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FACT SHEET

MICROPLASTIC DELUGE:
HOW THESE SMALL PLASTIC PARTICLES HARM OUR HEALTH AND THE ENVIRONMENT

Microplastics are everywhere in our environment. These tiny and sometimes microscopic particles of plastic are present in our air, water, soil, and food; in lakes, rivers, and oceans; even at the top of Mount Everest. Microplastics are also in our bodies, with scientists finding them everywhere from the human heart and brain to testes and placentas. There is a growing concern that microplastics could be harming ecological and human health, in particular digestive, reproductive, and respiratory systems.

Microplastics are not only intentionally added to some consumer products but are also created during the normal use and disposal of many products, as well as when plastic breaks down in the environment. Their ubiquity is due to the growing use of plastic in the United States and around the world. Global annual production of plastic has increased exponentially over the past 75 years, climbing from 2 million metric tons in 1950 to 460 million metric tons in 2019—that's equivalent to the weight of about 267 million cars.[1] Global use of plastic is expected to almost triple between 2019 and 2060.[2]

Our growing use of plastics means microplastics and the thousands of chemicals associated with them will continue to be released into the environment. As the harms associated with microplastics continue to come into focus, it is time we take action to limit our ongoing exposure and prevent future impacts.

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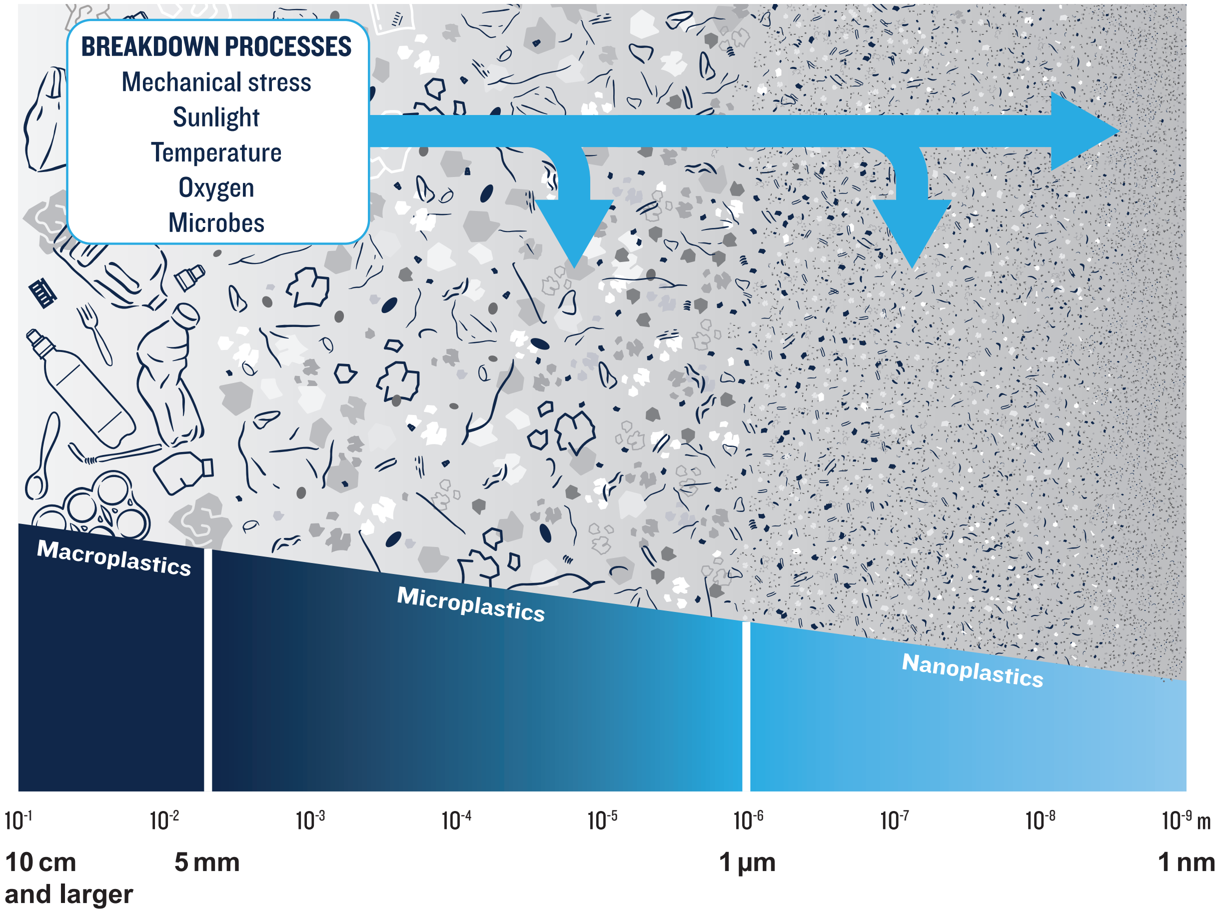
Figure 1: Plastics break down into ever smaller micro- and nanoplastics

