

Does microplastics cause any human health risk

Extensive research is still underway to determine the full impact of microplastics on human health, but studies have identified several potential risks. Tiny plastic particles have been detected throughout the human body, including in the blood, lungs, liver, brain, and placenta.

The primary concerns come from three sources: the physical damage the particles can cause, the release of toxic chemical additives, and the absorption of other harmful pollutants.

Physical and cellular effects

- Inflammation: Microplastics can be seen as foreign invaders by the immune system, which can trigger chronic inflammation.
- Oxidative stress: Studies on human cells show that micro- and nanoplastics can cause oxidative stress and damage DNA.
- Cell damage: In laboratory settings, high concentrations of microplastics have been linked to cell death and inhibited cell viability.
- Bioaccumulation: Nanoplastics, which are smaller than 1 micrometer, are of particular concern as they can cross cellular and tissue barriers, including the blood-brain and placental barriers, and may build up in organs.

The potential impact of nano- and microplastics on human ...

Jun 15, 2024 — Highlights * • Exposure to nano- and microplastics in humans potentially leads to serious health issues, including various cancers, respiratory disorders, and i...



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Potential Health Impact of Microplastics: A Review of Environmental ...

Abstract. Microplastics are ubiquitous in the global environment. As a typical emerging pollutant, its potential health hazards have been widely concerning. In ...

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Chemical toxicity

Microplastics are not just inert particles; they can contain and absorb toxic chemicals that pose additional risks.

- **Toxic additives:** Plastics can contain thousands of chemical additives, including endocrine disruptors like bisphenol A (BPA) and phthalates, which can interfere with hormones and lead to reproductive, metabolic, and developmental disorders.
- **Absorbed pollutants:** Microplastics can also act as carriers for other environmental pollutants, such as heavy metals and persistent organic pollutants, which can then be transported into the body.

Potential health problems

While much of the current research is based on animal models and cell studies, researchers have identified links between microplastic exposure and several health issues.

- **Cardiovascular disease:** A study published in *The New England Journal of Medicine* in 2024 found that patients with microplastics in the plaque of their carotid arteries had a significantly higher risk of stroke, heart attack, or death.
- **Respiratory issues:** Inhaling microplastics, particularly in occupational settings, has been linked to lung inflammation, fibrosis, and a higher risk of lung and respiratory diseases.
- **Gastrointestinal damage:** Studies have found a higher concentration of microplastics in the feces of people with inflammatory bowel disease (IBD) compared to healthy individuals, and exposure has been shown to cause gut barrier dysfunction in animals.
- **Neurological effects:** Evidence suggests that nanoplastics can cross the blood-brain barrier. Higher levels have been found in the brains of dementia patients, and animal studies link exposure to learning and memory problems.

- Reproductive and developmental harm: Animal studies indicate that microplastics can affect fertility and fetal development. Nanoplastics have been detected in the human placenta, raising concerns about potential impacts on fetal growth.

Limitations of current research

Despite the growing evidence, the field of microplastic-related health research is still in its early stages.

- Causal links vs. association: Many human studies show an association between microplastics and adverse outcomes, but a direct causal link has not yet been proven.
- Diverse exposures: Laboratory studies often use controlled, uniform particles, but humans are exposed to a wide variety of microplastic types, sizes, shapes, and chemical compositions.
- Long-term effects: It is difficult to study the long-term health effects of microplastic exposure in humans, especially since plastics have only been widely produced since the mid-20th century.

What's the relationship between microplastic shape/size and the likelihood of it crossing biological barriers?

Size is the single most critical factor determining a microplastic's ability to cross biological barriers, with smaller particles (nanoplastics) exhibiting a far greater capacity for cellular and tissue penetration. Shape also plays a significant role, affecting the particle's movement, uptake efficiency, and potential to cause physical damage.

The role of particle size

The relationship between size and penetration ability is inverse: as particles get smaller, their ability to cross biological barriers dramatically increases.

- **Nanoplastics ($<1\mu\text{m}$):** These are the most dangerous plastic particles in terms of barrier permeability. Their minute size and large surface-area-to-volume ratio allow them to:
 - Easily cross specialized, tightly-packed biological barriers, including the blood-brain barrier, placental barrier, and cell membranes.
 - Accumulate in vulnerable and sensitive tissues like the brain and fetus.

- Infiltrate cell organelles, such as mitochondria and the nucleus, potentially causing significant cellular damage.
- **Larger microplastics (>1µm is greater than 1 µm >1µm):** These particles have a more limited ability to cross deeply into tissues.
 - Larger microplastics, such as those found in the 1–10 µm range, can still enter cells but are less efficient at it than nanoplastics.
 - These larger particles are often trapped by physical barriers like the mucus layer of the gut and excreted from the body.
 - Even if they are absorbed, larger microplastics tend to cause more localized inflammation and damage to the barrier they are crossing, rather than reaching multiple organs via systemic circulation.

The role of particle shape

While size dictates the possibility of entry, shape influences the specific mechanism and nature of the interaction.

