



Invisible Invaders

Tiny plastic particles have infiltrated the human body. The potential health risks are not yet clear **By Anne Pinto-Rodrigues**

Tiny particles of plastic have been found everywhere—from the deepest place on the planet, the Mariana Trench, to the top of Mount Everest. And now more and more studies are finding that microplastics, defined as plastic pieces less than 5 millimeters across, are also in our bodies.

“What we are looking at is the biggest oil spill ever,” says Maria Westerbos, founder of the Plastic Soup Foundation, an Amsterdam-based nonprofit advocacy organization that works to reduce plastic pollution around the world. Nearly all plastics are made from fossil fuel sources. And microplastics are “everywhere,” she adds, “even in our bodies.”

In recent years, microplastics have been documented in all parts of the human lung, in maternal and fetal placental tissues, in human breast milk and in human blood. Microplastics scientist Heather Leslie, formerly of Vrije Universiteit Amsterdam, and colleagues found microplastics in blood samples from 17 of 22 healthy adult volunteers in the Netherlands. The finding, published last year in *Environment International*, confirms what many scientists have long suspected: These tiny bits can get absorbed into the human bloodstream.

“We went from expecting plastic particles to be



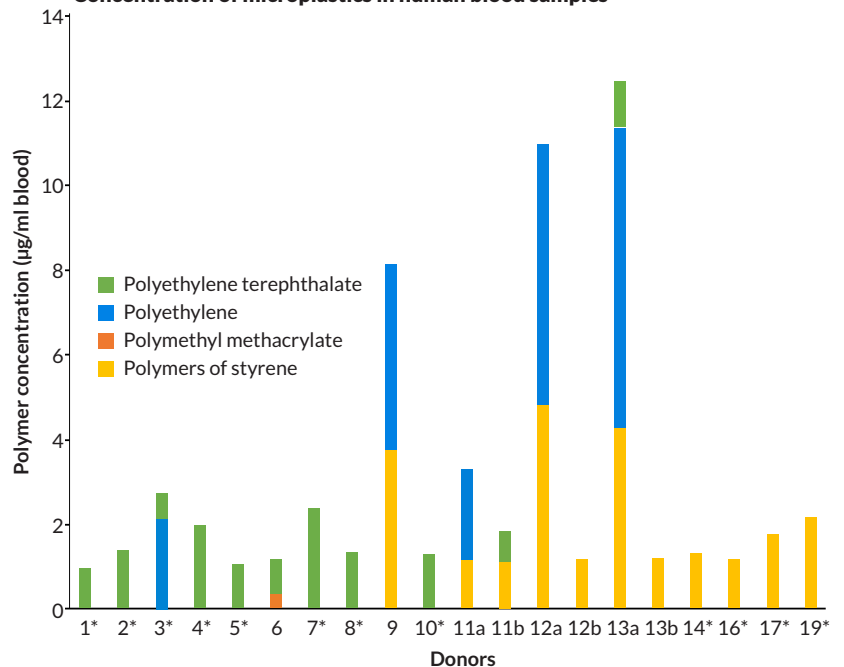
absorbable and present in the human bloodstream to knowing that they are,” Leslie says.

The findings aren’t entirely surprising; plastics are all around us. Durable, versatile and cheap to manufacture, they are in our clothes, cosmetics, electronics, tires, packaging and so many more items of daily use. And the types of plastic materials on the market continues to increase. “There were around 3,000 [plastic materials] when I started researching microplastics over a decade ago,” Leslie says. “Now there are over 9,600. That’s a huge number, each with its own chemical makeup and potential toxicity.”

Though durable, plastics do degrade, by weathering from water, wind, sunlight or heat—as in ocean environments or in landfills—or by friction, in the case of car tires, which release plastic particles along roadways during motion and braking.