The size ranges shown here correspond to the most widely used definitions of microplastics and nanoplastics.



Note: the size scale is logarithmic.

WHAT ARE MICROPLASTICS?

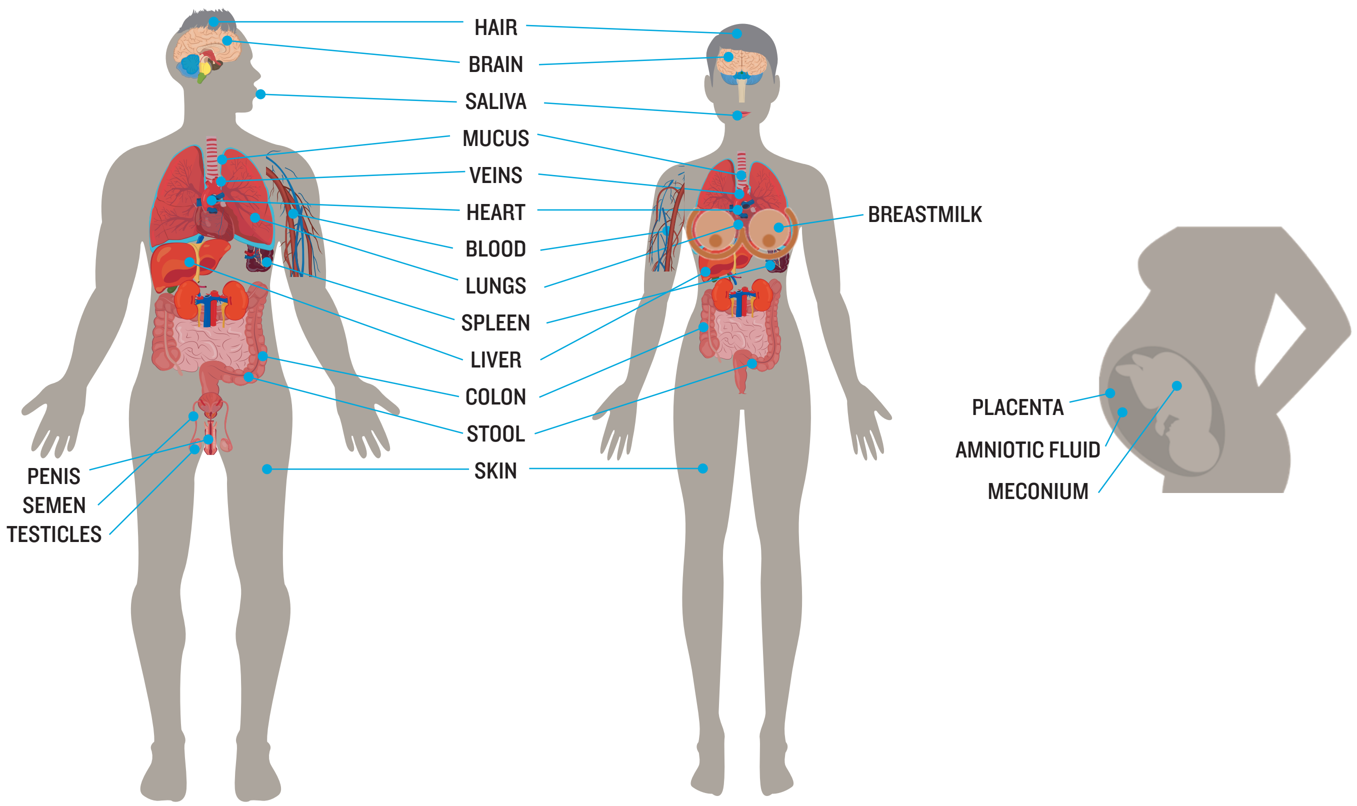
Scientists define microplastics as tiny pieces of plastic that are less than five millimeters (mm) long (Figure 1).[3] But that simple definition obscures how diverse microplastics can be. Some may be visible to the naked eye, while others are so small that they are microscopic. Plastic particles even tinier than microplastics (< 1 micron, µm) are called nanoplastics. For simplicity, throughout this fact sheet, we refer mostly to microplastics, though much of the information holds true for both micro- and nanoplastics.

