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REVIEW ARTICLE

Microplastic A Global Threat to Environment and Food Safety: Review

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ABSTRACT
Plastic particles that are between 5 mm and 1 micron in size are microplastics. Primary microplastics are plastic materials that are deliberately produced and released into the environment in their original form, while secondary microplastics are formed via the breakdown, decomposition, disintegration, photolysis, and biodegradation of larger plastic materials. Microplastics have been found in a range of products and environmental samples, including drinking water and foods such as salt and sugar. People can also be exposed to microplastics through inhalation. Animal studies have shown that microplastics and nanoparticles can be stretch out to the liver, spleen, heart, lungs, thymus, uterus, kidneys, and even the brain via inhalation. Additionally, microplastics hold higher concentrations of persistent pollutants and heavy metals than non-toxic organisms. The additives and monomers they contain will disrupt important processes in the human body after consumption, leading to endocrine and immune system disorders, and affecting exercise, productivity and growth. It will not only negatively affect human health but also the country's economy. In addition, since there will be a lot of waste due to personal protective equipment, it will also harm the environment. The spread of face masks, the main material of which is polypropylene, leads to an increase in microplastic pollution and inadequate waste management worldwide, while its long-term consequences may be as follows.
Keywords; *Food, Pollution, Health, Microplastic*

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INTRODUCTION

If urgent action is not taken, there is a risk of serious damage. Introduction Synthetic polymers first appeared in the late 19th century, in the 1860s. However, the "plastic boom" really began towards the end of World War II. Since its initial creation from a phenol formaldehyde resin called Bakelite, plastic has become one of the most widely used materials today. Although plastics were originally created to improve human living conditions, they have now become a threat to the environment and the safety of the planet[1-2].

Today, plastics are found to be present in all layers of the environment, including air, water, and soil. The main reason for this spread is the use of plastic packaging for food products such as dairy products, meat, fish, and beverages (such as bottled water). When food and plastic packaging come into contact, there is frequent transfer of substances between the container and the contents.

The quality of food can be affected by contamination caused by the interaction of materials in the packaging, which can sometimes lead to a decrease in nutritional value and jeopardize food safety. Microplastics have been found in many places, including soil ecosystems, surface waters, coastal sediments, beach sand, brackish water and deep ocean waters. Rain and snow also contain large amounts of microplastics,

Rain and snow hold abundant of microplastics that are invisible to the naked eye. Plastic waste has a remarkable effect on the environment due to the omnipresent utilization of plastics, bad waste management, and inappropriate collection and identification at the end of their life cycle. The release of plastic materials into the environment is considered a significant problem. The enlarge quantity of microplastics gain access to the environment is causing earnest pollution worldwide. Since synthetic materials have a high polymer content, microplastics smaller than 5 mm in size do not dissolve in water and do not decompose, and easily enter the environment and remain there for a long time. The release of hydrophobic organic chemicals has a notable impact on food. Marine life is found in a variety of aquatic environments, including surface waters, oceans, and estuaries, and is directly or indirectly reveal to microplastics. The negative impact of microplastics on benthic organisms has been established by scientific studies. The toxic effects of these pollutants on the nutrition, growth, and reproduction of various aquatic organisms have been investigated. Therefore, people are at risk of contracting these diseases by eating seafood, fish, and shellfish. The objective of this article is to focus on the dangers of microplastic pollution and its negative impacts on food and human health, so that more efforts can be made to guard against many diseases and pollutants [3-10].

The introduction of food products with the highest risk of contamination, along with the organisms that interact with living foods and the degradation processes in the body, will once again provide a better understanding of the damage that microplastics cause to the environment and human food safety. Microplastics cause negative effects on living organisms, especially aquatic organisms, which are considered an important food source for humans. The accumulation of microplastics in marine life poses a threat to food products, both in terms of the health benefits of patients. Bacteria are unfortunately found in many food groups. Some of them eat microplastics, drink water and salt every day[11-18].

SOURCE

Because plastic garbage is not properly managed, freshwater and ocean are contaminated in many ways. Between 60 and 80 percent of marine garbage is made of plastics. Because plastic garbage can be consumed by marine life, it is a threat to both the environment and marine life. Statistics show that this issue affects at least 267 species globally. This contains many fish species, 86% of sea turtles, 44% of birds, and 43% of mammals. Plastic garbage is causing more and more harm to marine life. This material can cling to debris or the water, obstructing the flow of oxygen [19-20].