In addition to studying microplastic particles, researchers are also trying to get a handle on nanoplastics, particles which are less than 1 micrometer in length. “The large plastic objects in the environment will break down into micro- and nanoplastics, constantly raising particle numbers,” says toxicologist Dick Vethaak of the Institute for Risk Assessment Sciences at Utrecht University in

Concentration of microplastics in human blood samples

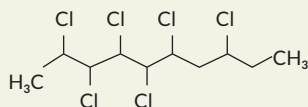


In the blood Microplastic particles were detected in blood samples from 17 of 22 healthy adult volunteers in the Netherlands. The types of polymer present varied across the group—as did the concentrations. Donors 11, 12 and 13 contributed two samples, both with microplastics. For many others (starred), one sample had microplastics and a second did not. SOURCE: H. LESLIE ET AL/ENVIRONMENT INTERNATIONAL 2022

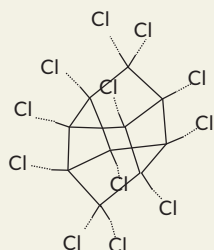
Concerning chemicals

Bits of plastic floating in the world's air and water contain chemicals that may pose risks to human health. A 2021 study identified more than 2,400 chemicals of potential concern found in plastics or used in their processing. Here are a few of the most worrisome.

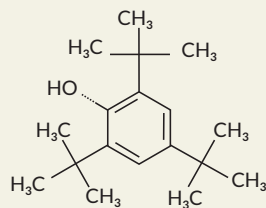
SOURCE: H. WIESINGER, Z. WANG AND S. HELLWEG/ENVIRONMENTAL SCIENCE & TECHNOLOGY 2021



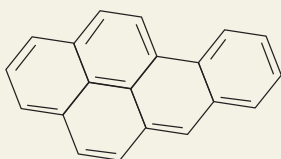
Short-chain chlorinated paraffins are used as lubricants, flame retardants and plasticizers. They can cause cancer in lab rodents, but the mechanisms may not be relevant for human health.



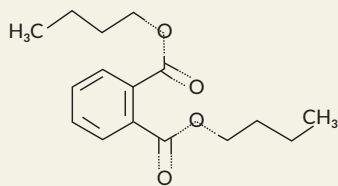
The chlorinated compound mirex was once used as a flame retardant and can persist in the environment. It's suspected of being a human carcinogen and may affect fertility.



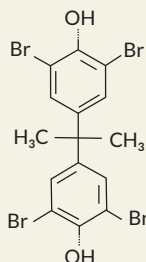
2,4,6-Tri-tert-butylphenol is an antioxidant and ultraviolet stabilizer, added to plastics to prevent degradation. There's evidence that it causes liver damage in lab animals with prolonged or repeated exposure.



Benzo(a)pyrene is a polycyclic aromatic hydrocarbon that can be released when organic matter such as coal or wood burns. It is also produced in grilled meats. It has been shown to cause cancer, damage fertility and affect development in lab animals.



Dibutyl phthalate is a plasticizer that is known to cause endocrine disruption, may interfere with male fertility and has been shown to affect fetal development in lab animals.



Tetrabromobisphenol-A is a flame retardant that can cause cancer in lab animals and may be an endocrine disruptor. It is chemically related to bisphenol A, which has been linked to developmental effects in children.

the Netherlands, who collaborated with Leslie on the study finding microplastics in human blood.

Nearly two decades ago, marine biologists began drawing attention to the accumulation of microplastics in the ocean and their potential to interfere with organism and ecosystem health (SN: 2/20/16, p. 20). But only in recent years have scientists started focusing on microplastics in people's food and drinking water—as well as in indoor air.

Plastic particles are also intentionally added to cosmetics like lipstick, lip gloss and eye makeup to improve their feel and finish, and to personal care products, such as face scrubs, toothpastes and shower gels, for the cleansing and exfoliating properties. When washed off, these microplastics enter the sewage system. They can end up in the sewage sludge from wastewater treatment plants, which is used to fertilize agricultural lands, or even in treated water released into waterways.

What if any damage microplastics may do when they get into our bodies is not clear, but a growing community of researchers investigating these questions thinks there is reason for concern. Inhaled particles might irritate and damage the lungs, akin to the damage caused by other particulate matter. And although the composition of plastic particles varies, some contain chemicals that are known to interfere with the body's hormones.

Currently there are huge knowledge gaps in our understanding of how these particles are processed by the human body.

How do microplastics get in?

Research points to two main entry routes into the human body: We swallow them and we breathe them in.

Evidence is growing that our food and water is contaminated with microplastics. A study in Italy, reported in 2020, found microplastics in everyday fruits and vegetables. Wheat and lettuce plants have been observed taking up microplastic particles in the lab; uptake from soil containing the particles is probably how they get into our produce in the first place.

Sewage sludge can contain microplastics not only from personal care products, but also from washing machines. One study looking at sludge from a wastewater treatment plant in southwest England found that if all the treated sludge produced there were used to fertilize soils, a volume of microplastic particles equivalent to what is found in more than 20,000 plastic credit cards could potentially be released into the environment each month.

