

Microplastics: Invisible Pollutants and Their Effects on Human Health

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Abstract:

Plastic particles smaller than 5 mm in diameter are known as microplastics, and they have become ubiquitous contaminants in both terrestrial and aquatic settings. The chemical makeup of microplastics, how they enter the body, and the possible health effects of long-term exposure are all examined in this essay. We focus on the chemistry of microplastics, analysing their surface chemistry, polymer composition, and ability to adsorb harmful compounds that can lead to endocrine disruption, oxidative stress, and other negative health effects.

Keywords:

Plastic particles, microplastics, chemicals, surface chemistry, polymer, health effects

Introduction :

Plastics are used all around the world. Only 9% of the 460 million tons of plastic products produced annually worldwide in 2019 were recycled, and by 2060, that number is expected to rise to 1.2 billion tons. A lot of plastics end up in the environment due to high yield and low recovery. Among the most common commercial plastics on the market are polyvinyl chloride (PVC), polypropylene (PP), polyethylene (PE), polyethylene terephthalate (PET), and polystyrene (PS). As plastics are crushed, broken, and degraded during usage, tiny fragments or particles are produced. Plastic particles were initially found in Atlantic surface waters in the 1970s. Thompson et al. introduced the idea of “microplastics” for the first time in a publication published in Science.

Plastic particles and pieces less than 5 mm in diameter are referred to as microplastics. When their diameter is less than 1 μm , they are referred to as nanoplastics. Microplastics actually have particle sizes ranging from a few microns to a few millimeters. In contrast to manufactured nanomaterials, this mixture of diversely shaped plastic particles is posing a growing threat to human health. In addition to the bigger plastics, microplastics are also made specifically and incorporated into cosmetics and face cleansers, among other personal care items.

Numerous microplastics are also produced by industrial processes including the flocking, plastics, and synthetic textile industries. After being cleaned by the sewage treatment plant, an estimated 65 million microplastic particles are discharged into the water each day.

From the south to Antarctica, from the north to the Arctic, from the south to the Mariana Trench, and from the top of Mount Everest, microplastics have been found. The majority of marine trash is made up of plastic. Over eight million tons of plastic debris entered the oceans in 2017, which is more than 33 times the total amount of plastic debris that had accumulated in the oceans by 2015. Nevertheless, the amount of microplastics in the environment can be overestimated because of the limitations of capturing techniques. According to Lindeque et al., the concentration of microplastics is 2.5 times higher when using nets with a 100 μm mesh and 10 times higher when using nets with 333 and 500 μm mesh, respectively.

Additionally, they estimate that using nets with a 1 μm mesh size could result in microplastic concentrations exceeding 3700 microplastics m^{-3} . Through the bioaccumulation of the food chain, microplastics can have a significant effect on the food web by reducing the availability of nutrients in microalgae or by being directly consumed by creatures.

One of the biggest environmental problems of the twenty-first century is plastic pollution. The United Nations Environment Assembly (UNEA) has debated it and passed a landmark resolution named “End plastic pollution: Towards an international legally binding instrument.” It is very difficult to identify the harmful impacts and possible health

risks of microplastics in the actual world because of their incredibly complicated sources, more varied occurrences, and more hidden hazards. The dearth of knowledge regarding the microplastics to which humans are exposed is one of the primary issues in assessing the risk of microplastics to human health.

Research on the origin, prevalence, and toxicity of microplastics in the real world is constrained by the qualitative and quantitative examination techniques. There is a rapid rise in toxicological research on microplastics. According to experiments, exposure to microplastics causes a number of harmful effects, such as immunological response, metabolic disorders, oxidative stress, neurotoxicity, and toxicity to the reproductive and developmental systems. Nevertheless, systematic research on the absorption, metabolism, migration, transformation, and accumulation of microplastics is lacking due to the limitations of current technical approaches. Additionally, there is a lack of research regarding possible harmful impacts and health risks, such as the primary determinants of microplastics' hazardous effects. This study focuses on the latest findings about the toxicity of microplastics and provides a brief overview of the routes by which humans are exposed to them as well as the identification of microplastics in living things and human bodies. Next, we make recommendations for potential development paths.

