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Microplastics in Aquatic Ecosystem: A Threat to Environment and Human Health

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SUMMARY
A rising concern across the globe is the presence of microplastics in the aquatic ecosystem. Microplastics (MPs) are a threat to the ecosystem and have a negative impact on both human health and the ecology when present, especially in the water. Microplastics are directly released into the environment through commonly used plastic objects, plastic degradation, industries, and wastewater treatment facilities. MPs enter the food chain and pose serious health risks after contaminants reach the water and are consumed by aquatic species. Evaluating the ecological threats posed by microplastics is necessary, but given the current state of knowledge, it is difficult. This article provides consolidated information on microplastics and their characteristics, sources, transport, and environmental and human health effects in the aquatic environment to understand the effect of microplastics and their current status.

INTRODUCTION

Microplastics (MPs) are plastic fragments that are less than 5 mm in size, according to the European Chemical Agency (ECA) (European Chemicals Agency, 2020). Microplastics are frequently divided into two categories: primary microplastics, which are produced for a specific application (such as microbeads), and secondary microplastics, which are created when primary microplastics, such as the fibers from synthetic fibers, are fragmented and degraded (Zeng, 2018). Microplastics frequently reach the environment through all of the stages in the life cycle of plastic products (from producers to waste management systems), which have the potential for trophic transfer and human health exposure. According to a study, 6300 million tonnes of plastic trash were produced in 2015, of which 79% ended up in landfills or were incinerated (Vivekanand et al., 2021).

Many suspended objects are transported to the surfaces of aquatic bodies and even to urban, rural, and remote regions via the atmosphere by wind speed and direction, up/down draughts, convection lifts, and turbulence. The aquatic environment is greatly impacted and enhanced by human activity (Vivekanand et al., 2021). According to a study, coastal nations release between 4.8 and 12.7 million metric tonnes of unprocessed plastic debris into the ocean every year (Jambeck et al., 2015). The movement of plastic waste in the aquatic environment has drawn a lot of interest. The manner in which microplastics infiltrate water bodies relies on those materials' features. The hydrodynamics, attachment, and uptake of the aquatic environment, as well as other physical and chemical characteristics of the water bodies, have an impact on the settlement, re-suspension, and travel distance of the plastic particles, which has an adverse effect on the ecosystem (Huang et al., 2021).

Source and transport of microplastics

The main sources of microplastics are domestic waste, which accounts for roughly 5000–80,000 tonnes and includes polymeric plastic from cosmetics and cleaning goods, feedstocks used to make these items, and plastic powder or pellets used for air blasting (Jiang, 2018). These are the secondary sources of microplastics. Regular fragmentation of larger plastic (1.1-41.8 mm) under the specified atmospheric circumstances, such as mechanical deterioration or exposure to UV light, results in significant amounts of microplastics entering the environment (Vivekanand et al., 2021). Most microplastics found on land are dumped directly into water bodies as effluent from wastewater treatment facilities or industrial discharge. The larger or heavier debris is submerged beneath the surface of the water bodies, while the smaller or lighter debris is suspended and deposited in the water bodies.

The dispersed particles of these deposited microplastics continue to circulate on the surface and are stored in sediments, where marine species most likely consume them. In some instances, the water currents and drifts will impact the plastics floating on the surface, causing microplastic accumulation in certain locations and raising ecological threats to aquatic and surrounding habitats.

Microplastics are found in both the natural and anthropogenic water cycles due to their ubiquity. In the anthropogenic cycles, microplastics are detected in municipal sewage as well as the intake and output of wastewater treatment facilities (WWTPs). The inflow of WWTPs is found to be heavily dominated by microplastics since they contain microfibers from personal care products and microbeads from residential washing operations (Carr et al., 2016). Due to the scarcity of microplastics literature, it is difficult to characterize the complex composition of microplastics in the influent of the WWTP. According to Karrman et al. (2016), microbeads have been detected in seawater since the 1990s and are a common source of microplastics in WWTPs. According to studies, personal care and cosmetic items emit about 94,500 microbeads per wash (Napper et al., 2015).

Ecotoxicity of microplastics on the environment

In order to enhance the performance of the final product, chemical additives like plasticizers, heat stabilizers, antioxidants, and colorants are frequently utilized during the production of polymers. Chronic risks result from these chemicals' presence when exposed to the environment. The plasticizers negatively impact plants and are hazardous to mammals (Rehse et al., 2016). Monomers, unbound plastic precursors, and other additives could be another area of concern due to the existence of chemicals connected with microplastics. Migration of monomers and oligomers from food packaging materials is possible. Microplastic toxicity is caused by unreacted plastic fractions that have leaked, such as monomers, oligomers, and chemical additives (Vivekanand et al., 2021). Right now, climate change and ozone depletion are seen as less of a threat to the aquatic ecosystem than plastic waste. Microplastics can have detrimental effects on both human health and the ecosystem by counting traps, ingestion, retaining hazardous substances, and movement of invasive species (Jiang, 2018). Figure 1 depicts the major environmental channels for microplastic trafficking and the hazard they pose to human health. Microplastics also pose a hazard since they can retain these substances on their surface and disperse them into different ecosystems (Vivekanand et al., 2021).

