Breathing Plastic
The Health Impacts of Invisible Plastics in the Air

Key Messages

- **Multiple Sources, Same Origin**: Micro- and nanoplastics are ubiquitous in our environment, but they are mainly invisible. They can be intentionally produced or result from the fragmentation of larger plastics. Regardless of the source, they are part of the bigger story of plastics, as they are fundamentally a human creation.

- **Moving through Air**: Airborne micro- and nanoplastics can travel quickly and cover great distances. They can move thousands of kilometers in a matter of days to weeks, affecting even remote populations.

- **Inside the Body**: Humans can breathe airborne micro- and nanoplastics. Small particles can enter the lungs and move through the body, migrating to lymph nodes or other tissues and secondary organs via the bloodstream.

- **A Trojan Horse**: Micro- and nanoplastics act like a “Trojan Horse,” hiding harmful substances and carrying them inside bodies via inhalation, absorption, and ingestion. These harmful substances include hormone-disrupting chemicals linked to diabetes, infertility, and hormone-related cancers.

- **Health Impacts**: Studies on the inhalation of micro- and nanoplastics show a series of adverse effects along the respiratory tract and beyond, ranging from irritation to the onset of cancer in cases of chronic exposure. Studies also indicate a potential range of effects in early childhood development.

- **A Toxic Cocktail**: Exposure to airborne micro- and nanoplastics is not happening in a vacuum. Humans are exposed to multiple pollutants and hazardous chemicals daily, including micro- and nanoplastics ingested via other sources, such as food or drink. While research on airborne micro- and nanoplastics is in its infancy, plastic exposure typically happens alongside other toxic substances. Regulators need to apply the precautionary principle to address the risks of combined exposure.

- **The Bigger Picture**: If no action is taken, the volume of airborne microplastic emissions will follow the expected rise in plastic production, resulting in a greater risk of toxic impacts and spreading potentially toxic chemicals. Regulators need to dramatically reduce the production of plastics and phase out hazardous chemicals.
Introduction

As the world’s understanding of the plastics crisis grows, new facets of the problem emerge and reveal impacts on human health and the environment. Recent advances in science are allowing scientists to explore how micro- and nanoplastics form a critical piece of the plastic pollution problem. First thought to be mainly a marine pollution issue, over the last decade, scientists have discovered micro- and nanoplastics exist in every environmental compartment — from freshwater to soil and air — and in thousands of species, including humans. But like climate change and hazardous chemicals, most plastics are invisible to the naked human eye, meaning their impact goes relatively unseen.

Contrary to popular depictions, oceans are not “the final sink” for microplastics. These tiny plastic particles can travel worldwide, ending up in urban, rural, and remote areas. They take an even faster transport pathway than oceanic currents: the atmosphere. Moving through the air, micro- and nanoplastics can cover thousands of kilometers in a matter of days to weeks, creating what could be a “never-ending loop” of plastic transport. The serious potential for long-range transport means that micro- and nanoplastics can affect locations and populations vast distances from the sources of plastic pollution, making microplastics “one of the most ubiquitous pollutants released by anthropogenic activities” and a grave public health issue. While scientists may not yet know the full scope of the health impacts of micro- and nanoplastics, the cause is undeniably clear: the production and use of plastics.

The Problem: Micro- and Nanoplastics Are Ubiquitous, Invisible, and Can Pass through the Human Nose and Lungs

Everywhere they look, scientists are finding microplastics. Often so small that they are invisible to the human eye, these tiny plastic particles are imperceptible as they pass through airways and reach the very bottom of the lungs. Scientists have found that inhalation is a major contributor to human intake of micro- and nanoplastics, and exposure rates — the amount of atmospheric micro- and nanoplastics in an individual’s vicinity — can be as high as 5,700 microplastics per cubic meter. It’s estimated that humans can inhale up to 22,000,000 micro- and nanoplastics annually. Evidence of inhalation as an uptake pathway of atmospheric microplastics was substantiated in 2022 when a study identified abundant microplastics within human lung tissue samples for the first time. Estimates of human intake increase when they include ingestion of micro- and nanoplastics deposited on food and beverages. Studies show that individuals can ingest up to 1 million pieces of deposited atmospheric microplastics over a year.
Microplastic Inhalation over the Average Human Lifetime

If we think of microplastic inhalation as a visual height chart, over the course of these periods of time, the average human inhales the equivalent of...