Microplastics come in numerous colors and shapes and may appear as tiny fibers, flakes, or smooth pellets or have very irregular and jagged edges. The chemical composition of microplastics also varies tremendously, almost infinitely, in terms of both their basic polymer makeup and additional chemicals that may be present. All plastics are polymers, which means that they consist of repeating chemical units called monomers, like repeating beads on a necklace. When plastic products are made, the pure polymers are typically mixed with one or more chemical additives. These additives can change the properties of the polymer, such as its flexibility or color, and in turn are also present in microplastics. The diversity of these chemicals is immense: Some 16,000-plus chemicals are used to make different kinds of plastic.[4]

MICROPLASTICS ARE EVERYWHERE

It has been more than 20 years since the term *microplastic* was first used to describe tiny plastic particles observed in the ocean.[5] Today scientists find microplastics nearly everywhere they look: in fresh and saltwater, soil, sand, air, even our food.[6] Scientists first looked for microplastics in tap water in 2017 and found them in 81 percent of the samples collected from 14 countries.[7] More recent research found that a liter of bottled water contained about 240,000 tiny pieces of plastic representing all of the seven major kinds of plastic polymers, including polyamide (PA, also known as nylon), polyethylene terephthalate (PET), and polyvinyl chloride (PVC), indicating that bottled water and other beverages could be a major source of human exposure.[8] Microplastics have also been found in beer, salt, seafood, meat, plant-based protein sources like tofu, and processed foods.[9] Alarmingly,

Figure 2: Microplastics in the Human Body



plastic infant and toddler food containers and pouches release large amounts of micro- and nanoplastics, the amounts of which can increase with microwaving.[10]

Microplastics are also in and on our bodies (Figure 2). They have been found in the human brain, heart, blood, lungs, veins, colon, liver, placenta, penis, testicles, and amniotic fluid.[11] They are found on human skin and hair.[12] They have also been detected in breast milk, stool—including meconium, a baby's first fecal matter—mucus, saliva, and semen samples.[13]

Microplastics can enter our bodies by several different routes including inhalation (breathing contaminated air and dust) and ingestion (eating food and drinking beverages, or using toothpaste containing these tiny plastic particles).[14] Children and adults may get microplastics on their hands through crawling on the ground, touching synthetic materials that shed microplastics, or using personal care products containing microplastics, and end up ingesting them through hand to mouth contact.[15] Nanoplastics in particular may also enter the body directly through broken skin, sweat glands, and hair follicles.[16] Other routes of exposure—including through vaginal tissue from period products or through contact with the eyes—are also of concern, but are understudied.[17] While it is helpful to know that microplastics can sometimes leave our bodies, the rate at which they do so is not currently known.

TYPES AND SOURCES OF MICROPLASTICS

Despite the nearly unlimited variety of microplastics, they can be broadly classified into primary microplastics (intentionally created or added) and secondary microplastics (shed from products or created during plastic breakdown).

