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REVIEW ARTICLE

Microplastics: Not a Micro Issue.

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ABSTRACT

Plastic, the most common type of marine trash is found in our oceans and lakes. In a period of few decenniums since the mass production of plastic, in the 1950s, the debris of plastic has piled up in terrestrial environments, open oceans, on the banks of the most secluded islands and in the deep sea. The durability of plastic is estimated from decades to millenniums but is far more in deep-sea and environments. The debris of plastic poses a menace by chocking and perishing wildlife by distributing harmful organisms, absorbing lethal chemicals and degrading microplastics that may be ingested afterward. The main objective of this review is to discuss the sources of microplastics; its effects on aquatic organisms as well as potential human health impacts and its increasing concern.

1) INTRODUCTION

Microplastics are commonly defined as water-insoluble and particles of solid polymers that are less than five millimeters in diameter [1]. MPs can be categorized as primary or secondary depending on the aspect of their production.

Primary MPs are those small particles that are released directly into the environment through spills, domestic and industrial discharge, sewage or indirectly through run-off. The range of primary MP particle types include fragments, fibres [2], pellets [3], film [4, 5] and spheres [6]. The spheres are generally related to the cosmetic and pharmaceutical industries [7, 8].

Secondary MPs are formed by the result of continuous degradation of larger particles of plastic e.g. UV radiation (photo-oxidation), mechanical transformation (e.g. waves abrasion) and biological degradation by microorganisms that are already present in the environment [9, 10, 11].

Microplastics that are present in the environment are further degraded producing nano-particles that range from 1 to 100 nanometers. When these nanoparticles are compared with other forms of plastic debris, they have larger toxicological properties and unknown fates. [12, 13]. The presence of MPs are reported in air samples, food and drinking water [14, 15, 16, 17, 18, 19] and recently the significance of microplastics for human health have been analyzed [18].

2) SOURCES

Microplastics come from various sources which include larger pieces of plastic that are degraded into smaller particles, resin pellets that are used in the manufacturing of plastic products or in the form of microbeads. The main or dominant source of MPs if often the fragmentation of larger plastic products or product wears, however, the rate of fragmentation is unknown under the natural conditions [20].

The unceasing increase in the synthetic production of plastic and impoverished execution of plastic waste has led to an enormous increase in the dumping of waste into our aqueous environment. The source of MPs in the freshwater system is various with the largest part involved from the wastewater treatment plants. The abundance of microplastics varies with the location, from above 1 million pieces per cubic meter to less than 1 piece in 100 cubic meters.

Microplastics from primary sources entering aquatic systems through household sewage effluent [21] include polyethylene, polypropylene, and polystyrene particles in cosmetics and cleaning products. Other primary microplastics include those of industrial origin in spillage of plastic resin powders or pellets used for air blasting [22], and feedstocks used to manufacture plastic products [23]. MPs from secondary sources are considered to be the major contributors in substantial amounts of microplastics present in the environment [24]. Secondary MPs that arise from washing clothes are mainly made of polyester, acrylic, and polyamide, and may reach more than 100 fibers per liter of effluent [25].

3) EFFECTS ON AQUATIC ORGANISMS

There is a growing societal and scientific concern about the

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effects of microplastics on marine and freshwater organisms [26, 27, 28]. Studies have suggested that MPs can rack up and can cause particle toxicity in aquatic organisms by causing an immune response [15]. Chemical toxicity can occur due to the percolation of plastic associated chemicals like additives as well as absorbed toxins [29, 30]. The number of MPs present in the aquatic environment is increasing continuously because of the increase in the production of plastics, with a total global production of 335 Metric tons in 2016 [31]. There is a wide range of plastic polymers that are produced and released into the environment. In Europe, polyethylene (PE) comprised 28%, polypropylene (PP) 19%, polyvinylchloride (PVC) 10% and polystyrene 7% of total production [31].

Different plastic polymers have a different range of densities (from 16 to 2200 kgm^{-3}; [32] which influences the behavior of MPs in the aquatic environment. Moreover, MPs are found in a wide range of shapes also (e.g. spheres, fiber, film, irregular). Due to these differences in shape and density, the MPs disperse diversely in different areas of the aquatic environment (water surface, water column and sediment) and effect the organisms at different trophic levels by occupying different habitats [33, 34, 11].

For instance, organisms like phytoplankton [35] and small crustaceans like zooplanktons [36] are more prone to confront less dense and floating MPs. While organisms such as amphipods [37], polychaete worms [38], tubifex worms [39], molluscs [40, 41] and echinoderms [42] are more prone to confront MPs that are denser than water. On the other hand, fishes may accumulate MPs directly, or indirectly i.e. consume them in prey. The birds [43] and mammals [44] that feed on aquatic organisms or are living in aquatic environments are also known to ingest or accumulate MPs. Microplastics are found in almost all aquatic environments (marine and freshwater) and are also detected in protected and remote areas [45] which makes their harmful effects a global problem.

