

Micro- and Nanoplastics: A Deep Dive into a Global Issue

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Our plastic problem

Modern society relies on plastic—it touches almost all aspects of our lives, used in everything from packaging, clothing, the cars we drive, to our toothbrushes. Despite the vast amount of plastic production, it remains a mostly nonbiodegradable material and can take up to an estimated 400 years to break down depending on the type of plastic. However, our reliance on the substance is only increasing. For example, worldwide plastic production increased from 2.3 million tons in 1950, to 448 million tons by 2015, and this figure is expected to double by 2050.¹

Microplastics are a consequence of this global consumption of plastic and the subsequent plastic pollution it causes. Microplastics are minuscule pieces of plastic, which measure between 1 µm to 5 mm in size,² approximately the size of a sesame seed.³

These tiny plastic particles have the potential to spread to all corners of our environment—in the land, water, air, and ultimately our bodies.⁴ Current research believes that microplastics will also degrade into smaller particles on a nanoscale,⁵ called '**nanoplastics**', which measure in the range of 1 to 1000 nm.⁶

Invisible plastic pollution is a growing global concern that is receiving increasing attention from government bodies and academic institutions. The drive to understand more about the impacts of micro- and nanoplastics is rooted in the lack of expert knowledge we have on the implications of plastic pollution for our health and the environment. Moreover, significantly less is known about the consequences of nanoplastics, but their size and subsequent ability to penetrate even more areas in our ecosystem means that their presence has the potential for more severity.⁷

A closer look...

There are **two categories** of plastic particle pollution to be aware of:

- **Primary micro- and nanoplastics:** very small plastic pieces that have deliberately been manufactured in products (e.g., shower gel, toothpaste)
- **Secondary micro- and nanoplastics:** small plastics originating from larger plastics that have since degraded (e.g., paints, abraded tires from driving, textiles)⁸

Common forms of micro- and nanoplastics:

- **Fibers:** plastic particles that originate from synthetic fibers, such as polyester
- **Microbeads:** small spherical plastics manufactured to be added into cosmetics and personal care products
- **Fragments:** extremely small plastic pieces broken off from larger pieces of plastic, that continue to break down over time
- **Plastic pellets:** plastic particles that are melted down to form larger plastic products

1. National Geographic. The World's Plastic Pollution Crisis Explained. Available at: <https://www.nationalgeographic.com/environment/habitats/plastic-pollution/>. Accessed: November 2019. 2. Frias, J. P. G. L.; Nash, R. *Mar. Pollut. Bull.* 2019, 138, 145–147. 3. National Ocean Service. What Are Microplastics? Available at: <https://oceanservice.noaa.gov/facts/microplastics.html>. Accessed: November 2019. 4. Plastic Oceans. The Facts. Available at: <https://plasticoceans.org/the-facts/>. Accessed: November 2019. 5. Gagné, F. J. *Xenobiot.* 2019, 9(1), 8147. 6. Gigault, J et al. *Environ. Pollut.* 2018, 235, 1030–1034. 7. Galloway, T. S. *Marine Anthropogenic Litter.* 2015, 13, 343–366. 8. GESAMP. Sources, Fate and Effects of Microplastics in the Marine Environment. Available at: <http://www.gesamp.org/publications/reports-and-studies-no-90>. Accessed: November 2019.

Micro- and nanoplastics come from several sources, some of the most common include:



- **Plastic pollution**

Littering and plastic pollution of larger plastics on the land and sea eventually leads to breakdown into smaller micro- and nanoplastics.



- **Clothing**

Much of our clothing generates microfibers, and the production of these fibers has been intensified by the “fast fashion” industry.



- **Plastic pellets**

These are the primary form of most plastics, which are then molded to create larger plastic products. Pellet loss during transportation and manufacturing leads to the emission of these particles into the environment.



- **Personal care products**

Many cosmetics, like exfoliators and toothpaste, contain microbeads, which are intentionally added into cosmetics to increase exfoliation and cleaning quality. The US, Canada, New Zealand, South Korea, and some EU countries are among those who have prohibited the manufacturing of products containing microbeads.⁹



- **Tire abrasion**

Tire dust produced from erosion against the road contains tiny plastic particles that are then transferred into the atmosphere.