Recent research indicates that humans may ingest approximately 52,000 microplastic particles annually, based on analyses of their presence in a variety of food sources. When inhalation is considered, exposure could rise to around 74,000 particles per year. Additional contributions come from drinking water, with tap water accounting for roughly 6,000 particles and bottled water adding about 9,000 more. However, these estimates are likely conservative and may not fully capture total exposure levels [21].

Dietary intake remains a major pathway for microplastic exposure, particularly through foods such as seafood, commercially available fish, sea salt, honey, beer, and certain food additives. Contamination can also occur during food processing and through packaging materials. Inhalation of airborne particles, especially from dust, represents another significant route of exposure [22-24].

Seafood, valued for its nutritional benefits, is of particular concern, as it can act as a major carrier of microplastics—especially in the case of small fish that are consumed whole. Microplastics originate either from the breakdown of larger plastic debris or from the synthesis of polymer-based materials. In aquatic environments, these particles are readily ingested by organisms such as plankton, small invertebrates, filter feeders like bivalve mollusks, and even macroalgae. Their distribution and movement in marine systems often resemble that of plankton. Furthermore, microplastics can adsorb and accumulate toxic chemicals and additives, thereby acting as carriers of harmful pollutants within the food chain.

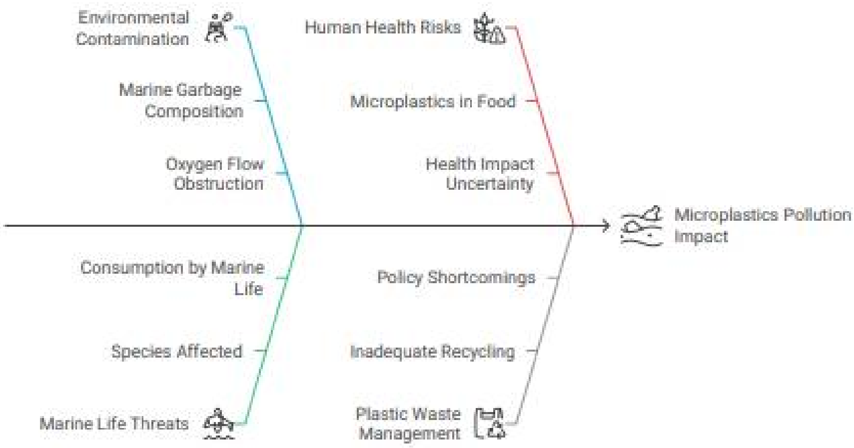

Fig. 1: Sources of Microplastics

The entire bacterial community is called the plastosphere and includes bacteria of the genus Vibrio. It is al so produced from microplastics [25].
Numerous investigations have demonstrated the presence of microplastics in a variety of commercial aquatic species, including fish, oysters, crabs, shrimp, and mussels [38, 39]. According to these studies, consuming seafood that contains microplastics may be hazardous, and drinking tainted water may expose people to microplastics. The consumption of food, particularly fish and shellfish, is the primary way that humans are exposed to microplastics. Consumer health may be impacted by eating food tainted with MPs. In this food environment, it is crucial to know the destiny and toxicity of microplastics in humans, which calls for specialized research [40]. It is crucial to remember that MP particles enter the lymphatic and circulatory systems after being absorbed from the gastrointestinal tract. The toxicological consequences of microplastics and nanoplastics in seafood are not well understood enough at this time to
to assess the risks associated with this emerging problem[26-28].
As noted earlier, microplastics are typically characterized based on their size, shape, and color. Although definitions may differ slightly among researchers, they are commonly classified into five categories: fragments, spheres, fibers, industrial pellets, and foam particles (such as those derived from expanded polystyrene). In aquatic environments, microplastics originate from two principal sources: primary microplastics, which are manufactured at microscopic sizes for specific uses, and secondary microplastics, which result from the breakdown of larger plastic items (greater than 5 mm) through physical, chemical, or biological processes.
biological, chemical, and physical mechanisms. This categorization can pinpoint the precise origins of microplastics and evaluate initiatives to lessen their environmental impact. Depending on where they are found, microplastics can be classified as main or secondary [46]. Primary microplastics are tiny synthetic materials that are employed in many different processes, such as polishing items, maintaining different plastic products, exfoliating pharmaceutical formulations, and creating synthetic materials. Commonly found in cosmetics and personal care items, microbeads are main microplastics (less than 2 mm in size) made of polyethylene (PE), polypropylene (PP), and polystyrene (PS) beads. Because of their high surface-to-volume ratio, microplastics can encourage the biogrowth and bioaccumulation of a variety of chemicals and contaminants [29-30].

