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Assessment Of Microplastics In Water And Fish Of Lower Lake, Bhopal

Roshi Sahu* and Abhilasha Bhawsar

Department of Environmental Sciences and Limnology
Barkatullah University, Bhopal, Madhya Pradesh, India

Abstract

The present investigation assessed the concentration and distribution of microplastics (MPs) in water and fish samples collected from the Lower Lake (L1–L4) of Bhoj Wetland during the wet season. The abundance of MPs in water ranged from 2.00 ± 0.20 to 11.00 ± 0.20 MPs L^{-1}, with the highest concentration recorded at site L2 and the lowest at L4. The spatial variation suggests a greater influx of domestic sewage and urban runoff into central and northern sectors of the lake. Microplastic ingestion was detected in five fish species, with *Oreochromis niloticus* showing the highest mean abundance (0.6 ± 0.89 MPs ind^{-1}), followed by *Wallago attu*, *Clarias batrachus* and *Channa striata* whereas *Cyprinus carpio* showed no ingestion. The findings indicate that omnivorous and carnivorous fishes are more susceptible to microplastic ingestion due to their feeding behaviors and habitat preferences.

Keywords: Microplastics, Lower Lake, water quality and Fishes

1. Introduction

Microplastics have emerged as one of the most persistent and concerning pollutants in modern aquatic environments because of their ability to transfer through the food web and ultimately reach humans. These small plastic particles are easily ingested by lower trophic organisms such as phytoplankton, zooplankton, and small benthic invertebrates, which serve as the primary food sources for fish and other aquatic animals. Once consumed by fishes, microplastics can accumulate in their gastrointestinal tract and other tissues. Larger predatory fishes feeding on smaller contaminated species further enhance this bioaccumulation process, leading to the gradual movement of microplastics up the food chain. Humans, being at the top of this chain, are finally exposed to these particles through the consumption of contaminated fish, seafood, and even drinking water (Cole *et al*., 2011; Haris *et al*., 2020).

Microplastics are defined as synthetic polymer particles smaller than 5 mm in diameter (Thompson et al., 2004). They originate either as primary microplastics, which are deliberately manufactured in small sizes for use in cosmetics, personal care products, and industrial abrasives, or as secondary microplastics, formed from the fragmentation and weathering of larger plastic debris due to physical, chemical, and biological processes (Barnes et al., 2009; Lusher et al., 2017). Because of their microscopic size, low density and resistance to degradation, these particles remain suspended in water for long periods, allowing easy ingestion by aquatic organisms. Moreover, microplastics can absorb and transport hazardous chemicals such as heavy metals and persistent organic pollutants (POPs) which further increase their toxicity when transferred to higher trophic levels (Eriksen *et al*., 2014).

Thus, the accumulation and movement of microplastics from aquatic organisms to humans represent a serious environmental and health concern. Their persistence in the environment and potential to interfere with ecological balance highlight the urgent need for systematic monitoring and assessment of microplastic contamination in aquatic ecosystems including freshwater bodies such as the Bhoj Wetland.

Plastic is everywhere in our homes, kitchens and bathrooms. We start our day using a plastic toothbrush, pour milk from a plastic packet and drink tea from plastic cups. Even personal care products like face wash and scrubs come in plastic containers and contain harmful microbeads. These microplastics particles are discharged into aquatic systems via household drainage and ultimately re-enter the human body through contaminated drinking water endangering both public health and ecological systems. Due to their affordability, durability and versatility plastics are extensively used in daily life (Boucher and Friot, 2017).

Plastic is widely used in modern life because of its versatile nature, long-lasting properties and easy of production. Plastics which are primarily composed of polymers long chains of repeating monomer units can be molded into various shapes when subjected to heat or pressure. These monomers are mostly derived from petrochemical sources. Plastics vary in their physical properties from the rigidity of polycarbonate (PC) to the flexibility of polyvinyl chloride (PVC).

Plastics act as effective barriers against oxygen and moisture due to their low density resistance to corrosion and good electrical and thermal insulating properties. Because of these diverse properties plastics are widely used in sectors such as construction, packaging, electronics and transportation. Although plastics have contributed significantly to convenience and industrial development their excessive and improper use has led to serious environmental problems. With the continuous increase in global plastic production and consumption it is important to understand and address the impacts of plastic waste on the environment (Walker and Fequet, 2023).

