

MICROPLASTICS (MPS) IN DRINKING WATER: USES, SOURCES AND TRANSPORT

Abstract

Microplastics (MPs) are small fragments of plastics. These fragments are abundant in nature and can enter the environment of freshwater from wastewater effluent and surface run-off, degraded plastic waste, atmospheric deposition, and industrial effluent. These fragments are never destroyed but converted into another phase. These fragments are a cause of air contamination and occur in airborne particles. Some particles are biodegradable while some are non-biodegradable. Biodegradable particles can be disintegrated by the action of microorganisms or in the occurrence of ultraviolet (UV) light. Thermo-analytical, spectroscopic, and chemical processes are the available popular methods for the estimation of the size and chemical composition of these particles. The present study discusses the uses, health hazards, transport, and sources of MPs particles.

Keywords: Microplastics (MPs); Drinking Water; Nanoplastics (NPs)

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I. INTRODUCTION

Small particles of plastic with a size < 5 mm are known as MPs. If the size of these particles is below $1 \mu\text{m}$ then these particles are known as nanoplastics (NPs). These particles are also known as “plastic debris” (Hartmann et. al., 2019). These small particles have been distinguished in freshwater, wastewater, drinking water, marine water, air, table salt, food, beer, etc. These particles are hydrophobic and present in cosmetic products, clothes, plastic bags, etc. Some MPs come from distribution systems and are found in tap water as well as bottled water. These particles characterize a varied range of colors, types, and sizes (Eerkes-Medrano et. al., 2015). The production of plastic increased in 2015-2017 from 322 million tonnes to 348 million tonnes and represented <0.1 % of the whole production of plastics (Plastics Europe 2019).

These particles are classified as primary and secondary microplastics. Plastic pellets, plastic fibers, and microbeads are used in synthetic textiles, industrial manufacturing, and personal care products (PCPs) and are known as primary microplastics. These MPs enter the environment through abrasion during washing, spills during manufacturing or PCPs being splashed into wastewater from households. While secondary microplastics are made from the larger particles of plastic (e.g. bags, clothes, tyres, bottles, etc.) after fragmentation and the fragmentation occurs when the larger particles expose to wave action, wind abrasion, and sunlight.

Plastics are manufactured from polymers which are formed through the condensation or polymerization reaction. Plastics are two types (i) thermoset plastics (ii) thermoplastics. Thermoplastics are soft after heating while hard after cooling and they can be recycled. Polystyrene (PS), polyethylene (PE), polypropylene (PP), polyamides (PA), polyvinylchloride (PVC), polycarbonates (PC), and polyethylene terephthalate (PET) are the examples of thermoplastics. Thermoset plastics cannot be recycled and are not soft after heating. Epoxy resins, acrylic resins, polyesters, and polyurethane (PUR) are example of thermoset plastics. Several scientists have studied the existence of MPs in several products (Oßmann et. al., 2018; Uhl Eftekhardadkhah and Svendsen 2018; Mason et. al., 2018; Schymanski et. al., 2018; Kosuth et. al., 2018; Mintenig et. al., 2019; Strand et. al., 2018;).

II. USES

Plastic is used in various products which are used on a regular basis in daily life (Bhardwaj and Sharma 2021; Bhardwaj 2022). It is generally used in different sectors like packaging, electrical, sports, automotive, toy, construction, etc. It is also used in water treatment systems. It is useful in some cases, for example, in the food industry, it increases the life of food by avoiding bacterial contamination while in the health industry, it is used in intravenous tubes, prosthetics, surgical gloves, heart valves, and syringes.

III. HEALTH HAZARD

The occurrence of MPs in bottled water is harmful to the health of humans. It may be in physical, chemical, and microbiological forms.

