

## **Environmental pollution by microplastics and its consequences on human health**

**Poluição ambiental por microplásticos e suas consequências para a saúde humana**

**Contaminación ambiental por microplásticos y sus consecuencias para la salud humana**

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### **Abstract**

**Introduction:** In recent years there has been a considerable increase in the use of plastic products for different purposes. Many of the plastics generated are dumped into the environment inappropriately. Therefore, it is possible to find plastic waste in different ecosystems, with the marine environment being one of the most impacted. The objective of this review is to identify the impacts of microplastics on the environment and their impact on human health. **Methodology:** This work corresponds to a narrative literature review, using articles published from 2017 to 2022. The search for articles was carried out in the following databases: *Scencedirect*, *Scholar Google* and *Springer-Verlag*, using the descriptors: microplastics, plastic pollution and environmental impact. **Result:** Plastics discarded in the environment go through different processes, such as environmental and biological stresses synergistically which allow these plastics to be broken down into particles smaller than 5 mm called microplastics. The current scenario of microplastic pollution is in evidence and has been causing concern to researchers around the world, since these

pollutants are complex contaminants and have significant toxic effects. Current research proves that prolonged exposure to these particles jeopardizes the survival of marine life and induces serious damage to human health, since they can cause damage to the cell and its genetic material, in addition to providing a surface for the transport of microorganisms. And other chemical compounds. Conclusion: Studies show that microplastics pose potential risks to the marine environment and threaten human health, requiring urgent action to recover and avoid environmental impacts.

**Keywords:** Marine environment; Plastic pollution; Environmental impact.

### Resumo

**Introdução:** Nos últimos anos houve um aumento considerável no uso de produtos plásticos para diferentes fins. Muitos dos plásticos gerados são despejados no meio ambiente de forma inadequada. Logo, é possível encontrar resíduos plásticos em diferentes ecossistemas, sendo o ambiente marinho um dos mais impactados. O objetivo desta revisão é identificar os impactos dos microplásticos no meio ambiente e sua repercussão para a saúde humana. **Metodologia:** Este trabalho corresponde a uma revisão da literatura do tipo narrativa, utilizando artigos publicados no período de 2017 a 2022. A busca pelos artigos foi realizada nos seguintes bancos de dados: *Sciencedirect*, *Scholar Google* e *Springer-Verlag*, utilizando os descritores: microplásticos, poluição plástica e impacto ambiental. **Resultado:** Os plásticos descartados no meio ambiente passam por diferentes processos, como estresses ambientais e biológicos sinergicamente os quais possibilitam que esses plásticos sejam divididos em partículas menores que 5 mm chamadas então de microplásticos. O cenário atual de poluição por microplástico está em evidência e vem causando preocupação nos pesquisadores do mundo todo, uma vez que estes poluentes são contaminantes complexos e apresentam efeitos tóxicos significativos. Pesquisas atuais comprovam que a exposição prolongada a essas partículas coloca em risco a sobrevivência da vida marinha e induz danos gravíssimos à saúde humana, uma vez que podem causar danos a célula e ao seu material genético, além de ser possibilitar uma superfície para transporte de microrganismos e outros compostos químicos. **Conclusão:** Os estudos demonstram que os microplásticos apresentam riscos potenciais ao ambiente marinho e ameaçam à saúde humana sendo necessário ações urgentes para recuperar e evitar impactos ambientais.

**Palavras-chave:** Ambiente marinho; Poluição plástica; Impacto ambiental.

### Resumen

**Introducción:** En los últimos años se ha producido un aumento considerable en el uso de productos plásticos para diferentes fines. Muchos de los plásticos generados se vierten al medio ambiente de forma inadecuada. Por tanto, es posible encontrar residuos plásticos en diferentes ecosistemas, siendo el medio marino uno de los más impactados. El objetivo de esta revisión es identificar los impactos de los microplásticos en el medio ambiente y su impacto en la salud humana. **Metodología:** Este trabajo corresponde a una revisión narrativa de la literatura, utilizando artículos publicados desde el año 2017 al 2022. La búsqueda de artículos se realizó en las siguientes bases de datos: *Sciencedirect*, *Scholar Google* y *Springer-Verlag*, utilizando los descriptores: microplastics, plastic freedom and ambiental impact. **Resultado:** Los plásticos desechados en el medio ambiente pasan por diferentes procesos, como estreses ambientales y biológicos de manera sinérgica que permiten que estos plásticos se descompongan en partículas menores a 5 mm llamadas microplásticos. El escenario actual de contaminación por microplásticos está en evidencia y ha causado preocupación a investigadores de todo el mundo, ya que estos contaminantes son complejos y tienen efectos tóxicos significativos. Las investigaciones actuales demuestran que la exposición prolongada a estas partículas pone en peligro la supervivencia de la vida marina e induce graves daños a la salud humana, ya que pueden causar daños a la célula y su material genético, además de proporcionar una superficie para el transporte de microorganismos y otros. compuestos químicos. **Conclusión:** Los estudios muestran que los microplásticos presentan riesgos potenciales para el medio ambiente marino y amenazan la salud humana, lo que requiere una acción urgente para recuperar y evitar impactos ambientales.