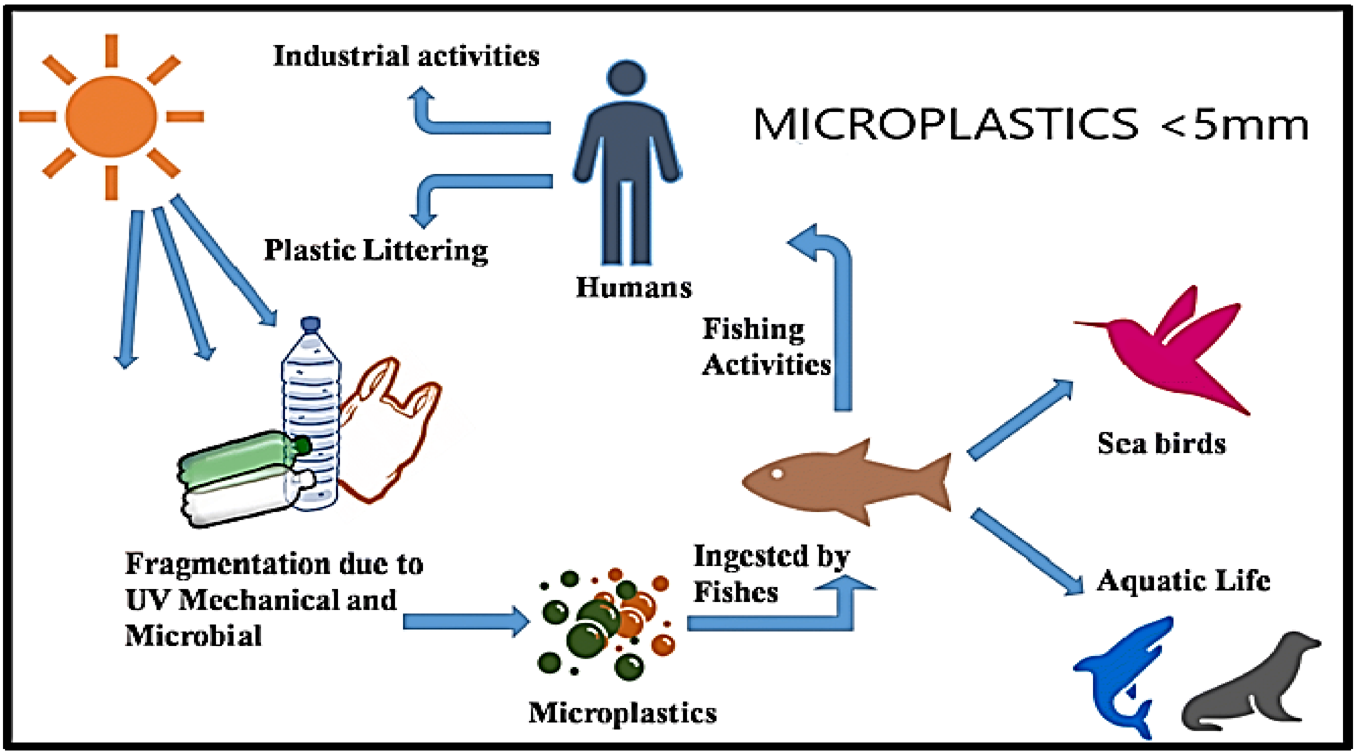

Figure 1. Effect of microplastics on the environment and human health

Microplastic enters and concentrates in the tissues of aquatic species by ingestion and then enters the food chain. Trophic exchange is an important pathway for fish to consume microplastic. They feed on mysids, which break down the microplastics as part of their metabolism. According to Hasegawa and Nakaoka (2021), fish absorb 3–11 times more microplastics from mysids than the surrounding aquatic environment. Fish of different species ingest microplastic at varying rates; for example, carnivorous fish absorb fewer plastics than omnivorous fish. Due to their poor excretion abilities, omnivorous fish typically have significant concentrations of microplastics (Zhang et al., 2021). Fishes frequently ingest long-fiber microplastics and big fragments of microplastics found in sediments and aquatic environments, respectively (Vivekanand et al., 2021).

It has been shown that the presence of microplastics increases the toxicity of a number of pollutants. For instance, feeding zebrafish microplastics enhanced their intake of phenanthrene. Together, the combined pollutants may have synergistic effects that weaken the immune system and increase oxidative stress (Xu et al., 2021).

