RESEARCH BRIEF

Clean Wisconsin Environmental Health Initiative

Microplastics in Our Bodies: Exposure & Potential Health Harms

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SUMMARY – Micro- and nanoplastics—small plastic particles—are ubiquitous in the environment. This includes the water we drink, the food we eat and the air we breathe. Microplastics are tiny plastic materials ranging in size from 1 µm (100 times smaller than a grain of sand) to 5 mm (the size of a pencil eraser). Nanoplastics are particles smaller than 1 µm.

Due to this exposure, microplastics have been found in numerous human organs and tissues. Little is known about the health effects of microplastics in our body, but there are three primary concerns. First, simply due to their physical presence as a foreign object, microplastics may interfere with normal cell and tissue function. Second, microplastics can have toxic additives like flame retardants or plasticizers that are harmful once introduced into the body. Third, microplastics can absorb toxic pollutants in the environment like PCBs, PFAS and heavy metals, which can cause harm once in the body. Numerous laboratory and animal studies have reported harmful effects of microplastic exposure. These studies, combined with the knowledge that microplastics in our food, air and water are getting into our bodies, create a need to better understand the human health effects of microplastics.

Key takeaways from this brief include:

- Most microplastic in the environment is from the breakdown of larger plastic pollution. Another important source to the environment is from wastewater treatment plants (WWTP). Microplastics collected at these plants from the community at large are in the discharged treated water as well as in biosolids spread on farmland.
    - WWTP effluent discharges millions to billions of microplastic particles to the environment every day.
    - Hundreds of millions more particles are estimated to be transported to our rivers, streams, and lakes from biosolids applied to farmland in Wisconsin every year.
- Microplastics in food and drinking water are considered the primary source of exposure to microplastics.
    - Estimates suggest that we eat up to 5 g of microplastics per week, the equivalent of a credit card's worth of plastic.
    - Bottled water contains over 20 times more microplastic particles than tap water.
- Micro- and nanoplastics have been found throughout the human body, including in the human nervous, respiratory, cardiovascular, and reproductive systems.

  - A recent study found that the typical adult brain had the equivalent of a plastic spoon's worth of micro- and nanoplastics.
  - Concentrations in human tissues have increased by 50% between 2015 and 2024.
- Recent studies have found a correlation between increased micro- and nanoplastic concentrations in the body and adverse health outcomes, suggesting a need to better understand the role of microplastic exposure as a driver of health conditions.
  - Patients with carotid artery disease have been found to have more micro- and nanoplastics in their arteries than those without disease.
  - People with dementia have been reported to have 10 times more micro- and nanoplastics in their brain than those without dementia.

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Introduction

Micro- and nanoplastics (MNPs) are an emerging environmental contaminant. Microplastics (MP) are tiny plastic materials ranging in size from 1 µm (100 times smaller than a grain of sand) to 5 mm (the size of an eraser). Plastic particles smaller than 1 µm are considered nanoplastics (Gigault et al. 2018). These plastic particles are further categorized as fragments, pellets/beads, fibers/lines, and foams (Lenaker et al. 2020).

MNPs are directly manufactured or created through the environmental degradation of larger plastic material (Campanale et al. 2020). Primary microplastics are plastics specifically manufactured to be microplastics for commercial or industrial purposes. These are utilized mainly in cosmetics, facial cleansers, and air-blasting media or as “nurdles” which are small plastic pellets used to make plastic products (Cole et al. 2011, Fuschi et al. 2022). In 2015, the utilization of microbeads in personal care products such as toothpaste and rinse-off cosmetics was banned in the United States (Fuschi et al. 2022). However, because of the consistent use before the ban, PMPs continue to persist in surface waters (Fuschi et al. 2022).

Another important source of MNPs is the washing of clothing with polymer-based fabrics such as polyester, acrylic, and nylon. Such releases account for over 70% of all microplastics in the surface waters (Fuschi et al. 2022).

Secondary microplastics (SMPs) are tiny plastic fragments produced from the breakdown of larger plastic debris like plastic bags and bottles. This occurs through biological and chemical processes that reduce the structural integrity of plastic debris, resulting in fragmentation (Cole et al. 2011). Main sources of SMPs include the abrasion/wearing of paint and plastic products, fragments of plastic waste that have not been treated, and discarded fishing equipment and textiles (Yuan et al. 2022). SMPs are considered to be the largest source of microplastics in the environment.