2. Material and methods

2.1 Study area

Lower Lake

The Lower Lake, located southeast of the Upper Lake, was constructed in 1794 by Nawab Chhote Khan to enhance the city's visual appeal. It is also retained by an earthen dam and drains into the Halali River through the lower stretch of the Kolans River now commonly referred to as the Patra Drain.

3.2 Collection of sample

3.2.1 Water sample

Water samples were collected in triplicate from four sampling stations in the Lower Lake. At each site surface water (0–30 cm depth) was sampled using a stainless-steel water sampler with a 5 L capacity. Collected water was immediately transferred into pre-cleaned 1 L glass containers to minimize contamination. Two identical samples were obtained from each site to ensure representativeness and no plastic materials were used at any stage of sampling, storage or processing (Briggs *et al*., 2019).

3.2.2 Fish sample

The fish samples were collected from fishermen harvesting their catch from the Lower Lake and selling it at Mangal Baazar. The samples were transported to the Environmental Science and Limnology Laboratory, Barkatullah University, Bhopal, stored in a deep freezer under controlled conditions until further analysis.

Table 1: Sampling stations at Bhoj Wetland

SN.	Station	Station Code	GPS Coordinates	Anthropogenic activity details
	Lower Lake			
6	Sultania Road	L1	23.254306° and 77.40913°	Religious offerings
7	Talliya Road	L2	23.253672° and 77.408705°	Fishing, sewage
8	Jahangirabad	L3	23.245193° and 77.407977°	Sewage
9	Central Zone	L4	23.248338° and 77.406961°	No anthropogenic activity, maximum depth

2.*3 Microplastic Extraction*

Microplastic extraction was performed using the Wet Peroxide Oxidation (WPO) method following Briggs et al. (2019). Initially 30mL of 30% hydrogen peroxide (H_2O_2) containing 0.05 M iron (Fe^{2+}) solution was added to each sample beaker. An additional 30mL of 0.05 M Fe2 solution was added after 5 minutes. Each beaker were placed on a hotplate and heated to 75°C still keeping glass covers placed on top. Once bubbling began, the beakers were removed from heat. If visible organic matter remained 20mL of H_2O_2 was added and heating was repeated until complete digestion. Following digestion 6 g of NaCl per 20mL of sample was transferred to the solution to make it denser and help the microplastic particles float. The solution was heated to completely disperse the salt for density separation and it was then allowed to settle disturbed in a conical flask for twenty-four hours. Floating particles were collected on filter paper placed in Petri dishes and covered to prevent airborne contamination (Briggs et al.,2019).

From fish

Using sterile scissors, the gastrointestinal tracts of all sampled fish were carefully dissected, weighed using an analytical balance, and placed into labeled glass tubes. Each tube was then filled with 10–25 mL of 10% KOH solution and covered with aluminum foil to facilitate the digestion of organic matter. The tubes were incubated at 60 °C for 24 hours. After digestion, the solution was filtered through a 0.45 µm nitrocellulose membrane, and each filter paper was transferred to a clean glass beaker. To enable further microscopic examination of microplastics, the filtered membranes were *placed in sterile Petri dishes and air-dried at room temperature (Bora et al., 2025).*

2.4 Microplastics (MPs) Detection

The physical characteristics of individual microplastics, including their type, size, and color, were recorded from photographic documentation for all three sampling sites on a monthly basis. For quantitative assessment, the microplastics retained on the filter membranes were counted to determine their abundance at each site. Each identified microplastic particle was carefully isolated, photographed individually, and categorized according to its type, size, and color following the method described by Li *et al*. (2015).

3. Result

3.1 Lower Lake (L1-L4)

During the present study, the highest concentration of microplastics 11.00 ± 0.20 MPs L^{-1} at site L2 whereas the lowest concentration 2.00 ± 0.20 MPs L^{-1} was observed at site L3. L2 has 10.00±0.15 MPs L^{-1}.

Seasonal variation in microplastics concentration (Mean ± SD, MPs L^{-1}) in Lower Lake

Sampling site	Mean ± SD, MPs L^{-1}
L1	10.00 ± 0.15
L2	11.00 ± 0.20
L3	6.00 ± 0.15
L4	2.00 ± 0.20