**Palabras clave:** Ambiente marino; Contaminación plástica; Impacto ambiental.

## 1. Introduction

Water contamination is a problem that affects the whole world, and it occurs when compounds that are hazardous to human health reach rivers, lakes, and oceans (Karimi-Maleh et al., 2022). Anthropogenic activity is responsible for much of this pollution, as well as industries and industrial waste disposal. Currently, the global production of plastic has drawn the attention of researchers worldwide for presenting some characteristics of its own, such as being present in many environments and causing several impacts both on the environment and human health (J. Li et al., 2018).

Plastics have lightweight corrosion resistance and take years to decompose, which makes them persist in the environment for decades (Hu et al., 2022; Rios Mendoza et al., 2018). This production has generated an excessive

accumulation of plastic fragments in the environment (Geyer et al., 2017a; Issifu & Sumaila, 2020). Currently, the most used types according to their physical and chemical properties are Low/High-Density Polyethylene (PE), Polypropylene (PP), Polyethylene Terephthalate (PET), Polystyrene (PS), and Polyvinyl Chloride (PVC), from petroleum products (Hu et al., 2022).

There estimated that from 1950 to 2015, the production of plastics went from 2 million tons to 380 million tons, and there estimated that in the next 20 years, this number will only work (Geyer et al., 2017b; D. Huang et al., 2021). A large part of plastic waste is incorrectly disposed of, reaching the environment in the form of large plastics larger than 2.5 cm, medium plastics with sizes between 0.5 and 2.5 cm, Microplastics (MPs) with dimensions between 1  $\mu\text{m}$  –5 mm, and Nanoplastics (NPS) smaller than one  $\mu\text{m}$  (D. Huang et al., 2021). MPs reach the environment in many ways, one of which is the discharge of untreated effluents into it (Woodward et al., 2021). Due to the relevance and need for an update on this subject, this work aims to identify the microplastics' impact on the environment, and their repercussions on human health, by analyzing articles from 2017 to 2022.

## 2. Methodology

The presente research is a literature review of the narrative type, with a search in the following databases: Science Direct, Scholar Google, and Springer-Verlag. The search for articles used the following descriptors: Marine environment, plastic pollution, and environmental impact. As an inclusion criterion, the articles should address issues related to the descriptors already mentioned and published period from 2017 to 2022. We used as criteria exclusion publications that did not adhere to the study topic and did not fit within the established period.

## 3. Results and Discussion

### 3.1 Environment pollution by MPs

Over the years, plastics have become indispensable to humanity. As a result, there is produced about 380 million tons annually. Of these, there converted 250 million tons into plastic waste; however, there collected only 60% (Paço et al., 2017; Skoczinski et al., 2021). There is known that many organic wastes are degraded or mineralized when entering aqueous environments; however, plastics are fragmented into smaller particles, called MPs (Khalid et al., 2021). Studies such as those by Geyer et al., (2017b) show that a good part of these MPs, more precisely 79%, are dumped in landfills or the natural environment, and the other 29% are recycled or incinerated. There is considered that around 2050, the number of plastic waste in landfills and the natural environment will reach 12,000 million tons.

MPs received this name because they are smaller than 5 mm in diameter and formed by particles from a varied polymer set (Horton et al., 2017). It depends on their origin and can be divided into primary MPs; when they are within the previously mentioned size range or secondary MPs formed from the disintegration of larger plastics (Hartmann et al., 2019). According to studies by Dawson et al., (2018), McIlwraith et al., (2019), Silver (2018), and Saborowski et al., (2019). MPs are generated from wearing or washing natural or synthetic materials such as carpets, artificial grass, tires, textile fabric, household dust, and ultraviolet radiation. The most frequently found forms are fibrous, granular, and fragmented (Avio et al., 2017; Reineccius et al., 2020).

