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Review

Toxicity of microplastics in fish: A short review

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Abstract: Microplastic pollution is a growing environmental concern globally, attracting significant attention due to its potential impacts on aquatic ecosystems. This short review aims to provide a comprehensive overview of the research conducted on microplastic pollution in fish, focusing on its occurrence, sources, impacts, and potential mitigation strategies. By analyzing existing studies, this review highlights the urgent need for continued research and increased awareness to address this persistent issue.

Keywords: microplastic; fish; pollution

1. Introduction

In recent years, many efforts have been directed to the discovery and cleaning of pollutants that are called contaminants of emerging concern (CECs), which include any type of chemical substance found in water or the environment, even in small concentrations, or substances that have just been identified.

Microplastics (MP) have all the features mentioned to be in the group of worrisome pollutants, the most important of which is the presence of this pollutant in water environments [1].

According to the National Oceanic and Atmospheric Administration's (NOAA) report, plastic particles with a diameter of less than 5 mm are known as microplastics (MP). While there is no theoretical unity for the dimensions of nanoplastics (NP) in various studies, some researchers define nanoplastics as particles with a diameter of less than 1 micrometer, and some others define them as less than 100 nanometers.

Microplastics, defined as plastic particles smaller than 5 mm in size, have emerged as a pervasive and persistent type of pollution in aquatic environments. These tiny particles often result from the breakdown of larger plastic debris and are now found extensively in marine and freshwater ecosystems worldwide. Concerns surrounding microplastic pollution in fish arise due to their potential adverse effects on both individual organisms and the ecosystem as a whole [2].

Various aquatic environments are contaminated with microplastics; seas close to land and oceans, estuary waters, lakes, reservoirs, freshwater rivers, sewage, and urban and industrial effluents are all contaminated with microplastics [3]. Researchers have shown that oysters, edible crustaceans, and commercial fish are often contaminated with microplastics [4].

Several studies showed MPs contaminations in fish species in different aquatic environments around the world, which is an alarm for paying more attention to this recent known contamination (**Table 1**). Similarly, many studies have described the toxic effects of MPs in different fish species and in different organs (**Table 2**).

Table 1. Reports of MPs contaminations in fish.

S. No	Type of microplastic	Fish	Country/ water bodies	Reference
1	Fibers and fragments	*220 species of marine*	South coast of India	[5]
2	Fibres, pellets, fragments	*Ammodytes personatus*	Yellow Sea	[6]
3	Fibers, fragments, films	*Engraulis encrasicolus*	Med. Sea (east)	[7]
4	Not reported	*Engraulis encrasicolus*	Med. Sea (west)	[8]
5	Fibers	*Engraulis encrasicolus*	Med. Sea (west)	[9]
6	Fibers	*Engraulis encrasicolus*	North East Atlantic	[10]
7	Fragments and beads	*Engraulis japonicus*	North Pacific Ocean	[11]
8	Fibers, fragments and Pellets	*Engraulis japonicus*	Yellow sea	[6]
9	Fibers, fragments, films	*Euthynnus affinis*	Malaysia (fish-market)	[12]

Table 2. Toxic effects of microplastics in fish.

S. No	Type of microplastic	Fish	Organ	Reference
1	Ethylene propylene	*Scophthalmus maximus*	Liver and gills	[13]
2	Polypropylene	*Oreochromis mossambicus*	Liver	[14]
3	Propylene copolymer	*Danio rerio*	Brain, liver	[15]
4	Polystyrene	*Nothobranchius guentheri*	Liver	[16]
5	Polystyrene	*Ctenopharyngodon idella*	Liver	[17]
6	Microfiber types microplastics	*Oryzias latipes*	Liver	[18]
7	Polyethylene	*Pseudobagrus fulvidraco*	Gut, gills and liver	[19]
8	Polystyrene	*Sparus aurata*	Intestine	[20]
9	Polyacrylamide	*Oreochromis niloticus*	Gills, liver and intestine	[21]

2. Occurrence of microplastic pollution in fish

Numerous studies have documented the presence of microplastics in the gastrointestinal tracts of various fish species. For instance, in a study conducted in the Mediterranean Sea, Romeo et al. [22] reported that 18% of the examined fish contained microplastics in their digestive tracts. Abbasi et al. [23] also reported microplastic particles isolated from guts (gastrointestinal tracts), skin, muscle, gills, and liver of demersal and pelagic fish (*Platycephalus indicus*, *Saurida tumbil*, *Sillago sihama,* and *Cynoglossus abbreviatus*) obtained from Musa estuary, Persian Gulf, Iran. **Table 1** shows some of the studies on MPs contamination in fish in several aquatic environments.

The first evidence of the presence of microplastics in marine environments dates back to 1970, when grains with a diameter of 5–2.5 mm were found on the surface of the Sargasso Sea, spherical structures with a diameter of 0.2–0.1 mm in the coastal waters of New England, structures Spheroids and discs with a diameter of 0.9–4.2 mm were observed in the surface waters of the Atlantic Ocean, and grains with a diameter of 1–5 mm were observed in the surface waters of the Pacific Ocean [3].

Since 2004, when Thompson measured the abundance of microplastics in coastal, estuarine, and intertidal sediments of England's coasts, several researchers have investigated the presence of microplastics, their fate, and their transfer in marine environments and beaches across the continent. They have studied small and large islands, the width of the Atlantic Ocean, the Pacific Ocean, the Arctic Ocean, the Adriatic Sea, the Baltic Sea, the Mediterranean Sea, and even the depths of the sea [24].