Sources of Microplastic:

There is ample evidence that watercourses contain microplastics with various shapes, sizes, densities, structures, and chemical compositions (Auta et al. 2017) There are different sources of microplastics such as:

Land-based sources of microplastics: Land-based sources are responsible for 80–90% of microplastics in water bodies (Duis and Coors 2016). These sources include plastic bags, bottles, personal care products, construction materials, and clothing. Plastic incinerators, which generate bottom ash that contains microplastics, are also a land-based source of these particles (Yang et al. 2021). Among the most important sources are trash from shipbuilding, construction materials, household goods, packaging, and food and Drink packaging of bigger plastic items on land (Alomar et al. 2016; Eulin and Bieliæ, 2016). Other likely sources of microplastic discharge into the aquatic environment include sewage sludge and industrial operations, especially those utilizing granules and tiny resin pellets (Rolsky et al. 2020; Hale et al. 2020).

Apart from medications and building supplies, some cosmetics and personal hygiene items are also thought to be possible contributors to plastic pollution because they could include microplastics that are either components or medication transporters (Rochman 2018). Typical examples of these goods are face washes, hand soaps, hand gels, laundry detergents, toothpaste, washing powder, face creams, mascaras, lipsticks, sunscreen, and

shower gels (Guerranti et al. 2019).

It has been discovered that a variety of synthetic fibres, including polyester, nylon, and acrylics, shed off garments and enter aquatic bodies with wastewater. Microplastics are released into the environment in large quantities by car tire wear and tear (Kole et al. 2017). Consequently, it is evident that many sources of microplastics need to be efficiently managed and reduced as much as feasible.

Ocean-based source of microplastics:

Between 10 and 20 percent of the microplastics released into the aquatic environment originate from ocean-based sources, such as commercial fishing, marine vessels, and beachside tourists. And offshore sectors (Karbalaee et al. 2019; Li 2018). Fishing gear that is lost or discarded, such as nylon nets and plastic monofilament lines, is a major source of microplastics, which can float in the water at various depths (Naji et al. 2017). The issue is exacerbated by the annual disposal of more than 600,000 tonnes of fishing gear into the ocean (Good et al. 2010). The issue is further exacerbated by shipping microplastic trash, which is frequently discharged from naval and shipping boats (Peng et al. 2018). Additionally, an enormous amount of Marine ecosystems are being exposed to plastic trash from offshore sectors like petrochemicals (Calero et al., 2021). Although not as large as land-based sources, ocean-based sources nevertheless contribute significantly to microplastic contamination. To lessen this contribution, control measures are required. Around 4.3 billion people worldwide get 15% of their animal protein from fish. Laboratory studies have shown that fish can consume microplastics, but they used much larger amounts of microplastics than those found in the natural environment .

Since the source is typically not consumed, the presence of microplastics in fish gastrointestinal tracts (GIT) does not directly indicate human exposure. Following the consumption of microplastics, it has the ability to leach and accumulate related chemical pollutants in edible tissue. Because microplastics can enter the circulatory system through paracellular diffusion or transcellular absorption and pass through the gastrointestinal tract or gills, exposure to microplastics is possible in fish. This exposure route is less likely in fish because the gill's respiratory epithelium is much lighter and tighter than that of mammalian lungs; uptake through the fish's gut is more likely . Humans may be directly exposed to microplastics (e"lim) if they consume skin or gill tissue.

Currently, bivalved mollusk shellfish are the main source of dietary exposure to microplastics. Around 22 million tons of fish were produced worldwide in 2012 from capture and aquaculture, making shellfish a significant food source (nearly \$15 million USD).