- **Height of two giraffes**
  12.69 meters
- **Height of the Eiffel Tower**
  363 meters
- **Height of Snowdon Mountain, Wales**
  1,019 meters

Over a year  |  Over a lifetime (minimum)  |  Over a lifetime (maximum)
---|---|---
Source: [Data from an investigation by the University of Portsmouth and Good Morning Britain.](#)

To better understand the issue, it is essential to examine the scales used to classify plastic particles. Microplastics are plastic particles less than 5 millimeters (mm) in diameter, about the size of an orange seed.\(^4\) Airborne microplastics, however, are much smaller — even a 0.5mm (500 micrometer (µm)) particle is considered large. When plastic fragments are below 0.001 mm in size (equivalent to 1 µm or 1,000 nanometers (nm)), they are less than 1/100th of the thickness of a human hair. Particles this small are called nanoplastics and cannot be seen by the naked eye.\(^5\)
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The Size of Micro- and Nanoplastics

While size matters in assessing the risks and their regulation, the small scale does not change the fact that micro- and nanoplastics are part of a continuum of manufacturing plastic products. Microplastics fall into categories based on their source. Primary microplastics are intentionally produced at microscale for a specific use (such as agrochemicals or pharmaceuticals). In contrast, secondary microplastics result from the mechanical, chemical, and physical fragmentation of larger (macro) plastics, which can include “legacy” plastics disposed of in the environment decades ago. Every stage of the plastics life cycle, from the extraction of feedstocks to production, transport, use, disposal, and remediation, emits both primary and secondary microplastics and other hazardous substances.

Micro- and Nanoplastics in the Air Originate from Multiple Sources

Fundamentally, atmospheric microplastics come from human creation and use of plastics. Microplastics originate from a variety of sources. They can be found in both outdoor and indoor environments, from the inner city and industrial areas to the most remote locations on the planet — spanning the Arctic to the Antarctic. The sources of primary micro- and nanoplastics include nurdles (the industry term for pellets used to transport plastic resins before production and processing into familiar plastic products), personal care products, pharmaceuticals, their intentional introduction in agricultural seed and fertilizer products, printing ink, and electronics. Secondary microplastics can result from discarded plastic products deteriorating, tire abrasion (including car, truck, and airplane tires), and the wear and tear of synthetic textiles like clothes, carpets, furniture, and household goods. Other sources include tumble dryer exhaust; thermoplastic road markings; artificial turf; waste incineration; landfills; construction; emissions from industrial processes; 3D and laser printing; agricultural materials; degradation of paint, wallpaper, flooring, and furniture; and the opening of plastic packaging.

Beyond primary and secondary forms, microplastics can be transferred from one environment to another. A study published in 2020 examined the potential for the ocean to serve as a genesis for the release of micro- and

Source: Based on a visual by Deonie and Steve Allen, presented in a webinar hosted by Plastic Pollution Coalition.
nanoplastics into the atmosphere. It discovered that microplastics found in marine environments can be released into the atmosphere via sea spray.\textsuperscript{33}

Given the \textit{anticipated rise in plastic production}, the volume of microplastics will only increase if there is no drastic reduction in plastic manufacturing.

The increase in plastic production corresponds to the presence of microplastic deposits in studies of atmospheric records. When scientists examined ombrotrophic peatlands and high-altitude lake sediments for microplastic pollution, they discovered that an increase in worldwide plastic production and plastic waste management policies over the last several decades corresponds with a rise in atmospheric microplastic deposition.\textsuperscript{34} Given the anticipated rise in plastic production, the volume of microplastics will only increase if there is no drastic reduction in plastic manufacturing.

