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# Microplastics (MPs) in Drinking Water: Uses, Sources & Transport

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**Abstract:** Microplastics (MPs) are small pieces of plastics. They are ubiquitous in the environment and can enter the freshwater environment from surface run-off and wastewater effluent (treated and untreated), industrial effluent, degraded plastic waste, and atmospheric deposition. They are not usually destroyed but convert into one phase to another. They are a source of air pollution, occurring in dust and airborne fibrous particles. Mostly MPs are non-biodegradable while some MPs are biodegradable, which can be decomposed in the presence of ultraviolet (UV) light or by the action of microorganisms. Popular methods: chemical, spectroscopic, and thermo-analytical are available for the determination of the chemical composition and size of plastic particles. This chapter discusses the uses, health hazards, sources, and transport of MPs particles.

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

1. **Introduction:** MPs are plastic particles with a small diameter (< 5 mm or 0.2 inches). If the length of MPs is smaller than 1 μm then they are called nanoplastics (NPs). Hartmann et. al., (2019) used the term first time "plastic debris" for MPs. They have been detected in marine water, wastewater, freshwater, drinking water, food, beer, air, table salt etc. They are hydrophobic in nature and are present in a variety of products, from cosmetics to synthetic clothing to plastic bags. Some MPs are found in bottled water as well as tap water and come from distribution systems. They represent a diverse range of material sizes, types, colors, and shapes (Eerkes-Medrano et. al., 2015). According to the study of Plastic Europe (2019), plastic production increased from 322 to 348 million tonnes from 2015 to 2017. The MPs production represents <0.1% of total plastic production intentionally (Plastics Europe 2019).

MPs are divided into two types: primary microplastics (PMPs) and secondary microplastics (SMPs). PMPs include plastic fibers used in synthetic textiles (e.g., nylon), plastic pellets used in industrial manufacturing, and microbeads found in personal care products. They enter the environment through several routes, for example unintentional loss from spills during manufacturing or transport, abrasion during washing (e.g., laundering of clothing made with synthetic textiles), or personal care products being washed into wastewater systems from households. While SMPs are formed by the fragmentation of larger plastic items (e.g. bottles, bags, tyres, clothes, etc.) and this happens when larger plastics expose to wind abrasion, wave action, and ultraviolet radiation from sunlight.

Plastics are made up of polymers which are mixed with plasticizers, additives, stabilizers, including colorants and fillers. Some polymers are formed by the polymerization reaction while some are formed by the condensation reaction. There are two types of plastics: thermoset plastics (TSPs) and thermoplastics (TPs). After heating, TPs are soft while hard after cooling. It means TPs can be recycled, for example, polypropylene (PP), polyethylene (PE), polyethylene terephthalate (PET), polystyrene (PS), polyvinylchloride (PVC), polyamides (PA), and polycarbonates (PC). TSPs are not soft upon heating. It can't be recycled, for example,

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polyurethane (PUR), epoxy resins, some polyesters, and some acrylic resins. Several researchers have reported the presence of MPs in various products (Kosuth et. al., 2018; Mason et. al., 2018; Oßmann et. al., 2018; Schymanski et. al., 2018; Strand et. al., 2018; Uhl Eftekhardadkhah and Svendsen 2018; Mintenig et. al., 2019).

2. **Uses:** Plastics are used regularly in daily life. They are commonly used in the electrical industry, packaging industry, automotive industry, sports industry, building material, and construction industry. In some cases, plastics are useful for humans, for example, they can increase the shelf-life of food by preventing microbial contamination. In the medical field, it is used in syringes, intravenous tubes, surgical gloves, prosthetics, and heart valves. Plastics are also used in membrane filters of water treatment systems.

3. **Health Hazard:** The MPs presence in drinking water is hazardous to human health. This hazard is in three forms: physical, chemical, and microbiological.