The removal process of MPs from the environment is still challenging and has awakened the scientific community to search for effective methods for their degradation (Vivekanand et al., 2021). Since MPs are abundantly present in the environment, they take years to degrade and are easily fragmented, spreading faster (Padervand et al., 2020). MPs are present in food, beverages, and even in the air (Senathirajah et al., 2021). In 2017, analyzes were performed on tap water from global

samples, and there confirmed the presence of MPs in 83% of the samples (Vivekanand et al., 2021). Studies by Senathirajah et al., (2021) showed that most of the MPs ingested by humans in the world come from drinking water present in taps and bottles. In another study by Schymanski et al., (2018), a high amount of MPs was observed in bottled water, believed to come from processing and-or packaging.

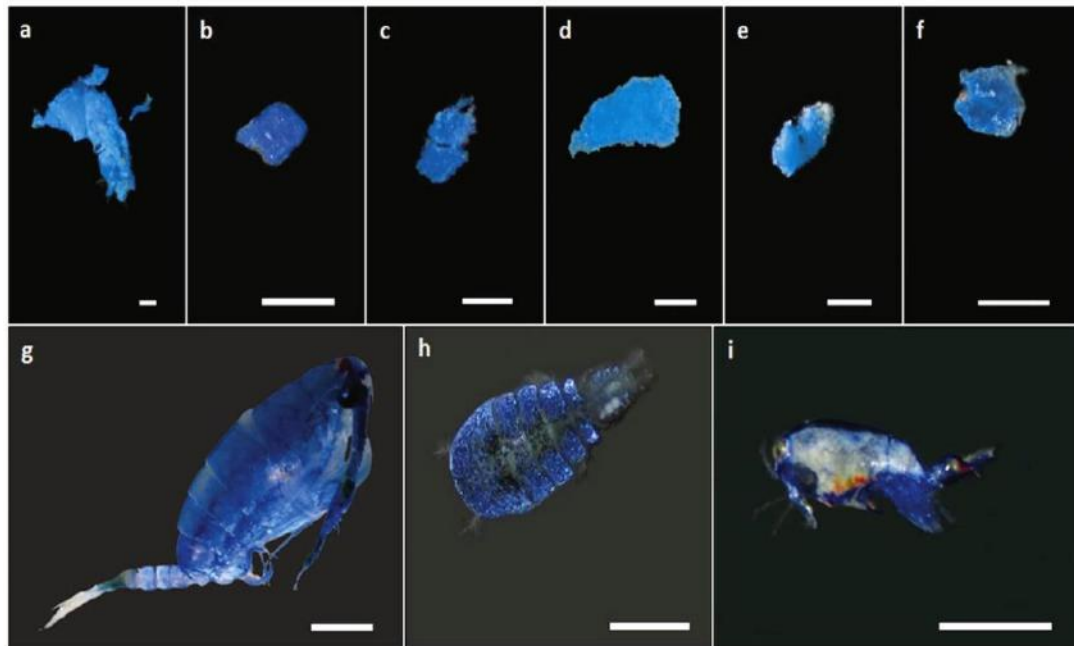
MPs bring with them a cascade of adverse effects on ecosystems. In aquatic environments, they impede the photosynthesis process of algae and promote the spread and growth of microorganisms, which are often harmful pathogens to human health and accumulate in marine organisms (Feng et al., 2020; W. Huang et al., 2021; R. J. Wright et al., 2020; T. Zhang et al., 2022). Due to their large surface area, many organic pollutants such as Polycyclic Aromatic Hydrocarbons (PAHs), Antibiotics, Polychlorinated Biphenyls (PCBs), and heavy metals adhere to the surface of MPs (T. Zhang et al., 2022).

The presence of MPs in aquatic ecosystems has numerous negative impacts, as it influences the food chain and disturbs marine species and microorganisms in this habitat (Ma et al., 2020). Studies such as those by Catarino et al., (2018); Kim et al., (2018a); and Qu et al., (2018) reveal that MPs reach rivers, lakes, and oceans through domestic and commercial effluents and return to consumers' tables through seafood and table salt, which is directly linked to high amounts of MPs in aquatic environments. This high level of MPs in environments poses a high risk to human health, as there is high consumption of contaminated fish and seafood (Hale et al., 2020; Yang et al., 2020).

Ingestion is the gateway for MPs to marine organisms. They accumulate over time, becoming more harmful at higher trophic levels in the food chain (Vivekanand et al., 2021). Trophic exchange of MPs between fish occurs commonly. Fish are easily attracted to Mysids, which is part of their metabolism to break down MPs. Thus, from mysids consumption, fish ingest MPs 3 to 11 times more than those present freely in their surroundings (Hasegawa & Nakaoka, 2021). The MP's intake varies according to the different types of fish. Omnivorous fish consume more plastic materials when compared to carnivores. Because they have a lower excretion capacity, omnivorous fish keeps a higher MPs amount (C. Zhang et al., 2021).