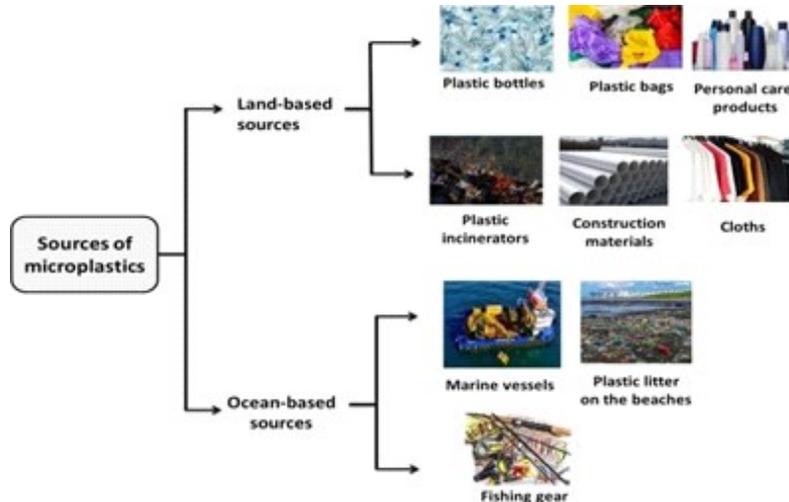


FIGURE 1: Sources of marine and terrestrial microplastics. 80–90% of the microplastics found in aquatic bodies come from land-based sources, such as plastic bags, bottles, and personal hygiene items. Textiles, building materials, and plastic incinerators. Ten to twenty percent of microplastic flow into water bodies comes from ocean-based sources, mostly fishing gear, marine boats, and beach litter

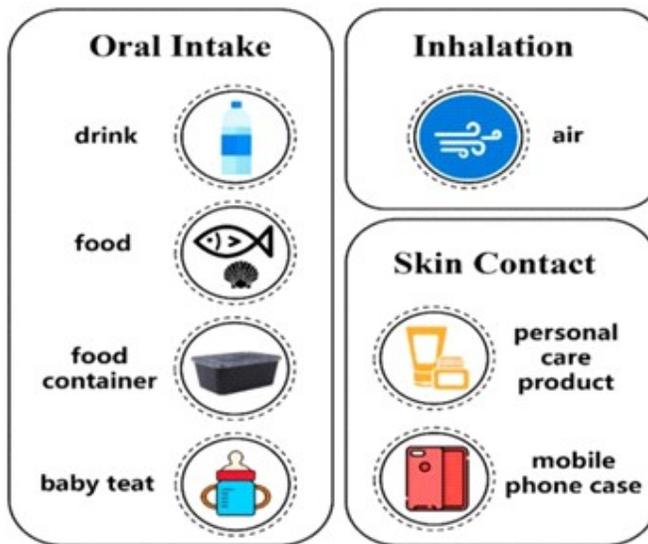
Other sources of invisible plastics are as follows :

- **Synthetic fibers in the wash :** Thousands of minute fibers are released with each washing of synthetic clothing, such as polyester, fleece, and acrylic. Over half of the one million tons of these microscopic fibers that are released into wastewater each year avoid treatment and end up in the environment.
- **Tire Dust:** Tires made of styrene butadiene that wash into sewers and then into rivers, streams, and the ocean. For every 100 kilometres driven, cars and trucks release almost 20 grams of tire dust. It builds up. For instance, every Norwegian woman, man, and child generates one kilogram of tire and road dust annually.
- **Paints:** Over 10% of the microplastic pollution in the oceans is caused by dust from house paint, ship paint, and road markings. Studies have demonstrated that the ocean surface is covered in paint dust.
- **Secondary Microplastics:** Every year, at least 8 million tons of improperly disposed of plastic debris end up in the world’s rivers, lakes, and seas. Paints that include chemicals pose a serious Risk to one’s health. More than 8 million microbes are thought to have contaminated US waters in 2015 , and they are prohibited in the US and Canada in face cleansers and some other cosmetics.