**3.1. Physical Hazard:** It is present in the form of particles and the toxicity is dependent on surface characteristics, and physical properties such as size, shape, surface area. MPs greater than 150 µm are not absorbed in the human body while the absorption of small particles may be limited. The absorption and distribution of very small particles of MP may be higher.

**3.2. Chemical Hazard:** It is present in the form of polymer which is made up of monomers and after the polymerization reactions polymers are formed such as vinyl chloride, ethylene oxide, and 1,3-butadiene. Polybrominated diphenyl ether (PBDEs), phthalate esters and tetrabromobisphenol A (TBBPA) are not bound to the polymer but are present in MPs. The chemical hazard can easily travel into the environment. The migration of the chemical hazard is depending on the molecular weight of the compounds, low molecular weight molecules migrate at a faster rate than a large molecule.

**3.3. Microbiological Hazard:** It is present in the form of biofilm and it is formed after the attachment of microorganisms on the surface of the MPs. In drinking water, it is formed when microorganisms grow on the pipes of drinking water and other surfaces. These microorganisms are non-pathogenic and attach faster to hydrophobic nonpolar surfaces than to hydrophilic surfaces.

4. **Sources and Transport:** There are different sources of MPs into drinking water such as wastewater effluent, run-off from land-based sources, combined sewer overflows, atmospheric deposition, industrial effluent, drinking water production and distribution, fragmentation and degradation of macro plastics. Transport mechanism of MPs is described in fig 1.

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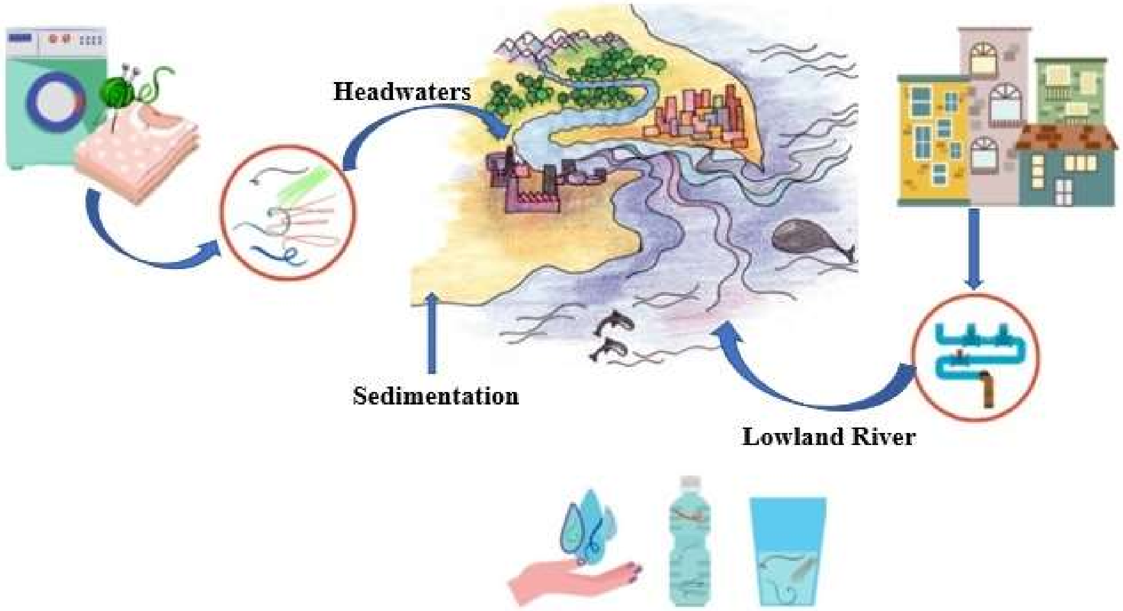


**Fig 1: Transport Mechanism of Microplastics (MPs)**

(i) **Wastewater Effluent:** It is a widely recognized source of MPs in freshwater (Li et. al., 2018). Cosmetic microbeads, disintegrated parts of larger consumer products, synthetic fibers from clothes washing are the major domestic inputs into sewage systems. The wastewater treatment plant's effluent can carry high numbers of MPs. As per the study of Murphy et. al., (2016), 65 million MP particles were released each day in the effluent from a wastewater treatment plant (WWTP).

