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Investigating Micro-Plastic Pollution and its Consequences on Aquatic Communities

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Abstract

Aquatic communities, as one of the sources of human food supply, are affected by various environmental threats, among which the accumulation of microplastics has attracted concerns about their acute affect. This pollution is a threat to wildlife and can have serious economic effects; notwithstanding the increase in international attention, the presence of these materials in the environment is a hazardous problem due to the increasing of plastic production in the world and inadequate disposal of plastic waste. Previous studies were reported the presence of microplastics in the water column and offshore sediments worldwide. The life span, durability, and strength of plastics are estimated at tens of years to hundreds of years, which significantly lead to micro-plastic contamination. Due to the buoyancy and durability of microplastics, these particles accumulate throughout the aquatic environment and human food chain through fish or other aquatic organisms, which can cause various types of cancer, digestive problems, and reduced fertility.

Keywords: Microplastics; Pollutants; Aquatic communities

Introduction

The release of various pollutants from various sources has caused concerns for the health of ecosystems and humans [1-5]. Among different pollutants, in addition to the level of pollutant toxicity, small amounts of their emissions are also important issues that are considered in various studies. In the meantime, with the release of various pollutants, plastic production has enjoyed a very high growth since the 1950s, so its global production reached 311 million tons in 2014 [6]. Studies show that between 5 and 13% of them find their way into aquatic ecosystems [7,8]. The most important factors affecting the widespread production of these compounds are their flexibility, formation at low temperatures, inertness, and high relative resistance [9,10] Cited. Therefore, they have been widely used in various industrial sectors such as the production of paints, pipes and fittings, various tanks and appliances, medicine and pharmaceuticals, cosmetics, textiles, car tires, electrical insulation, personal appliances, etc. Have. These products can enter the environment in different sizes from microns to meters and become smaller sizes under the influence of various physical factors such as wind waves and storms hitting hard surfaces. Over time, physical processes (abrasion, wave movement, and turbulence) biologically and chemically can reduce the structural integrity of plastic waste, and as a result, it breaks into pieces. The presence of small pieces of plastic in the open oceans was first highlighted in 1970. These small pieces of plastic, fibers, and granules are called "microplastics" which have been considered an emerging pollutant since the beginning of the 20th century. These compounds with different densities can spread on the surface and water column and the surface of sediments. Microplastics have a larger surface area-to-volume ratio than macro-plastics and are more susceptible to contamination by several airborne pollutants. (i.e., manufactured POPs and to some extent, metals). Because plastics are made of highly hydrophobic materials, the chemical pollutants are concentrated in and/or onto their surfaces, and microplastics act as reservoirs of toxic chemicals in the environment [11].

In addition to the potential side effects caused by eating microplastics themselves, the release of pollutants in microplastics and non-main pollutants, attached to microplastics, can also increase the destructive effect of these pollutants. Such additives and monomers may affect important biological processes and cause endocrine disruption, which in turn can affect motility, reproduction, and growth and cause cancer. In addition, since micro-plastic shave the potential for bioaccumulation, eating them may initiate the accumulation of toxins in the basic food chain. Since 2005, micro-plastic studies have been widely conducted worldwide [12].

1-Types of Microplastics

Small pieces of plastic, fibers, and granules, which are called microplastics, have been considered pollutants since the beginning of the 20th century. Over time, physical processes (abrasion, movement of waves, and turbulence) biologically and chemically reduce the structural integrity of plastic waste, and as a result, they are broken into pieces (Figure 1).