Similar to this, Tien et al. (2020) reported that fish accumulate microplastics contaminated with acenaphthylene, anthracene, benzoanthracene, benzofluorine, benzoperylene, phenanthrene, 2-ring PAHs, and 5,6-ring PAHs. The bioavailability of microplastics to fish is influenced by a number of water quality factors, including total suspended solids (SS), pH, and conductivity (Tien et al., 2020). There have been reports of further harmful consequences of microplastics in aquaculture facilities overseas. It is also causing the presence of plastic trash in the larvae and tadpoles. A variety of histological alterations, such as blood vessel dilatation, infiltration, congestion, hydropic degeneration, and hypertrophy, are brought on by the deposition of microplastics in the liver of tadpoles (da Costa Araújo and Malafaia, 2020). Additional concern has been generated by the link between microplastics and an increase in antibiotic resistance (Dong et al., 2021). A small number of studies have suggested that the co-pollution of the oceans with metals, antibiotics, human infections, and now microplastics poses serious threats to the ecosystem globally (Xu et al., 2020).

Human health effects due to microplastics

Airborne dust, drinking water, and seafood are just a few examples of sources of exposure to microplastics. Human systems can eliminate small amounts of microplastics through feces, bile, the urinary system, and other biological excretory pathways. However, the build-up of these particles could enter the bloodstream or gastrointestinal tract and then travel via the lymphatic and circulatory systems before reaching the organs (Vivekanand et al., 2021). These polymers can induce irritation or even leach toxins once they are inside the body (Ragusa et al., 2021). Four human placentas were examined in a recent study employing Raman Micro-spectroscopy, and 12 little plastic fragments with spherical or irregular shapes and sizes between 5 and 10 micrometers were found (Xu et al., 2020). Also, He detected microplastics were colored, and several of them were stained polypropylene, a thermoplastic polymer (Ragusa et al., 2021). Other studies have shown that microparticle exposure during pregnancy can have negative impacts on the unborn child's metabolism and reproduction (Ragusa et al., 2021)

In vitro exposure to microplastics may promote nuclear bud, micronucleated, and nucleoplasmic bridge development in human peripheral blood cells. The variability of the genome may rise even at low microplastic concentrations (Zhang et al., 2021). According to studies, eating fish that contain microplastics puts humans at risk by inducing inflammation and necrosis of cells (Xu et al., 2020). Microplastics contain a variety of chemical additives, such as polybrominated diphenyl ethers, bisphenol A, and phthalates, which are added to plastics during production to increase their plasticity. It is concerning that these pollutants can accumulate in the human body through the food chain or biological processes (Tien et al., 2020). According to a study, phthalate esters (PAEs) are transported and released in the stomach by micropollutants. A change in the composition of the gut microbiota, specifically the bacteria responsible for energy consumption and immunological function, was caused by DEHP-contaminated microplastics, among other examined phthalates (Deng et al., 2020). Recent research (Cox et al., 2019) has identified additional health impacts from environmental exposure and seafood consumption.

Recently, a probabilistic lifetime exposure model for kids and adults was put forth. It takes into account exposure through inhalation, intestinal absorption, biliary excretion, and exposure to chemicals linked to plastics, as well as microplastics consumption from eight different food categories (Ragusa et al., 2021). However, there is not enough information available to understand the effects of microplastics on human health. The harmful consequences of exposure to microplastics might differ depending on their physical characteristics (size, shape, and length), as well as their chemical characteristics, which are due to the presence of a variety of additives and polymers (Cox et al., 2019; Xu et al., 2020). Therefore, additional research is advised to comprehend the genotoxic and cytotoxic potential of smaller microplastics as well as their long-term impact on human health.

CONCLUSION

The demand for plastics in both direct and indirect uses has made plastic polymers an indispensable part of people's lives. When plastic is used, it is discharged into the environment, breaking down into smaller debris (microplastics) and transported to aquatic systems. To comprehend the movement of microplastics and risk evaluations, models must be created using data and practical verification. It is vital to have a deeper understanding of microplastic pollution in the aquatic environment. It is important to investigate the consequences on the ecosystem's living species. The scientific community has not yet looked at the effects of microplastics on humans. Microplastic research must adopt a more useful methodology. Multidisciplinary approaches must be promoted to develop microplastic removal processes. Understanding environmental elements and anthropogenic activities can be improved with sociological, epidemiological, engineering, biological, and technological approaches. To reduce risks to human health, treatment methods for removing microplastics from contaminated water urgently need to be evaluated and improved. The current issue that needs to be resolved is developing the technology to legislate the contaminant or set universal, national or even statewide laws due to the complicated mixture of diverse microplastic particles.

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