There are estimated more than 800 species, including birds, fish, invertebrates, whales, and dolphins, are threatened due to the high presence of plastic waste in their natural habitat (Pan et al., 2019). MPs are inevitably and actively ingested by marine organisms due to similar characteristics such as the color, size, and shape of their prey, as seen in figure 1. MPs pose a high threat only not to marine species but also to humans due to their toxicological effects and bioaccumulation along the food chain (Kumar et al., 2021; T. Zhang et al., 2022).

**Figure 1** - Similarity of marine prey to MPs.



Source: (Ory et al., 2017). <https://doi.org/10.1016/j.scitotenv.2017.01.175>.

### 3.2 Routes of exposure to MPs and distribution in the human body

Over the years, there believed that MPs reached the human body through processes like ingestion, inhalation, and dermal contact. However, researchers have investigated the present concentrations of MPs in food, beverages, air, and daily consumables, yet there was a significant difference in the amount of MPs present (Mason et al., 2018; P. Wu et al., 2022; Zuccarello et al., 2019). In a study by Leslie et al., (2022), it was possible to identify the presence of MPs in human blood, confirming human exposure to plastic particles. The pores of the human body are 40 to 80  $\mu\text{m}$ , so they are vulnerable to NPs (<100 nm), synthetic fibers (<25  $\mu\text{m}$ ), monomers, as well as additives. Consequently, contact with exfoliants, toothpaste, clothes, and body cleansers exposes the organism to MPs (P. Wu et al., 2022).

In addition, atmospheric air is capable of spreading MPs to the soil, aquatic environments, and remote areas (Allen et al., 2019). Currently, there is high consumption of seafood such as shellfish and fish, and the contamination by MPs identified in these foods is very high, as shown by Yap; & Al-Mutairi, (2022). Another growing problem is the ingestion of MPs through table salts. The MP mixing present in the oceans with the table salts takes place during their production process (Kim et al., 2018b). The high MPs concentration present in these salts shows us that salt consumption is a principal entry point for MPs in human organisms (P. Wu et al., 2022).

There is known that even with effluent treatment plants and drinking water, it is still possible to find MPs on a large scale in water for human consumption. With the use of equipment to remove present pollutants in drinking water is possible to eliminate about 90% of plastic waste (Pivokonsky et al., 2018; P. Wu et al., 2022). However, studies such as those by Pivokonský et al. (2020) revealed that the MP amount in these treated waters is still high. With this, it is possible to affirm that the methods traditionally used to remove effluents from water do not entirely eliminate MPs, only partially (P. Wu et al., 2022). In addition, there is also a high consumption of MPs through tap and bottled water (Kosuth et al., 2018).

Almost all food needs to be stored in plastic packaging, which in turn is considered an unintended source of MPs that reach the human body (Du et al., 2020; Hernandez et al., 2019; D. Li et al., 2020). Like plastic cups, tea bags exposed to high temperatures are also responsible for releasing MPs (Hernandez et al., 2019; Ranjan et al., 2021). Recent studies show that the presence of MPs in the soil makes many plants and vegetables vulnerable once MPs penetrate their roots (Sun et al., 2020;

Taylor et al., 2020). Some authors demonstrate this vulnerability in studies carried out with wheat (L. Li et al., 2020; Lian et al., 2020; Taylor et al., 2020), carrots (Dong et al., 2021), lettuce (L. Li et al., 2020) and rice seedlings (Y. Liu et al., 2022). In addition to the trophic transfer observed between earthworms and chickens (Huerta Lwanga et al., 2017).

As seen so far, MPs enter the human body through various mechanisms such as ingestion, inhalation, and dermal contact (Gouin et al., 2022). These are then digested in the stomach within approximately 2 to 6 h after passing through the esophagus (Dawson et al., 2018). Subsequently, those with a smaller size than 1.09  $\mu\text{m}$ , called insoluble, penetrate the intestinal epithelium, then enter the circulatory system. The larger MPs move towards the midgut and hindgut (Cox et al., 2019). According to Barlow et al., (2018), airborne MPs are stored in the alveolar regions of human lungs and then translocate to the epithelial layers through gas exchange between the alveoli and capillaries.

NPs can be present in all organs of the human body, in addition to accumulating in the liver, and kidney, crossing the blood-brain barrier and being held in the brain (Dick Vethaak; Legler, 2021; Gregory et al., 2020; McCright et al., 2022). Thus, there is believed that smaller particles, considered inert, have a higher concentration in the brain (Prüst et al., 2020).