4) EFFECTS ON HUMAN HEALTH

Microplastics can cause various harmful physical effects on humans and other living organisms by mechanisms such as ingestion and entanglement. The global threat imposed by very persistent plastic waste that is fragmenting and accumulating in the oceans of the world, lakes, rivers and terrestrial environments is becoming more and more evident [46, 47]. Humans are exposed to both particles of plastics and chemical additives that are being released from the plastic debris of consumer society. Humans accumulate plastic particles by the consumption of seafood, terrestrial food products, drinking water and also through the air. [46, 48] Uptake of plastics by humans (and animals) can cause severe health effects by at least three possible means:

a) **Particle toxicity:** Our knowledge about the interaction of particles of plastics with the cells and tissues in humans is still poor. Yet, the physical effects of particles observed until now in human cells and tissues and also in animals give us an insight into the possible risks and effects of plastic particles in humans. The studies show that they can cause lung and gut injuries, and especially the ones which are very fine particles can even cross cell membranes, the blood-brain barrier, and the human placenta [46, 48]. The effects observed include oxidative stress, cell damage, inflammation, and impairment of energy allocation functions [46, 48].
b) **Chemical toxicity:** Plastic trash can be regarded as a complex combination of contaminants, including both micromolecular substances (i.e., chemical additives, residual monomers, and ambient chemical substances) and macromolecular substances (i.e., polymeric materials). Many of these substances like bisphenol A, phthalates and some of the brominated flame-retardants, are known as to be the endocrine disruptors that adversely affect human health upon exposure through accumulation, ingestion, and inhalation. [46, 48]. Also, the airborne and waterborne hydrophobic contaminants with large plastic-air and plastic-water partition coefficients, absorb to plastic litter [46]
c) **Pathogen and Parasite Vectors:** Plastic debris whether small or large, acts as a substratum for the pathogenic parasites and micro-organisms [46, 47]. For instance, the plastic trash has been found to contain human pathogenic bacteria e.g., *Escherichia coli, Bacillus cereus, Stenotrophomonas maltophilia*, from a little distance from the surrounding water and sediment. This indicates that plastic debris can act as a habitat and a reservoir for pathogens and parasites [47]. Plastics carrying pathogens can enter bathing or drinking water after emitting to the surface water. It leads to an increased risk of infection and human exposure.

5) INCREASING CONCERNS

Ingestion of MPs has been observed in a range of animals of that are consumed by humans as food, such as fish (e.g. Atlantic cod, Atlantic horse mackerel, red mullet, European sea bass), bivalves (e.g. mussels, oysters), and crustaceans (e.g. brown shrimp) [49]. Animals from wild populations as well as those from aquaculture can also ingest or accumulate microplastics [50]. For example, bivalves cultured in estuaries are more susceptible to ingesting microplastics because the water and sediments of such areas are contaminated with plastic particles [16]. Moreover, fishes, shrimps, and other farmed species are fed with materials produced from fish and other animals (e.g. fishmeal) that may be contaminated with microplastics [51]. The plastic debris has also been detected in seafood sold for human consumption, as well as in fish and shellfish purchased from markets [52]. These pieces of evidence raise high concerns about the ingestion of microplastics by humans through the consumption of aquatic species contaminated with MPs. Apart from this several records also provide evidence of the presence of other synthetic microparticles and microplastics in human food and the ingredients used to prepare it, and also in the drinking water. For example, microplastics were found in canned sardines and sprats [53], salt [19] beer [54], honey and sugar [55]. Furthermore, drinking water in plastic bottles, glass bottles and beverage cartons obtained from grocery stores in Germany also contain microplastics [56] as well as tap water from different countries [57]. Therefore, the occurrence of MPs in other food items and drinking water increases the concerns regarding the risks and health hazards associated with their long-term exposure and ingestion by humans [53].

However, by using the biodegradation processes with the help of microorganisms can be achieved for the degradation of microplastics (synthetic polymers). Various species of bacteria's have been reported to degrade plastic polymers. For instance, polyethylene was degraded by *Staphylococcus* sp., *Pseudomonas* sp., and *Bacillus* sp., isolated from soil [58], and polystyrene was degraded by *Rhodococcus ruber* [59]. Also, the degradation of polyvinyl chloride (PVC) by *Pseudomonas putida* has been reported [60]. Thus, the biodegradation process is an environmentally safe program that could enable the natural cleaning of microplastics contaminating the environments.

6) CONCLUSION

Comparing to many other anthropogenic impacts on the environment, microplastic is one of that problems that is still growing and even if it is stopped immediately it will last for centuries.

MPs originate from multiple sources and their abundance is expected to increase further because of the breakdown of larger plastic items. This review suggests that strategies should be developed as well as new regulations should be set up for controlling the manufacture, sale, and distribution of plastic and plastic goods on a large global basis in order to avoid critical environmental and health hazards. Regarding the issues related to treatment, it seems difficult to remove MPs because of their small size and less visibility. Moreover, the rate of MPs entering the environment is much higher than the rate of its removal.

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