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Review Article

A Review on Microplastics (MPs) Affecting Aquatic Environment

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Abstract

Microplastics (MPs), a small piece (<5mm) of plastic debris, are amongst the most serious threats to aquatic ecosystems. These are commonly found in aquatic environments due to the widespread use of plastic items. Plastic components are broken down from the large fragments into small fragments during the treatment procedure in treatment plants of wastewater, these plants can operate as the entry points for the MPs into the aquatic ecosystem; So it is necessary that MPs must be removed from the wastewater during the treatment process. However, there isn't sufficient data available about MPs' impact on the ecological services cascade and how it is linked with the declining biodiversity. This review examines the outcomes of MPs in the aquatic environment, their role as carriers, and the possible influence of MPs on aquatic biota. A detailed overview of existing knowledge regarding MP aggregation in the aquatic ecosystem is provided through this review.
Keywords: Microplastics; Aquatic environment; Degradation; Vectors; Pollutants

Introduction

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 [1]. Packaging materials (39.5% of the total plastic production), electronic equipment (5.7 %), automotive equipment (8.6%), building supplies (20.1%), and farmland materials (3.4 %) are among the many fields where plastic is broadly utilized, with the rest along with home appliances, sports gear, and other items [2]. Plastic production has surpassed 300 million tonnes in 2013 and is presumed to hit 33 billion tonnes by 2050, according to the expert's calculation [3]. The widespread use of plastic-based safety gear to prevent the transmission of the pandemic causing the COVID-19 virus is expected to rise the percentage of microplastic pollution in the environment [4]. Ineffectively dumped plastic waste has been infiltrating the surrounding water bodies and traveling over a wide area with the hydrodynamic mechanism, resulting in global plastic pollution [5]. Plastic contributes roughly 60–80 percent of waste to an aquatic environment [6]. Microplastics (MPs) are usually described as pieces of plastics with an average diameter of less than 5 mm, with no precise size restriction [7,8]. They can be found throughout the globe, from the land area to the sea, towns, and distant locations. There can be two different types of sources from where microplastics come: first, known as primary microplastics, these are usually formed in the size range of micron such as plastic beads used in cosmetics and toothpaste, commercial abrasives (polyster beads or propenoic acid), etc. [9,10]; and the second type is known as secondary microplastics, these are the fragments or the pieces of plastics that have been broken or degraded from massive plastic debris present in the environment [11]. Plastics do not endure forever, and because the material from which the plastics are made is a durable synthetic polymer, the marine environment is conducive to its degradation [12]. As a result, the disappearance of plastic in the aquatic environment shows that microplastics are formed by the fragmentation of bigger plastic waste [13].

Microplastics in Aquatic Environment

When rivers flow through urban centers, effluents from plastic-related industries, and some other sewage spill into them, MPs waste in the aquatic ecosystem is highly tied to the terrestrial ecosystem [14]. The quantity of plastic garbage produced in the upstream drainage basin has been proven to have a positive link with the plastic concentration found in the river [15,16]. Plastic pollutants can be traced back to urban areas [17]. Agricultural land is another key terrestrial source of plastic pollution. A considerable number of MPs are found in agricultural soil due to agricultural irrigation [18], fertilizers, and plastic greenhouse or polymeric material for heat retention in crops. In the freshwater habitat, atmospheric precipitation has also been confirmed as a producer of MPs.It has been revealed that MPs in the atmosphere are transported and sedimented into the aquatic environmentby various studies [19]. Simultaneously, sewage water treatment plants are another source that should not be overlooked, as they can reduce a fraction of MPs [20].

MPs can be found in the ocean surface, silt, and water column [21] and also in marine animals [22]. They can sometimes be found in places that are far distant from the sources of pollution, such as the Polar Areas [21]. Every day, the MPs dispersed in the water column settle down slowly; the quantity of MPs discovered in the bottom seabed's vertical distribution is about four times more than that of the surface layer [23]. As a consequence, MPs found in the water column of the ocean (which may be vertical or horizontal) are likely to settle down. The main factors that cause MPs to migrate horizontally are periodic ocean currents and wind [8].