(ii) **Run-off from Land-based:** They can originate from the infrastructure, land-use practices, road surface run-off, road marking paints, and tyre wear debris. Several researchers have reported the various inputs of MPs into the aquatic environment from land-based sources (Sundt et. al., 2014; Lassen et. al., 2015; Sherrington et. al., 2016; Verschoor 2016; Boucher and Friot 2017). MP fibers are another important source and are released from the textiles due to wear and tear and washing (Lassen et. al., 2015; Henry et. al., 2019; Schöpel and Stamminger 2019). Boucher and Friot (2017) have reported that city dust is the best example of a land-based source. Agricultural run-off has been identified as a potential source of MPs in freshwater environments (Horton et. al., 2017).

(iii) **Combined Sewer Overflows:** Heavy rainfall is the direct source of MPs in freshwater because the barrier provided by wastewater treatment is temporarily bypassed.

(iv) **Atmospheric Deposition:** It is an additional possible contributor to MPs in freshwater environments through dry and wet deposition, precipitation, and run-off (Wright and Kelly 2017).

(v) **Industrial Effluent:** Kooi et. al., (2017) stated that the contribution of industrial effluents to MPs in wastewaters has yet to be examined. However, industry related MPs have been reported in freshwaters. Eerkes-Medrano et. al., (2015) have reported the presence of MPs in the Danube River and Great Lakes.

(vi) **Drinking Water Production and Distribution:** Drinking water treatment provides a barrier to MPs. Mintenig et. al., (2019) have reported that some components of the treatment plants are made up of plastics and their degradation or erosion formed the MPs in drinking water.

Schymanski et. al., (2018) and Oßmann et. al., (2018) stated that the bottles and their caps are the sources of MPs in drinking water.

**(vii) Fragmentation and Degradation of MPs:** MP debris may also represent an important source of MP formation by fragmentation (Gasperi et. al., 2014; Morritt et. al., 2014) and can enter the freshwater systems. Research data are limited on the macroplastics fragmentation and degradation in the freshwater and marine water environment. According to Barnes et. al., (2009), the presence of macroplastics in the marine environment has been suggested to be a significant source of MPs. Andrady (2007 a & b) studied the fragmentation and degradation process in the aquatic environment and stated that due to the chemical changes in the presence of UV light and high temperature the macroplastic debris fragmented into the MPs. Zbyszwski and Corcoran (2011) have studied the degradation patterns of MPs in freshwater by using a scanning electron microscope and found similar to those found on marine beaches. MPs can further be fragmented into NPs. The environmental levels of NPs are yet to be quantified (Alimi et. al., 2018).

**5. Conclusions:** Repetitive monitoring of MPs in drinking water is not required because there is no indication to show a human health concern. The use of microorganisms is capable of the break-down of synthetic MP polymers. A number of fungal and bacterial species possess biodegradation capabilities and break down the chemicals such as polystyrene, polyester polyurethane, and polyethylene. These types of microorganisms theoretically can be applied to sewage wastewater and other contaminated environments. United States passed an act in 2015 named Microbead-Free Waters Act which bans the distribution and manufacture of cosmetics products that contain the microbeads of plastic. Many other countries also ban microbeads. There are several recommendations for the removal of MPs from the drinking water.

- In city, the suppliers of water should confirm that control measures should optimize and are effective.
- Water treatment processes should be improved for the removal of MP particles.
- An educational campaign should be organized for the awareness of pollution from the plastics and encouraging recycling or reuse of plastics.
- Policies should be made by the government for the removal of the plastic pollution from the environment and the benefits of plastic must also be considered before introducing the policies and initiatives.

**Conflict of Interest:** The authors declare that they have no conflict of interest.

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