Wastewater Treatment Plants (WWTPs) are a recognized source of MP discharge to aquatic environments. WWTPs with preliminary and primary treatment remove about 72% of MPs from processed wastewater, while plants with secondary treatment remove about 88%, and plants with tertiary treatment remove nearly 94% (Fuschi et al. 2022).

In the United States, secondary treatment is considered the minimum standard for all WWTPs. In 2014, 1,450 metropolitan WWTPs discharged an estimated 4.8 billion gallons of treated wastewater into the Great Lakes basin. 98% of the wastewater discharged was treated by secondary or higher treatment levels (Fuschi et al. 2022).

Studies of MPs in WWTP effluent in the United States found between 0.02 and 30 MP particles per liter of effluent, resulting in millions to billions of MPs being discharged per day (Mason et al. 2016, Sutton et al. 2016, Michielssen et al. 2016, Conley et al. 2019).

The MPs removed by WWTP get concentrated in sludge or biosolids, the accumulated residue after wastewater treatment, which are disposed of in landfills or land spread. Biosolids have MP concentrations of up to nearly 300 parts per gram (Beni et al. 2023). Land spreading biosolids has been speculated to be a major pathway of MP contamination of agricultural soils and the soils acting as a reservoir of MP pollution.

Currently, there is a lack of research on the fate and behavior of MPs in biosolids and subsequent concentrations in agricultural soils (Harley-Nyang et al. 2023). However, one study estimated that 64 billion MPs are transported to surface waters in the United States from biosolids spread on corn and soy fields, including 250 million-2.5 billion from Wisconsin fields (Beni et al. 2023).

What is the Extent of the Problem: How Pervasive are They?

MNPs are ubiquitous on Earth, and found around the globe in groundwater, surface water, soil, and the atmosphere, contaminating our air, food and drinking water. (Yuan et al. 2022, Lenaker et al. 2019, Wagner et al. 2014, Kosuth et al. 2018, Sajjad et al. 2022, Panno et al. 2019, Allen et al. 2019, Peeken et al. 2018).

Indeed, microplastics literally rain down on us, as microplastics are found in raindrops. One study estimated that national parks and wilderness areas in the Western United States receive over 1,000 tons of microplastics every year falling from the atmosphere in raindrops and dust (Brahney et al. 2020).

MNP pollution will continue to increase as the amount of plastic in the environment continues to increase (Stubbins 2021, Sajjad et al. 2022). In 2015, it was estimated that 4.9 billion metric tons (nearly 60% of all plastics created) were found in landfills or the natural environment. Projections suggest that if unconstrained, that number could rise to about 12 billion metric tons by 2050 (Cox et al. 2019).

Concentrations in Wisconsin Waters

The Great Lakes region has been a focal point in the research of MNPs, accounting for 95% of freshwater in the U.S. (Fuschi et al. 2022). An estimated 22 million pounds of plastic debris enter the Great Lakes annually, with 11.6 million pounds entering Lake Michigan, the largest amount across all the Great Lakes (Fuschi et al. 2022). There is a high variation of recorded MP concentrations within the Great Lakes across several studies, caused by differences in sample locations and sampling and analytical methods (Fuschi et al. 2022). A review by Earn et al. found average microplastic concentrations of 35,000 particles/km^2 (and up to 318,000 particles/km^2) in Lake Superior and 17,000 particles/km^2 in Lake Michigan (and up to 100,000 particles/km^2). National Park beaches Great Lakes in found to have 65 to 221 MP pieces/kg of sand, with the highest count in Apostle Island beaches here in Wisconsin (Whitmire & Van Bloem 2017).

A study conducted by Lenaker et al. (2019) analyzed the contamination of MPs in the inland streams of the Milwaukee River estuary to Lake Michigan. MPs were found in all sampling locations of Milwaukee streams, estuaries, and near-shore Lake Michigan. Higher population density and increasing percent urban land use was positively correlated to higher MP concentrations (Lenaker et al. 2019). Concentrations ranged from 0.21 to 19.1 particles per m^3, which is similar to concentrations from other freshwater studies.

