Medical News & Perspectives

Microplastics Are Found Outside in Nature and Inside the Body—but Evidence of Health Risks Is Inconclusive

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From the depths of the Mariana Trench to the heights of Mount Everest, tiny pieces of debris known as microplastics have permeated the globe. And they're congregating in the human body.

Defined by the National Oceanic and Atmospheric Administration as plastic particles smaller than 5 mm, microplastics have been detected recently in human lungs as well as blood samples. Nevertheless, despite the ubiquity of microplastics, scientists have yet to find enough evidence that consuming these particles is harmful to human health.

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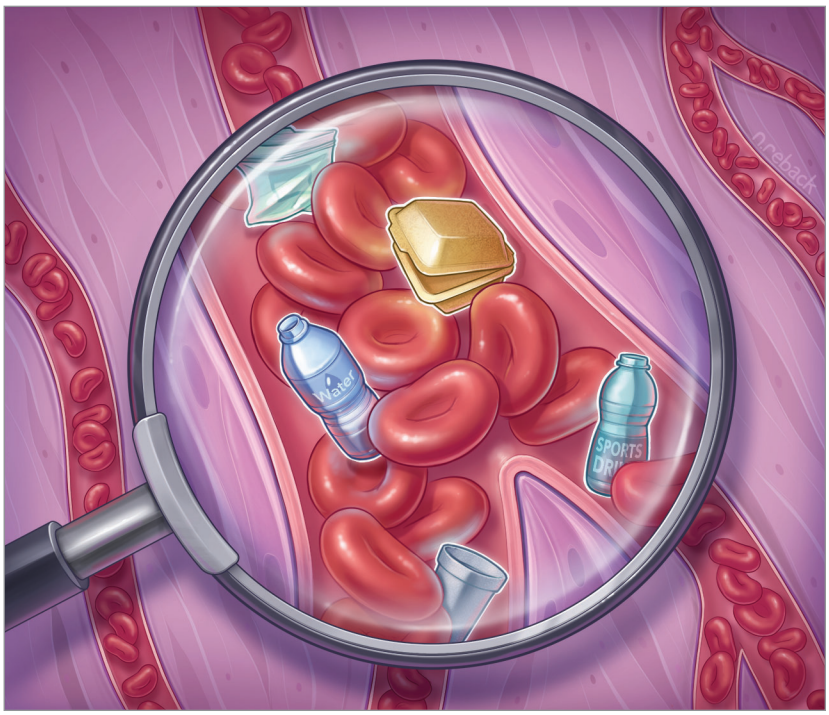

Too Much of a Small Thing

Microplastics are fragments or fibers of polymer-based items ranging from bottles and fabrics to tires and paints. As synthetic clothes fray in the washing machine and car tires wear down on the road, plastic particles release into the air and waterways. *Frontiers in Chemistry* research from 2018 found microplastics in 93% of bottled-water samples derived from 9 countries. Microplastics have also been detected in chicken eggs and fish, while billions are released into drinks through plastic teabags. They're also in beer, salt, and tap water—to name a few other products.

A 2011 study in *Environmental Science & Technology* determined that microplastics are dispersed across 6 continents. Antarctica made the list this year when particles were discovered in fresh snow, though prior research found microplastics in surrounding marine environments—and in the feces of gentoo penguins.

Part of the problem is that most plastics are nonbiodegradable; even if they continuously fragment into tinier pieces—ultimately becoming nanoplastics ranging from 1 nm to 1000 nm—those pieces may take decades or centuries longer than natural fibers, like cotton or linen, to completely decompose. The Pew Charitable Trusts estimated that 1.3 million metric tons of microplastics from tires, textiles, production pellets, and personal care products accounted for plastic pollution in 2016, and that's just in the ocean. Microplastics are also in the Great Lakes and US rain; most plastic rainfall debris consists of microfibers from synthetic clothes, according to a 2020 *Science* study.

Taking Your Breath Away

Research dating as far back as 1998 published in in *Cancer Epidemiology, Biomarkers & Prevention* reported plastic fibers in human lung tissue—but from autopsied patients who died of lung cancer.

A 2021 article in the *Journal of Hazardous Materials* also found microplastics in autopsied lungs. However, a recent pilot study in *Science of The Total Environment* that used micro-Fourier transform infrared spectroscopy confirmed the presence of microplastics deep in the lungs of living humans for what may be the first time.

Twelve varieties of microplastics were detected in 11 of 13 lung tissue samples from patients undergoing surgery for cancer or lung volume reduction. Polyethylene terephthalate (PET) and polypropylene were among the most common finds. PET is often used for textiles and beverage bottles; products like straws and potato chip bags are typically made of polypropylene. The researchers also noticed low levels of microplastics in every region of the lungs. These small amounts, they speculated, indicate that microplastics were likely inhaled in the environment.