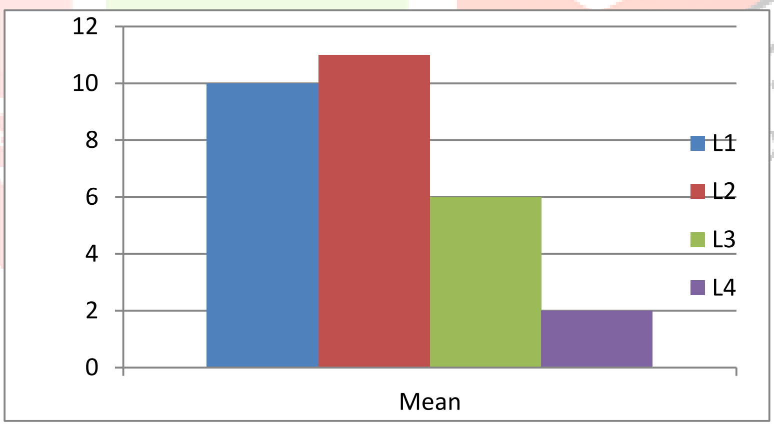

Fig.1 MPs show in Lower Lake

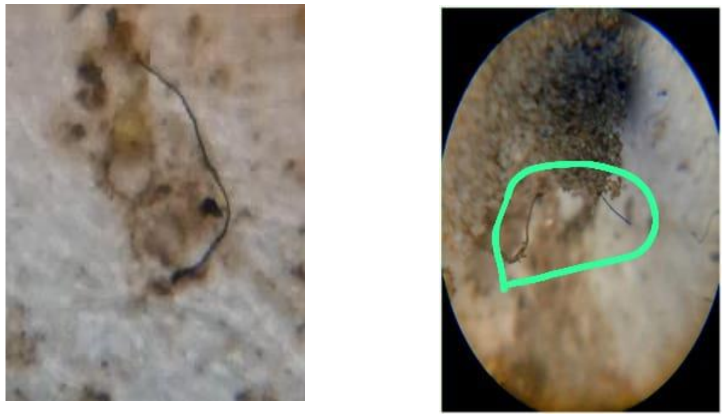

Fig.2 Microscopic images (a) and (b) in Water

3.2 MPs in Fish of Lower Lake

During the study in wet season, a total of 15 fish specimens belonging to five different classes were collected from the Bhoj Wetland (Table 13; Fig. 22). The MPs presence was examined in these fishes after confirming presence of MPs in the water samples of Bhoj Wetland. Out of 15 fish individuals collected from wetland, 5 individuals showed presence of MPs throughout the study. The highest microplastics load was observed in *Oreochromis niloticus* (Tilapia) with an average of 0.6 ± 0.89 MPs particles per individual, followed by *Wallago attu* (Helicopter Catfish) with 0.4 ± 0.49 MPs particles per individual, *Clarias batrachus* (Walking Catfish) with 0.33 ± 0.57 MPs particles per individual and *Channa striata* (Striped Snakehead) with 0.2 ± 0.4 particles per individual.

Among the captured fishes *Wallago attu* was the largest fish species with an average weight of 56 ± 11.57 g and length of 11.8 ± 2.04 cm. *Oreochromis niloticus* averaged 52 ± 5.43 g and 11.6 ± 1.02 cm while *Channa striata* averaged 51.6 ± 5.32 g and 11.8 ± 1.48 cm. *Clarias batrachus* had an average weight of 50 ± 10 g and length of 11.33 ± 2.31 cm whereas *Cyprinus carpio* was smaller (35.4 ± 4.56 g, 9.4 ± 1.14 cm) and contained no MPs.

Overall, omnivorous and carnivorous fish species were more dominant during the wet season and contained higher microplastic loads whereas bottom-feeding species were less represented and contained no MPs in Bhoj Wetland. This indicates that microplastic ingestion in the Bhoj Wetland during the wet season was species-specific and not extended to bottom dwellers in lakes.

Table 13 : Morphometric and feeding characteristics of fish species collected from Lower Lake

Common name	Scientific name	Feeding habit	Body weight (g)	Length (cm)	Numbers individual^{-1}
Helicopter Catfish	*Wallago attu*	Carnivorous	56±11.57	11.8±2.04	0.4±0.49
Tilapia	*Oreochromis niloticus*	Omnivorous	52±5.43	11.6±1.02	0.6±0.89
Striped Snakehead	*Channa striata*	Carnivorous	51.6±5.32	11.8±1.48	0.2±o.4
Walking catfish	*Clarias batrachus*	Omnivorous	50±10	11.33±2.31	0.33±0.57
Common carp	*Cyprinus carpio*	Bottom feeder	35.4±4.56	9.4±1.14	0