- **Airborne synthetic fibers:** Researchers are starting to look at how small fibers enter the atmosphere and how they contribute to pollution on land and in the ocean. One theory is that clothes fibers break off into the air due to common abrasion, which is the simple friction of your limbs rubbing against one another. According to a 2015 research conducted in Paris, 3–10 tons of aerial fibre reach the city’s surface annually.

Pathways of Human Exposure To Microplastics:

Because of their widespread presence in the environment and their documented harmful consequences, microplastics could be dangerous to human health. It’s critical to comprehend how humans are exposed to microplastics.. Oral ingestion is the primary exposure method among them. In actuality, people frequently encounter microplastics in a variety of ways at once. According to Rilling et al., the term “plastic cycle” in science refers to the ability of microplastics to move between various environmental media. The risk of human exposure is increased by the mobility of microplastics.



ORAL INTAKE : The consumption of shellfish exposes Europeans to approximately 11,000 microplastic particles per person annually , and the human body absorbs between 39,000 and 52,000 particles per person annually based on food consumption. It’s possible that microplastics were extensively dispersed throughout the soil, particularly in agricultural systems. They can enter a plant’s water transport system and proceed to the roots, stems, leaves, and fruits, particularly if they have a negative charge. Microplastics will pollute food once they get into agricultural systems through sewage sludge, compost, and plastic mulching, which could raise the danger of human exposure.

INHALATION: Although microplastics are generally thought to be unable to penetrate the skin barrier, their accumulation on the skin can nevertheless raise the risk of exposure. For instance, using consumer goods like face cream and cleanser that contain microplastics will raise the chance of PE exposure. When used, protective mobile phone covers (PMPCs) have the potential to produce microplastics that end up on human hands. Children may encounter microplastics on the ground while they crawl or play. Certain common plastic additives, such as triclosan (TCS), bisphenols (BPs), phthalates, and brominated flame retardants (BFRs), may be absorbed when microplastics are exposed topically.

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Effects of Microplastics On Human Health :

Microplastics are typically thought to be expelled from the human body through the gastrointestinal and biliary systems after entering it. Nonetheless, scientists find that human blood contains microplastics. The dangers of microplastics to human health are being re-examined. More and more attention is being paid to the consumption, movement, buildup, and metabolism of microplastics in the human body. Investigating the possible negative consequences of microplastics requires first understanding their concentration in the human body. According to a recent assessment, microplastics have been discovered in 15 human biological components, including the spleen, liver, colon, lung, feces, placenta, breastmilk, and more. They are also carried throughout the body by blood circulation.

Babies and expectant mothers are particularly vulnerable to microplastic exposure. Infants may be exposed to significantly more microplastics than adults, as evidenced by the fact that the concentration of PET in their feces (5700–82,000 ng/g, median: 36,000 ng/g) is 10 times higher than that of adults (2200–16,000 ng/g, median: 2600 ng/g). For the first time, the Ragusa team found 12 microplastic fragments in human placenta, with sizes ranging from 5 to 10 μm . They also found PVC and PP microplastics in human breastmilk, with sizes ranging from 2 to 12 μm . Since then, other research has found microplastics in breastfeeding, meconium, and placenta. Zhu et al. Identify 11 different types of polymers with diameters ranging from 20.34 to 307.29 μm and find microplastics in 17 placental samples. In order to identify 16 different forms of microplastics in samples of

placenta, meconium, newborn feces, breastmilk, and infant formula, Liu et al. enlist 18 pairs of mothers and infants. Over 74% of microplastics have a size between 20 and 50 μm . The DOHaD theory states that persons who encounter negative circumstances during their early development are more likely to develop obesity, diabetes, cardiovascular disease, and other chronic illnesses as adults. . The discovery of microplastics in the human placenta highlights the possibility that these non-biodegradable substances could impact the developing fetus and have an impact on the human body over generations. Therefore, the possible effects of early exposure on babies and early embryonic development should receive further investigation.

