



MICROPLASTICS AS AN EMERGING THREAT TO THE FRESH WATER FISHES: A REVIEW

Ashok Kumar Verma¹ and Sadguru Prakash^{2*}

¹Department of Zoology, Govt. P. G. College Saidabad, Prayagraj (U.P.), India

²Department of Zoology, M. L. K. P. G. College, Balrampur (U.P.), India

*Corresponding author: sadguruprakash@gmail.com

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Abstract: In the present scenario, microplastics (MPs) are emitted into the environment either directly from the use of cosmetic products or indirectly from the decomposition of big plastic items. These are commonly found in aquatic environments and amongst the most serious threats to freshwater ecosystems. Plastic components are broken down into the small fragments from large fragments during the treatment procedure in treatment plants of wastewater. Such plants act as an entry point for the MPs into the aquatic ecosystem; so it is necessary that MPs must be removed from the wastewater during the treatment process. Microplastics can be consumed directly by fish or indirectly through prey that contains these particles. These MPs can have a variety of ecotoxicological consequences on fish, including behavioural changes, cytotoxicity, neurotoxicity, and liver stress, among other things. The presence of microplastics along with the contaminants can boost the deposition of such contaminants in aquatic biota. Since the microplastics are of emerging concern, hence authors attempted to explain the possible impacts of these particles on aquatic species and human beings.

Keywords: Contamination, Freshwater, Impacts on fishes, Microplastic, Pollution, Wastewater.

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INTRODUCTION

Plastic has been widely used in industry due to its unique properties such as low price, lightweight, high strength, and durability. Plastics are used in a wide range of sectors and are likely to be the most common sort of debris on land and in the waters for years (Sridharan *et al.*, 2021). Plastic is a durable product and eventually registers its presence in the environment for a longer period. Plastics, in most cases, are thrown away after use in the natural habitats as a waste. Plastic

production has surpassed 300 million tonnes in 2013 and is presumed to hit 33 billion tonnes by 2050 (Law, 2017). Due to the use and throw policy and mismanagement of the waste, the plastics in the waste debris continue to contaminate the natural resources. Plastic contributes roughly 60-80 per cent of waste to an aquatic environment (Aytan *et al.*, 2020).

Large pieces of plastic would break down into microplastics which are emerging pollutants.



Microplastics, defined as plastic debris with a particle size of less than 5 mm, can be divided into primary and secondary microplastics according to the origin of microplastics (Yang *et al.*, 2022). Basically, primary microplastics are manufactured into small-size plastics (e.g., microbeads, plastic pellets, and microfibers), while secondary microplastics are originated from large plastics through physical, chemical, and biological degradation (Wang *et al.*, 2020). Microplastics detected in the environment are of different types [e.g., polypropylene (PP), polyethylene (PE), polystyrene (PS), polyvinyl chloride (PVC), and polyethylene terephthalate (PET)], shapes (e.g., fiber, fragment, pellet, film, and foam), and colors (e.g., black, colored, and white) (Zhao *et al.*, 2022).

Microplastic particles have been found in almost all aquatic habitats on the planet, including deep oceans, rivers, lakes, and sediments, in a variety of shapes, polymers, sizes, and concentrations in marine water, freshwater, agro ecosystems, the atmosphere, food and drinking water, biota, and other remote locations. Microplastics are made up of polymer chains of carbon and hydrogen atoms. Other compounds found in microplastics include phthalates, polybrominated diphenyl ethers (PBDEs), and tetrabromobisphenol A (TBBPA), and many of these chemical additions leach out of the plastics when they enter the environment. Microplastics are a collection of various poisons that come in a variety of colours and sizes (Rochman *et al.*, 2013).

The freshwater environments are experiencing threat from the microplastics, which are in fact anthropogenic in nature. The anthropogenic activities are causing severe threats to biodiversity and sustainable development (Verma, 2019; Prakash and Verma, 2022). The microplastics ultimately pollute the terrestrial and marine ecosystems as well. Possible sources include sewage or drainage runoffs from urban and rural areas, thickly populated residential and industrial sectors, water treatment plants (WWTPs), unmanaged wastes, agricultural runoffs, etc. to the freshwater ecosystems (Bhalerao, 2020). Electronic wastes are also polluting the environment (Prakash and Verma,

2020). These contaminants may include inorganic, organic, biological and toxic pollutants. The quality, hygiene, biota, the food web, etc., of the freshwater ecosystems are at stake due to the microplastic contamination.

Microplastics are easily ingested by aquatic organisms like zooplankton, fish, and bivalves causing a decreased reproduction rate, mechanical injuries, and low growth rate of these aquatic organisms (Fu and Wang, 2019). Moreover, plasticizers or toxic additives, released from microplastics, are transferred to water, sediments, and biota which aggravate the pollution of the freshwater environment (Horton *et al.*, 2017). Meanwhile, microplastics carrying toxic pollutants may be transferred to higher nutritional levels, through the food chain, reaching the human body and causing various health issues (Setälä *et al.*, 2014).