Primary Microplastics

The main microplastics are intentionally made from industrial plastics that are smaller than 5 mm in diameter and have many uses. Due to their small size, they can provide a grinding effect while controlling the viscosity, stability and shape of the product. These important microplastics are found in many products such as cosmetics, cleaning products, astroturf and fishing nets. Domestic microplastics can also be found in commercial products, but this is usually unintentional. The outcome is the same: environmental contamination by microplastics. Car tires, paint, plastic resins, and synthetic garments made of synthetic fibers are the four primary ones, in order of significance. The wear of tires and the discharge of microplastics into the road are caused by the friction between the tire and the road, particularly while braking, accelerating, or driving on uneven surfaces [31].
Rainwater can carry these substances into the cleaning system. Unfortunately, these systems are not designed to capture these small particles, which mean they are released into the water supply. The same problem occurs with microplastics in synthetic fibers in clothing.

Secondary microplastics

Plastics are subject to a variety of physical and biological factors, particularly in the marine environment. Low temperatures, UV radiation, and material deterioration from sand and waves can all harm and degrade plastics. Secondary microplastics are created during this process when macroplastics decompose. Just 9% of the 370 million tons of plastic generated globally in 2019 were recycled, 12% were burned, and the remainders were dumped in landfills or the environment, despite warnings about the dangers of microplastic pollution. The creation of secondary microplastics is greatly aided by this waste.
. Marine life and plant ecosystems are under risk due to microplastic contamination brought on by aquatic activities related to transportation, commercial and recreational fishing, tourism, aquaculture, and marine industry (such as oil rigs). Due to tourist and leisure activities, plastics of all kinds are frequently left as litter on beaches and coastlines. One of the most frequent sources of pollution in the water is fishing gear that has been lost or discarded, such as nylon nets and monofilament fishing lines. Usually, MP determination is carried out in two stages: first, to ascertain the explosive's physical characteristics, and then, to ascertain the product's chemical characteristics[32].

IDENTIFICATION METHOD

Numerous inspection methods, including transmission electron microscopy (TEM), atomic force microscopy, scanning electron microscopy (SEM), stereo, and fluorescence microscopy, are used for physical characterization. Among these, the physical and chemical characteristics of different kinds of capture polymers can be identified and determined using the analytical powers of TEM, SEM, and fluorescence microscopy. Chemical characterisation commonly involves the use of Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy, differential scanning calorimetry, thermogravimetric analysis, pyrolysis-gas chromatography-mass spectrometry (py-GC-MS), and thermal techniques that combine these techniques.

Because of their quick analytical speeds, hybrid techniques like py-GC/MS and thermal extraction-desorption gas chromatography-mass spectrometry (TED-GC/MS) usually don't need extra, time-consuming sample preparation. outcomes. As more and more analytical results are acquired, their popularity is growing. Microplastics as a potential hazard

MP itself or its dispersed monomers and additives used during production can cause adverse health effects. When discussing the effects of MP on human health, it is important to distinguish between physical and chemical effects. Although MPs are generally considered weak chemicals and are not considered toxic, they may provide similar health benefits to the immune system depending on their chemical composition. They have the potential to affect the immune system. An example of a systemic effect is “blocked phagocytosis”, which occurs when macrophages are unable to engulf and destroy their targets, leading to long-term damage and tissue injury.

Most data on the effects of MPs are derived from in vitro studies, marine mammals or experimental animals. Various physiological effects of microplastic ingestion have been associated with effects such as damage to internal organs, gastrointestinal tract, reduced response to food intake and replacement of digestible food with microplastics. Sublethal effects for marine invertebrates resulting in reduced survival and growth. retardation. and reduced physical activity.