\textbf{Atmospheric Micro- and Nanoplastics Comprise a Diverse Range of Polymers and Toxic Components}

\textbf{The Diverse Polymer Makeup of Atmospheric Microplastics}

So far, all types of plastic polymers in other environments (i.e., soil, marine, or freshwater) have also been found in the atmosphere in micro- or nano-form. Air in living and work spaces continually mixes with outdoor air. It carries micro- and nanoplastics from both close sources (like carpets or clothing) and far-flung sources (after being transported distances up to thousands of kilometers).
Atmospheric microplastics come in a diverse range of polymer types, sizes, and shapes (also called morphologies) and represent the diverse range of plastics created and used globally. Examining microplastics from a variety of locations reveals key information, including:

- While there is an understood relationship between particle quantity and size, there are no clear trends in polymer type.
- As the particle size decreases, there is an exponential to logarithmic increase in particle quantity. For example, there are approximately ten times as many 10 µm (inhalable) microplastics as there are 100 µm microplastics.
- The lack of pattern among polymer types could be due to the cumulative nature, local and long-distance transport of these particles, and the continual creation of micro- and nanoplastics that can potentially be airborne.
- There is some indication that location (city, country, or land use), seasonality, and meteorological conditions play a part in the atmospheric polymer composition.

In general, some known atmospheric microplastic polymer types evidenced in urban, rural, or remote areas include polyethylene terephthalate/polyester (PET), but also polyethylene (PE), polypropylene (PP), polystyrene (PS), polycarbonate (PC), and about a dozen different petrochemical-based polymers (e.g., polyacrylonitrile (PAN), polyurethane (PUR), polyamide (PA), and polyvinyl chloride (PVC)).

The “Trojan Horse” Problem: Toxic Components of Micro- and Nanoplastics

The very characteristics of microplastics reveal their potential to be a dangerously potent vector for toxics and pathogens. Microplastics often have large specific surface areas and are predominantly hydrophobic, meaning they repel water. These characteristics make airborne microplastics a “Trojan Horse” capable of hiding and carrying harmful substances inside the animals or humans who inhale, absorb, and ingest them. Therefore, knowing what’s inside plastic is as important as knowing what lies on it.
Microplastics can contain “intrinsic” pollutants introduced during manufacturing (additives such as plasticizers and flame retardants, dyes and pigments, and unreacted monomers). More than 10,000 substances have been identified as part of plastic production, with more than 2,400 flagged for potential concern because they meet one or more of the European Union’s criteria for persistence, bioaccumulation, and toxicity. Many others have not been adequately tested. Concerningly, most of the substances added to plastics are not (and cannot be) chemically bound and can therefore leach out into the environment or organisms during degradation.

Further, airborne microplastics also carry associated contaminants adsorbed from the surrounding environment. These include heavy metals, persistent organic pollutants (POPs), and polycyclic aromatic hydrocarbons (PAHs). Concerningly, it is not possible to know what “legacy” substances microplastics may contain. A particle may include both unknown contaminants and well-known hazardous chemicals whose uses are currently prohibited or restricted due to their persistence in the environment, such as dichloro-diphenyl-trichloroethane (DDT).

While studies quantifying toxic chemicals sorbed on the surface of airborne microplastics are limited, the effects of indoor dust contaminated by hazardous chemicals used in plastic production are well-documented. Studies showing the effects of hazardous chemicals used in plastic production are linked with reproductive toxicity, endocrine disruption, carcinogenicity, and mutagenicity, including bisphenol A (BPA), polybrominated diphenyl ethers (PBDEs), and phthalates.

Alarmingly, microplastics’ intrinsic pollutants and adsorbed contaminants are not the only cause for concern. Microplastics can carry antibiotic-resistant genes and bacterial and viral pathogens when in water and soil. Thus, it cannot be excluded that airborne microplastics may also be a carrier of microbial or viral infections and serve as a potential vector for COVID-19.