"We are only just beginning to identify the extent of human exposure," the pilot study's corresponding author, Laura Sadofsky, PhD, said in an email.

Although Sadofsky—a senior lecturer in respiratory medicine at Hull York Medical School in the UK—and her colleagues expected to find microplastics in their samples, they were surprised at how large the particles were. Numerous pieces weren't filtered in the high lobes of the lungs and instead lodged deeper, where airways are

smaller. In fact, the majority of microplastics were concentrated in the lungs' lower lobes.

Runs in the Blood

We're not only inhaling microplastics; we're also ingesting them. A 2019 article in *Environmental Science & Technology* estimated that humans consume up to 52 000 microplastic particles annually—and that estimate increases up to 121 000 when accounting for those inhaled. Moreover, there's a chance of particles making their way through the intestines and being absorbed into the bloodstream.

In a study published earlier this year in *Environment International*, researchers found polymer particles between 700 nm and 500 000 nm in 17 out of 22 blood samples from healthy donors. Half of all samples tested positive for PET, 36% contained polymerized styrene, and 23% had polyethylene.

"We do not know yet if microplastic exposure can cause serious health effects," one of the study's coauthors, Dick Vethaak, PhD, MS, said in an email. "However, it is becoming more evident every day that plastic particle pollution of food, water, and air could pose a serious hazard to our health."

The average concentration of plastic particles per sample was 1.6 µg/mL of blood. But according to Vethaak, these findings cannot be extrapolated to the general population because of the small sample size and because the amount of microplastics required to cause disease are unknown.

"While plastic pollution and exposure to plastic particles is expected to continue to increase globally, we still do not know the real dose in our bodies or the concentration in the environment," explained Vethaak, who's also a professor emeritus of water quality and health at Vrije Universiteit Amsterdam and was a European Registered Toxicologist for 25 years. "And that is what concerns me the most."

The Tipping Point

Even though scientists have firmly established that microplastics are migrating into human bodies, several knowledge gaps remain. A 2018 article in *Current Opinion in Environmental Science & Health* called for increased attention to plastic microfibers in particular. Last year, Vethaak coauthored a perspective in *Science* about the urgency to conduct more microplastic research. "A major issue when determining the risks of microplastics to human health is the lack of information on human exposure," the authors wrote, remarking that "internal exposure measurements of plastic particles in human body fluids and tissues are still in their infancy."

This year, Vethaak coauthored a similar paper in *Exposure and Health* on a grimmer topic: The potential carcinogenicity of microplastic ingestion. Once again, the paper pleaded for further investigation.

Cries for help haven't fallen on deaf ears, at least in some industries. The outdoor-clothing company Patagonia has acknowledged that microplastic and microfiber pollution is an emerging concern, pointing out that public health implications need to be better understood; it's also initiated relevant research. Plastics Europe, a trade association that represents European plastic manufacturers, invested in a 5-year project to gauge the possible risks of ingesting microplastics. And the International Council of Chemical Associations, which represents chemical manufacturers and producers worldwide, launched an initiative for scientists to share microplastic research—including Plastics Europe's results.

Senior Director of Regulatory and Scientific Affairs at the American Chemistry Council (ACC) John Norman, PhD, noted that unknown health effects of microplastics have prompted further inspection in the US as well.

"Specifically, ACC and its global partners have launched research programs collaborating with academic institutions and governmental agencies to develop standardized sampling protocols and testing materials, examine environmental fate and potential routes of exposure to microplastics, identify potential hazards of microplastics, and develop a risk assessment framework capable of integrating the complex information developed," Norman said in an email. "Results from this research have already been presented at scientific conferences and submitted for publication in peer-reviewed journals. More research will be published in the next several years as results become available."

Hints About Health Risks

Despite that the health consequences of microplastic consumption are yet to be determined, there's a trail of clues. A recent study published in *Environmental Science & Technology* found that the concentration of microplastics was significantly higher in the stool of patients with inflammatory bowel disease than in stool from healthy patients. And according to 2021 research in the *Proceedings of the National Academy of Sciences of the United States of America*, microplastics not only can cling to and deform model membranes of human red blood cells, but they also can impact cellular functions. It wasn't the only study to show that microplastics and nanoplastics can affect cellular function negatively. Shape is another element to consider; a 2022 review in the *Journal of Hazardous Materials* discerned that irregularly shaped microplastics were more likely than spherical ones to be associated with cell viability.

The type of plastic ingested may be a risk indicator, too. There's evidence that certain plastics, such as polyurethanes, polyacrylonitriles, and epoxy resins, are among the most hazardous polymers to human health. Although it's difficult to say whether the average person consumes or inhales enough microplastics to cause illness, in some cases, chronic bronchitis and other respiratory issues have been linked to high levels of microplastic exposure in the workplace.