Degradation and Fate of Microplastics in Aquatic Environment

Degradation of MPs occurs in a variety of ways, comprising chemical, physical, and biological degradation. Many microorganisms are engaged in biological deterioration primarily mold (fungi), algae, and bacteria [24]. Numerous elements influence the rate at which MPs degrade. Different sorts of MPs have different crystalline nature, biocompatibility, surface characteristics, chemical stability, and remnant monomers, resulting in different rates of breakdown [25]. Biofilm deposition on the surfaces of MPs happens as a consequence of the relationship between MPs (particularly non-biodegradable) and the microorganisms, making breakdown unfavorable [26]. MPs are much more susceptible to microbial adherence and contamination when the breakdown rate is low. A protective shield is usually generated by the biofilm on the exterior of contaminated microorganisms, which slows the rate of disintegration even more. The pace of MP breakdown can be influenced by various environmental variables. In pure water, their deterioration rate is better than those in simulated ocean water [27]. 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 [28]. Likewise, in the marine or saltwater environment, MPs along the shore will breakdown or degrade at a much faster pace than those drifting in the water column and settling in sediments [24]. As a result, in the freshwater, aging, mineralization, or breakage of MPs will be difficult to achieve [28]. MPs degrade after infiltrating the marine ecosystem, resulting in mineralization and size fluctuation. This implies that the MPs' polymer chain is damaged, even more, lowering the polymer's molecular weight. MPs, on the other hand, take decades to completely mineralize, according to studies [29].

Different environmental conditions, like the ocean current, the amount of food for marine animals, and others, influence the MPs future in the marine ecosystem [30]. 70–80 percent of MPs in the open sea end up in the seafloor silt or infiltrates the seabed [26]. The quantity of MPs present in the water is barely 1% of what was theoretically poured into it. Rest 99 % are not detected because they've been degraded into too little bits to be discovered, or they have been deposited on the ocean floor rather than vanishing [31].

Microplastics as Carriers for Pollutants

There have been numerous investigations on the interaction of MPs with other contaminants. according to the studies, 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 by-products inherent in MPs [32,24]. Propenoic acid and 2-Methyl-2-propenoic acid monomers, vinyl monomers, monomers soluble in water (surface active monomers), and functional or crosslinking monomers are all frequent monomers of plastics. Phosphate epoxy compounds, esters of phthalic acid, and aliphatic binary esters are typical additives of plastic. The most frequent of these are esters of phthalic acid.

Cadmium, chromium, lead, and zinc are popular heavy metals that MPs absorb [33]. According to research, the value of pH of the aqueous medium and the retention period of MPs in the surroundings are crucial factors affecting MPs' adsorption ability to metal ions. [34]. Polybrominated diphenyl ethers, polychlorinated biphenyls, organochlorine insecticides, petroleum, and polycyclic aromatic hydrocarbons, and bisphenol A are just a few of the hydrophobic environmental contaminants that adsorb by the MPs [35]. Research has demonstrated that organic compounds, due to their hydrophobicity, may be easily deposited on MPs [36]. Aside from the adsorbed chemicals' properties, MPs' features, the aging/weathering effect of plastics, and the ionic strength and pH of the aquatic environment can all have an impact on the adsorption process [19,37-39].

Microplastics as Carriers for Microorganisms

MPs have a hydrophobic surface, which allows bacteria to settle on them readily, forming a biofilm known as a "plastic ring." [40]. The development of plastic rings has been studied in the marine environment, but the situation in freshwater is unclear. MPs in treatment plants of wastewater can be employed as vectors for microbe adherence, and the composition of biofilm is linked to features such as roughness, hydrophobic nature, and the MPs' living habitat. Microorganism attachment is usually better when the hydrophobicity is higher and the surface where it is has to adhere is rough. Also, a variety of microbes, including bacteria resistant to antibiotics and pathogenic microorganisms, were discovered adhering to the MPs, indicating that the MPs could be probable vectors for pathogenic microorganisms. Thus, both antibiotics and MPs are presumed to be found in the discharge of treatment plants of sewage [31].

