



REVIEW ON MICROPLASTIC PARTICLES

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ABSTRACT

Microplastics are tiny plastic particles measuring less than 5 mm in diameter that originate either from the intentional manufacture of microscopic plastics or from the degradation of larger plastic materials. Due to the extensive use of plastic products worldwide, microplastics have become ubiquitous contaminants in marine, freshwater, and terrestrial environments. These particles have been detected in drinking water, seafood, salt, honey, and even in atmospheric air, leading to widespread human exposure through ingestion, inhalation, and dermal contact. Once inside the body, microplastics and nanoplastics can distribute to various organs including the liver, lungs, kidneys, heart, brain, and blood. Studies indicate that these particles can cross biological barriers such as the blood–brain barrier and may cause oxidative stress, inflammation, endocrine disruption, immune dysfunction, and cellular damage. Microplastics also act as carriers for toxic chemicals and persistent organic pollutants, further increasing their potential health risks. Experimental and epidemiological evidence suggests that prolonged exposure may contribute to neurological disorders, respiratory diseases, metabolic disturbances, reproductive toxicity, and cardiovascular complications. In addition to human health concerns, microplastics significantly impact marine ecosystems by entering the food chain and accumulating in aquatic organisms. The increasing global production of plastics and inadequate waste management have intensified the problem of microplastic pollution. Therefore, understanding the sources, distribution, exposure pathways, and toxicological effects of microplastics is essential for assessing their environmental and biological impacts and for developing strategies to mitigate plastic pollution and protect both ecosystem and human health.

INTRODUCTION

Microplastics are either intentionally created or plastic degraded. Microplastics are ubiquitous in nature. They affect both wildlife and humans. They have been detected in many marine species, but also in drinking water and in numerous foods, such as salt honey and marine organisms.

Microplastic exposure can also happen by inhaling air. Data from animal studies have shown that once absorbed, plastic micro and nano particles can distribute to the liver, spleen, heart, lungs, thymus, reproductive organs, kidney and even the brain [crosses the blood-brain barrier]. After the entry they cause disruption of endocrine, immune system, can have



negative impact on mobility, reproductive and can cause carcinogenesis.

“Microplastics are any synthetic solid particle or polymeric matrix, with regular or irregular shape and with size ranging from 1 μm to 5 mm, of either primary or secondary manufacturing origin, which are insoluble in water”. [1]

Microplastics are the particles which size ranges below 5mm [$<5\text{mm}$] in diameter. They are of two types.

1. Primary microplastics
2. Secondary microplastics

PRIMARY MICROPLASTICS

These are the microplastics which are manufactured intentionally. Examples of primary microplastics include microbeads found in personal care products, plastic pellets (or nurdles) used in industrial manufacturing, and plastic fibres used in synthetic textiles (e.g., nylon). [2]. Their release into the environment can be blocked as long as we stop production. [3]. It is worth noting that for the definition of primary microplastics, we should also focus on “artificially generated”. Thus, we can define primary microplastics as “*plastics are intentionally manufactured by people to be of microscopic sizes*”. Primary microplastics are estimated to represent between 15-31% of microplastics in the oceans.

SECONDARY MICROPLASTICS

Large plastic particles will undergo biodegradation to form microplastics. Degradation of plastics occurs due to exposure of plastic to UV radiation, mechanical forces and biodegradation. Secondary microplastics contribute more in plastic pollution. we can define secondary microplastics as “larger plastic fragments become unintentionally

produced smaller particles through physical, chemical, and/or biological processes”. The problem with microplastics is that—like plastic items of any size—they do not readily break down into harmless molecules.[4]. Microplastics have been detected in marine organisms from plankton to whales, in commercial seafood, and even in drinking water. It is estimated that in last decade, more plastic has been manufactured and used than in whole last century. The first known research on Microplastics was reported by E. J. Carpenter and K. L. Smith in the year 1972. The study was based on the smallest plastic debris. (Carpenter et al., 1972). The study was based on the smallest plastic debris. [5]. Another plastic particulate is nanoplastics, they are the plastic fragments which are less than 100 nm in size. Due to fragmentation and weathering effects of plastic material trash nano plastics are formed. The microplastics and nanoplastics became a normal use of production materials as it is widely used in different fields like semiconductors, clothes, drugs carriers and cosmetics materials. “Microplastics are of particular concern due to the negative effects on marine and freshwater environments, aquatic life, biodiversity, and possibly to human health since their small size facilitates uptake and bioaccumulation by organisms or toxic effects from the complex mixture of chemicals these particles consist of.” Account for 69-81% of microplastics found in the oceans.

