World Health Organization

Microplastics in drinking-water

Key messages

- Microplastics are ubiquitous in the environment and have been detected in a broad range of concentrations in marine water, wastewater, fresh water, food, air and drinking-water, both bottled and tap water. The data on the occurrence of microplastics in drinking-water are limited at present, with few fully reliable studies using different methods and tools to sample and analyse microplastic particles.
- The potential hazards associated with microplastics come in three forms: physical particles, chemicals and microbial pathogens as part of biofilms. Based on the limited evidence available, chemicals and biofilms associated with microplastics in drinking-water pose a low concern for human health. Although there is insufficient information to draw firm conclusions on the toxicity related to the physical hazard of plastic particles, particularly for the nano size particles, no reliable information suggests it is a concern.
- Limited evidence suggests that key sources of microplastic pollution in fresh water sources are terrestrial run-off and wastewater effluent. However, optimized wastewater (and drinking-water) treatment can effectively remove most microplastics from the effluent. For the significant proportion of the population that is not covered by adequate sewage treatment, microbial pathogens and other chemicals will be a greater human health concern than microplastics.

Recommendations

- **Water suppliers and regulators** should continue to prioritize removing microbial pathogens and chemicals from drinking-water that are known significant risks to human health. As part of water safety planning, water suppliers should ensure that control measures are effective, including optimizing water treatment processes for particle removal and microbial safety, which will incidentally improve the removal of microplastic particles. Routine monitoring of microplastics in drinking-water is not necessary at this time.
- To better assess the human health risks and inform management actions, **researchers** should undertake targeted, well-designed and quality-controlled investigative studies to better understand the occurrence of microplastics in the water cycle and in drinking-water throughout the water supply chain, the sources of microplastic pollution and the uptake, fate and health effects of microplastics under relevant exposure scenarios.
- Irrespective of any human health risks posed by exposure to microplastics in drinking-water, measures should be taken by **policy makers and the public** to better manage plastics and reduce the use of plastics where possible, to minimize plastics released into the environment because these actions can confer other benefits to the environment and human well-being.

Key questions and answers

What are microplastics?

As a category, microplastics encompass a wide range of materials composed of different substances, with different densities, chemical compositions, shapes and sizes. There is no scientifically-agreed definition of microplastics, although they are frequently defined as plastic particles <5 mm in length. However, this is a rather arbitrary definition and is of limited value in the context of drinking-water since particles at the upper end of the size range are unlikely to be found in treated drinking-water. A subset of microplastics <1 µm in length are often referred to as nanoplastics.

How do microplastics get into drinking-water?

Microplastics may enter drinking-water sources in a number of ways: from surface run-off (e.g. after a rain event), to wastewater effluent (both treated and untreated), combined sewer overflows, industrial effluent, degraded plastic waste and atmospheric deposition. Surface run-off and wastewater effluent are recognized as the two main sources, but better data are required to quantify the sources and associate them with more specific plastic waste streams. Plastic bottles and caps that are used in bottled water may also be sources of microplastics in drinking-water.

How much microplastic has been found in drinking-water and drinking-water sources?

In freshwater studies, reported microplastic particle counts ranged from around 0 to 1000 particles/L. Only nine studies were identified that measured microplastics in drinking-water; these studies reported particle counts in individual samples from 0 to 10 000 particles/L and mean values from 10^{-3} to 1000 particles/L. A comparison of the data between fresh water and drinking-water studies should not be made because in most cases freshwater studies targeted larger particles, using filter sizes that were an order of magnitude larger than those used in drinking-water studies.

What kinds of microplastics are being found?

In fresh water a wide variety of particle shapes have been found while the polymers most frequently detected roughly correlates with plastic production volumes. In drinking-water, fragments and fibres were the predominant particle shapes and polyethylene terephthalate and polypropylene were the polymers most detected.

Can these studies be trusted?