Baldwin et al. (2016) measured MP concentrations in Great Lakes tributaries, including several rivers in WI: Namadji (0.9 particles per m^3), Fox (3.7 particles per m^3), Manitowoc (0.7 particles per m^3), Sheboygan (0.6 particles per m^3), and Milwaukee (5.5 particles per m^3). As with the Lenaker study, population density and urban land use were significantly related to increased concentrations of MPs.

Fish in the Milwaukee River are reported to have MP concentrations ranging from 5-23 particles per fish (McNeish et al. 2018). Similarly, mussels in Milwaukee Harbor are reported to have up to 3 particles per individual (Hollein et al. 2021).

General Ecological Concerns

MNPs have seen a continually increasing presence within aquatic ecosystems in concert with overall plastic production, being detected in biota from plankton to invertebrate species to vertebrate species (Yuan et al. 2022, Hou et al. 2021).

While the toxic effects of microplastic exposure is still a developing area, there are three primary areas of concern:

1. Based on their size and shape, MNP particles have the potential to induce intestinal obstruction or tissue abrasion in smaller aquatic life. Further, MNP surface area is significant enough to possibly activate the intestinal immune system and trigger local inflammation, further accelerating the intestinal uptake of MNPs (Yuan et al. 2022).
2. MNPs can include toxic additives such as pigments, antioxidants, flame retardants, and plasticizers that may be toxic (Yuan et al. 2022).
3. MNPs are also suspectable to absorbing toxic pollutants from the surrounding environment, such as Persistent Organic Pollutants like PCBs and PAHs, as well as PFAS and heavy metals.

Toxic additives used in the production of these plastics can leach out into the surrounding water and sediment as the plastics degrade in the environment (Cera et al. 2020, Fuschi et al. 2022). MPs that are ingested and enter the digestive tract of an organism can leach additives and absorbed pollutants. Consumption of MNPs by aquatic organisms has the potential to introduce these additives to the food chain and accumulate to higher trophic levels, known as biomagnification (Cera et al. 2020, Fushchi et al. 2022, Yuan et al. 2022).

Human Health Concerns

How are We Exposed to Microplastics?

A primary exposure route for MPs into the human system is through the ingestion of contaminated food and water. An often-cited analysis estimated that humans ingest 0.1 to 5 grams of microplastics per week through inhalation, food, and beverages (de Wit & Bigaud 2019, Senathirajah et al. 2021). The upper end is equivalent to eating a credit card's worth of plastic every week. However, this estimate has been criticized as an overestimate (Pletz 2022) and a much lower estimate of 4 µg per week has also been reported (Mohamed Nor et al. 2021).

A typical American diet is estimated to lead to the ingestion of 39,000 – 52,000 MP particles annually from seafood, sugars, honey, and alcohol alone (Cox et al. 2020). Only drinking bottled water (94 particles per L) adds another 90,000 particles annually, while only drinking tap water would add about 4,000 particles annually (4.23 particles per L).

Microplastics have been identified in untreated water sources used by public water systems, but treatment processes at conventional drinking water have removal efficiencies of 70 to >90% (Cherian et al. 2023).

An analysis of various protein products for human consumption, including seafood, chicken, pork, beef, and tofu and found 0.3 MP/g across all products. Chicken breasts and pork loin chops had the lowest concentrations at 0.01 MP/g and shrimp had the highest at 1.3 MP/g (Milne et al. 2024).

There is a lack of studies analyzing MNP concentrations in edible fruits and vegetables (Lazar et al. 2024). However, one study from Italy reported MPs found in apples, pears, carrots, lettuce, broccoli, and potatoes available at markets (Oliveri Conti et al. 2020).

A recent study estimated that bottled water contained on average about 240,000 particles/L of micro- and nanoplastics, significantly higher than prior analyses looking at only MP concentrations (Qian et al. 2024). Nanoplastics accounted for 90% of the total amount of plastic in the bottled water.

However, not all of these particles get into the body from the digestive tract. It is estimated that only 0.3% of particles less than 150 µm are expected to be absorbed and cross the gastrointestinal epithelium, while 0.1% of particles larger than 10 µm can reach organs and cellular membranes (Campanale et al. 2020).

