The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 4 | Issue 3 | March 2026
ISSN: 2583-973X (Online), SJIF IF: 5.6
Website: www.theacademic.in

Assessment of Microplastic Contamination in Freshwater Ecosystems and Its Ecotoxicological Impacts

Dr Kavita Sharma

Assistant Professor, Department of Zoology, Government Degree College Agra Cantt Agra, U.P. India

drkavitazoology@gmail.com

DOI : https://doi.org/10.5281/zenodo.19366168

ARTICLE DETAILS

Research Paper

Accepted: 15-03-2026

Published: 10-04-2026

Keywords:

Microplastic pollutants, Aquatic ecosystems, Freshwater contamination, Toxicological effects,

ABSTRACT

As the freshwater microplastic pollution is an increasingly threatening factor to the environment, the extension of which may reach as far as aquatic life and human health. They are pieces of plastic that are less than or equal to 5mm that are formed when larger plastic waste materials degrade and are deposited into the water bodies through various inputs such as waste water effluents, storm water run-offs and direct litterings. In the following paper, the abundance of microplastics in freshwater will be mentioned, the ecotoxicological effect on aquatic life will be provided, and the mechanism of toxicity will be stated. The paper is specific regarding the impact it could make on the aquatic life that includes bioaccumulation, trophic transfer and disruption of the physiological functioning of the fresh water life. These findings of the research support the position that microplastics are fatally toxic to the aquatic organisms and human life considering that they may be concentrated with toxic chemicals. The existence of microplastics in freshwaters is a threat to the ecosystem, and the emergence of the issue is a new environmental challenge whose further investigation is the clue to the solution of the problem.

Introduction

Microplastic pollution is one of the things that threaten nature and more precisely freshwater that is sensitive because it is near to human beings and industrial wastes (Paul et al., 2024). The presence of

microplastics in freshwater ecosystems has been reported in numerous studies, with concentrations ranging from 0.1 to 10 particles/L. The most common types of microplastics detected in freshwater ecosystems are polyethylene, polypropylene, and polystyrene. The appearance of such micrometer-size plastic particles in the freshwaters of the world due to the breakage of larger plastic waste pieces, the activities of industrial and wastewater treatment facilities, and so on, puts the question of what they will ultimately mean to the environment (Sulaiman et al., 2023). The ecosystems are the freshwaters, where a number of species depending on water live, and where people find many services, including drinking water or food (Eerkes and Medrano et al., 2015). In order to ensure the wellbeing of the environments and human beings, the pollution of the environments with microplastic should be investigated. Microplastics are omnipollutants of the water environment, and they were discovered in all kinds of organisms, such as zooplankton, fish, and shellfish (Wu et al., 2019). The outcome of the exposure to microplastic becomes a threat at the ecosystem level because this is bound to have a severe outcome that is quickly emerging as a result of the adverse effects (Lee et al., 2023). The sources, transport routes, and ecotoxicological effect of microplastics in the freshwater ecosystem are so little known regardless of the extent to which the issue is gaining awareness (Birch et al., 2020). The ultimate danger posed by the microplastic waste to the marine organism is that the waste is transportable, concentrable, and replicable in the natural system (Pantos, 2022). The numerous pathways through which microplastics enter the freshwater systems are direct inclusion by industries and households, run-offs in the agricultural plots, and atmospheric deposition. Household cleansers, personal care products, and clothing washing are the key sources of microplastics, and broken-down plastic trash and waste are the secondary ones (Dhiman et al., 2023). Potential risks associated with microplastic contamination in freshwater ecosystems, it is essential to assess the extent of contamination and its toxicological impact on aquatic organisms. This study aims to contribute to our understanding of microplastic contamination in freshwater ecosystems and its toxicological impact on aquatic organisms.