Primary microplastics are plastic particles that are deliberately manufactured to be very small in order to achieve their desired function. There are three major categories of primary microplastics:

- **Pre-production materials,** such as pellets, flakes, and powders. These small, uniform plastic particles, sometimes called nurdles, are melted down and formed into other plastic products.[18] Because of their use in manufacturing, pre-production microplastics have some unique attributes compared with other microplastics. They are often considered a "pure" plastic, meaning they typically contain only one specific plastic polymer, without other chemicals (which are added when the microplastics are transformed into a final product). These primary microplastics are often more uniform in terms of size and shape than are secondary microplastics, and they also tend to be on the larger end of the spectrum (~1 to 5 mm). Pre-production microplastics enter the environment through direct point source releases at manufacturing sites or through spills during transportation and other mismanaged handling activities.

- **Microplastics intentionally added to other products** to provide a specific function. Common products containing added microplastics include cosmetics and personal care products, detergents and polishes, fertilizers and pesticides, paints and other coatings, and artificial turf.[19] The functions of the microplastics can range from providing abrasive properties to encapsulating fragrance to creating slow-release fertilizers, among other functions. The European Union recently banned most uses of intentionally added microplastics.[20] In contrast, only a small subset of personal care product uses of intentionally added microplastics have been banned in the United States—you will still find many products including cosmetics and personal care items that contain microplastics on the shelves.[21]
- **Microplastics used directly as products themselves.** Some microplastics, like glitter and confetti, are primary microplastics that are used as is. They also may be (but are not necessarily) added to or used in the manufacture of other products.

Secondary microplastics are the breakdown products of larger plastic items and plastic litter. There are also three major categories of secondary microplastics:

- **Microplastics shed by products during use.** Many products, including drinking water bottles, clothing, carpets, plastic cutting boards, nonstick pans, and food packaging, can shed microplastics during normal use. Synthetic textiles, tires, and paints are thought to be among the largest sources of secondary microplastics released to the environment.
  - Popular clothing items including leggings and fleece jackets shed large amounts of microfibers during normal use, including during laundering. The highest levels are released during the first few washes of new clothes.[22] "Fast fashion," which generally consists of low-quality synthetic clothing designed to last for only a short time, is a major source of microplastic release.[23]
  - Tires, which contain synthetic rubber, wear down with use and create microplastics over time. Due to their size and chemical composition, these microplastics pose unique challenges for monitoring, and therefore their presence in the environment may be currently underestimated. Most if not all tires contain a chemical that is lethal to certain salmon species, and microplastic shedding from tires containing this chemical has been linked to salmon die-offs.[24]
  - Large volumes of paint that contain and/or break down into microplastics are used in many sectors, including in buildings and in automotive, general industrial, and marine applications. Some research now suggests that paint is a major source of microplastics found in oceans and waterways.[25] Marine paint used on boats and other marine structures is particularly concerning, given that it often contains not only plastic but also heavy metals like copper, zinc, and lead.[26]
- **Microplastics generated in waste management.** When plastic waste is recycled, it is typically crushed, shredded, or pulverized; these processes can create microplastics.
- **Microplastics generated by breakdown of larger plastic waste found in the environment.** All plastic is subject to breakdown by normal environmental processes including those involving mechanical forces, sunlight, temperature, oxygen, and microbes (see Figure 1). These processes work together over time to break down large macroplastics found in the environment into smaller micro- and nanoplastics. The rate at which this breakdown occurs is not known, but given that plastics are manufactured to be durable during their use, this breakdown is relatively slow.

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Textiles like carpets and clothing can shed fiber shaped microplastics

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Rubber tires can shed microplastics as they wear down.

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Shredding plastic generates macro- and microplastics.