On top of that, fertilizers are coated with plastic for controlled release, plastic mulch film is used

as a protective layer for crops and water containing microplastics is used for irrigation, says Sophie Vonk, a researcher at the Plastic Soup Foundation.

“Agricultural fields in Europe and North America are estimated to receive far higher quantities of microplastics than global oceans,” Vonk says.

A recent pilot study commissioned by the Plastic Soup Foundation found microplastics in all blood samples collected from pigs and cows on Dutch farms, showing livestock are capable of absorbing some of the plastic particles from their feed, water or air. Of the beef and pork samples collected from farms and supermarkets as part of the same study, 75 percent showed the presence of microplastics. Multiple studies document that microplastic particles are also in fish muscle, not just the gut, and so are likely to be consumed when people eat seafood.

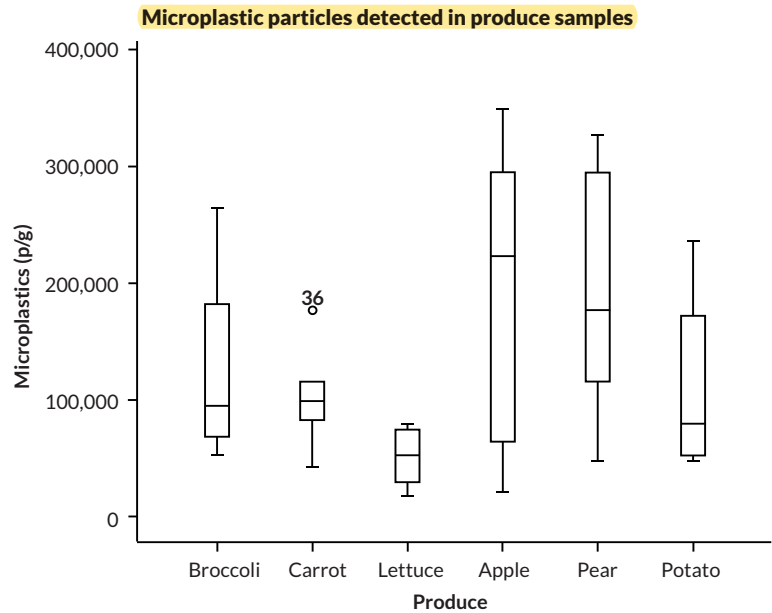
Microplastics are in our drinking water, whether it's from the tap or bottled. The particles may enter the water at the source, during treatment and distribution, or, in the case of bottled water, from its packaging.

Results from studies attempting to quantify levels of human ingestion vary dramatically, but they suggest people might be consuming on the order of tens of thousands of microplastic particles per person per year. These estimates may change as more data come in, and they will likely vary depending on people's diets and where they live. Plus, it is not yet clear how these particles are absorbed, distributed, metabolized and excreted by the human body, and if not excreted immediately, how long they might stick around.

Babies might face particularly high exposures. A small study of six infants and 10 adults found that the infants had more microplastic particles in their feces than the adults did. Research suggests microplastics can enter the fetus via the placenta, and babies could also ingest the particles via breast milk. The use of plastic feeding bottles and teething toys adds to children's microplastics exposure.

Microplastic particles are also floating in the air. Research conducted in Paris to document microplastic levels in indoor air found concentrations ranging from three to 15 particles per cubic meter of air. Outdoor concentrations were much lower.

Airborne particles may turn out to be more of a concern than those in food. One study reported in 2018 compared the amount of microplastics present within mussels harvested off Scotland's coasts with the amount of microplastics present in indoor air. Exposure to microplastic fibers from the air during the meal was far higher than the risk of ingesting microplastics from the mussels themselves.



Probing produce Fruits and vegetables purchased at local markets in Catania, Italy, showed wide variability in the numbers of microplastic particles present. The research highlights the need for more studies on the sources of microplastic exposure. SOURCE: G.O. CONTI ET AL/ENVIRONMENTAL RESEARCH 2020

Extrapolating from this research, immunologist Nienke Vrisekoop of the University Medical Center Utrecht says, “If I keep a piece of fish on the table for an hour, it has probably gathered more microplastics from the ambient air than it has from the ocean.”