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**Chemicals Used in Plastics**

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Airborne Micro- and Nanoplastics Enter Human Bodies

The Diverse Polymer Makeup of Atmospheric Microplastics

Exposure to airborne microplastics can occur through inhalation, penetration through skin pores, and ingesting foods that contain them. Microplastics’ reach inside the human body depends on their properties, size, shape, and an individual’s metabolism, susceptibility, and lung anatomy. They can enter the respiratory system through the nose or mouth before being deposited in the upper airways or deep in the lungs.

Microplastics in the Human Body

Studies now show that micro- and nanoplastics can circulate through the human body and accumulate in the following locations:

- Brain
- Lungs
- Respiratory System
- Digestive System
- Breast Milk
- Stomach
- Spleen
- Liver
- Kidneys
- Skin
- Placenta

Source: Based on visuals by the United Nations Environment Programme (from the 2021 report, "From Pollution to Solution") & the World Health Organization (from the 2022 report, "Dietary and inhalation exposure to nano- and microplastic particles and potential implications for human health").
Once there, evidence shows that micro- and nanoplastics can be transferred from the lung epithelial surface to lung tissue, potentially to internal organs and the vascular system, and beyond.

**The Respiratory System**

Particles that enter the respiratory system and can deposit in the upper airways are referred to as “inhalable” microplastics. These are typically between 5–30 µm and are small enough that they can undergo clearance, including through: (1) mucous, leading to gastrointestinal exposure, (2) alveolar macrophage phagocytosis, and (3) migration through the lymphatic system.

It is *not only* microplastics’ reach into the human body that is concerning; it is *also* the potential for damage.

Removing particles can occur through regular bodily functions like sneezing, but there may be greater difficulty if particles have particularly large surface areas, or if an individual has a compromised clearing mechanism. The latter can occur if an individual is immunocompromised, has a pre-existing lung condition (e.g., cancer, viral infections), or experiences particle overload due to exceptionally elevated exposure.

Studies in rats show that ultrafine particles ranging from <100 nm to 0.1 µm move from the nasal cavity through the olfactory bulb located in the forebrain — the more direct connection between air and internal organs bypassing the lungs. This movement suggests that micro- and nanoplastics have a direct route along the upper respiratory tract to blood and the brain.

Microplastics with lower density and smaller particle size have “a greater probability of reaching deep airways,” including lungs. These are referred to as “respirable” microplastics. Once there, microplastics likely persist and eventually accumulate, leaching any chemicals they have carried into a warm, wet, and conducive environment. There is also evidence that particles transfer from the lungs to lung tissue, into cells, and through the cell barrier.

It is not only microplastics’ reach into the human body that is concerning; it is also the potential for damage. In smaller particles, the surface area takes up a large percentage of the overall volume, making them more reactive. Therefore, it is particularly concerning that most of the plastics humans breathe in are not food grade. They originate from objects such as car tires, carpets, and clothing that do not guarantee safety standards or come with easily accessible ingredient lists for the plastics themselves, additives, or the substances carried on their surface.
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**Beyond the Respiratory System**

Once inhaled nanoparticles overcome the pulmonary cells barrier, they can move across the body, migrating to lymph nodes or other tissues and secondary organs via the bloodstream. Studies in pregnant and fetal rats have found microplastics in the adult placenta, heart, spleen, fetal liver, heart, kidney, lung, and brain. A recent study on humans also found microplastics in breastmilk.

There are few targeted studies on micro- and nanoparticles’ translocation to secondary organs and their consequences. Nevertheless, existing studies on metallic and carbonaceous nanoparticles highlighted their impact on the neurological, reproductive, cardiovascular, immune, and other systems.