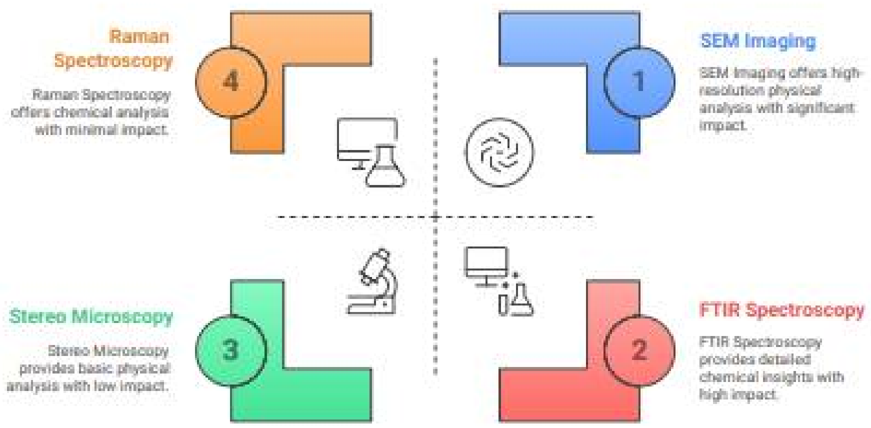

Fig. 2: Identification Methods

Therefore, it is important to determine whether MPs remain in the intestinal lumen or are absorbed after ingestion and enter the body and other tissues. It is thought that more than 90% of MPs taken into the human body are excreted through the excretory system via feces. Particle size affects the intestines; the intestines appear to be very small. Particles smaller than a few microns can be directly absorbed by cells via phagocytosis and endocytosis; particles larger than 130 µm can enter tissues via paracellular transport; from specialized cells. Particles larger than 150 Åm are not absorbed and only have a local effect on the immune and gastrointestinal systems[33-36].

TOXIC EFFECTS

Due to the abundance of data on the toxicity of diffusive monomers and additives, public health concerns about their toxicity, in addition to the effects of the MPs themselves, are raised. While

longterm exposure is a significant concern, levels of these chemicals in MP are thought to be moderate compared to other sources. Polymerization reactions are rarely complete and the polymerized material

contains unaffected residual materials. Because the noncovalent bonds between the additive and the polymer backbone are weak, they are rapidly leached into the environment [37-38].
As MP decomposes in the air, the rate of chemicals and monomers leaking into the environment increases. Although little is known about how MP is broken down in the digestive tract, terrestrial organisms, freshwater organisms, and Antarctic krill have been shown to produce MP during feeding and digestion. 55 monomers, including 16 of the most common polymers, have been identified as carcinogenic, mutagenic, or toxic. The most dangerous of these include acrylamide, vinyl chloride, styrene, and bisphenol A (BPA). BPA is also an additive used in other plastics and is a component of epoxy and polycarbonate plastics. Food cans, utensils, containers, baby bottles, and reusable bottles are products that may come into contact with food and contain BPA. According to the information in this document and many other sources, BPA is one of the most common compounds to which humans are directly exposed worldwide. BPA has been shown to have endocrine disruptive effects in humans by interacting with a variety of chemical receptors, including thyroid hormone receptors, androgen receptors, and estrogen receptors. It poses a threat to the development and growth of spring, as well as to the health of children, the immune system, metabolism, and nervous system [39-40].

MICROPLASTICS AS CARRIERS

In addition to monomers and additives, persistent, pollutants such as heavy metals, pesticides. The composition of MP is also believed to include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and polybrominated diphenyl ethers (PBDEs).
Due to their composition and wide distribution, MPs are particularly susceptible to the adhesion and leaching of organic pollutants present in water. The concentration of this pollutant in plastic can be up to 106.
PCBs can affect the thyroid and reproductive systems in men and women, cause infertility, promote tumor growth, enhance the effects of other carcinogenic chemicals, and cause cancer. Risk of diabetes, liver, disease, and heart disease. Exposure to PCBs can lower IQ and alter behavior, especially in the fetus and early in life. PAHs are a class of organic pollutants that are toxic, genotoxic, mutagenic, and carcinogenic and pose a threat to environmental and public health. Disruption of thyroid homeostasis, neurodevelopmental disorders, reproductive abnormalities, and even cancer are among the possible toxicological consequences of PBDE exposure.
Antibiotics are classified as emerging pathogens and are becoming a growing concern due to their release into the environment in large quantities each year.
According to available data, PE, PS, PP, PA and PVC can absorb hydrophilic antibiotics such as trimethoprim, ciprofloxacin hydrochloride, tetracycline, amoxicillin and sulfadiazine.
Plastic disease and illnesses, colonial MPs. The only evidence we currently have comes from studies on the existence of MP in aquatic environments; a large number of bacteria colonize MPs, forming various biofilms defined by microbial cells attached to the surface and encapsulated in a matrix of extracellular polymeric substances.
A variety of bacterial species, as well as flame eating bacteria and algae, have been found on the MP surface [41-43].

