging time and increased flight responses, suggesting stress due to pollution and human activity. (Fig. 4)

IV. Results and Discussion

The ecological assessment of the T.S. Chanakya Wetlands revealed clear patterns of pollution across the three study sites, with significant implications for wetland health and migratory bird populations.

Heavy Metal Contamination: Cadmium and chromium concentrations exceeded permissible limits at both the Creek–Mangrove and Urban Coastal Sites, with the latter recording the highest levels (Table 1). Such contamination is primarily attributed to untreated industrial effluents, urban sewage, and port-related activities in Navi Mumbai (Pawar, 2013). Increased levels of heavy metals are

recognized to bioaccumulate within aquatic food webs, particularly among benthic organisms acting as primary absorbers. Birds consuming contaminated invertebrates or fish face risks of organ damage, reproductive failure, and weakened immune systems (Singh & Ramesh, 2018; Sharma & Bhattacharya, 2022). The existence of elevated chromium concentrations is particularly alarming from an ecological standpoint, as it has been demonstrated to disrupt enzyme functionality and metabolic activities in aquatic species, consequently diminishing the availability of prey for birds.

Table 1. Heavy Metal Observations at Different Sites

Sites	Cd Obs. (µg/100mL)	Cd Std.	Cr Obs. (µg/100mL)	Cr Std.
Foraging & Feeding	0.0	6.0	71.43	50.0
Creek/Mangrove	9.5	6.0	100.0	50.0
Urban Coastal	11.0	6.0	100.0	50.0

Organic Pollution and Oxygen Deficiency: High BOD and COD values at the Creek–Mangrove and Urban Coastal Sites indicate severe organic loading, reflecting the impact of domestic sewage and industrial waste (Table 2). The Urban Coastal Site, with a BOD of 10.30 mg/L and COD of 573.9 mg/L, showed drastic oxygen depletion, making it unsuitable for sensitive aquatic fauna. Under these low-oxygen conditions, the numbers of fish, mollusks, and crustaceans decline, which are vital food sources for migratory shorebirds. (Pradhan et al., 2022). Consequently, birds are forced to expend more energy in search of food, leading to reduced body condition and lower survival rates during migration (Gill et al., 2019).

Table 2: BOD, COD, and DO Observations at Different Sites

Sites	BOD (mg/L)	COD (mg/L)	DO Before	DO After
Foraging & Feeding	4.2	234.3	8.4	4.2
Creek/Mangrove	4.95	407.4	—	—
Urban Coastal	10.3	573.9	10.8	1.5

Nutrient Enrichment and Eutrophication: While nitrate levels were within the acceptable range, increased nitrite levels at the Creek–Mangrove Site (1.37 mg/L) suggest nutrient enrichment (Table 3)Excess nutrients accelerate eutrophication, leading to algal blooms and oxygen depletion, as observed in similar Indian wetlands (Chowdhury et al., 2023). Eutrophication reduces the availability of benthic prey by smothering mudflats, altering community composition, and creating dead zones. Such ecological shifts have been linked to changes in bird distribution, with species abandoning highly polluted habitats in favor of less degraded sites (Mitra & Ganguly, 2020).

Table 3: Nutrient and pH Observations at Different Sites

Sites	Nitrate (mg/L)	Nitrite (mg/L)	pH
Foraging & Feeding	3.7	0.8	7.0
Creek/Mangrove	7.7	1.37	6.8
Urban Coastal	5.5	0.9	7.2

Avifaunal Responses: Field observations confirmed the presence of key migratory species, including flamingos, curlews, and sandpipers, but their distribution was uneven across sites. Birds focused their foraging activities in areas with lower pollution levels, like the Foraging and Feeding Site, where the water quality stayed within acceptable parameters. In contrast, the Urban Coastal Site supported fewer bird numbers and shorter foraging bouts, suggesting habitat avoidance due to poor water quality. Similar behavioral adaptations have been reported in urban wetlands, where birds exhibit altered feeding strategies, reduced roosting time, and increased alertness in response to human disturbance and pollution (Bonnet-Lebrun et al., 2020; Gill et al., 2019).

Flamingos displayed filter-feeding behavior in shallow mudflats, while waders such as sandpipers and plovers probed for invertebrates along the intertidal zones. However, in heavily polluted areas, algal blooms and litter deposition limited access to feeding grounds (Fig. 4). These findings line up with earlier studies reporting that pollution-driven habitat degradation alters migratory bird behavior, forcing species to modify foraging strategies or extend migratory routes, thereby increasing energetic stress (Palacín et al., 2016; Bhagat et al., 2022).

Broader Ecological Implications: The findings highlight the susceptibility of urban wetlands to human-related impacts. The accumulation of heavy metals in birds endangers their health and also presents dangers to whole food webs. Oxygen depletion from organic pollution undermines wetland productivity, while eutrophication accelerates habitat degradation. These processes collectively erode the environmental health of wetlands, jeopardizing their ability to maintain migratory bird populations. Species that migrate, like flamingos, curlews, and sandpipers, serve as indicators of wetland health (Zöckler, 2005), and a decrease in their numbers or changes in their behavior emphasize the critical need for conservation efforts.

Conservation Outlook: To mitigate these impacts, integrated conservation strategies are essential. Pollution control measures, stricter enforcement of effluent treatment, and restoration of mangrove buffer zones are critical for maintaining water quality. Long-term monitoring of avian populations, coupled with community participation, can enhance conservation outcomes (Ripley & Ali, 2020). Protecting wetlands such as T.S. Chanakya is not only vital for biodiversity but also for sustaining ecosystem services in rapidly urbanizing landscapes.

V. Conclusion

The ecological assessment of the T.S. Chanakya Wetlands in Navi Mumbai highlights the fragile balance between urban development and biodiversity conservation. Analysis of water quality showed considerable contamination by heavy metals, organic pollutants, and nutrients, particularly at the Creek–Mangrove and Urban Coastal Sites. Elevated cadmium and chromium concentrations pose risks of bioaccumulation, while high BOD and COD levels indicate severe organic loading and oxygen depletion, threatening aquatic food webs. Nutrient enrichment has further accelerated eutrophication, reduced prey availability and altering the ecological structure of wetlands.

Field surveys confirmed the presence of diverse migratory bird species, including flamingos, curlews, and sandpipers, but their distribution and behavior were strongly influenced by pollution levels. Birds concentrated in less-polluted zones for foraging, while heavily degraded sites showed reduced activity, shorter feeding durations, and higher disturbance responses. These results indicate that habitat degradation caused by pollution not only undermines bird survival but also endangers the lasting ecological health of the wetland.

Protecting the T.S. Chanakya Wetlands requires immediate and coordinated conservation efforts. Stricter pollution control, improved sewage and industrial effluent management, mangrove restoration, and sustainable urban planning are essential to safeguard these habitats. Furthermore, long-term ecological monitoring and community participation can strengthen conservation outcomes. As migratory birds act as indicators of ecosystem health, ensuring the survival of these species will also secure the ecological resilience of urban wetlands in Navi Mumbai.

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