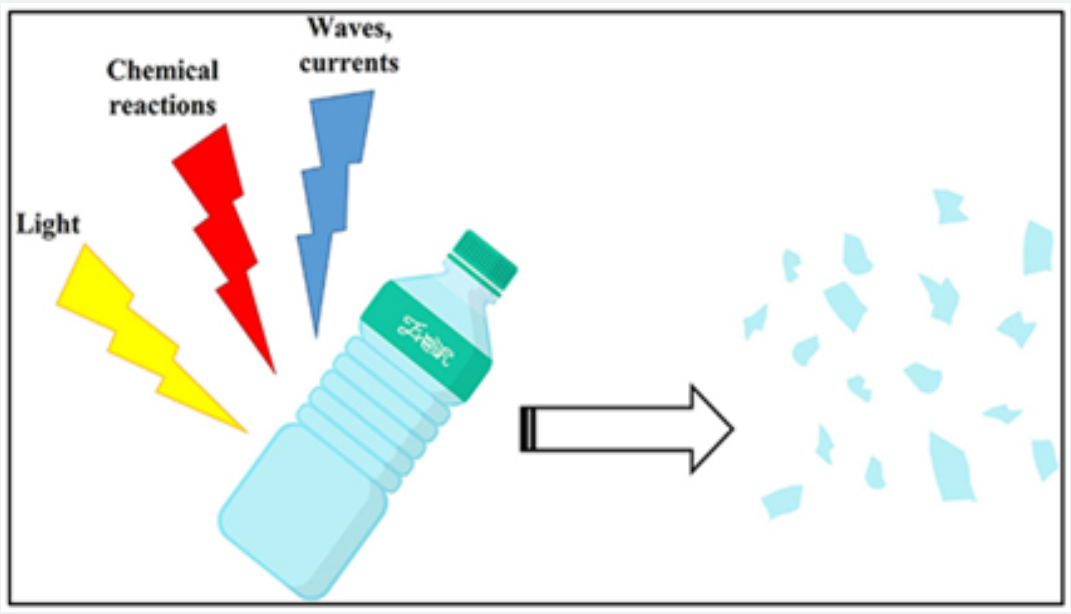

Figure 1: Schematic description of the effect of environmental factors on the shape and size of abandoned plastic compounds.

In general, there are two types of microplastics

a) Primary microplastics: These are plastic particles that are purposefully made in microscopic dimensions and are directly introduced into the environment. These materials are used in cosmetics (cleansers and exfoliators), in chemical industries as raw materials, ventilation technology, anti-moss materials, and as carriers of drugs in medicine [13].

Primarily sourced microplastics are directly released to the environment in the form of small (mm) pellets that are used as abrasives in industrial (shot blasting) and domestic applications. They can also be released by spilling virgin plastic pellets (mm). Facial cleansers that are used by millions of people, especially in developed countries, contain PS particles (mm) that directly enter sewage systems and adjacent coastal environments [14].

b) Secondary microplastics: Secondary microplastics describe small pieces of plastic obtained from the breakdown of larger plastic debris, in the sea and on land, during chemical and physical mechanisms.

There are also two types of microplastics in terms of particle size

a) Large micro-plastic (L-MPP): plastic pieces in the range of 1-5mm

b) Small microplastics(S-MPP): plastic particles smaller than 1mm

Degradation of plastics

Small plastics enter the environment directly, whereas larger items are continuously fragmenting. Larger plastics eventually undergo some form of degradation and subsequent fragmentation, which leads to the formation of small pieces [15]. Degradation is a chemical change that reduces the average molecular weight of polymers. The most-used polymer types (i.e., PE and PP) have high molecular weights and are non-biodegradable. However, once in the marine environment, they start to suffer photo-oxidative degradation by UV solar radiation, followed by thermal and/or chemical degradation. This renders plastics susceptible to further microbial action (i.e., biodegradation). The light-induced oxidation is orders of magnitude higher than other types of degradation. Any significant extent of degradation inevitably weakens the plastic, and the material becomes brittle enough to fall apart into powdery fragments when subjected to sea motion. This process essentially occurs forever, including on the molecular level. It is well-established that plastics will fragment in the marine environment and form micro and nano pieces [16], however, no long-term studies have been undertaken to estimate the actual residence time of these fragments.

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a) F: Foams: They are usually made from shredded Styrofoam. They have an irregular and soft shape, and their color varies from white to yellow [17,18].