Microplastics in human nutrition

Along with Vibrio species, MPs have also been found to contain bacteria or other human pathogens, including Aeromonas, Pseudomonas, Haemophilus, Acinetobacter, Escherichia coli, and members of the Campylobacteraceae, Proteobacteriaceae, and Pseudomonadaceae families Additionally, because BET improves MPs' adsorption capacity through their surface area, adding bio films can enhance the adsorption of pollutants. Human nutrition and microplastic.

Microplastics in water, drinking water and alcoholic beverages

Microplastics can reach drinking water through multiple pathways, including the breakdown of larger plastic debris, sewage discharges, industrial effluents, and runoff from land surfaces—particularly after heavy rainfall events [13]. They may also be introduced through both treated and untreated wastewater streams. Although advanced wastewater treatment processes are capable of removing a substantial proportion—often exceeding 90%—of microplastic particles, complete elimination is not yet achievable. Additional contamination can arise from packaging materials such as plastic bottles and their caps [34]. The occurrence of microplastics in drinking water has therefore become a significant focus of scientific investigation, with growing concern over their widespread detection, including in bottled water, highlighting the global scale of the issue.
Because MP may be present in bottled water, MP pollution is a global issue. Similar to water, a variety of drinks, including alcohol, have been discovered to contain MP contamination. Some items, like soft drinks

or beer, could be polluted by water, while other products might be contaminated by other ingredients, the production process, the environment, or the packaging [44].

Microplastics in fish and shellfish

These products contribute roughly 17% of the global intake of animal-derived protein, with total production reaching about 170 million tons in 2015, in addition to nearly 29 million tons generated through aquaculture activities. Plastic pollution enters aquatic systems from a variety of sources, including both freshwater bodies and marine environments.

However, it is believed that commercial landfills, waterways, wastewater, aviation, and maritime transportation account for 80% of the plastic debris that is discovered in the marine environment. Depending on their size, shape, and behavior, both vertebrates and invertebrates can consume these materials. Many marine organisms have a well-documented history of ingestion. A reliable indicator of MP pollution in water is the amount of MP found in fish and shellfish.

MPs are generally thought to be less harmful to larger fish because they are eliminated from the digestive tract prior to consumption.

On the other hand, eating little fish and various kinds of fish, such as sardines, anchovies, mussels, and other fish, may make MP more likely. Because predators may indirectly consume MP when they eat animals, there is also growing worry about the possibility that MP could contaminate aquatic, benthic, and marine food chains. Similarly, when detrital animals and predators dig into MP-containing detritus, they may ingest MP.

By far the best-studied and best-understood MPs are fish and shellfish.

Food lovers, their availability and cost have been studied in many studies. Over the years, scientists have found MPs in fish and shellfish from aquaculture and wild populations. Store or farm. The vast majority (62%) of the more than 400 primary research articles reporting MPs in fish during this period focused on marine organisms. species, the minority (38%) are only freshwater species.Therefore, they also provide the best tools for the expansion of MPs in the long term. In addition, salt and sugar are often used as thickeners, stabilizers and additives in the pharmaceutical and cosmetic industries [45-46].

Microplastics in salts and sugars

Salt is commonly classified into three categories based on its origin: rock salt extracted from underground deposits, sea salt produced through the evaporation of seawater or coastal brines, and lake salt obtained from inland saline lakes. While the occurrence of microplastics in salt has been extensively investigated, their presence in sugar remains comparatively underexplored. Although some studies have not employed advanced spectroscopic techniques to confirm the characteristics of these particles, available findings indicate that sugar may also contain notable levels of microplastic contamination [47].