The global scenario of plastic pollution

(a) It is estimated that the world uses around 5trillions of plastics bags annually.

(b) It is estimated that around

13millions of plastic waste get accumulate in the seas and oceans annually.

(c)It is estimated that in last decade, more plastic has been manufactured and used than in whole last century.

(d)We use 50% plastic as single-use plastics or disposable.

(e)Plastics waste makes up more than 10% of the total waste we generate daily.

Plastic is found everywhere in environment due to its wide use in packaging of dairy products, meat, fish or drinks, including mineral water are storing in plastic containers. Contact between food and plastic packaging is almost always cause of mutual transfers between containers and contents. [6]. The presence of microplastics has been detected in soil ecosystems, surface waters, coastal sediments, beach sands, freshwater sediments and deep environments; even rain and snow contain significant numbers of microplastics that can sometimes be invisible to the naked eye. Humans are potentially exposed to microplastics through oral intake, inhalation, and skin contact. We summarize the toxic effects of microplastics in experimental models like cells, organoids, and animals. These effects consist of oxidative stress, DNA damage, organ dysfunction, metabolic disorder, immune response, neurotoxicity, as well as reproductive and developmental toxicity. In addition, the epidemiological evidence suggests that a variety of chronic diseases may be related to microplastics exposure. [7]. Plastics are used worldwide. In 2019, the global annual output of plastic products reached 460 million tons, only 9% of which are recycled, and it is estimated that it will reach 1.2 billion tons

by 2060. Microplastics are also specially produced and added to personal care products such as facial cleansers and cosmetics. Plastic is the largest part of marine garbage. Microplastics in the real environment have extremely complex sources with more diversified occurrences and more hidden hazards, which brings about great challenges in revealing their toxic effects and potential health hazards.

SOURCES OF MICROPLASTIC



Inadequate management of plastic waste has led to increased contamination of fresh water and marine environments. Plastic materials represent between 60% and 80% of the waste present in the marine environment and 90% of the waste floating on the sea and oceans. Plastic waste present in the marine environment is a threat to both the environment and marine fauna due to the risk of being swallowed by marine life. Plastic waste has a negative impact on the health of marine ecosystems as evidenced by the increasing number of marine species affected. These fragments of plastic material, decomposed into microplastics in suspension in the water column or deposited in sediments, slowdown or prevent the vertical transfer of oxygen. In a recent study, it is specified that people consume on an average of 39,000 – 52,000 microplastic particles per year. This result was obtained on the basis of studies in which the amounts of

microplastics that different foods contain are evaluated. If the estimates for inhaled microplastic particles are added, the number can rise to around 74,000 particles. For drinking tap water, another 4000 particles; for drinking water stored in plastic bottles the number increased by 9000 particles. It is possible that in reality the values are much higher.



Microplastic behavior in the oceans is similar to that of marine planktons and they can be ingested by aquatic fauna, being mistaken for small natural prey and consumed by filter feeding species, such as bivalve mollusks or absorbed on macroalgae. Given their high nutritional value, seafood plays an important role in the human diet and therefore the consumption of these contaminated foods represents an increased health risk especially for small fish eaten whole. These microplastics are potential carriers of chemical contaminants, such as the additives that constitute them and persistent organic pollutants that are adsorbed and concentrated in them. Several studies have highlighted the presence of microplastics in numerous commercial aquatic species such as mussels, oysters, crabs, shrimps and fish.

The potential accumulation of microplastics in food chains, particularly in fish and crustaceans, appears to be the main source of human exposure to

microplastics. The passage of microplastics from the intestine into the circulatory system and tissues and cell in humans has been studied by several authors, and it has been observed that the absorption of microplastic particles from the gastro intestinal tract into the lymph and circulatory system occurs.