These findings demonstrate the pervasive nature of microplastic pollution in fish populations and highlight the need for further investigation into its implications.

3. Transfer of microplastics in the food chain

Like many other pollutants in aquatic environments, it's been demonstrated that microplastics could transfer through the food chain, and several organisms in different trophic levels could be contaminated by nutrition. Zooplanktons are one of the lowest trophic levels in aquatic ecosystems susceptible to microplastics through ingestion. Zheng et al. [25] demonstrated microplastic contamination of more than 30 species from 28 taxonomic orders of zooplanktons. Several other studies further described microplastic contamination of crustacean's zooplanktons, such as *Tigriopus fulvus*, *Acartia clausi*, *Centropages typicus*, *Calanus helgolandicus*, *Temora longicornis*, and *Neocalanus cristatus* [26–30]. Moreover, microplastics contamination is also described in gelatinous zooplankton such as jellyfish, tunicates, and salps, which are feeding on crustaceans and fish larvae. These gelatinous zooplanktons are key food sources for higher trophic levels, such as pelagic predators [31–36].

4. Sources of microplastic pollution

There are several sources of microplastic pollution in aquatic environments. One major source is the fragmentation of larger plastic debris, which can occur due to weathering, wave action, and photodegradation. Thompson et al. [37] estimated that the majority of microplastics in the ocean are derived from the breakdown of larger plastic items like bottles and bags. Additionally, microbeads found in personal care products, such as facial scrubs and toothpaste, contribute to microplastic pollution. Synthetic textile fibers, shed during laundering, also play a significant role in microplastic contamination. Šaravanja et al. [38] found that washing a single polyester garment can release up to 1900 microfibers into wastewater.

A small part of the microplastics in the ocean environment are related to marine activities such as the fishing industry (use of plastic equipment), while the majority of them (about 80%), in terms of origin, are plastic waste from land. To be reckless disposal of waste on beaches and coastal areas, rivers that flow into the sea, runoff from storms, passive absorption by marine species, sewage discharge, and deposition of atmospheric microplastics are all factors involved in the presence of microplastics. They are in marine environments.

Microplastic parts are widely transported by oceanic currents over long distances; wind, river, and sea currents are the main factors of microplastics transfer to distant and unpolluted areas, such as the poles, deep oceans, and interoceanic islands [24].

5. Impact of microplastic pollution on fish

The ingestion of microplastics by fish can have detrimental effects on their physiology and behavior. Studies have shown that microplastic ingestion can lead to reduced feeding efficiency, impaired growth, and altered reproductive success in fish. In addition to physical impacts, microplastics can act as vectors for harmful chemicals. Rochman et al. [39] demonstrated that exposure to microplastics can induce toxic effects and increase susceptibility to diseases in fish species.

Fish can accidentally consume microplastics as they mistake them for food. This can happen because microplastics resemble the size and shape of plankton, which is a common food source for many fish species. Once ingested, microplastics can cause several adverse effects on fish, such as reduced feeding ability, alteration in growth rates, impaired reproduction, and changes in behavior [40].

Moreover, microplastics can also have indirect impacts on fish by acting as carriers for chemicals. Many microplastics have the ability to absorb and accumulate toxic substances from their surrounding environment. These include persistent organic pollutants (POPs) and heavy metals that can adhere to the surface of microplastics. When fish consume these contaminated microplastics, they are essentially ingesting a concentrated dose of these harmful chemicals, which can lead to various health issues and long-term ecological consequences [41,42].

Another concern is the potential transfer of microplastics and associated contaminants up the food chain. Fish that consume microplastics may be preyed upon by larger predators, including humans. This means that the harmful effects of microplastic pollution can eventually be transmitted to humans through the consumption of contaminated fish [43].

6. Mitigation strategies

Efforts to mitigate microplastic pollution in fish should be multifaceted and focus on reducing plastic waste at the source, improving waste management practices, and promoting the development of biodegradable alternatives. Legislation has been enacted in some countries to ban or restrict the use of microbeads in personal care products, which has shown promise in reducing microplastic input into aquatic ecosystems. Innovative strategies, such as the installation of filters in washing machines to capture microfibers, are being researched to address the release of synthetic textile fibers. Public awareness campaigns and educational programs can help minimize the use of single-use plastics and promote responsible waste disposal among individuals and communities [44].

Among other ways to reduce microplastic pollution in water environments, we can refer to the precise treatment of wastewater in order to separate microplastic pollution. In this regard, several scientific ways have been proposed, including biotic degradation of microplastics, bacterial degradation, degradation of microplastics via fungi, removal of microplastics by algae and macrophytes, degradation of microplastics by periphytic biofilms, removal of microplastics through adsorption, degradation of microplastics by advanced oxidation processes, etc. [45].

7. Conclusion

Microplastic pollution poses a significant threat to fish species, with implications for both ecological health and human food safety. The widespread occurrence of microplastics in fish populations highlights the urgent need for further research to understand the long-term effects of microplastic exposure. Additionally, concerted efforts are required to develop effective mitigation strategies, reduce plastic waste, and promote sustainable practices. It is crucial that we take immediate action to protect our aquatic ecosystems and ensure the well-being of fish populations for future generations.

8. Future directions

Despite enormous studies on microplastic contaminations of aquatic environments and species, many aspects of this subject remained unstudied and needed further investigations. Along with further investigation of the microplastic contamination of the aquatic ecosystems, it is crucial to follow the mitigation strategies to lower the toxic effects of such pollution in aquatic environments.

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