MPs are far more quickly damaged in shallow lakes having smaller areas because they are readily exposed to sunlight and can be harmed by UV rays even on the bottom (Vaughan *et al.*, 2017). Currently a number of workers are giving special attention to microplastic pollution in the freshwater environment. Although, most of the studies focuses on the abundance, sources, and characteristics of microplastics in marine water. It ignores the freshwater environment, especially the microplastic pollution in India. Hence, the main purpose of this review is two folds: (1) to summarize the abundance and characteristics of microplastics in freshwater environments (e.g., rivers, lakes, sediments, and biota) of India, and (2) to introduce the source and impact of microplastics in freshwater ecosystems of India.

Microplastics as source of heavy metals and organic pollution

There have been numerous investigations on the interaction of MPs with other contaminants. MPs can carry two types of pollutants: first is heavy metals and nonpolar chemicals or substances from the atmosphere and the second type of pollutants are additives, monomers, along with other byproducts inherent in MPs (Adhana *et al.*, 2022). Plastics usually contain various additives, such as plasticizers, heat stabilizers, colorants,

foaming agents, and heavy metals which are considered to be carcinogenic and can damage the endocrine system also. Once these additives leached from microplastics do not only pollute the aquatic environment but cause potential harm to aquatic organisms (Luo *et al.*, 2019; Prakash and Shukla, 2021). For example, lead (Pb) released from PVC affects the gene expression in zebrafish (Boyle *et al.*, 2020).

Moreover, microplastics would adsorb persistent organic pollutants and heavy metals that can cause hormonal disorders, mutations, and cancer in aquatic organisms. The presence of microplastics along with the contaminants can boost the deposition of such contaminants in aquatic life. Later, these pollutants can reach high-nutrient organisms through the food chain (Zhao *et al.*, 2022). MPs' trophic transmission all along the food chain is primarily determined by their length of stay in the food chain, aggregation, size, and form. The prolonged retention of MPs in the biota will make it easier to transmit the MPs between trophic levels, and certainly, it will affect the entire environment (Adhana *et al.*, 2022).

Microplastics as a source of microorganisms

The MPs have a hydrophobic surface, bacteria can easily colonize it and create a biofilm known as a 'plastic ring' (Nobre *et al.*, 2015). In the marine environment, plastic ring formation has been researched, but it is unknown how it works in freshwater. MPs at wastewater treatment facilities can be used as vectors for microbe adherence and characteristics including roughness, hydrophobicity, and the MPs' living environment are all related to the composition of biofilm. When the hydrophobicity is higher and the surface where it must adhere is rough, microorganism attachment is typically better.

Additionally, a wide range of germs, including pathogenic microorganisms and bacteria resistant to antibiotics, were found sticking to the MPs, suggesting that the MPs may operate as vectors for pathogenic microorganisms. Toxic compounds affixed to microplastics, as well as deadly viruses adhering to them, have the potential to impair human health. Thus, both

antibiotics and MPs are presumed to be found in the discharge of treatment plants of sewage (Du *et al.*, 2021).

IMPACTS OF MICROPLASTICS IN FRESHWATER FISHES

Despite the greater knowledge on marine microplastics, to date, a limited studies have investigated the occurrence of MPs in freshwater fish. Within ecosystems, microplastics can have quite harmful consequences for the local fauna. Waste from MPs could directly mechanically affect aquatic organisms. Ingestion of plastic particles has been reported for over 600 taxa, being fish among the most affected taxa (Pinheiro *et al.*, 2017). Ingestion is the most common form of fish contamination by MPs. When swallowed, the MPs waste will give a false sense of satisfaction, which may influence appetite, result in internal blockages, or damage the digestive tract (Wang *et al.*, 2018). MPs congregate in the digestive tracts, and tiny particles may even sneak inside the circulatory systems and stay there (Du *et al.*, 2021).

MPs and associated contaminants can enter the aquatic biota in a variety of ways. Filter feeding, suspension feeding, inhalation at the air-water interface, and eating of prey exposed to MPs or direct ingestion are all examples. Several aquatic organisms are thought to be exposed to MPs by ingestion. Due of their inability to distinguish between MPs and food, aquatic organisms, including plankton, passively consume Mps.

Numerous studies have shown that MPs have harmful impacts on fish fauna, including both physical and physiological aspects. The physical dangers associated with its consumption include obstruction of the digestive tract and alimentary appendages, as well as inflammation and laceration of gastrointestinal tissues that limit proper nutrient absorption. The physiological interference can also be seen when MPs directly affect its immune system by stimulating degranulation and altering behavioural patterns, which makes it harder for a predator to detect the fish (Pinheiro *et al.*, 2017).

The consequences of MPs contamination on fish health are still not very well known to all.

Microplastics can be consumed directly by fish or indirectly through prey that contains these particles (Desforges *et al.*, 2014). Pinheiro *et al.* (2017) reported a sum of 34 freshwater fish species to be sensitive over the world. Raven *et al.* (2020) found microplastic in all 49 fish species studied in two freshwater reservoirs in Bloomington, Illinois, and found that microplastics were concentrated more in the intestines than the gills. Although the figures are small, it's possible that this is due to a lack of studies on MP accumulation and impact in freshwater fish. Microplastic's high adsorption capacity provides surface area for a variety of bio-organic or inorganic harmful compounds, and ingestion of these adsorbed toxin-containing MPs could pose a major health risk to fish.