What's more, a study of human lung tissue reported last year offers solid evidence that we are breathing in plastic particles. Microplastics showed up in 11 of 13 samples, including those from the upper, middle and lower lobes, researchers in England reported.

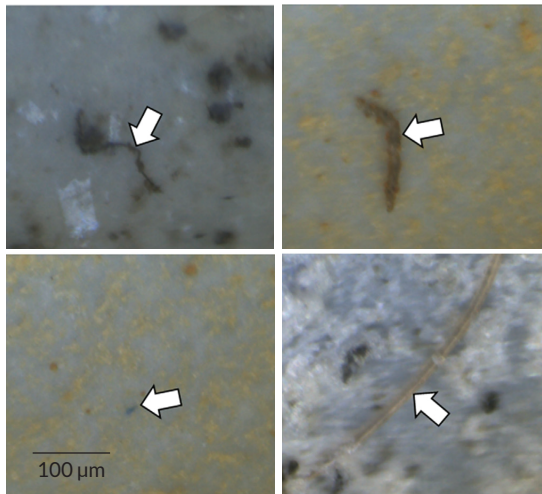
Perhaps good news: Microplastics seem unable to penetrate the skin. “The epidermis holds off quite a lot of stuff from the outside world, including [nano]particles,” Leslie says. “Particles can go deep into your skin, but so far we haven't observed them passing the barrier, unless the skin is damaged.”

What are the potential concerns?

Studies in mice suggest microplastics are not benign. Research in these test animals shows that lab exposure to microplastics can disrupt the gut microbiome, lead to inflammation, lower sperm quality and testosterone levels, and negatively affect learning and memory.

But some of these studies used concentrations that may not be relevant to real-world scenarios. Studies on the health effects of exposure in humans are just getting under way, so it could be years before scientists understand the actual impact in people.

A study reported last year identified microplastic particles in 11 of 13 samples of human lung tissue (examples shown). The plastics were found throughout the lungs, and their presence suggests that inhalation is one route for the particles to enter the body.



Immunologist Barbro Melgert of the University of Groningen in the Netherlands has studied the effects of nylon microfibers on human tissue grown to resemble lungs. Exposure to nylon fibers reduced both the number and size of airways that formed in these tissues by 67 percent and 50 percent, respectively. “We found that the cause was not the microfibers themselves but rather the chemicals released from them,” Melgert says.

“Microplastics could be considered a form of air pollution,” she says. “We know air pollution particles tend to induce stress in our lungs, and it will probably be the same for microplastics.”

Vrisekoop is studying how the human immune system responds to microplastics. Her unpublished lab experiments suggest immune cells don’t recognize microplastic particles unless they have blood proteins, viruses, bacteria or other contaminants attached. But it is likely that such bits will attach to microplastic particles out in the environment and inside the body. “If the microplastics are not clean...the immune cells [engulf] the particle and die faster because of it,” Vrisekoop says. “More immune cells then rush in.” This marks the start of an immune response to the particle, which could potentially trigger a strong inflammatory reaction or possibly aggravate existing inflammatory diseases of the lungs or gastrointestinal tract.

Some of the chemicals added to make plastic suitable for particular uses are also known to cause problems for humans: Bisphenol A, or BPA, is used to harden plastic and is a known endocrine disruptor that has been linked to developmental effects in children and problems with reproductive systems and

metabolism in adults (SN: 7/18/09, p. 5). Phthalates, used to make plastic soft and flexible, are associated with adverse effects on fetal development and reproductive problems in adults along with insulin resistance and obesity. And flame retardants that make electronics less flammable are associated with endocrine, reproductive and behavioral effects.

“Some of these chemical products that I worked on in the past [like the polybrominated diphenyl ethers used as flame retardants] have been phased out or are prohibited to use in new products now [in the European Union and the United States] because of their neurotoxic or disrupting effects,” Leslie says.

The remaining questions

The first step in determining the risk of microplastics to human health is to better understand and quantify human exposure. Polyrisk — one of five large-scale research projects under CUSP, a multidisciplinary group of researchers and experts from 75 organizations across 21 European countries studying micro- and nanoplastics — is doing exactly that.

Immunotoxicologist Raymond Pieters, of the Institute for Risk Assessment Sciences at Utrecht University and coordinator of Polyrisk, and colleagues are studying people’s inhalation exposure in a number of real-life scenarios: near a traffic light, for example, where cars are likely to be braking, versus a highway, where vehicles are continuously moving. Other scenarios under study include an indoor sports stadium, as well as occupational scenarios like the textile and rubber industry.