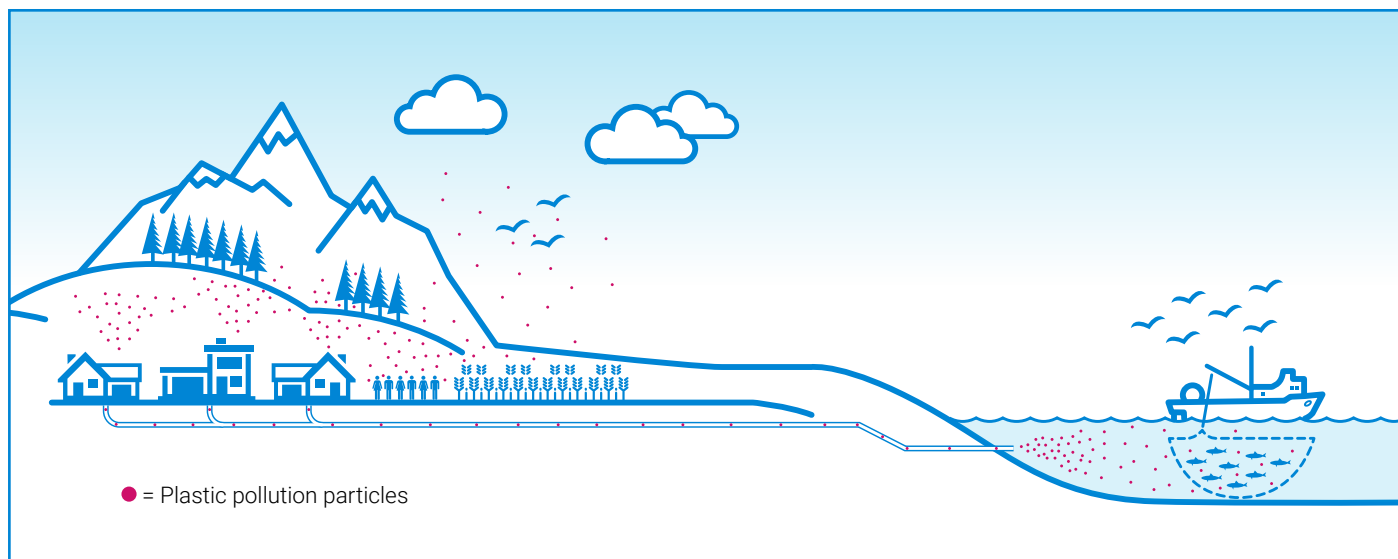


- **Road markings**

Road markings contain melted down plastic, and so when markings weather, they release small plastic pollution particles into the environment.

The scale of the global plastic pollution problem

Plastic production continues to grow at an exponential rate due to human dependency on plastics for everyday life use. Alternatives are simply not as cheap and accessible, and therefore a complete shift away from plastic use is not currently realistic. As a consequence, plastic particle pollution will increase and expand in reach to all areas of our ecosystem.



In the water

The majority of research in this field to date has focused on the presence of plastic pollution particles in water and their subsequent effects on aquatic life. Plastic litter carried by the weather, illegal waste disposal in oceans, and flushing plastic-infused products down the toilet are all examples of how everyday plastic ends up in both large and small bodies of water.¹⁰ These plastics all invariably shed and decay into various plastic particle forms, which can then enter our environment and bodies.

⁹. ChemSafetyPro. Global Ban on Microbeads in Personal Care Products. Available at: https://www.chemsafetypro.com/Topics/Restriction/Latest_Status_of_Global_Ban_on_Microbeads_in_Personal_Care_Products.html. Accessed: November 2019. ¹⁰. World Wide Fund for Nature. How Does Plastic End up in the Ocean? Available at: <https://www.wwf.org.uk/updates/how-does-plastic-end-ocean>. Accessed: November 2019.

The nature and size of these particles means that water-processing facilities are not always able to detect these particles in our water systems. For example, washing one piece of clothing in a washing machine can shed up to 700,000 microfibers into the drainage system. Many of these microfibers will filter into our lakes, rivers, and eventually end up in our oceans, where they can remain for hundreds of years.

To emphasize the scale of plastic particle pollution in the ocean, it has been estimated that 30% of ocean plastic pollution could derive from microplastics.¹¹ In addition to this, UV radiation from the sun against plastic waste in the sea has been found to generate nanosized particles, adding to this critical issue.¹²

By air

Microplastic particles present in the atmosphere are known as 'airborne' microplastics. The nature and size of these particles allows for far and easy travel through the air, which has subsequently led to the detection of airborne microplastics in large cities, but also in remote areas such as the French Pyrenees.¹³ Plastic particles can be detected from snow, which captures particles from the air as they fall. Increasingly, large levels of microplastic pollution have been found in snow samples, with approximately 24,600 microplastic particles per liter found in various European locations.¹⁴

In humans

Given the vast reach of these plastic particles, it is no surprise that such particles have also been found within our bodies. A recent study found that humans could be consuming between 39,000 to 52,000 microplastic particles a year.¹⁵ These pollution particles enter our bodies through a variety of avenues: ingestion of dust or air-carrying plastic particles, consumption of food processed and packaged in plastic, and drinking water contaminated with micro- and nanoparticles.¹⁶

Despite the ubiquity of plastics in our environment, some of the methods still used to test the pervading presence of micro- and nanoplastics in our ecosystem are inconsistent and unreliable. As we look to understand more about the nature of these tiny plastic particles, we must mature our techniques of measurement by moving away from common and error-prone processes such as visual counting under a microscope. Instead, incorporating analytical approaches like the adoption of strong QA/QC procedures and interlaboratory proficiency testing procedures would enable the advancement of research in this field.¹⁷

Call to research and further understanding

Several studies have drawn parallels between microplastics and negative health consequences for marine life and birds, but their potential toxicity to human health is still being researched. There is an urgent need to understand the impact of these plastic particles on human health.