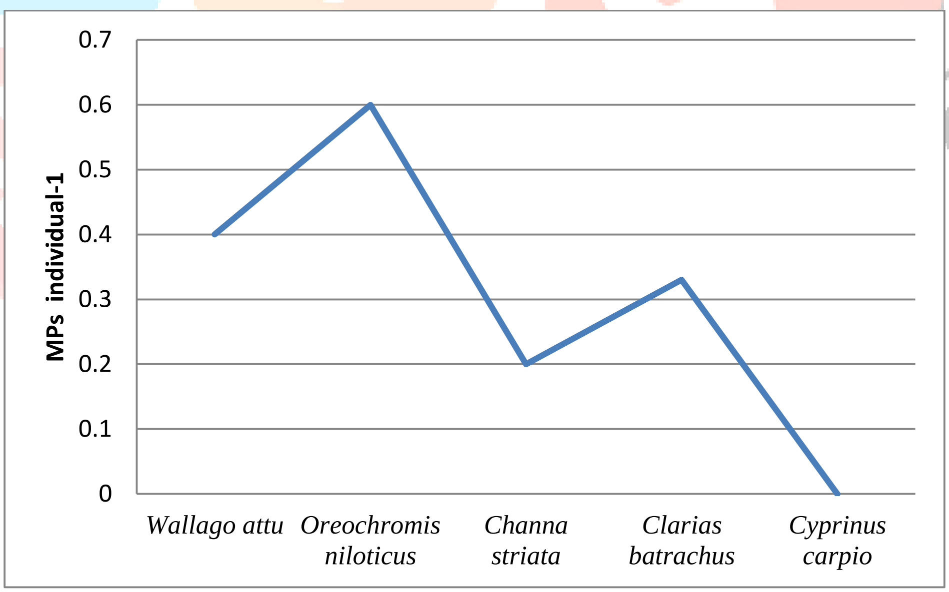

Fig. 22 Analysis of microplastics in fishes of Bhoj Wetland during wet season

4. Discussion

The spatial distribution of microplastics in the Lower Lake revealed marked variability among sampling sites. Site L2 exhibited the maximum MP concentration (11.00 ± 0.20 MPs L^{-1}), likely due to its proximity to urban discharge points and domestic drainage inflows. Comparatively, site L4 displayed the lowest concentration (2.00 ± 0.20 MPs L^{-1}), representing a relatively less anthropogenically influenced region of the lake. The gradient of MP abundance from L1 to L4 reflects the combined effects of sewage inflow, stormwater runoff, and localized hydrodynamics, consistent with earlier findings that densely populated zones tend to accumulate higher MP loads (Thompson *et al*., 2004; Cole *et al.*, 2011).

In the fish samples, the detection of microplastics confirms trophic transfer and bioavailability of these pollutants in the aquatic food web. The dominance of MPs in *Oreochromis niloticus* and *Wallago attu* indicates that species with omnivorous and carnivorous feeding habits ingest more MPs either directly from the water column or indirectly through prey. Bottom-feeding species like *Cyprinus carpio*, which did not contain MPs, are comparatively less exposed in the wet season, possibly due to sediment dilution and reduced resuspension under higher inflow conditions. The relatively low number of MPs detected per individual also corresponds with the wet season dilution effect when increased water volume reduces particle concentration.

The size, morphology and potential polymer composition of ingested MPs (based on complementary FTIR data from the overall study) further suggest that polyethylene and polypropylene fragments and fibers dominate the pollution profile. These materials are widely used in packaging, domestic utilities and fishing gear which are key contributors to freshwater microplastic contamination. Overall, the results from the Lower Lake demonstrate clear spatial and biological variability that align with anthropogenic activity patterns and feeding ecology.

5. Conclusion

The analysis of microplastics in the Lower Lake of Bhoj Wetland revealed a distinct spatial and species-specific distribution pattern. The higher MP abundance at site L2 highlights the influence of domestic discharge and surface runoff, while the minimal levels at L4 represent comparatively cleaner zones. Among fish, omnivorous and carnivorous species exhibited measurable microplastic ingestion, emphasizing the role of feeding habit and habitat in exposure dynamics. The absence of MPs in bottom feeders suggests reduced bioavailability in deeper strata during the wet season.

Overall, these findings confirm that microplastic pollution is biologically relevant even at low concentrations, and its transfer through aquatic organisms signifies an ecological concern for the Bhoj Wetland system. Continued monitoring integrating seasonal trends polymer characterization, and trophic interactions is essential for evaluating long-term ecological impacts and designing effective mitigation strategies.

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