- 1. Physical hazard:** This hazard exists in particle forms. The toxicity of MPs depends on physical properties (size and surface area) and surface characteristics. Large size ($> 150 \mu\text{m}$) MPs are not absorbed by the human body. While the distribution and absorption of minor MPs may be higher.
- 2. Chemical hazard:** This hazard exists in polymer forms, and the polymers are made up of monomer units. Polymers such as 1,3-butadiene, vinyl chloride, and ethylene oxide are formed after the polymerization reaction. Chemicals such as phthalate esters, tetrabromobisphenol A (TBBPA), and polybrominated diphenyl ether (PBDEs) are found in MPs while they are not bound with polymers. This hazard can easily travel into the atmosphere and migration depends on the molecular weight (MW) of the compounds. Low molecular weight (LMW) compounds travel at a quicker rate than large molecular weight (LMW) compounds.
- 3. Microbiological hazard:** This hazard exists in biofilm form, which is formed by microorganisms after the attachment to the surface of the MPs. In drinking water, biofilm is formed after the growth of microorganisms on the tubes of drinking water. These organisms are non-pathogenic and have a tendency to attach to surfaces which are hydrophobic and nonpolar.

IV. SOURCES AND TRANSPORT

Combined sewer overflows, atmospheric deposition, effluent of wastewater, land-based run-off, manufacture and distribution of drinking water, industrial effluent, degradation and fragmentation of macro plastics are various sources of MPs in drinking water. The mechanism of MPs' transport is shown in figure 1.