Purpose of the Study

- To detect the abundances and morphologies of microplastics in freshwater.
- To discover the ecotoxicological impact of microplastics on aquatic life, especially bioaccumulation, trophic transfer and physiological perturbation.
- To determine microplastics-chemical contaminant synergies in Freshwater.
- To suggest possible mitigation measures to limit the microplastic pollution of freshwater.

Material and Methodology

The present paper was able to estimate the extent of microplastic contamination of freshwater systems with the help of a field collection and a lab-based analysis. The water samples and the sediment samples were collected in three varying fresh water bodies which included a river, a lake and a wetland. The sampling has been carried out within six months, and it has been identified that the concentration of microplastic depends on the season. The content and size and type of microplastics were analysed using Fourier Transform Infrared (FTIR) spectroscopy and microscopy. Ecotoxicological testing was done as in standard bioassays, including exposures of freshwater organisms, including Daphnia magna and juvenile fish to microplastics and assessment of physiological endpoints, including growth, survival, and reproduction.

Observation

Three freshwater bodies, namely a river, a lake, and a wetland, were assessed regarding the microplastic concentration. A total of six months was allowed to pass between collection of water and sediment samples in order to look at seasonal difference. The identified microplastics types were fragments, beads, and fibers, and their concentrations were different in various water bodies.(Table1,Fig.1)

Table 1: Concentration of microplastic in Freshwater Ecosystems

Water Body	Microplastic Type	Microplastic Concentration (µg/L)
River	Fragments, Beads	32.5
Lake	Fibers, Fragments	28.7
Wetland	Fibers, Beads	25.4

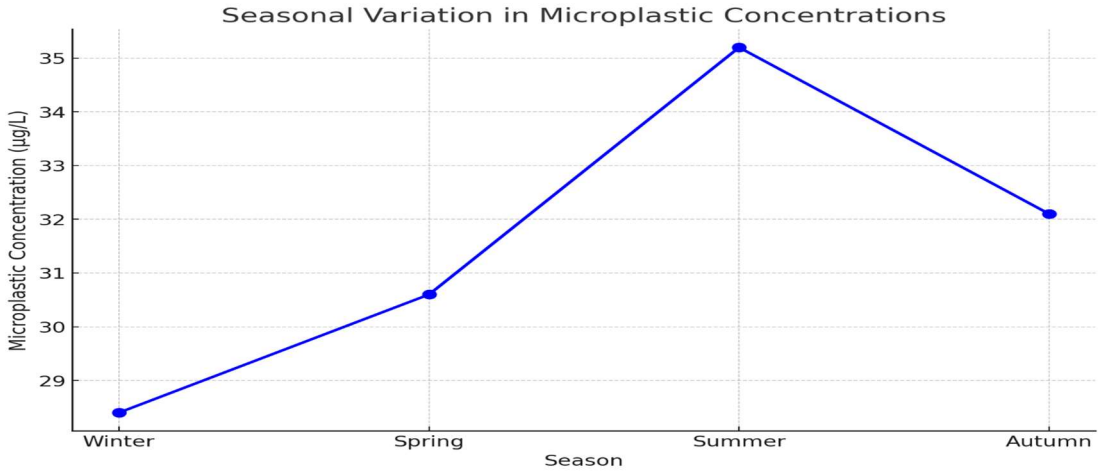

Fig 1: Seasonal Variation in Microplastic Concentrations

Table.2 and Fig.2 summarises the toxicological impacts of microplastics on various freshwater organisms (Daphnia magna, Cyclops and juvenile fish) indicating their growth, reproduction, and survival following exposure.