### 3.3 Impact and toxicity of MPs on individuals

Over the years, numerous studies have documented the impacts of MPs on human health. Until then, there known that MPs, although not metabolized by the human body, are responsible for transporting toxic compounds and microorganisms into the body, inducing health damage (Rist et al., 2018). Yan et al., (2022) suggests that prolonged MPs intake has a direct relationship with inflammatory bowel disease; since a higher fecal MPs amount was found in patients who contained the illness compared to healthy individuals (Yan et al., 2022). al., 2022).

Furthermore, *in vitro* studies reveal that a cascade of cellular damage initiates after the entry of MPs affecting organelles and mitochondria, causing instability in the mitochondrial membrane potential and production of cellular Reactive Oxygen Species (ROS) (Wang et al., 2021; P. Wu et al., 2022). In addition, it causes hemolysis and damage to the cell membrane of red blood cells and fibroblasts. It results in hemoglobin release and lactose dehydrogenase (Choi et al., 2020). Guimarães et al., (2021) revealed that MPs cause apoptosis and necrosis in erythrocytes due to their neurocytotoxic actions. According to W. Huang et al., (2021), MPs can penetrate the human cell membrane, and soon after, they are responsible for producing ROS, stimulating inflammation, activating immune responses, and triggering neurotoxicity at molecular levels.

As previously emphasized, commercial fish species have significant amounts of MP, which makes this a matter of concern since the consumption of this group is high (F. Wu et al., 2020). According to Prata et al., (2020), the ingestion of MPs causes serious consequences such as chronic inflammation and oxidative stress, which are responsible for inducing chronic diseases, including cardiovascular diseases, chronic kidney disease, acute lung injury, diabetes, and neuroinflammation. Besides, it expresses deleterious effects on carcinogenicity, chemotoxicity, and antimicrobial resistance among the gut microbiota (Campanale et al., 2020; Lu et al., 2019).

Evidence proves that MPs are responsible for transporting chemical compounds such as heavy metals. This action facilitates the entry of these compounds into the human body through fish consumption contaminated with MPs, which contributes to the emergence of diseases stimulated by heavy metals, such as obesity, diabetes, cancer, and Alzheimer (Bakulski et al., 2020; Campanale et al., 2020; Cortés et al., 2021; Huat et al., 2019; Javaid et al., 2021; S. Liu et al., 2021). Recent *in vivo* research reveals that the co-exposure of MPs and iron in the human body caused an increase in iron accumulation in the brain of C57BL/6 mice, generating changes in brain iron homeostasis and inducing neuronal ferroptosis (X. Liu et al., 2022).

Furthermore, individuals exposed to plastic particles are more likely to develop genotoxicity, cardiopulmonary complications, oxidative stress, cytotoxicity, and metabolic disorders. Besides, It has increased absorption or translocation in

all biological systems, inflammatory lesions, and changes in endogenous metabolites (Barboza et al., 2020; Kannan & Vimalkumar, 2021; Smith et al., 2018; Yong et al., 2020). In their study Prata et al., (2020) revealed that due to the non-removal of MPs by the immune system, individuals are vulnerable to chronic inflammation and a high chance of developing neoplasia. It is also highlighted in the literature that MP participation as a transport vehicle for pathogenic microorganisms resistant to several antibiotics classes into the human organism, disturbing the intestinal microbiota and defined as vectors of microbiological toxicity (Lu et al., 2019).

A recent survey that studied six pregnant women showed that it was possible to identify plastic particles of 5-10 µm in all placental membranes of patients, which can result in changes in immune responses and numerous risks to the pregnancy and the fetus (Jiang et al., 2020; Ragusa et al., 2021; S.L. Wright & Kelly, 2017). Similarly, Braun et al., (2021) detected MPs > 50 µm in human placentas and fetal meconium. Furthermore, studies show that the developing immunity of children and infants makes them more vulnerable to exposure to MPs when compared to adults (Sripada et al., 2022; J. Zhang et al., 2021).

#### 4. Final Considerations

The accelerated use of plastic products has caused an increase in MPs and NPs in several environments, especially in the aquatic environment. The accumulation of these residues in this environment significantly alters the behavior of the beings present there, also causing numerous disturbances in marine organisms and humans who feed on them. Currently, the scientific community has sought to develop measures aimed at mediating and mitigating the impacts caused by MPs and NPs. However, higher investment in these researches is necessary so that there is a reduction in health risks arising from prolonged exposure to these particles. In addition, it is suggested that there should be more future research focused on MP contamination and its impact on the human body.

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