In their latest report on microplastics and plastic pollution, the World Health Organization (WHO) called for further research into microplastics and nanoplastics to understand their true impact. The WHO suggests that "a number of research gaps need to be filled" to assess the true risk of these plastics on our health, as our current data is lacking.²¹

In order to increase our understanding, we must develop standardized scientific methods to detect, identify, and quantify micro- and nanoplastics. As we build our knowledge in this field, we can begin undertaking concrete actions for dealing with plastic particle pollution, like the implementation of standardized regulations on plastic use and disposal around the globe.

Why does this pose a threat?

Ongoing research is pointing to the negative impact of plastic particle pollution:

- As plastic continues to fill our oceans, aquatic animals are further exposed to microplastics. Studies have shown that microplastics block the digestive systems of aquatic creatures, reducing their appetite and stunting their growth and reproduction rates.^{18,19} Potentially hazardous chemicals absorbed by these plastic pieces can be released into the digestive systems of these animals, leading to critical illness and possibly death.¹⁹
- Due to their small size, plastic pollution particles can be consumed by filter-feeding organisms like zooplankton, and can therefore enter the food chain at an early stage. This has been proven, as microplastics have recently been detected in table salt, mussels, fish, beer, bottled water, and tap water.¹²
- While microplastic particles greater than 150 µm can pass through the body relatively easily, we do not yet fully understand the damage that nanoplastics can cause.²⁰ As such, there is a need to understand the implications for our health if such particles have the ability to penetrate cell membranes and organs.
- Plastics are a source of hazardous chemicals, and therefore there is a concern that the unintentional consumption of these micro- and nanoparticles can lead to health defects in the future.

11. Green Peace. What Are Microfibers and Why Are Our Clothes Polluting the Oceans? Available at: <https://www.greenpeace.org/international/story/6956/what-are-microfibers-and-why-are-our-clothes-polluting-the-oceans/>. Accessed: November 2019. 12. Ekvall, M. T. et al. *Nanoscale Adv.* 2019, 1, 1055–1061. 13. Allen, S. et al. *Nat. Geosci.* 2019, 12(5), 339–344. 14. The Guardian. Microplastics "Significantly Contaminating the Air", Scientists Warn. Available at: <https://www.theguardian.com/environment/2019/aug/14/microplastics-found-at-profuse-levels-in-snow-from-arctic-to-alps-contamination>. Accessed: November 2019. 15. Cox, D.C. et al. *Environ. Sci. Technol.* 2019, 53, 12, 7068–7074. 16. National Geographic. You Eat Thousands of Bits of Plastic Every Year. Available at: <https://www.nationalgeographic.co.uk/environment/2019/06/you-eat-thousands-bits-plastic-every-year>. Accessed: November 2019. 17. Hanvey, J. S. et al. *Anal. Methods.* 2017, 9, 1369–1383. 18. Science Daily. Microplastics entering ocean food web through zooplankton, researchers find. Available at: <https://www.sciencedaily.com/releases/2015/06/150629133813.htm>. Accessed: December 2019. 19. National Geographic. We Know Plastic Is Harming Marine Life. What about us? Available at: <https://www.nationalgeographic.com/magazine/2018/06/plastic-planet-health-pollution-waste-microplastics/>. Accessed: November 2019. 20. Get Green Now. The Effects of Microplastics on Human Health. Available at: <https://get-green-now.com/microplastics-health-guide/>. Accessed: November 2019. 21. World Health Organization. Microplastics in Drinking-Water. Available at: <https://apps.who.int/iris/bitstream/handle/10665/326499/9789241516198-eng.pdf?ua=1>. Accessed: November 2019.

A new era of scientific innovation in microplastics

Agilent Technologies is prioritizing the study of micro- and nanoplastics, and is committed to developing tools to equip us with the knowledge required to take appropriate action for combatting plastic particle pollution.

Agilent Technologies provides a range of tools for such analysis and detection, including:



FTIR (product pictured: 4300 Handheld FTIR)

This is a portable in-field device, which is effective in quick particle counting and size measurement of larger microplastics up to around 100 μm .



LDIR Chemical Imaging (product pictured: 8700 LDIR Imaging System)

This is an award-winning, lab-based instrument that provides complete particle characterization including particle size, area, number, and other surface characteristics. It is much faster in particle analysis and also has a larger imaging area than FTIR. In addition to the benefits of the handheld FTIR, this model has a minimum detection range between 10 and 20 μm .



GC/MS Systems (product pictured: 8890 GC System coupled to a 5977B MS)

The GC/MS is a staple of the environmental lab. Agilent's market-leading GC/MS can analyze different types and concentrations of microplastics in samples, with the application of relatively simple sample preparation techniques. GC/MS methods provide complementary analytical information following microplastic detection using IR technology.

For more information about Agilent's technology solutions in this space, please see [here](#).

As particle pollution increases in prevalence, it is critical that we obtain more data to assess the presence and impact of these small particles on the environment and human health. Once armed with this understanding, can we effectively address the problem.

For more information visit Agilent's newsroom or contact: Phoebe Small, Communications Specialist, Public Relations Agilent Technologies Inc. (phoebe.small@agilent.com)

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Published in the USA, November, 2019