Microplastics in processed food and honey

Generally speaking, the environment, raw material pollution and packaging contamination can lead to foo d being processed with microplastics. Products used in manufacturing (e.g. milk and beer) can contain MP s. Cleaning can help reduce MP in fish and shellfish, but it is still reasonable to assume that all MP in finish ed food is consumed. The production process or both have been identified as sources of honey contaminat ion[48-50].

MICROPLASTICS IN FOOD CONTACT MATERIALS

Products and materials that come into contact with food at any point during the production process—processing, cooking, storing, serving, etc.—are referred to as food. Numerous chemical, biological, and physical risks may arise from this. The safety principles of EU Regulations (EC) 1935/2004 and (EC) 2023/2006 (European Commission 2004, 2006) govern the management of food contact information. Certain materials that come into contact with food, like ceramics, cellulose films, active and smart materials, recycled materials, and specific items like BPA, epoxy derivatives, and nitrosamines, are subject to special regulations (EFSA 2020). However, there are also new and complicated food safety challenges brought up by the presence of lawmakers.

There is a widespread belief that some products, such as bottled water, contain MPs due to the substances they come into contact with. The study found that materials used in making bottles and caps. (2018). The y found polyethylene and biofilm widely used as lubricants and coatings for beverage containers and glas sware. Baby bottles made of PP can hold up to 16,200,000 baby items per liter. Kedzierski et al. [52] found that PS food containers were a source of MP contamination in meat. The results showed that PS particle counts in beef ranged from 4 to 18.7 particles/kg.

According to Du et al. [53], the number of microplastics detected in sample containers ranged from 3 to 29 particles per bin, with polystyrene (PS) containers featuring rough surfaces showing the highest concentrations. These particles are believed to originate from airborne contamination and the shedding of material from the containers themselves. Notably, rinsing containers with hot water does not significantly reduce microplastic presence. Everyday actions—such as opening water or beer bottles, tearing packaging tape, or unsealing plastic food containers—can also generate microplastics, with reported densities ranging from 0.46 to 250 particles per centimeter. Furthermore, exposure of plastic materials to hot liquids, such as immersing a plastic bag in a hot beverage, can lead to the release of considerable amounts of microplastics [51–55].

CONCLUSION

Microplastics are widespread, persistent pollutants that threaten environmental stability and food safety. Found in air, water, soil, and living organisms, they originate from the breakdown of larger plastics and direct industrial and domestic sources, eventually entering food systems through multiple pathways. Their presence in foods such as seafood, salt, water, and crops highlights continuous human exposure. Due to bioaccumulation and trophic transfer, microplastics intensify ecological damage and increase long-term health risks.

They are associated with oxidative stress, inflammation, metabolic disorders, and gut microbiota imbalance, while also acting as carriers of toxic substances and pathogens, raising serious food safety concerns. Environmentally, microplastics degrade soil quality, disrupt aquatic ecosystems, and hinder plant growth, ultimately threatening biodiversity and food security. Their persistence leads to long-term ecological impacts.

In summary, microplastics are a significant global concern requiring strict regulation, sustainable alternatives, improved detection, and ongoing research to protect environmental and human health.