MICROPLASTICS ARE TOXIC

The body of evidence that microplastics are toxic to human health is growing and highly concerning. In one study, scientists found that the presence of microplastics in arterial plaque is associated with an increased risk of heart attack, stroke, and death.[27] A review of 34 studies evaluating workers exposed to various types of microplastics in dust found that those exposed to polyvinyl chloride microplastics had increased risk of liver cancer.[28] Scientists have also found that patients with inflammatory bowel disease had more microplastics in stool samples than healthy subjects; patients with liver cirrhosis had more microplastics in their liver than patients without underlying liver disease; patients with chronic rhinosinusitis had more microplastics in their nasal cavities; and women with intrauterine growth–restricted pregnancies (where a baby doesn't grow to normal weight during pregnancy) had more microplastics in their placenta compared with women with healthy pregnancies.[29]

Studies finding that microplastics harm human health are further supported by a rapidly growing body of toxicological evidence in animals, particularly demonstrating that microplastic exposure harms reproductive, digestive, and respiratory health.[30] For example, several studies indicate that inhaled microplastics cause damage to lung tissue, alter lung function, and induce chronic inflammation and oxidative stress. Other studies indicate that as microplastic exposure increases, sperm quality and quantity decrease. Additionally, research has demonstrated changes in the structure and function of the digestive system. [31] There is also a growing body of evidence across species linking microplastic exposure to cardiovascular effects.[32]

It is not just the particles themselves that are toxic. As mentioned above, there are more than 16,000 chemicals used to make plastics or present in plastics, including groups of chemicals that have been identified as hazardous to human health and the environment.[33] Many of the most frequently used plastic polymers and plastic additives are inherently toxic.[34] For example, bisphenols are the chemical building blocks (i.e. monomers) used to create polycarbonate plastics. Bisphenols are well-known endocrine disruptors, meaning that they interfere with the body's endocrine system, which relies on carefully calibrated levels of hormones.[35] Exposure to bisphenols, which mimic the body's hormones, is associated with obesity, reproductive and developmental harm, and metabolic disease like type 2 diabetes in humans.[36] There are thousands of other chemicals of concern besides bisphenols. The degradation of microplastics to their toxic chemical constituents, including phthalates, polyaromatic hydrocarbons (PAHs), flame-retardant chemicals, per- and polyfluoroalkyl substances (PFAS, often referred to as "forever chemicals"), and other plastic polymers and additives provides a constant source of hazard to our environment and our bodies.

Microplastics can also act as carriers for other harmful chemical and biological contaminants. For example, chemicals like perfluorooctane sulfonic acid (PFOS), a toxic PFAS "forever chemical," and oxybenzone, an endocrine-disrupting chemical found in sunscreens and plastics that is thought to contribute to coral bleaching, can bind to microplastics and cause developmental harms in fish.[37] Viruses and microorganisms can also adhere to microplastics,

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Microplastics may be of particular concern for pregnant women.

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Polycarbonate water jugs are made from endocrine disrupting chemicals.

A crab walks across a microplastic covered beach.

which can prolong their survival, ultimately facilitating their transmission and increasing their ability to infect organisms.[38] It is especially concerning that microplastics have been found to harbor antibiotic-resistant microbes, which could further the transmission of antibiotic resistance across the food chain.[39] Importantly, the weathering of microplastics by sunlight or by other means changes their surface chemistry and can increase the tendency of some contaminants and viruses to adhere to them.[40]

Microplastics Cause Ecological Harm

The United Nations Environment Programme has estimated that there are between 15 trillion and 51 trillion microplastic particles in our oceans—as much as 500 times the number of stars in our galaxy.[41] Although an estimate of ocean nanoplastics is not yet available, experts predict their number to be several orders of magnitude higher.[42] Alarmingly, some research suggests that micro- and nanoplastic contamination on land could be even greater than in the ocean.[43] With such widespread environmental contamination, it is not surprising that studies have detected harm from microplastic exposures across many diverse species, ranging from plants and algae to invertebrates, fish, and larger wildlife higher up on the food chain.[44] A recent study found microplastics in the lungs of all 51 wild bird species tested and concluded that many of the levels present posed an ecological risk.[45]

Mounting research shows that microplastics aren't just present in the environment; they are causing widespread ecological harm. Microplastics can physically harm animals, negatively impact the ways their bodies function, and change their behavior.[46] Small animals ingest microplastics by mistaking them for food or prey. Once in the body, these particles may cause damage to the gastrointestinal tract or create blockages, either of which can reduce an animal's ability to survive.[47] Because microplastics can make an animal feel full without providing any nutrition, they can lower an animal's urge to eat.[48] This in turn can make them weak, reduce their ability to fight off infections, decrease growth, and impair their ability to reproduce. If these effects are felt by many individuals within a population, the impacts can have ripple effects throughout the community and wider ecosystem.