**Inhalation of Airborne Micro- and Nanoplastics Presents Health Impacts**

While airborne microplastics research is in its infancy, studies on the inhalation of micro- and nanoparticles of plastics show a series of adverse effects along the respiratory tract and beyond, ranging from irritation to the onset of cancer in cases of chronic exposure. These adverse effects include:

- immediate asthma-like reactions;
- inflammatory reactions and fibrotic changes, like chronic bronchitis;
- lung disorders such as extrinsic allergic alveolitis and chronic pneumonia;
- pulmonary emphysema;
- the development of interstitial lung diseases, resulting in coughing, difficulty breathing, and a reduction in lung capacity;
- oxidative stress and the formation of reactive oxygen species (ROS) and thus the ability to damage cells (cytotoxic effects); and
- autoimmune diseases.

**Human Health Impacts of Exposure to Chemicals in Microplastics**

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<thead>
<tr>
<th>Neurodevelopmental disorders</th>
<th>Metabolic disorders</th>
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<tr>
<td>Attention deficit hyperactivity disorder (ADHD)</td>
<td>Type 2 diabetes</td>
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<td>Autism</td>
<td>Excessive childhood weight gain</td>
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<td>Neurobehavioral deficits</td>
<td>Increased waist circumference</td>
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<tr>
<td>Decreased IQ</td>
<td>Serum lipid levels, e.g., total cholesterol and LDL cholesterol</td>
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<td>Cognitive deficits</td>
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<th>Hormonal diseases</th>
<th>Other health impacts</th>
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<tr>
<td>Thyroid disease</td>
<td>Decreased antibody response to vaccines</td>
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<td>Thyroid cancer</td>
<td>Physical damage</td>
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<th>Cardiovascular disease</th>
<th>Carcinogen absorption</th>
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<th>Respiratory diseases</th>
<th>Pregnancy outcomes</th>
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<td>Asthma</td>
<td>Preterm birth</td>
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<th>Male reproductive health impacts</th>
<th>Lower birth weight</th>
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<td>Subfertility</td>
<td>Abnormal genital structure (anogenital distance)</td>
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<td>Reduced sperm quality</td>
<td>Altered pubertal timing</td>
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<th>Female reproductive health impacts</th>
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<td>Polycystic ovarian syndrome</td>
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<td>Endometriosis</td>
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<td>Delayed time to pregnancy</td>
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<td>Abnormal Pap smears</td>
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<td>Pregnancy-induced hypertension and/or preeclampsia</td>
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Source: Based on visuals from a 2021 report by the United Nations Environment Programme, titled "From Pollution to Solution".
These health risks are particularly concerning for at-risk and vulnerable people and those who come into frequent contact with airborne microplastics, including workers. Exemplar studies of PVC and flock workers showed how their exposure can cause persistent inflammatory stimulation and lead to pulmonary fibrosis or even cancer.82

The presence of micro- and nanoplastics can also concur with other airborne pollutants, exposing people to a cocktail of toxins.

Exposure to chemicals and plastics also has gender-differentiated impacts: Women and individuals assigned female at birth are generally more disproportionately impacted by toxic exposures.83 Pregnancy and childhood are particularly susceptible to harm from airborne plastic due to the increased immune, vascular, and organ stress from growth rates. On the one hand, the impact of translocation of the chemicals associated with plastic and the other pollutants (e.g., BPA, PFAS, lead, and arsenic, etc.) that the particles could transform are known. On the other, it is plausible that nanoplastic particles that cross the placental barrier are taken up by the fetus and remain after birth. However, the potential translocation of the particle to the fetus and its impacts are not yet known.

Studies indicate the potential range of effects in early childhood development. When pregnant people (and therefore fetuses) are exposed to a greater amount of phthalates, they experience shorter gestation periods, and children are born with lower birth weights.84 In a different study, researchers observed reduced fetal and placental weight 24 hours after pulmonary exposure to nanoplastic particles.85 Given that low birth weight is associated with a high risk of complications, in-utero exposure to plastics and chemicals may have long-term developmental effects.