A final important point into the human system is inhalation. MPs can be carried by the wind and atmospheric depositions from the products of wastewater treatment, industrial emission, and dried sludges (Campanale et al. 2020). An estimated 35,000 – 70,000 particles are inhaled annually (Cox et al. 2022).

Dermal absorption (absorbing plastics through the skin) is a potential exposure avenue, but this is considered more likely for nanoplastics than microplastics (Campanelle et al. 2020).

How Does MNP Exposure Impact Health?

To date there is a significant gap in epidemiological studies examining the connection between micro-and nanoplastic exposure to adverse health outcomes. However, accumulation of MNPs in human tissues including the nervous, respiratory, cardiovascular, and reproductive systems has been widely documented (Donisi et al. 2024, Winiarska et al. 2024). For example, one study found MNPs in human kidneys, livers, and brains, with brains having 7-30 times as much plastic as the other organs (Nihart et al. 2025). The total mass of MNP in the average brain was about the same as a typical plastic spoon. Alarmingly, this study also found that MNP concentrations in the body increased by 50% between 2016 and 2024, mirroring the increase in plastics in the environment.

Numerous experiments in laboratory cell cultures or animal models demonstrate how MNPs can alter cell function, otherwise harm cells, and exacerbate disease, which, coupled with their widespread occurrence in the body lead to a wide range of potential health impacts (Donisi et al. 2024, Winiarska et al. 2024). This includes suspected connections to digestive, respiratory, and reproductive health (Chartres et al. 2024, Hu et al. 2024), cancer (Chartres et al. 2024), kidney function (Liang et al. 2024), Alzheimer's disease (Wang et al. 2024)

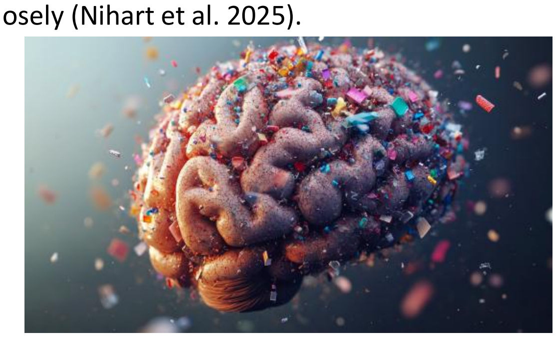
MNPs in the body can release additives, and absorbed toxins, which can lead to physiological harm ranging from oxidative stress and inflammation to cytoxicity to carcinogenic outcomes (Cox et al. 2019, Campanelle et al. 2020). The main additives to MNPs include flame retardants, plasticizers (e.g., BPA, phthalates) and heavy metals. These additives can affect endocrine function, brain development, kidney functions, and reproduction (Campanelle et al. 2020, Li et al. 2024). These plastic additives result in $249 billion annually on plastic-attributable disease burden in the United States (Trasande et al. 2024).

Toxicity is thought to depend on the particle size and characteristics of the plastic itself (e.g., presence of additives, plasticizers, etc.), with polyurethane, polyacrylonitrile, PVC, epoxy resin, and acrylonitrile-butadiene-styrene among the most toxic (Yuan et al. 2022).

MNPs can also be vectors for bacteria and organisms. The ingestion of MNPs has the potential to disrupt the gut microbiome and is associated with dysbiosis, frequent pathogen outbreaks, loss of resilience, and local and systematic metabolic disturbances. The presence of MNPs in the gastrointestinal tract has been associated with the development of diseases of the digestive tract and a decline of intestinal microbiota beneficial to health (Urrutia-Pereira et al. 2023).

In one of the first observational studies relating MNP exposure to health outcomes in humans, patients undergoing carotid endarterectomy for asymptomatic carotid artery disease were analyzed for the presence of MNPs. Patients with evidence of MNPs in carotid plaque samples had a higher risk of nonfatal myocardial infarction, nonfatal stroke, or death than patients with no evidence of MNPs (Marfella et al. 2024).

Another study found 10 times more MNPs in brains of people with dementia than those that did not, identifying a need to study that association more closely (Nihart et al. 2025).



Policy Implications: What Can We Do About This?

As MNPs are a pervasive threat to both human health and ecosystems, there is no single solution to address this widespread problem. Policy changes are needed at the local, state, and federal level, and across sectors, to tackle this issue.