One of the biggest questions is whether nanoplastics can cross the blood-brain barrier—that is, if they're small enough. The tinier the particle, the more easily it could make its way to various organs. Fine and ultrafine particulate matter, which is even smaller than microplastics, can cross this barrier and is known to cause a host of respiratory and cardiovascular issues. Whereas scientists have confirmed via in vivo rodent models and in vitro data that small microplastics are able to make their way to the brain, uncertainty remains about similar effects occurring in live humans.

Chemical Cocktails From Plastic Bottles

Though the jury's still out on several concerns related to microplastic toxicity, there is some consensus on a related concern. The US Environmental Protection Agency (EPA) announced in June that there are no safe drinking-water levels of perfluoroalkyl and polyfluoroalkyl substances (PFAS), which free-floating microplastics can adsorb.

Used to manufacture nonstick cookware and water-resistant clothes, PFAS are linked to a litany of health problems, including cancer, dyslipidemia, and thyroid dysfunction. Polymeric PFAS can even break

down into microplastics. In 2007, researchers from the Centers for Disease Control and Prevention detected PFAS in more than 98% of 2094 serum samples. Bisphenol A—a PFAS that the US Food and Drug Administration banned in baby products yet is still often used for food packaging and hard-plastic containers—has also been associated with poor semen quality.

The EPA's latest advisories on PFAS recommend improved regulation of these so-called forever chemicals. Furthermore, the National Academies of Sciences, Engineering, and Medicine reported that patients with a history of elevated exposure to PFAS should be tested for the substances, and depending on the results, be monitored and screened regularly.

Pathogens on Plastic

Although the toxicity of plastic itself is cause for concern, it's also unsettling that plastic particles can leak additives and act as vectors for not only chemical pollutants but also human pathogens. According to a series of experiments recently published in *Scientific Reports*, certain zoonotic protozoan parasites were capable of latching onto microplastics—including polyester microfibers—in seawater over a 7-day period. A similar experimental study in *Environmental Pollution* determined that some microbes, including rotavirus SA11, can stick to microplastics in freshwater for at least 2 days. Compared with viruses drifting around on their own, viruses survived longer when attached to synthetic particles, which shielded the pathogens from chlorine, ozone, and UV irradiation.

"[T]he recovery of both virus models used in this study emphasizes the potential for plastic pollution to act as a novel pathway for viral dissemination and persistence in the environment," the authors concluded. But the risk of becoming ill from viruses bound to microplastics is unclear.

"Our results are very preliminary," the study's lead author, Vanessa Moresco, PhD, said in an interview. "This was lab-based work with controlled conditions, and although we can't really predict how viruses will behave in environmental conditions, these preliminary results indicate the potential for these pathogens to bind and survive in plastic contaminants."

Despite the need for additional probing, Moresco—a postdoctoral researcher at the University of California, Riverside School of Medicine—emphasized that other environmental virologists should be aware of her team's findings moving forward. "The next step is to evaluate if viruses also persist in microplastics reaching wastewater treatment plants since domestic sewage is usually contaminated with pathogens that can infect humans."

A Call to Action

A 2013 *Nature* editorial suggested classifying plastic debris as hazardous material instead of solid waste. Coauthored by several leading microplastic researchers, the article highlighted that "Policies for managing plastic debris are outdated and threaten the health of people and wildlife." The plastic debris referenced includes microplastics.

Lately, the US government has lagged on microplastic regulation. Since the 2015 banning of plastic microbeads in cosmetics, federal legislation to regulate microplastic waste has slowed. A bill aimed at removing microplastics from the environment and preventing further waste hasn't budged since its introduction to the House of Representatives back in 2020.

"The Save Our Seas 2.0 Act calls for mitigation efforts for plastic waste in general but does not expand the authorities of any named federal agency," the EPA said in an emailed statement to *JAMA*. It also mentioned a Multi-Sector General Permit for Stormwater Discharges Associated With Industrial Activity requiring that "Facilities that handle pre-production plastic must implement control measures to eliminate discharges of plastic in stormwater."

The statement noted that the "EPA is not currently conducting any human health studies on microplastics. The agency is participating in global efforts to reduce plastic pollution."

Waiting for an Answer

As trepidation about microplastic debris escalates, questions regarding metabolization, interaction with biological tissue, the risk of disease from exposure, and long-term impacts remain unanswered. In the meantime, the amount of plastic on Earth continues to grow.

Humans have produced an estimated 8.3 billion metric tons of plastic materials since the 1950s—with approximately 6.3 billion metric tons having become waste—according to a 2017 study in *Science Advances*. If production and waste management trends continue on their current trajectories, roughly 12 billion metric tons of discarded plastic are projected to end up in landfills or the environment by 2050.

"I am afraid that our health problems will be evident a few decades from now…epidemiological studies may take many years to find associations between plastic particle burden and certain chronic diseases," Vethaak warned. "It is only the tip of the iceberg that is visible now." ■

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Note: Source references are available through embedded hyperlinks in the article text online.