While epidemiological studies have usually focused on adults,86 the threats associated with exposure to micro- and nanoplastics are also present in childhood and adolescence. One study followed the powdering of a plastic polymer-based floor polish at a secondary school: Young teenage students exposed to the floor dust reported irritation of eyes and airways.87

The presence of micro- and nanoplastics can also concur with other airborne pollutants, exposing people to a cocktail of toxins. Air quality is often measured by particulate matter (PM), a figure that encompasses everything from dust to dirt, airborne pollutants, and other toxins. Because airborne microplastics appear to be so prevalent, PM10, PM2.5, and PM1 (inhalable, fine particulate, and ultrafine matter, respectively) may include some percentage of airborne micro- and nanoplastics.

In 2019, air quality, exhaust, and non-exhaust pollution were shown to be the primary cause of 6.7 million deaths worldwide.88 Tragically, in 2020, a nine-year-old child in London died in what has been called the first certified death caused by air pollution.89 Given the prevalence of airborne micro- and nanoplastics and their potential to act as a carrier for PAHs, metals, viruses and bacteria, organics, and other toxins,90 it is not known how many deaths are directly related to atmospheric micro- and nanoplastics. However, the number of global deaths that are attributed to air quality should be cause for concern over the microplastics and nanoplastics contribution to this human health and premature mortality issue.

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1. Flocking is a method to apply very short (1/10 to 1/4 inch) fibers called flock to a substrate, such as fabric, foam, or film, coated with an adhesive. Flocking is an inexpensive method of producing an imitation extra yarn fabric, flocked in a design, or a pile-like fabric where the flock has an overall pattern. See Robyne Williams, Flocking, Love to Know, https://fashion-history.lovetoknow.com/fabrics-fibers/flocking (last visited April 26, 2022).
Global Trends: Growing Emissions and Long-Range Transport of Micro- and Nanoplastics

Since air is a strong environmental media, the spread and effects of airborne microplastics can remain localized or extend far beyond the point of release. While concentration levels vary, no location remains untouched. Airborne microplastics have been collected worldwide, but especially in the Northern Hemisphere, including France, Iran, China, Japan, Vietnam, Nepal, the United States, Colombia, Saudi Arabia, South Korea, Kuwait, Greece, Romania, Pakistan, and India.91

Close sources of micro- and nanoplastics, including, but not limited to, packaging, clothing, and carpets, help contribute to the substantial indoor deposition of airborne particles. Research shows that the concentration of indoor plastic particles could be even higher than what is found in the open air. This concentration is particularly concerning considering that humans (especially Americans and Europeans)92 spend an estimated 70 to 90 percent of their time indoors.93

For particles released outdoors, the atmosphere can serve as an efficient and rapid transport pathway for microplastics to travel great distances.94 The long-distance transport complicates source management as exposure within a specific location (e.g., a city street) will be a mixture of micro- and nanoplastics from local emissions, the regional atmosphere, and those traveling from outside the region (including from other countries with different management regimes). The relative speed of atmospheric transport differentiates it from slower transport seen in the marine environment.95 Therefore, plastic released in one country could be inhaled by citizens from a neighboring or distant country relatively quickly, with smaller particles potentially transported even further and in greater quantities.

The effects of airborne microplastics are not limited to inhalation. Air can also be a vector for microplastics to contaminate soils, foods, and water.96 Micro- and nanoplastics have been detected in drinking water,97 and scientists discovered that they can also penetrate edible fruits and vegetables, including seeds, roots, and leaves.98 Therefore, consuming water and food, including fruits and vegetables, may result in microplastic intake.99
Global trends show that the dimension of the threat will continue to grow. The production of plastic, including primary microplastics, is projected to increase in the coming decades, from 9.2 billion metric tons in 2017 to 34 billion metric tons by 2050.\textsuperscript{100} The estimated emissions of plastic waste into aquatic ecosystems are also projected to nearly triple between 2016 and 2040\textsuperscript{101} under “business-as-usual” practices.\textsuperscript{102} Relatedly, chemical production growth nearly doubled between 2000 and 2017, and sales are estimated to double again before 2030.\textsuperscript{103} The volume of airborne microplastic emissions will follow the expected rise in plastic production, use, and waste, providing greater opportunities to spread an increase of potentially toxic chemicals. The result is that every human and ecosystem will be susceptible to harm.\textsuperscript{104}