The pervasiveness of microplastics in the environment was highlighted in a recent report by the “World Health Organization” which also raised serious concerns about their exposure and potential health consequences on people. The consumption of tainted food is one of the main ways that nano and microplastics enter the human body. According to a recent study by sugar included 0.44 MPs/g of nano and microplastics, salt contained 0.11 MPs/g, alcohol contained 0.03 MPs/g, and bottled water had 0.09 MPs/g. Additionally, it is predicted that humans consume 80 g of microplastics daily through plants (vegetables and fruits) that absorb MPs from contaminated soil. It is now widely known that marine animals that humans eat, such as fish, bivalves, and crabs, contain microplastics. . For instance, it has been discovered that the microplastic quantity in *Mytilus edulis* and *Mytilus galloprovincialis* from five European nations varies between three and five fibers per 10 g of mussels.

The ability of synthetic particles smaller than 150 μm to pass through the gastrointestinal epithelium in mammalian bodies, resulting in systemic exposure, suggests that absorption in humans is possible after exposure through meals. Only 0.3% of these particles are anticipated to be absorbed, according to scientists, whereas a smaller fraction (0.1%) that contains particles larger than 10 μm should be able to pass through the placenta and blood–brain barrier as well as organs and cellular membranes. . Although there is currently little information on micro- and nanoplastics in the environment because of the analytical and technical challenges in extracting, characterizing, and quantifying them from environmental matrices, exposure concentrations are expected to be modest. The body may develop an immunological reaction to microplastics. According to Yuan ., zebrafish exposed to PE create mucosal immunoglobulin and activate their intestinal immune network route. Induction of cytotoxic effects on T98G and HeLa cell lines (human brain and epithelial cells) has been demonstrated through the use of metal nanoparticles (NPs) (AgNP and AuNP, ZrO₂NPs, CeO₂NPs, TiO₂NPs, and Al₂O₃NPs), carbon nanomaterials (C₆₀ fullerene, graphene), and polyethylene (PE) and polystyrene (PS) microplastics. . Furthermore, depending on the size (~20 μm and 25–200 μm) and doses

employed in the various assays, the usage of polypropylene (PP) particles has demonstrated distinct but detrimental effects on different cell types. Therefore, there may be a risk to human health when microplastics interact with humans since they can cause cytotoxicity, hypersensitivity, unintended immunological responses, and acute reactions including hemolysis. The majority of recent *in vitro* research on the effects of plastics on the human body has made use of manufactured nanoplastics, which, because of their size, charge, and shape, can affect not only their absorption but also the translocation and generation of ROS. Actually, the study examined the interaction between the gastrointestinal epithelium's secretory film—the first physical barrier following digestion—and positively-charged polystyrene nanoparticles (60 nm). In intestinal epithelial cell lines LS174T, HT-29, and Caco-2, nanoplastics demonstrated a potent ability to interact with the secretion film, affect cellular viability, and trigger apoptosis. The study, which used polystyrene nanoparticles of 20 and 40 nm on adenocarcinoma colon–rectal human differentiated cells, Caco-2, already showed those harmful effects. The impact of microplastics on reproduction is demonstrated by the quality of the embryo and the growth of germ cells. For example, Liu et al. find that PS exposure affects the development of oocytes and the size of female mouse follicles, lowering the quality of oocytes. Microplastics may affect pregnancy outcomes by causing immunological disorders. Deng claims that after extended exposure to ecologically suitable PS doses, male mice's fertility is affected by a significant drop in sperm quality.

WAYS TO REDUCE MICROPLASTIC: It is impossible to totally prevent microplastics or the toxins included in plastic. However, these minor actions can aid in preventing at least needless additional exposure.