MPs particles are great candidates for fish feeding due to their small size, buoyancy, and appealing colour (Sanjay *et al.*, 2020). Microplastics can be extremely detrimental to local fish species in aquatic settings if they have been contaminated by MPs. The absorption of MPs by fish can build up in their digestive tract, causing hunger due to a false sense of satiation or even perforation of the gastrointestinal tract. The physical and physiological consequences of these MPs on fish are unfavourable (Lonnstedt and Eklov, 2016).

Clogging and inflammation of the digestive system, as well as laceration of gastrointestinal tissues, are all unfavourable physical effects that disrupt the nutrient absorption mechanism of body (Lusher *et al.*, 2013). The physiological interference can also be seen when MPs directly interact with the immune system of fish by stimulating degranulation and changing their overall behaviour, limiting a predator's capacity to recognize them (Greven *et al.*, 2016; Lonnstedt and Eklov, 2016). The digestive enzyme as well as reproductive systems, may be harmed as a result of MPs digestion (Wright *et al.*, 2013; Talvite *et al.*, 2015). Tiny low-density polyethylene (LDPE) particles were subjected to environmental bay conditions for three months before being given to fish. Fish tissues had a higher quantity of PBTs after two months and displayed symptoms of liver stress, glycogen depletion, fatty vacuolation, and cell necrosis (Rochman *et al.*, 2013).

Jabeen *et al.* (2017) investigated the association between plastic pollution and freshwater fish feeding habits and habitats, finding that fish living in freshwater water bodies of metropolitan regions are more likely to be exposed to MPs. The MPs were ingested at a higher rate in these fish (Silva-Cavalcanti *et al.*, 2017). Some researchers made a similar observation, reporting that fish caught in rivers near populated regions had a considerably higher amount of plastic garbage in their stomachs than fish caught in less urbanized locations (Phillips and Bonner, 2015; Peters and Bratton, 2017). Sanchez *et al.* (2014) found no MPs in edible freshwater fish obtained from upstream areas, but found MPs in the guts of those gathered from urban rivers, supporting the idea that wastewater treatment plants in urbanized areas are a source of MPs in inland surface water. These MPs can influence the eating activity, oxidative stress, genotoxicity, neurotoxicity, developmental retardation, reproductive fitness decline, and finally death of the fish concerned (Raza and Khan, 2018).

The microplastics in the fishes, found in the stomachs, guts, and intestines, were in the form of tiny particles, fibers, pellets, beads of different sizes and colours (Sanchez *et al.*, 2014; Silva-Cavalcanti *et al.*, 2017; Bhalerao, 2020). The microplastic concentration in the GI tract of fish depends on the concentration of these pollutants in the water bodies, feeding habits of fishes, etc. The bioaccumulation and magnification of microplastics in fishes may lead to the ill metabolism and in turn degrade the fish flesh quality for top consumers of the food chain (Bhalerao, 2020). As a result, microplastics are absorbed by fish in a number of ways and induce undesirable consequences such as mortality, neurotoxicity, cytotoxicity, hepato-pancreatic stress, behavioural abnormalities, oxidative stress, and genotoxicity, among other things (Luis *et al.*, 2018).

The bioaccumulation and magnification of microplastics may drag the freshwater fauna in dangerous situations and may reach to the higher-order consumers including human beings (Emilyn *et al.*, 2019). Finally, microplastics can reach the human body, through the food chain,

causing potential health issues (Lithner *et al.*, 2011).

Suggestions to reduce the microplastic pollution

- The simplest and most straightforward approach to get started, is to reduce the usage of single-use plastics. Plastic bags, water bottles, straws, cups, cutlery, dry cleaning bags, take-out containers, and other single-use plastics are all examples of single-use plastics.
- Buy and use the plastic-free cosmetics.
- Recycle the plastic properly.
- Buy clothes made from natural materials.

CONCLUSIONS

It is noteworthy that microplastics, in a fresh water, not only cause environmental pollution but harm other aquatic organisms too. This review, concludes that freshwater fishes are extremely vulnerable to microplastics pollution and that urbanized areas appear to be a major factor contributing to the pollution of freshwater environments with microplastics. Since freshwater ecosystems are at high risk of microplastic concentration hence a proper and systematic survey with practical action plans are strongly recommended to improve the health of such fresh water bodies.

So, further studies are required to observe and manage the concentrations of the microplastics, particularly in the freshwater food fishes. Further, it is the need of today to check all the possible sources of pollution with priorities to prevent the entry of plastics in the freshwater bodies. However, there is still a lack of in-depth research on the sources of microplastics in fresh water bodies and the harms to the human body. To prevent microplastic pollution, governments of all countries, should draft relevant policies and regulations, as soon as possible, to reduce their pollution. It is also an utmost necessity to create awareness among the people and to provide appropriate solutions to restrict hazardous impacts of plastic pollution and their presence in the freshwater organisms including fishes.

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