Scientists have also found that microplastics harm plants and soil. They can alter the soil structure, how water and nutrients move through the soil, and the array of bacteria, insects, and other organisms that live in soil.[49] These changes to the soil, which differ with microplastics of various sizes, shapes, and compositions, impact plant performance and growth.[50] Studies have reported harm to plants including damage to roots, reduced growth, and changes in their ability to transform the energy from sunlight into food (i.e. perform photosynthesis).[51] One recent analysis suggested that the reductions in photosynthesis caused by microplastics could result in a decline in crop production that could threaten the security of the global food supply.[52]

As mentioned earlier, there is also a concern that harmful environmental substances including toxic chemicals and microbes that harbor antibiotic resistance genes can accumulate on microplastics in the soil, which could contribute to their spread and associated harmful effects throughout the ecosystem.[53]

MICROPLASTICS ARE PERSISTENT, MOBILE, AND BIOACCUMULATIVE

The continued and growing use of plastic polymers for numerous industrial and consumer products ensures that there will be a continual input of microplastics into the environment for the foreseeable future. This is particularly alarming given that microplastics are persistent, mobile, and bioaccumulative.[54] They share these hazardous properties with other problematic chemical classes such as PFAS and flame-retardant chemicals.

Microplastics Are Persistent

Microplastics are persistent in the environment, meaning that they can exist for decades or longer as they very slowly release their chemical monomers (chemical building blocks) and additives to the environment and break down into ever smaller micro- and nanoparticles. In fact, the European Chemicals Agency refers to microplastics as having "'extreme,' arguably permanent, persistence."[55]

Plastic polymers are very slow to break down in the environment. Breakdown rates depend on the chemical composition of the polymer and numerous environmental conditions such as the amount of mechanical stress, sunlight, temperature, oxygen, and the presence of microbes that might biodegrade the polymers. Some plastic polymers are marketed as "biodegradable," but because the term doesn't have a clear definition, many products labeled as biodegradable often are not.[56] In reality, they may persist in the environment long enough to constitute litter, blight, and a danger to land-based and marine animals that may ingest or become entangled in these products.

Microplastics Are Mobile

Microplastics are also highly mobile, meaning that they can readily move throughout the environment once they are released, traveling long distances from their source through the air and water. For example, microplastics have been detected in remote Arctic and Antarctic locations, far from industrial sources.[57]

Microplastics circulate through the water cycle; they are present in the air, clouds, and ocean spray.[58] Movement of microplastics from oceans to clouds to precipitation elsewhere furthers their transport from one location to another.[59] Microplastics have been detected falling from the sky in rainwater.[60] Crashing ocean waves can also cause widespread dispersal.[61]

The mobility of microplastics allows them to easily disperse, making them very difficult to clean up and remediate.

Microplastics Are Bioaccumulative

As described above, microplastics have been found throughout the human body, and there is growing evidence suggesting that they can bioaccumulate—meaning that they can build up in an individual's body over time. Bioaccumulation is particularly concerning when substances are harmful or toxic. The strongest evidence supporting the bioaccumulation of microplastics has thus far been found in aquatic species.[62] A recent review found bioaccumulation was prevalent in marine species across the globe at many levels of the food chain, from tiny zooplankton and crustaceans to large fish, reptiles, and birds.[63]

MICROPLASTICS AND THE CLIMATE

Plastics are made from fossil fuels, and their entire lifecycle causes serious climate impacts. A recent study conducted by scientists at the U.S. Department of Energy found that global plastic production is a major contributor to the greenhouse gas emissions that cause climate change.[64] The study estimates that by 2050, plastic production could account for between 21 and 31 percent of the global carbon emissions budget necessary to avoid the worst impacts of climate change.[65]