Effects of Microplastics on Aquatic Biota

MPs affecting organisms can be distinguished into chemical and physical components. Through tangling and ingestion, MPs waste could have a direct mechanical influence on aquatic life. The MPs waste will give an erroneous sense of satisfaction when you consumed, which can affect the appetite and possibly create an internal blockage or harm the digestive system [37]. MPs clump together in the digestive tracts, and fine particles may even penetrate and reside in the circulatory system of the organisms [31]. In rotifers, [41] studied the effects of accumulation and negative effects of MPs of different sizes. The findings revealed that finer MPs pieces were much more comfortably absorbed and stored by organisms, resulting in a decrease in the rate of growth, reproduction, and lifespan [41]. MPs transport the various chemicals found in the aquatic surroundings to the aquatic organisms. Toxic compounds or chemicals such as polychlorinated biphenyls, bisphenol A, which are absorbed by the MPs, cause mutations, teratogenicity, and cancer in organisms when ingested [37]. According to studies, MPs along with contaminants may encourage the aggregation of these contaminants in aquatic species [42].

Various additives, such as dyes and plasticizing agents, are used in the manufacturing process to ensure to satisfy the demands of production and utilization. In general, different plastics require different additives and chemical polymers. Antioxidants, plasticizing agents, and fire suppressants are all popular additives of plastics [43]. Bisphenol A, tri(2-chloroethyl) phosphoric acid, octyl phenol, boric acid, brominated flame retardant, nonylphenol, and other plastic additives have been discovered in natural waterways [44]. According to certain research, while MPs can transport contaminants into the organism and encourage their aggregation in aquatic animals, their presence does not raise the pollutants' influence on the organism [45,46].

Crustaceans, zooplankton, algae, bivalves, vertebrates, and other organisms found in freshwater and marine water can all be affected by the presence of MPs in their surroundings. MPs have a physical effect on the passage of air and light through algae, as well as on their chlorophyll [34]. As a result of each of these variables, algae's photosynthetic efficiency has decreased significantly [47].The MPs have quite an effect on crustaceans' usual lifestyle. Because of the toxic effects of MPs, the death rate increases when the treatment dose is increased, indicating a substantial dose-effect relation [48]. Simultaneously, the existence of MPs can cause crustaceans mortality through intestinal blockage by damaging the filtration systems of crustaceans [49]. According to studies, free-floating crustaceans ingest more MPs as compared to the immobile crustacean [50]. In comparison to other aquatic invertebrates, bivalves are self-sufficient due to their selective feeding mechanism, which enables them to eliminate non-food particles [51]. The amount and size of MPs consumed by fish influence their eating behavior [52-54].

Conclusions

MPs primarily enter the freshwater habitat via rainfall scouring, sewage effluents, atmospheric precipitation, and terrestrial and atmospheric environments. The majority of MPs in marine water come from land dumps and freshwater bodies. In aquatic ecosystems, these MPs are found in the silt, water column, and aquatic animals. In aquatic ecosystems, these MPs are found in the silt, water column, and aquatic animals. MPs influence biological populations as pollutant transporters in the aquatic ecosystem. Hydrophobic nature of the chemicals that are adsorbed, properties of MPs, aging or weathering of the plastics, ionic strength of water, and value of pH are some of the elements that influence MPs' ability to adsorb contaminants. The presence of MPs along with the contaminants can boost the deposition of such contaminants in aquatic life; however, this does not necessarily indicate that there will be an increase in toxic effects. Furthermore, microorganisms or algae can rapidly inhabit the MPs hydrophobic surface, forming biofilm due to which the degradation process becomes more difficult. 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 duration of MPs in the biota will make it easier to transmit the MPs between trophic levels, and certainly, it will affect the entire environment. Therefore, this review on MPs may aid in improving our awareness about the ecological effects, destination, and dispersal of MPs in aquatic ecosystems.

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