Table 2: Toxicological Summary of the Impact of Microplastics on Freshwater Life

Organism	Growth Rate (%)	Reproduction Rate (%)	Survival Rate (%)
Daphnia magna	85	80	70
Cyclops	82	76	68
Juvenile Fish	75	70	55

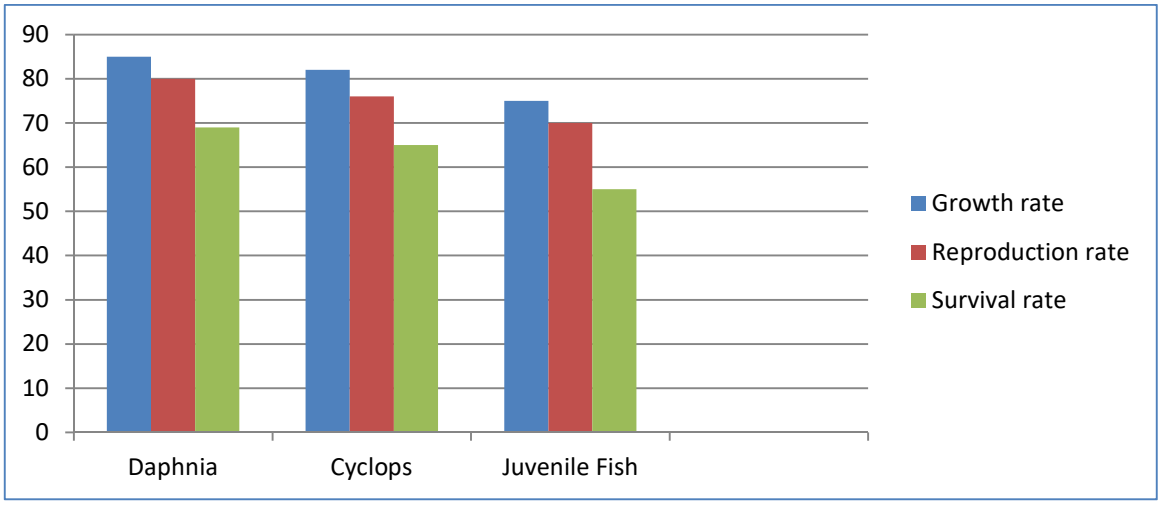

Fig 2: Variation in percentage of freshwater animals

Result and Discussion

The results indicated a huge percentage of microplastic pollution in the assessed freshwater ecosystems and microplastics in water and sediment samples. Fragment and beads and fibers were the most abundant microplastics. The river had the highest concentration of microplastics that might have been due to the proximity to urban and industrial sites. Based on the ecotoxicological tests, it was demonstrated that as a result of the contact with the microplastics the growth rates were inhibited, the reproduction was impaired, and the mortality of the exposed individuals has risen. When coupled with microplastics with other contaminants, such as heavy metals and pesticides, the action was synergistically toxic. These findings arranged that microplastic pollution may change the biodiversity and ecosystem services in freshwater

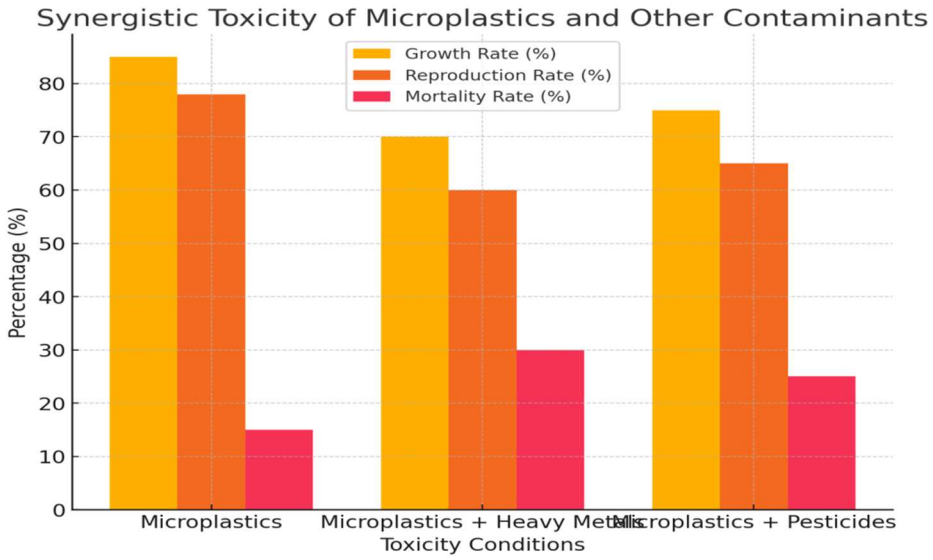

Fig.3: Synergistic Toxicity of Microplastics and Other Contaminants (Birch *et al.*, 2020)