- Drinking water is one of the main sources of microplastic consumption, but bottled water contains roughly twice as much microplastic as tap water, according to Sherri Mason, a chemist who has researched plastic in beer, tap water, sea salt, and bottled water at Penn State Behrens. Avoid cooking food in plastic since it has been shown that heating plastic might cause toxins to seep into food. It results in the leaking of BPA and phthalates from plastic into food.

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- Reduce household dust: Human health is also at risk from exposure to chemicals, such as phthalates, polyfluoroalkyl compounds, flame retardants, and flaws. According to the Silent Spring Institute, daily vacuuming can help lower exposure to dust in the home.

- Steer clear of plastic food containers: According to the AAP report, recycling codes “3, 6, and 7” successively denote the presence of BPA, phthalates, bisphenol, and styrene. Greenware or bio-based items should be used on a regular basis or added to

kitchenware since they don't contain bisphenol. Purchase eco-friendly, non-synthetic clothing: Companies like SLO Active are cleaning up the oceans by producing swimwear and wetsuits that are suitable for the ocean. Aizome Bedding is a zero-waste, all-cotton bedding company that uses natural indigo dyeing to create organic bedding. Natural fibers like cotton, linen, silk, and wool are used to make these kinds of bed linens, which are beneficial to the skin because they let it breathe and regenerate.

Conclusion :

Microplastics are inhaled, consumed orally, and come into contact with human skin. Numerous human body parts and a wide range of creatures have been found to have microplastics. We draw attention to the possible effects of microplastics on infants' early exposure and embryos' early development. According to current toxicity studies on microplastics, exposure will result in lipid buildup, flora imbalance, intestinal damage, and liver infection before developing into a metabolic illness. Furthermore, exposure to microplastics lowers the quality of germ cells, inhibits acetylcholinesterase function, raises the production of inflammatory markers, and has an impact on embryo development. Finally, we hypothesize that exposure to microplastics might be linked to the development of a number of chronic illnesses. The essential tools for accurate quantitative and dynamic tracking, multiscale characterisation, and exact

Identification of microplastics in living things. It is currently very difficult to accurately reveal the potential health risks of microplastics because commonly used analytical methods can only detect microplastics at the micron level. Nanoplastics, on the other hand, are much smaller and have a greater potential for harm. Additionally, efficient dynamic tracing methods are still lacking. Therefore, the main issue is how to correctly detect, quantify, and dynamically trace the microplastics in organisms. By fully leveraging current imaging and analysis technologies, such as SEM, CLSM, Raman spectroscopy, and others, it could be enhanced. The biological processes that include overcoming biological barriers and the absorption, metabolism, accumulation, and movement of microplastics. The main components of the microplastics' bioprocess cannot be clearly identified from the existing research findings, despite studies demonstrating that microplastics can penetrate the circulatory system and reach other tissues. A thorough investigation into the fundamental biological mechanisms of microplastics must be conducted at the "individual-tissue-cell-subcellular" level. The transport process, distribution in tissues and organs, single cell atlas, and intracellular localization are among the topics covered, however they are not the only ones. The "actual" quantitative correlation between microplastic exposure levels and their harmful consequences, as well as the combined harmful impacts of microplastics and other contaminants. Even though researchers have used a variety of experimental models to find some harmful consequences

of microplastic exposure, they typically use high exposure dosages. A more comprehensive assessment of the harmful consequences of microplastics must be conducted, taking into account both the full life cycle of organisms and the actual concentration in the environment. Microplastics typically absorb other contaminants, particularly hydrophobic organic compounds and heavy metals, due to their high surface energy. More research is necessary to determine whether the harmful mechanism and microplastics and adsorbed contaminants work in concert. The link between harmful health effects and microplastics. The damage that microplastics cause to the human body is currently unknown, and practically all research on their toxicity uses experimental models. It is necessary to gather clinical and epidemiological data. The internal link between exposure to microplastics and potential negative health effects can be investigated using biomarkers. To detect the risk of microplastic exposure early, a machine learning-based health risk assessment model should be developed.

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