Microplastics are divided based on their appearance

a) Small particles: they are usually the most abundant. They have an irregular shape, thick with sharp and strong edges, and have different colors (Figure 2).

b) Films: They are transparent and have an irregular shape, but compared to particles, they are thin and flexible (Figure 3).

c) Tablets: They are round and irregular and are usually bigger than other microplastics (diameter 5mm) and are available in different colors.

d) Granules: They are round and have a regular shape and smaller dimensions compared to tablets (about 1 mm). Their coloring is more limited and they are brown, white, and beige (Figure 4).

e) Fibers: next to particles, they are the most abundant. They are long or short, thick or thin, and have a variety of colors (Figure 5).

Figure 2: Differences between colors, shape and size of microplastic particles.

Figure 3: Films shape of microplastics in aquatic environments.

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Figure 4: Ca, Na and K levels (in %) in *S. brachiata* and *S. brachiata*-based feed.

Figure 5: Fibers: next to particles form of microplastic particles.

Sources of microplastics in marine environments

The main sources of microplastics entering the sea are divided into two groups:

a) Those that are directly exposed to runoff.

b) Macro-plastics and mesoplastics are exposed to decomposition and weathering.

Distribution of Microplastics

Due to the buoyancy and durability of microplastics, these particles accumulate throughout the aquatic environment. The coast, water column, deep-sea sediments, and Arctic ice have recently been detected in fresh water and human food and drink.

Potentially, microplastics with low and high densities are

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ingested when present in the marine environment and tend to float on the sea surface. There, they are available to a wide range of organisms that may ingest microplastics passively or actively. If the polymer is denser than the seawater or becomes covered by biological films, then it tends to sink (eventually reaching the seabed) or becomes neutrally buoyant [19].

Microplastics as a Pollutant

Microplastics transport pollutants over large oceanic areas and contaminate the marine biota when ingested. By eating the contaminated microplastics, individuals are susceptible to physical damage and to doses of pollutants that were not previously accessible in other tangible matrices, such as seawater and sediments. Organisms at every level of the marine food web ingest microplastics, but those inhabiting industrialized areas are exposed to higher amounts and may be more contaminated.

Negative Consequences of Microplastics

a) In terms of aesthetics.

b) Economic costs for beach cleaning.

c) Different living organisms consume them.

d) Lack of nutrition, long-term starvation, and reduction of fish population.

e) Carrier of hydrophobic organic pollutants and heavy metals.

What Happens after Fish Consume Microplastics?

a) Pass through the digestive system and finally be excreted.

b) They remain in the digestive system and cause scratching and damage.

c) In high concentrations, microplastics can enter the blood circulation system.

d) Artificial fibers can block organs and prevent existing nutrition.

The Consequences of the Accumulation of Microplastics in the Human Body

Occurrence of problems and diseases of the digestive system

a) Entering the bloodstream and organs

b) Cell death

c) Risk of cancer

d) Endocrine disorder (decrease in fertility)

e) Brain and bone development problems

f) Carrying other toxic substances in the body [20]

Solutions to Reduce Microplastics

a) Buying organic clothes

b) Changing the way to wash clothes

c) Not using single-use plastic

d) Using plastic-free cosmetics

e) Reduce oyster consumption

f) Use of public transportation

g) Do not heat food with plastic containers

These suggestions will require the implementation of educational programs, the cooperation of urban and rural facilities, and, above all, persuasion through practical examples of environments that easily and directly exhibit proper control of waste [21-23].

Conclusion

The appearance of microplastics in a wide range of nutritional levels can create risks for the health of consumers, including animals and humans. The occurrence and abundance of microplastics consumed throughout the coasts of the seas show the importance of microplastics projects in future efforts to control pollution. Microplastics can't be sieved from sand or filtered out of seawater. Collecting all of these microparticles would take forever, and even so it would not be effective. Microplastics will continue their slow, intricate paths toward the bottom of the ocean and ultimately become buried in sand and mud for centuries. However, rather than despair, scientists should propose solutions that can be considered by academia, society, and industry.

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