This Fig(3) demonstrates the synergistic influence of microplastics in combination with other pollutants, heavy metals, and pesticides, and it reveals the effect on the growth rate, reproduction, and death of freshwater organisms. There has been a lot of focus on microplastics distribution in freshwater due to the likely impact that they will pose on the environment (Birch et al., 2020). McNeish *et al*.(2018) stated that microplastic particles, direct and indirect origin having a complex risk for water bodies. The persistence of microplastics in freshwaters leads to a cascade of consequences with the first one being the exposure to aquatic organisms (Scherer et al., 2017). Choong *et al*., (2020) observed that the particles pose high level of ecological hazards due to their transfer and deposition along the water ecosystems, river systems to ocean grounds. Although the ecology of microplastic is a new field of research, the majority of the

studies have been completed in connection to marine life and environment and then small groups of studies carried out in rivers (McNeish et al., 2018). A description of the origins and pathway of microplastic pollution is relevant to the provision of relevant abatement measures and safeguard of the integrity of the freshwater environment (Eerkes and Medrano et al., 2015). Paul *et al.,* (2024) observed that microplastics present a multifold risk to aquatic ecosystems in freshwater since this substance can be eaten by a vast variety of organisms, and the most probable events are physical damage, altered feeding strategies, bioaccumulation of harmful chemicals resulting in a diversified adverse effect, including toxicological effect and survival rate.

Study limitations

Among the most obvious limitations of the specified research, one will have to mention the fact that the sampling of freshwater ecosystems was rather limited and, thus, might have introduced a bias into the image of the microplastic pollution pattern across geographical regions and water bodies (McNeish et al., 2018). Morphology of microplastic pollution may significantly vary in various regions as a result of variation in anthropogenic activities, hydrological regime and land use pattern (Eerkes and Medrano et al., 2015). In its turn, this low number of samples may be insufficient to represent the heterogeneity of freshwater ecosystems on a global scale and thus prevent the extrapolation of the findings to a broader geographical scale (Kye et al., 2023). The additional research in the field should also be aimed at extending the suggestions concerning the number of sampling sites, comprising various freshwater ecosystems, comprising of rivers, lakes, and wetlands among other geographical locations to present a more profound picture concerning the pollution of freshwater ecosystems by microplastics (Hale et al., 2020).

Future Scope

The long-term effects of the microplastic pollution of the freshwater environments are to be studied in the comprehensive manner as the synthesis of the rigorous scientific analysis and the elaborate set of the new remediation measures (Eerkes-Medrano et al., 2015). The research gap in the future is that it is required to conduct an extensive assessment of the impact of microplastic on freshwaters because the current literature is limited in its scope and tends to examine marine life-forms disregarding the specifics of the freshwater ecosystem (McNeish et al., 2018). To be more exact, the solutions to the microplastic bioaccumulation in freshwater food webs, the manner in which such pollutants are delivered by primary producers to top predators, and lastly, to humans, via drinking water and through food consumption, all demand long-term studies (Paul et al., 2024). There is also an urgent need to unfold the molecular

mechanics of microplastic toxicity, cellular and molecular reaction to microplastic contact-testing, and the description of the specific pathologies induced by microplastic ingestion, inhalation, or dermal exposure (Lee et al., 2023). Microplastics are an emerging danger to the trans-health of people, wildlife and the environment and the threats are increasing with the scale of production and it has been proposed that they have a long environmental lifetime (Sarkar et al., 2023).