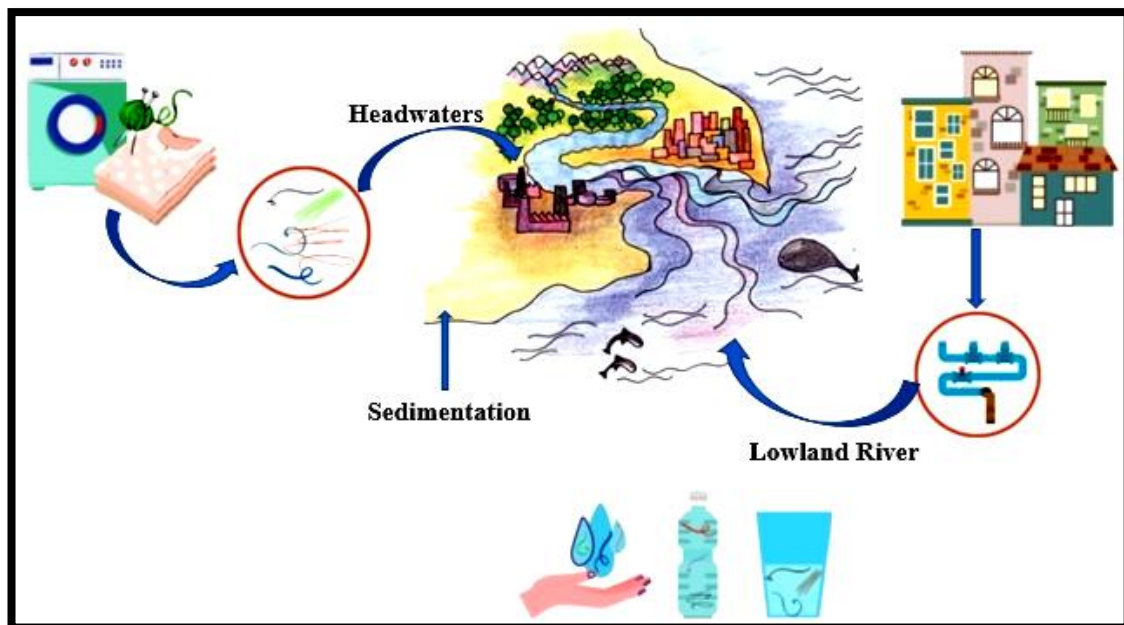


Figure 1: Mechanism of Microplastics (MPs) Transport

1. **Combined sewer overflows:** The barrier of wastewater treatment is provisionally bypassed by high rainfall. The highest rainfall is the main source of MPs in the freshwater environment.
2. **Atmospheric deposition:** Through precipitation, run-off, and wet and dry deposition, atmospheric deposition is the possible source of MPs (Wright and Kelly 2017).
3. **Effluent of wastewater:** The effluent from the wastewater treatment plants can carry the maximum number of MPs and it is a commonly known cause of MPs in the environment of freshwater (Li et. al., 2018). Fibers from the washing of clothes, broken parts of consumer goods, and cosmetic microbeads are the chief sources of MPs in sewage systems. Murphy et. al., (2016) reported that 65 million particles of MP are released in the effluent of a treatment plant in each day.
4. **Land-based run-off:** Land-use practices, infrastructure, road marking paints, tyre wear debris, and road surface run-off are the major sources of MPs. Several scientists reported different MPs in the aquatic environment and stated that they came from land-based run-off (Lassen et. al., 2015; Verschoor 2016; Sherrington et. al., 2016; Boucher and Friot 2017). MP fibers which are out from the textiles due to tear, washing, and wear, are an important source of MPs (Schöpel and Stamminger 2019; Henry et. al., 2019). Dust of the city and agricultural run-off are the best instance of a land-based cause of MPs in freshwater environments (Horton et. al., 2017; Boucher and Friot 2017).
5. **Drinking water manufacture and distribution:** In drinking water production water treatment provides a barricade for MPs. Some apparatuses of the plants are made up of plastics which contribute to the formation of MPs in water (Mintenig et. al., 2019). Schymanski et. al., (2018) and Oßmann et. al., (2018) studied the presence of MPs in drinking water bottles and reported that the caps of bottles and bottles are the major causes of MPs in water bottles.
6. **Industrial effluent:** The input of industrial effluents to MPs in wastewaters has yet to be studied (Kooi et. al., (2017). However, several MPs particles related to the industry have been informed in the freshwater environments. Different types of small plastic particles are reported in the Great Lakes and Danube River (Eerkes-Medrano et. al., 2015).
7. **Fragmentation and degradation of MPs:** Morritt et. al., (2014) and Gasperi et. al., (2014) studied the fragmentation of the larger particles of plastics and described that large particles can be an important source of MP in the freshwater environment. Limited data are available on the degradation and fragmentation of macroplastics in the marine and freshwater environment. The occurrence of macroplastics in the ocean has been recommended to be an important source of MPs (Barnes et. al., 2009). In the presence of high temperature and UV light the macroplastic particles are fragmented into small plastic particles (Andrady 2007 a & b). Zbyszwski and Corcoran (2011) used a scanning electron microscope for the estimation of MPs in freshwater. Alimi et. al., (2018) reported nanoplastics (NPs) in the freshwater environment and stated that these NPs are formed from the MPs.

V. CONCLUSIONS

There is no sign of a human health concern, so repetitive monitoring of the presence of MPs in drinking water is not compulsory. The usage of microorganisms is accomplished by the breakdown of artificial MP particles. Some bacterial and fungal species have the capabilities of biodegradation and break down the chemicals like polyethylene, polyurethane, polystyrene, and polyester. These microorganism species are used in sewage wastewater and other polluted environments. Microbead-Free Waters Act was passed by the United States (US) government in 2015 to ban the manufacture and distribution of those products which contain microbeads of plastics. Several other nations are also prohibiting the use of microbeads. At the end of this chapter, the author is giving numerous recommendations for the elimination of MPs from drinking water.

1. In metro cities, the suppliers of drinking water should check the effectiveness of the control procedure. These control procedures should be optimized.
2. The processes of water treatment should be enhanced for the elimination of small plastic particles.
3. An instructive movement should be planned for the awareness of contamination from the plastic particles and encourage the reuse or recycling of these plastic particles.
4. Strategies should be made by the management for the elimination of the plastic particles from the freshwater and drinking water and the benefits of plastic must also be measured before announcing the strategies.

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