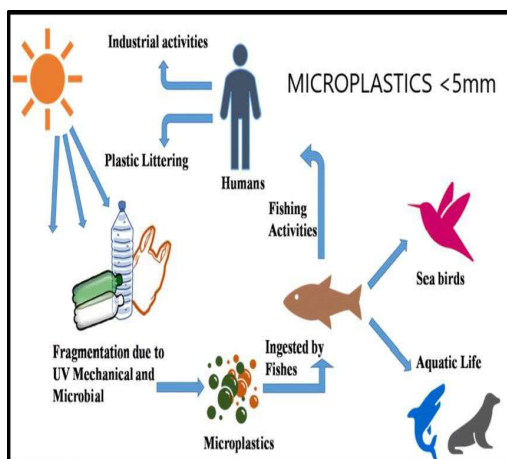
Microplastics found in the sea can be ingested by marine animals. The plastic then accumulates and can end up in humans through the food chain. They have been found in food and drinks, including beer, honey and tap water. Not surprisingly, plastic particles have also recently been discovered in human stool. [8]. Microplastics are present in soil [9], marine environment [10].

ENTRY OF MICROPLASTIC

Microplastic particles enter the human body primarily through ingestion, inhalation, and dermal contact ingestion is the most common route, with microplastics found in food, water and even air inhalation can also occurs, as airborne particles are known to be present in the environment. Dermal contact, while less studied, is another potential entry point.

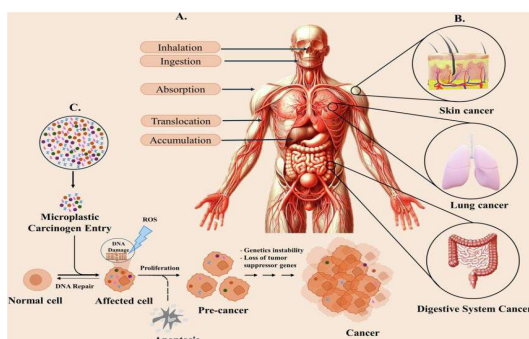
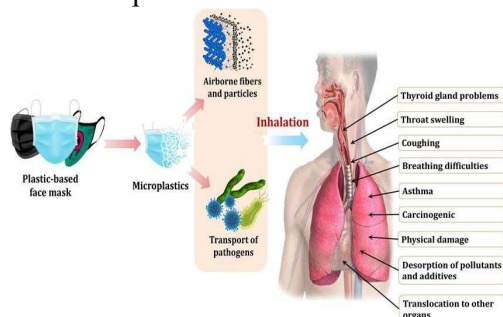
INGESTION

Microplastics are found in various foods, including sea food, and can leach from plastic packaging or containers. They can also be present in drinking water, bottled water, and even common beverages like tea and coffee. Studies have found microplastics in salts from lakes and oceans, as well as commercial salts and bottled water. Some research suggests that infants may be exposed to high levels of microplastics through formula prepared in propylene feeding.



INHALATION

Microplastics can be found in the air we breathe. Small airborne particles can potentially travel to the brain via the olfactory bulb. While not a major route, inhalation can still contribute to the overall exposure.

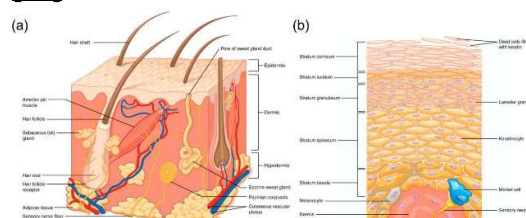


DERMAL CONTACT

Microplastics can potentially enter the body through the skin via personal care

products and cosmetics. This route is less understood than ingestion or inhalation, but it's still a potential pathway for exposure.

Evidence is growing that our food and water is contaminated with microplastics. [11].