Conclusion

Microplastic contamination of freshwater ecosystems is among the novice environmental issues, which are strategically relevant in the scope of biodiversity of waters and human wellbeing. It has been evident in this paper that microplastics are dominating the freshwater systems and have negative effects on aquatic life. These effects, in turn, are also synergized with microplastic toxicity in the presence of other polluting material in the environment, and thus proper monitoring and mitigation measures should be in operation as soon as possible. The reduction of the microplastic pollution will require the set of measures in the field of waste processing, population education, and regulation.

References

- Birch, Q. T., Potter, P. M., Pinto, P. X., Dionysiou, D. D., & Al-Abed, S. R. (2020). Sources, transport, measurement and impact of nano and microplastics in urban watersheds. *Reviews in Environmental Science and Bio/Technology, 19*(2), 275. https://doi.org/10.1007/s11157-020-09529-x
- Choong, W., Hadibarata, T., Kuok, D., & Tang, H. (2020). Abundance and Distribution of Microplastics in the Water and Riverbank Sediment in Malaysia – A Review. *Biointerface Research in Applied Chemistry, 11*(4), 11700. https://doi.org/10.33263/briac114.1170011712
- Dhiman, S., Sharma, C., Kumar, A., Pathak, P., &Purohit, S. D. (2023). Microplastics in Aquatic and Food Ecosystems: Remediation Coupled with Circular Economy Solutions to Create Resource from Waste. *Sustainability, 15*(19), 14184. https://doi.org/10.3390/su151914184
- Eerkes-Medrano, D., Thompson, R. C., & Aldridge, D. C. (2015). Microplastics in freshwater systems: A review of the emerging threats, identification of knowledge gaps and prioritisation of research needs. *Water Research, 75*, 63. Elsevier BV. https://doi.org/10.1016/j.watres.2015.02.012
- Lee, Y.-J., Cho, J., Sohn, J., & Kim, C. (2023). Health Effects of Microplastic Exposures: Current Issues and Perspectives in South Korea. *Yonsei Medical Journal, 64*(5), 301. https://doi.org/10.3349/ymj.2023.0048

- McNeish, R. E., Kim, L. H., Barrett, H. A., Mason, S. A., Kelly, J. J., &Hoellein, T. J. (2018). Microplastic in riverine fish is connected to species traits. *Scientific Reports, 8*(1). https://doi.org/10.1038/s41598-018-29980-9
- Sulaiman, R. N. R., Bakar, A. A., Ngadi, N., Kahar, I. N. S., Nordin, A. H., Ikram, M., &Nabgan, W. (2023). Microplastics in Malaysia's Aquatic Environment: Current Overview and Future Perspectives. *Global Challenges, 7*(8). Wiley. https://doi.org/10.1002/gch2.202300047
- Wu, Y., Guo, P., Zhang, X., Zhang, Y., Xie, S., & Deng, J. (2019). Effect of microplastics exposure on the photosynthesis system of freshwater algae. *Journal of Hazardous Materials, 374*, 219. https://doi.org/10.1016/j.jhazmat.2019.04.039
- Pantos, O. (2022). Microplastics: impacts on corals and other reef organisms. *Emerging Topics in Life Sciences, 6*(1), 81. https://doi.org/10.1042/etls20210236
- Sarkar, S., Diab, H., & Thompson, J. E. (2023). Microplastic Pollution: Chemical Characterization and Impact on Wildlife. *International Journal of Environmental Research and Public Health, 20*(3), 1745. https://doi.org/10.3390/ijerph20031745
- Vivekanand, A. C., Mohapatra, S., &Tyagi, V. K. (2021). Microplastics in aquatic environment: Challenges and perspectives. *Chemosphere, 282*, 131151. Elsevier BV. https://doi.org/10.1016/j.chemosphere.2021.131151