### Projected Growth in Chemicals and Plastics Production

- **Global Plastics Production**
- **Global Chemical Industry Sales**

Source: Based on a graph from a 2021 report by the International Pollutants Elimination Network, titled “Plastic’s Toxic Chemical Problem.”
Taking Action

While research on the human health impacts of microplastics is continuing to evolve and grow (for example, five newly-funded projects on micro- and nanoplastics and health in the European Union), the existing information combined with the growing trends is enough to warrant taking action and adopting precautionary measures.

Some countries have banned specific plastic items or plan to restrict certain types of intentionally added microplastics into products. Still, no comprehensive national or regional regulation covers intentional and unintentional releases of microplastics. Specific legally binding measures could target different sources of airborne microplastics. For instance, in the case of tire dust, there should be standards and minimum requirements for tire abrasions, combined with a general objective to reduce road transport. In the case of synthetic textiles, measures should include maximum thresholds on the release of microplastics, a mandatory industrial pre-washing of garments, and the use of filters to capture microplastic releases (with a funded management process for the collection and control of the waste). These should be combined with efforts to incentivize eco-design and provide quantitative targets to reduce synthetic textile products (rather than redesign products to support the ongoing use of plastics or a proportion of recycled plastic material).

No comprehensive national or regional regulation covers intentional and unintentional releases of microplastics.

Individual-facing mitigation actions can include wiping off the deposited dust and microplastics from floors and tables; use of high-efficiency particulate air (HEPA) filters in the home and work environments; ensuring minimal use of plastic in food preparation, cooking, and storage (including freezing and microwaving); covering a cup during drinking and rinsing dishware before use; and avoiding plastic packaging. However, these mitigation measures are a temporary bandage for a systemic problem. Micro- and nanoplastic fibers will continue to shed from textile products, legacy plastics, tire dust, and air deposits, resulting in the urgent need for more sustainable and longer-term solutions.

Recommendations

1. **Consider the combined “cocktail” effect.** Exposure to micro- and nanoplastics is a multi-faceted problem touching on air, water, terrestrial environments, food, and more. Regardless of how exposure occurs, it typically happens alongside other toxics. Humans are exposed to multiple pollutants and hazardous chemical compounds daily, including endocrine disruptors and POPs linked to diabetes, infertility, and hormone-related cancers. Regulators need to apply the precautionary principle to address the risks of combined exposure. Such an approach should include ensuring access to information on the petrochemical compounds in plastics products and processes (both voluntary and non-intentionally added) for ALL plastic products, not just food-grade plastics.

2. **Adopt legally binding measures without any further delay.** Self-regulation and voluntary approaches have failed to reduce plastic and microplastic pollution. Banning intentionally added microplastics is the first step. Mandatory regulations will need to reduce the production and release of plastic and its associated compounds and reduce human exposure to plastics, microplastics, and nanoplastics.

3. **Address the full life cycle of plastics.** Airborne micro- and nanoplastics are part of the bigger story of plastics. Thus, a systemic effort is needed to address the full issue, beginning with the extraction of fossil fuels and associated chemicals used in plastic production. Decision makers should further support action at the global level, supporting ambitious and effective provisions, including strict enforcement measures, in the future international legally binding agreement on plastic that will be negotiated before the end of 2024.
Endnotes


2. Allen et al., 2.


92. Amato-Lourengo et al., “An Emerging Class of Air Pollutants.”


97. Zhang et al., “A Review of Microplastics in Table Salt, Drinking Water, and Air.”


104. VishnuRadhan et al., “Atmospheric Plastics- a Potential Airborne Fomite with an Emerging Climate Signature.”


107. Zhang et al., “Microplastic Fallout in Different Indoor Environments.”
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