ORGANS CONTAINING MICROPLASTICS

Microplastics have been found in a wide range of human organs and tissues including the brain, lungs, liver, kidney, heart, gastrointestinal tract and even blood, breast milk and placenta

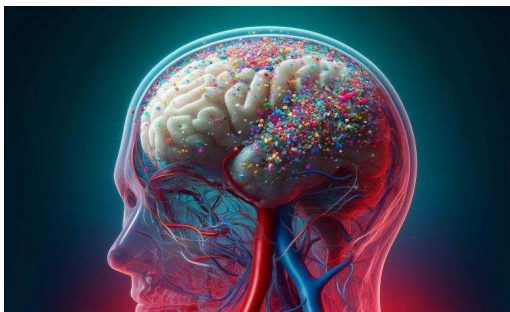
BRAIN

Microplastics can enter the brain and negatively impact brain cells, potentially leading to inflammation, altered brain function, and even neurodegenerative diseases. Prolonged exposure to microplastics or nanoparticles can lead to a series of health problems in humans, particularly toxicity to the nervous system, with consequences including neurological inflammation, and neurodegenerative diseases. "Our brains today are 99.5 % brain and the rest is plastic." Researchers also found an additional three to five times of shard-like plastic fragments in the brains of 12 people who had been diagnosed with dementia before their death compared to healthy brains. Nanoscale plastics can breach the blood brain barrier, leading to neurotoxic effects. When microplastics/ nano plastics are present in the brain they can initiate a series of

molecular or cellular reactions that may harm the blood-brain barrier, cause oxidative stress, trigger inflammatory responses, affect acetyl cholinesterase activity, lead to mitochondrial dysfunction, and impair autophagy.

EFFECTS ON BRAIN CELLS

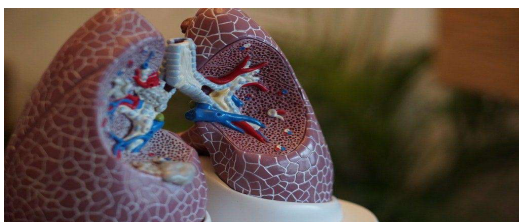
Inflammation, Cell death, Disruption of proteins, impaired brain function, Neurodevelopmental issues, Neurodegenerative diseases, Oxidative stress. [12]



LUNGS

Microplastics, tiny plastic particles, can enter the lungs through inhalation and have various negative effects. They can induce inflammation, oxidative stress, and potentially lead to impaired lung function and respiratory illnesses. Research suggests that microplastics can contribute to conditions like asthma and pneumoconiosis. [13] [14]

Entry of microplastics into the Lungs:



Inhalation:

Microplastic can be inhaled into the respiratory system, reaching even the

deepest parts of the lungs

PARTICLE SIZE

Smaller microplastic [less than 2.5 micrometers] can penetrate the alveoli, the tiny air sacs in the lungs.

PERSISTENCE

Microplastics are not easily cleared from the lungs and can accumulate over time.

Effects of microplastics on lung health:

Inflammation, Oxidative stress, Lung function impairment, Respiratory diseases Fibrosis, Synergistic effects, Cellular damage

LIVER

Microplastic can enter the liver through the gut-liver axis, leading to various adverse effects, including liver damage, altered metabolism, and increased oxidative stress. Once ingested, microplastics can accumulate in the gut, disrupt the gut microbiota, and weaken the intestinal barrier [portal vein channel along gut-liver axis] and reach liver, causing liver damage [inflammatory damage, metabolic disorders, oxidative stress, etc.]. Microplastics have been observed in liver samples from patients with cirrhosis; however, the exact mechanism is unclear. [15]

Entry of microplastics into the liver:

GUT-LIVER AXIS

Microplastics, once ingested, can disrupt the gut microbiome and intestinal barriers, allowing harmful bacteria and metabolites to enter the blood stream and reach the liver through the portal vein. [16]

ABSORPTION AND CIRCULATION:

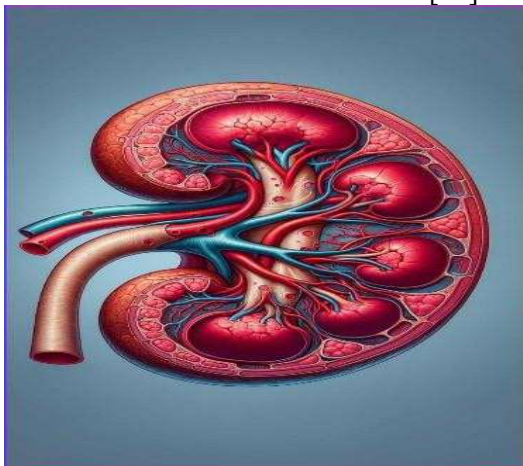
Nano plastics, especially, can be absorbed by epithelial cells and enter the lymphatic and blood circulation, eventually reaching the liver. [17]