In addition, there are emerging questions as to whether the presence of microplastics in the oceans, the soil, and the atmosphere may impact the climate.[66] For example, some preliminary studies have suggested that microplastics affect cloud formation, which could disrupt atmospheric cooling.[67] Scientists also speculate that as microplastic concentrations increase in the ocean, they may impact the ability of the ocean to sequester carbon, thereby exacerbating climate change.[68] Microplastics may also cause sea ice and glaciers to melt faster since they can change how much sunlight is absorbed by the ice.[69] While we don't yet have all the answers about how microplastics may affect the climate, given the potential consequences, these are important questions to be asking.

Plastics break down slowly in the environment and the resulting microplastics can travel long distances in the air and water.

RECOMMENDATIONS

The sources of microplastics are diverse, and therefore there is not a single solution to address widespread microplastic pollution. To begin to take on the microplastic crisis, we need both preventive and curative measures. Preventive measures include restrictions on the addition of microplastics to products, phaseouts or reductions of throwaway plastics such as single-use packaging or products, and product redesign that reduces the creation of microplastics. Curative measures include those that clean up the existing and ongoing pollution. Because microplastics are so persistent, pervasive, and hard to recapture once dispersed, preventive measures ultimately are the most critical to protect human health and the environment. Therefore, NRDC's recommendations have a strong focus on preventive measures.

For policymakers

- **Support policies that reduce the use of unnecessary and avoidable plastics.** Minimizing the overall amount of plastic and associated chemicals produced will reduce the amount of microplastics entering the environment.
- **Ban the use of intentionally added microplastics in products.** Fewer microplastics in products means fewer microplastics in the environment and ultimately in our bodies.
- **Enact policies to limit the impacts of fast fashion.** The rise of fast fashion is not only driving an increase in plastic usage globally but is also a major source of microplastic release.
- **Establish government purchasing policies.** Policies specifying that local, state, and federal governments must purchase non-plastic products and those that do not contain intentionally added microplastics will help to directly reduce plastic usage as well as drive market momentum.
- **Invest in nontoxic reuse infrastructure.** Shifting away from single-use plastics and toward nontoxic reuse/refill/return systems will lead to less plastic usage and therefore fewer microplastics.
- **Set limits on the amount of microplastics in drinking water and wastewater.** Fewer microplastics in our water means fewer microplastics in our bodies, soil, and food.
- **Fund microplastic research.** Although we know enough to take action now, more research on the prevalence of microplastics in our water, air, food, soil, and bodies is needed to better understand the problem. Funding for independent academic science is also needed to further examine the potential impacts of microplastics on human and environmental health.
- **Address plastic pellet pollution.** Enact policies to prevent industrial spills of plastic pellets, to reduce the unintentional release of microplastics to the environment, and to provide oversight and guidance for cleanup.
- **Support a strong global plastics treaty.** To truly address the plastics crisis, policymakers across the world need to finalize their negotiations and enact a strong, binding treaty that sets mandatory limits on plastic production; includes restrictions on the use of intentionally added microplastics, single-use plastics, and high-priority chemicals and polymers of concern; requires full chemicals transparency; and does not allow toxic forms of waste disposal such as incineration or "chemical recycling."[70]

For companies

- **Stop using intentionally added microplastics** in products and move to safer alternatives.
- **Switch to non-plastic materials and packaging**, where possible.
- **Move to reuse/refill/return systems** rather than single-use plastic.
- **Avoid business models such as fast fashion** that lead to massive plastic consumption and microplastic release.
- **Take action to prevent spills** of plastic pellets.

For individuals

It shouldn't be up to individuals to reduce the world's burden of microplastics. However, there are some things you can do to reduce your exposures and your contribution to the explosion of microplastics. For ideas on how to get started, see NRDC's *10 Things You Can Do to Reduce Your (And Your Family's) Exposure to Microplastics*.[71]

Endnotes

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