Melgert wants to know how much microplastic is in our houses, what the particle sizes are and how much we breathe in. “There are very few studies looking at indoor levels [of microplastics],” she says. “We all have stuff in our houses — carpets, insulation made of plastic materials, curtains, clothes — that all give off fibers.”

Vethaak, who co-coordinates MOMENTUM, a consortium of 27 research and industry partners from the Netherlands and seven other countries studying microplastics’ potential effects on human health, is quick to point out that “any measurement of the degree of exposure to plastic particles is likely an underestimation.” In addition to research on the impact of microplastics, the group is also looking at nanoplastics. Studying and analyzing these smallest of plastics in the environment and in our bodies is extremely challenging. “The analytical tools and

“Before you purchase something, think if you really need it, and if it needs to be plastic.”

HEATHER LESLIE

techniques required for this are still being developed,” Vethaak says.

Vethaak also wants to understand whether microplastic particles coated with bacteria and viruses found in the environment could spread these pathogens and increase infection rates in people. Studies have suggested that microplastics in the ocean can serve as safe havens for germs.

Alongside knowing people’s level of exposure to microplastics, the second big question scientists want to understand is what if any level of real-world exposure is harmful. “This work is confounded by the multitude of different plastic particle types, given their variations in size, shape and chemical composition, which can affect uptake and toxicity,” Leslie says. “In the case of microplastics, it will take several more years to determine what the threshold dose for toxicity is.”

Several countries have banned the use of microbeads in specific categories of products, including rinse-off cosmetics and toothpastes. But there are no regulations or policies anywhere in the world that address the release or concentrations of other microplastics – and there are very few consistent monitoring efforts. California has recently taken a step toward monitoring by approving the world’s first requirements for testing microplastics in drinking water sources. The testing will happen over the next several years.

Pieters is very pragmatic in his outlook: “We know ‘a’ and ‘b;’” he says. “So we can expect ‘c;’ and ‘c’ would [imply] a risk for human health.”

He is inclined to find ways to protect people now even if there is limited or uncertain scientific knowledge. “Why not take a stand for the precautionary principle?” he asks.

For people who want to follow Pieters’ lead, there are ways to reduce exposure.

“Ventilate, ventilate, ventilate,”

Melgert says. She recommends not only proper ventilation, including opening your windows at home, but also regular vacuum cleaning and air purification. That can remove dust, which often contains microplastics, from surfaces and the air.

Consumers can also choose to avoid cosmetics and personal care products containing microbeads. Buying clothes made from natural fabrics like cotton, linen and hemp, instead of from synthetic materials like acrylic and polyester, helps reduce the shedding of microplastics during wear and during the washing process.

Specialized microplastics-removal devices, including laundry balls, laundry bags and filters that attach to washing machines, are designed to reduce the number of microfibers making it into waterways.

Vethaak recommends not heating plastic containers in the microwave, even if they claim to be food grade, and not leaving plastic water bottles in the sun.

Perhaps the biggest thing people can do is rely on plastics less. Reducing overall consumption will reduce plastic pollution, and so reduce microplastics sloughing into the air and water.

Leslie recommends functional substitution: “Before you purchase something, think if you really need it, and if it needs to be plastic.”

Westerbos remains hopeful that researchers and scientists from around the world can come together to find a solution. “We need all the brainpower we have to connect and work together to find a substitute to plastic that is not toxic and doesn’t last [in the environment] as long as plastic does,” she says. ■

Explore more

■ The CUSP research effort:
<https://cusp-research.eu>

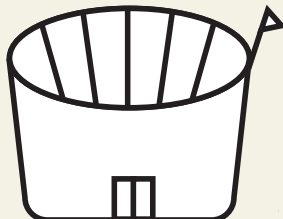
Anne Pinto-Rodrigues is a Netherlands-based independent journalist reporting on social and environmental issues.

Where in the air?

Concentrations of microplastics and nanoplastics in the air likely vary with location. Researchers are interested in studying various settings to better understand human exposure and risk.



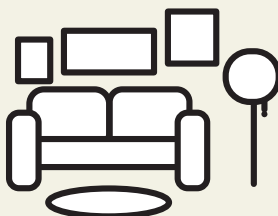
Traffic lights



Indoor sports stadium



Textile factory



Living room