EFFECTS ON LIVER

Inflammatory damage, Metabolic disorders, Oxidative stress, Metabolic disturbances, Hepatocyte toxicity, Mitochondrial damage, Liver fibrosis

KIDNEYS

Most of the studies performed on nano plastics and microplastics toxicity on kidney have been published in the last two years. Microplastics can enter the kidneys through various pathways, including ingestion, inhalation, and potentially through the bloodstream. In the kidneys, microplastics can cause damage by disrupting nephrogenesis, impairing cell function, and inducing oxidative stress and inflammation. [18]



ENTRY OF MICROPLASTICS INTO THE KIDNEYS

Ingestion

Microplastics present in food and water can be ingested and enter the bloodstream, eventually reaching the kidneys.

Inhalation

Microplastics in air can be inhaled and deposited in the respiratory system, potentially entering the bloodstream and reaching the kidneys.

Other Routes

While less well studied, microplastics may also enter the body through the skin or other routes, potentially reaching the kidneys through the blood stream.

Effects of microplastics on the kidneys:

Oxidative stress, Inflammation, Disruption of kidney function, Nephrogenesis disruption, Gut kidney axis, Kidney stone formation.

HEART

Microplastics can enter the heart and blood vessels and have negative effects, potentially increasing the risk of heart disease, stroke, and even death. They can accumulate in plaques in arteries, leading to a higher risk of heart attacks and strokes. Microplastics can also impair blood flow, regulate blood pressure, and alter the heart's natural rhythm. Laboratory studies have shown that animals exposed to microplastics often exhibit abnormalities in the cardiovascular system, such as increased blood pressure, vascular inflammation, and myocardial damage. Epidemiological surveys have also revealed that people exposed to microplastics are more likely to suffer from cardiovascular diseases, such as hypertension and myocardial infarction. Entry of microplastic into heart: Microplastics can enter the body through inhalation, ingestion, or even skin contact. They can also be absorbed from the environment and accumulate in various tissues, including the heart and blood vessel. 9 types of microplastics are found in 5 different types of cardiac tissues in the patients who undergone cardiac surgery. [19] [20]

ACCUMULATION

Microplastics can accumulate in blood vessels and the heart, potentially leading to

inflammation, oxidative stress, and impaired blood flow



EFFECTS OF MICROPLASTICS ON HEART

Inflammation and oxidative stress [21], Disruption of hormonal regulation, Impaired blood flow [Microplastics can accumulate in blood vessels, potentially leading to narrowing and hardening of arteries. This condition, known as atherosclerosis, is a primary contributor to cardiovascular diseases], Blood pressure regulation [Leads to hypertension, another risk factor for heart diseases]

BLOOD

Microplastics enter the bloodstream through various pathways like ingestion, inhalation, and even potentially skin absorption, and can lead to a range of negative effects, including inflammation, oxidative stress, and impaired blood cell function. Research suggests they can cause blood clotting problems, vascular inflammation, and may accumulate in organs, potentially impacting heart health.

ENTRY INTO THE BLOODSTREAM: INGESTION

Microplastics can enter the body through contaminated food and water.

INHALATION

Microplastics can be inhaled through the air, potentially reaching the bloodstream.

SKIN ABSORPTION:

Studies suggest that chemicals within microplastics can be absorbed through the skin, potentially leading to systemic exposure.

Infusion Therapy:

Microplastics have been detected in infusion solutions, suggesting a potential direct route into the bloodstream via IV therapy.

Effects on the Blood:

Inflammation, Oxidative Stress, Blood Cell Function, Blood Clotting, Vascular Issues, Immune System.

Potential Health Risks:

➤ Cardiovascular Disease ➤ Cerebral Thrombosis ➤ Neurobehavioral Abnormalities

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