A WHO-commissioned study concluded that most of these studies are not fully reliable because their methods lacked sufficient quality control. Results should therefore be interpreted with caution. The quality control areas requiring the most improvement included sample treatment, polymer identification, laboratory preparation, clean air conditions and positive controls. For example, in two drinking-water studies and for a subset of smaller particles in a third study, no spectroscopic analysis was conducted to confirm that the particles identified were plastic. Four of the 52 studies that scored highest for quality were published in 2017 and 2018, indicating some improvements in quality control.

What are the potential threats posed by microplastics in drinking-water?

The potential hazards associated with microplastics come in three forms: physical particles, chemicals and microbial pathogens that are part of biofilms. Particles may cause impacts in the body, depending on a range of physicochemical properties of the particle, including size, surface area and shape. However, the fate, transport and health impacts of microplastics following ingestion are not well studied, with no human studies on ingested microplastics. Although plastic polymers are generally considered to be of low toxicity, plastics and microplastics can contain unbound monomers and additives. Hydrophobic chemicals in the environment, including persistent organic pollutants, may also sorb to the plastic particle. Biofilms in drinking-water are formed when microorganisms grow on drinking-water distribution systems and other surfaces. Most microorganisms that are part of biofilms are non-pathogenic. However, some biofilms can include pathogens such as *Pseudomonas aeruginosa*, *Legionella* spp., non-tuberculosis *Mycobacterium* spp. and *Naegleria fowleri*.

The health risk from microplastics in drinking-water is a function of both hazard (potential to cause adverse effects) and exposure (dose). The same substance can have different effects at different doses, which depends on how much of the substance a person is exposed to and may also depend on the route by which the exposure occurs, e.g. ingestion, inhalation or injection. The risks associated with each hazard class are further described below.

What is the human health risk of ingesting microplastic particles through drinking-water?

Although there is insufficient information to draw firm conclusions on the toxicity of plastic particles and particularly the nano size particles, no reliable information suggests it is a concern. Studies on absorption indicate that microplastics >150 µm are likely to be excreted directly through faeces. Uptake of smaller particles is expected to be limited, although absorption and distribution of very small microplastic particles including nanoplastics may be higher. Toxicology studies in rats and mice reported some impacts including inflammation of the liver. However, these few studies are of questionable reliability and relevance, with findings reported at very high exposures that would not occur in drinking-water.

What is the human health risk from chemicals associated with microplastics in drinking-water?

Risk assessments have been conducted for many chemicals to determine the level at which no or limited adverse effects should occur (toxicological point of departure, POD). To assess health risks of chemicals associated with microplastics, a margin of exposure (MOE) assessment was conducted for the chemicals that have been detected in microplastics, are of toxicological concern and have adequate or accepted toxicological PODs. Since there are several orders of magnitude difference between estimated intakes from a very conservative exposure scenario and the PODs, chemicals associated with microplastics in drinking-water are a low concern.

What is the human health risk associated with biofilms that attach to microplastics in drinking-water?

Biofilms associated with microplastics are considered a low health concern considering the relative concentration of microplastics compared to other particles that pathogens can adhere to in fresh water. For microplastics that are not removed during drinking-water treatment, the relative significance of microplastic-associated biofilms is still likely negligible due to the larger mass of drinking-water distribution systems and their subsequent ability to support more biofilms, compared to microplastics. Disinfection, including in distribution systems can inactivate pathogens and control their growth.

How do the risks from microplastics stack up against other potential risks to drinking-water?

Microbial pathogens represent the most significant public health threat in drinking-water. In 2016, 485 000 diarrhoeal related deaths were attributed to microbially-contaminated drinking-water (Prüss-Ustün, 2019) and it is estimated that 2 billion people are drinking faecally contaminated water (WHO, UNICEF, 2017).