- **Fragments and fibers:** These irregularly shaped plastics, a major component of microplastic pollution, tend to have more pronounced harmful effects than smooth, uniform spheres.
 - **Fibrous particles**, such as those from synthetic textiles, are easily inhaled and can lodge deep in the lungs, where their elongated shape makes them difficult for macrophages to clear.
 - **Fragments with sharp edges** can cause direct physical and mechanical damage to cell membranes upon contact.
- **Spherical particles:** These are often used in laboratory studies for their uniformity but may not accurately represent the risks posed by real-world microplastics.
 - Even spherical particles can disrupt cell function, with some studies showing they can cause cellular membranes to stretch and potentially lose function.

Combined effects

The full picture of microplastic interaction is a complex combination of both size and shape, in addition to other factors like polymer type, surface charge, and the presence of a "biomolecular corona"—a coating of proteins and other biomolecules that forms around the particle in a biological fluid.

For example, smaller particles with irregular shapes and a high surface area have a greater potential to carry adsorbed toxins and cause localized damage, while the smallest nanoparticles can circulate throughout the body, affecting multiple organs systemically.

What techniques identify and characterize microplastics in tissues?

A range of microscopic, spectroscopic, and thermal analysis techniques are used to identify and characterize microplastics in human tissues. The choice of method often depends on the required information, such as particle number, mass, size, shape, or chemical composition. Due to the complexity and tiny size of many microplastics, a combination of techniques is often necessary.

Sample preparation for tissue analysis

Before analysis, the biological tissue matrix must be removed without damaging or contaminating the plastic particles.

- **Digestion:** The tissue is digested using a strong chemical, such as hydrogen peroxide (H_2O_2) or potassium hydroxide (KOH), or with enzymes.
- **Filtration and separation:** The remaining particles are separated from the liquid via filtration or density separation.
- **Contamination control:** Extreme care is taken to avoid contamination from airborne microplastics or plastic materials used in the lab.

Spectroscopic techniques

These methods identify a microplastic's chemical composition by analyzing its interaction with light.

- **Micro-Raman spectroscopy ($\mu\mu$ -Raman):** This technique uses a laser to identify the molecular vibrations of a polymer, producing a unique "fingerprint." It offers high spatial resolution (down to $1\ \mu\text{m}$) and can analyze individual particles directly on a filter.
 - **Application:** Researchers used $\mu\mu$ -Raman to detect microplastics ranging from 1 to $29\ \mu\text{m}$ in human kidney tissues and urine.
- **Micro-Fourier-transform infrared (FTIR) spectroscopy ($\mu\mu$ -FTIR):** This method uses infrared light to identify a material's chemical bonds. It provides information on chemical composition, size, and shape.

- **Application:** $\mu\mu$ -FTIR was used to find microplastics in human lung tissues, though it is typically limited to particles larger than 10–20 μm .
- **Laser Direct Infrared (LDIR) spectroscopy:** This is an advanced form of FTIR that uses a laser source. It is known for high-speed chemical mapping, allowing researchers to quickly analyze large areas, such as an entire filter.
 - **Application:** LDIR has been used to detect and characterize microplastics in human placenta.

Thermal analysis techniques

These methods destroy the sample to identify the polymers present, providing a mass-based quantification instead of particle counts.

- **Pyrolysis-Gas Chromatography/Mass Spectrometry (Py-GC/MS):** This powerful technique heats a sample to break down polymers into characteristic volatile fragments. These fragments are then separated and identified by a mass spectrometer, providing precise data on the polymer types and additives present.
 - **Application:** Py-GC/MS was used to quantify the total mass concentration of microplastics in human blood, showing a mean concentration of 1.6 $\mu\text{g/ml}$ across 22 healthy volunteers.

Imaging techniques

These approaches are used to visualize the physical characteristics of microplastics.

- **Scanning Electron Microscopy with Energy-Dispersive X-ray Spectroscopy (SEM-EDX):** SEM produces high-resolution images of microplastic surface topography. When coupled with EDX, it can analyze the elemental composition of the particles, revealing inorganic additives.
- **Fluorescence Microscopy with Nile Red staining:** This is a rapid and cost-effective screening method. The hydrophobic dye Nile Red selectively stains most types of plastic, causing them to fluoresce under blue light. This helps researchers quickly locate microplastics among other particles. However, some biological matter can also be stained, requiring follow-up with other techniques for definitive identification.
- **Confocal Laser Scanning Microscopy (CLSM):** This technique uses laser light and advanced optics to capture high-resolution images of fluorescently labeled particles, including their 3D distribution within a sample.

Combined approaches for comprehensive analysis

To gain a complete picture of microplastic contamination, researchers often combine several techniques. A common workflow might include:

1. **Initial screening:** Use fluorescence microscopy with Nile Red to quickly locate and count potential microplastic particles.
2. **Chemical verification:** Select suspicious particles for chemical analysis using $\mu\mu$ -Raman or $\mu\mu$ -FTIR spectroscopy to confirm their polymeric nature.
3. **Mass quantification:** If mass concentration is required, use Py-GC/MS to get precise, mass-based quantitative data.
4. **High-resolution imaging:** Utilize SEM-EDX to examine the surface features and elemental composition of specific particles.