Currently, there is limited policy and regulations occurring at the federal level. (Fuschi et al. 2022). However, a recent petition signed by over 100 consumer advocacy groups was submitted to the EPA that called for the development of a microplastics in drinking water monitoring program (Coneski & Rainer 2024). This petition has the potential to create the groundwork for the official regulation of MNPs in drinking water and align with the National Strategy to Prevent Plastic Pollution (EPA 2024). Additionally, the Clean Drinking Water Act could be utilized more to address plastic pollution on the industry and preproduction side. Currently, most MNP regulations fall on individuals rather than industries, creating policies such as plastic bag taxes and litter collection efforts (Fuschi et al. 2022).

On a state and local level, there are little standards regulating MNPs in Wisconsin. However, there are many efforts aiming to address MNPs throughout the state and the Great Lakes. In 2015, a Microbeads Law was passed to keep microplastics out of state waterways and the Great Lakes (Clean Wisconsin 2015). Additionally, the Alliance for the Great Lakes (AGL) has created an advocacy toolkit to address MNP pollution through policy solutions. Policy solutions include banning single-use foam and plastic bags, requiring ongoing monitoring of MNPs in drinking water, passing laws that enable refilling water containers at local grocery and beauty stores, treating plastic pellet spills like other chemical spills, and requiring washing machine manufacturers to have built-in microfiber filters (AGL 2024).

The health care sector is one of the largest producers of plastic waste in the United States, producing 7 million pounds of plastic waste per day (Ong 2025). Mass production of plastic waste increases the creation of MNPs. Policies are needed at an organizational level to preserve essential uses of plastics while banning unnecessary single-use plastic products in health care, such as returning to cloth sheets or gowns and returning to sterilizable, reusable instruments (Landrigan 2025).

Five states, including the state of Minnesota, passed an Extended Producer Responsibility law that holds packaging manufacturers accountable for their waste production (AGL 2024). Extending these types of laws to other Great Lake states, like Wisconsin, is crucial to the reduction of MNPs in our water. Lastly, a notable example of local action includes a Milwaukee-based coalition known as Plastic-Free MKE. This coalition encourages cross-sector partnerships working to eliminate single-use plastics throughout the city of Milwaukee.

Addressing MNPs in our drinking water and waterways requires a multi-faceted approach, with policy implementation at all levels. Other policy recommendations include:

- Prioritize funding for MNP research and its impact on human and environmental health to address current data gaps.
- On a large-scale level, streamline data collection methods and monitoring measures related to MNPs.
- Uphold the Great Lakes Water Quality Agreement and extend it to include pollution originating from land (Fuschi et al. 2022).

- Extend policies such as the Microbead-Free Waters Act to also include products like lotion and makeup (current products include toothpaste, nonprescription drugs, and rinse-off cosmetics) (Fuschi et al., 2022).
- Advocate for federal bills like the Plastic Pellet Free Waters Act, that requires the EPA to prohibit certain discharges of plastic pellets into U.S. waters (Fuschi et al. 2022).
- Encourage cross-sector collaboration efforts to reduce MNP pollution in Wisconsin waterways. For example, the Great Lakes Land-Based Marine Debris Action Plan created by NOAA (National Oceanic and Atmospheric Administration) is an effort between governments, researchers, NGOs, and businesses to address pollution around the Great Lakes (Fuschi et al. 2022).
- Hold plastic manufacturers responsible for their production through state Extended Producer Responsibility laws.
- Implement local and statewide working groups that coordinate with stakeholders to drive action-based MNP interventions.
- Encourage cities to pass ordinances to reduce the use of single-use plastics and develop public education campaigns surrounding this issue (i.e. plastic water bottles, plastic packaging and plastic bags) (AGL 2024).

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Additional Resources

Clean Wisconsin: Clean Water, Clean Air, Clean Energy - Clean Wisconsin

EPA Microplastic Research: Microplastics Research | US EPA

Plastic-Free MKE: PlasticFreeMKE

EPA's National Strategy to Prevent Plastic Pollution: National Strategy to Prevent Plastic Pollution: Part Three of a Series on Building a Circular Economy for All

Alliance for the Great Lakes Plastic-Free Advocacy Toolkit: AGL_AAB_PlasticToolkit_July_2024_FINAL.pdf