A significant source of faecal contamination in drinking-water is inadequately or untreated wastewater. About 20% of wastewater collected in sewers does not undergo at least secondary treatment and an even higher proportion of people lack access to sewage connections or other appropriate systems for collecting and treating wastewater. Therefore, although wastewater effluent is recognized as a key source of microplastic pollution in freshwater, pathogens and other chemicals associated with the lack of effective sewage treatment are of greater concern. By addressing the bigger problem of exposure to faecally contaminated water, communities can simultaneously address the smaller concern related to microplastics.

How can microplastics be removed from drinking-water?

Wastewater and drinking-water treatment systems—where they exist and are optimized—are considered highly effective in removing particles of similar characteristics and sizes as microplastics. According to available data, wastewater treatment can effectively remove more than 90% of microplastics from wastewater with the highest removals from tertiary treatment such as filtration. Drinking-water treatment has proven effective in removing far more particles of smaller size and at far higher concentrations than those of microplastics. Conventional treatment, when optimized to produce treated water of low turbidity, can remove particles smaller than a micrometre. Advanced treatment can remove even smaller particle; for example, nanofiltration can remove particles >0.001 µm while ultrafiltration can remove particles >0.01 µm.

Based on the conclusions of the report, should any actions be taken to minimize microplastic pollution in drinking-water? If so, what actions should be taken?

Irrespective of any human health risks posed by microplastics in drinking-water, policy-makers and the public should take action to minimize plastics released into the environment, since these actions will confer multiple other benefits for the environment and human well-being. Actions could include reducing the use of plastics where possible, improving recycling programmes, reducing littering, improving circular solutions and decreasing industrial waste inputs into the environment. Care must be taken, however, to select mitigating actions that do not create new problems.

Based on the conclusions of the report, what actions should be taken by water suppliers and drinking-water regulators?

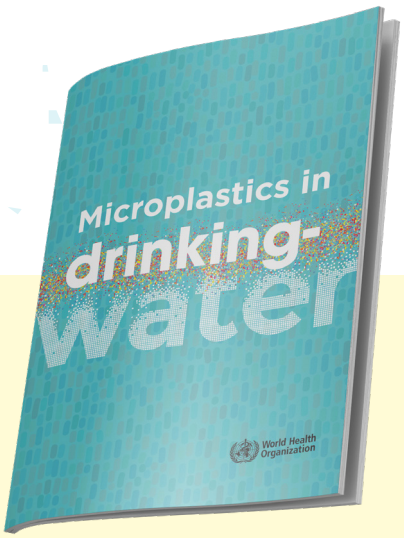
Water suppliers and regulators should continue to prioritize the removal of microorganisms and chemicals in drinking-water that pose a public health concern. As part of water safety planning, water suppliers should ensure that control measures are effective and should optimize water treatment processes for particle removal and microbial safety, which will incidentally improve the removal of microplastic particles. Routine monitoring of microplastics in drinking-water is not recommended at this time, as there is no evidence to indicate a human health concern.

What further research is needed?

A number of research gaps need to be filled to better assess the risk of microplastics in drinking-water and inform management actions. Targeted, well-designed and quality-controlled investigative studies should be carried out to better understand microplastics occurrence throughout the water supply chain, including the numbers, shapes, sizes, composition and sources of microplastics and to better characterize the effectiveness of water treatment. Research is also needed to understand the significance of treatment-related waste streams as contributors of microplastics to the environment. Quality-assured toxicological data are needed on the most common forms of plastic particles relevant for human health risk assessment. Further, a better understanding on the uptake and fate of microplastics and nanoplastics following ingestion is needed. Finally, given that humans can be exposed to microplastics through a variety of environmental media, including food and air, a better understanding of overall exposure to microplastics from the broader environment is needed.

Where will WHO direct its future research on the human-health effects of microplastics in the environment?

Given that humans can be exposed to microplastics through a variety of environmental media, WHO has initiated a broader assessment of microplastics in the environment. A future report will characterize the potential human health risks due to total microplastic exposure from the environment, including through food and air.



This information sheet summarizes key findings, recommendations and conclusions from the WHO technical report, Microplastics in drinking-water (WHO, 2019).

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