REFERENCES

1. Patterson, G.D. (2011). Materia Polymerica: Bakelite. ACS Symp. Ser. 1080, 21–29.
2. Millican, J.M.; Agarwal, S. (2021). Plastic Pollution: A Material Problem? Macromolecules, 54, 4455–4469.
3. Pradeau, D. (2006). Migration of components from plastic materials into food.. Ann. Pharm. Françaises 64, 350–357.
4. Faure, F.; Saini, C.; Potter, G.; Galgani, F.; de Alencastro, L.F.; Hagmann, P. (2015). An evaluation of surface micro- and mesoplastic pollution in pelagic ecosystems of the Western Mediterranean Sea. Environ. Sci. Pollut. Res, 22, 12190–12197.
5. Browne, M.A.; Dissanayake, A.; Galloway, T.S.; Lowe, D.M.; Thompson, R.C. (2008). Ingested Microscopic Plastic Translocates to the Circulatory System of the Mussel, Mytilus edulis (L.). Environ. Sci. Technol. 42, 5026–5031.
6. Liebezeit, G.; Dubaish, F. (2012). Microplastics in Beaches of the East Frisian Islands Spiekeroog and Kachelotplate. Bull. Environ. Contam. Toxicol. 89, 213–217.
7. Castañeda, R.A.; Avlijas, S.; Simard, M.A.; Ricciardi, A. (2014). Microplastic pollution in St. Lawrence River sediments. Can. J. Fish. Aquat. Sci. 71, 1767–1771.
8. Woodall, L.C.; Sanchez-Vidal, A.; Canals, M.; Paterson, G.L.J.; Coppock, R.; Sleight, V.; Calafat, A.; Rogers, A.D.; Narayanaswamy, B.E.; Thompson, R.C. (2014). The deep sea is a major sink for microplastic debris. R. Soc. Open Sci. 1, 140317.
9. Sutherland, W.J.; Clout, M.; Côté, I.M.; Daszak, P.; Depledge, M.H.; Fellman, L.L.; Fleishman, E.; Garthwaite, R.; Gibbons, D.W.; De Lurio, J.; et al. (2010). A horizon scan of global conservation issues for 2010. Trends Ecol. Evol. 25, 1–7.
10. Lambert, S.; Wagner, M. (2016). Characterization of nanoplastics during the degradation of polystyrene. Chemosphere, 145, 265–268.
11. Dobaradaran, S.; Schmidt, T.C.; Nabipour, I.; Khajeahmadi, N.; Tajbakhsh, S.; Saeedi, R.; Mohammadi, M.J.; Keshtkar, M.; Khorsand, M.; Ghasemi, F.F.; et al. (2018). Characterization of plastic debris and association of metals with microplastics in coastline sediment along the Persian Gulf. Waste Manag. 78, 649–658.
12. Bakir, A.; O'Connor, I.A.; Rowland, S.J.; Hendriks, A.J.; Thompson, R.C. (2016). Relative importance of microplastics as a pathway for the transfer of hydrophobic organic chemicals to marine life. Environ. Pollut. 219, 56–65.
13. Besseling, E.; Wegner, A.; Foekema, E.M.; van den Heuvel-Greve, M.J.; Koelmans, A.A. (2012). Effects of Microplastic on Fitness and PCB Bioaccumulation by the Lugworm Arenicola marina (L.). Environ. Sci. Technol. 47, 593–600.
14. Chua, E.M.; Shimeta, J.; Nugegoda, D.; Morrison, P.D.; Clarke, B.O. (2014). Assimilation of Polybrominated Diphenyl Ethers from Microplastics by the Marine Amphipod, Allorchestes Compressa. Environ. Sci. Technol. 48, 8127–8134.
15. Nurshad Ali, Jenny Katsouli, Eric Auyang, Jorge Bernardino de la Serna, (2025). Microplastic and nanoplastic pollution and associated potential disease risks,The Lancet Planetary Health, Volume 9, Issue 12, https://doi.org/10.1016/j.lanplh.2025.101390.

16. Jiang, B.; Kauffman, A.E.; Li, L.; McFee, W.; Cai, B.; Weinstein, J.; Lead, J.R.; Chatterjee, S.; Scott, G.; Xiao, S. (2020). Health impacts of environmental contamination of micro- and nanoplastics: A review. Environ. Health Prev. Med. 25, 29.
17. Lambert, S.; Sinclair, C.; Boxall, A. (2013). Occurrence, Degradation, and Effect of Polymer-Based Materials in the Environment. Rev. Environ. Contam. Toxicol. 227, 1–53.
18. Lambert, S.; Scherer, C.; Wagner, M. (2017). Ecotoxicity testing of microplastics: Considering the heterogeneity of physicochemical properties. Integr. Environ. Assess. Manag. 13, 470–475.
19. Martín-Lara, M.A.; Godoy, V.; Quesada, L.; Lozano, E.J.; Calero, M. (2021). Environmental status of marine plastic pollution in Spain. Mar. Pollut. Bull. 170, 112677.
20. Mancia, A.; Chenet, T.; Bono, G.; Geraci, M.L.; Vaccaro, C.; Munari, C.; Mistri, M.; Cavazzini, A.; Pasti, L. (2000). Adverse effects of plastic ingestion on the Mediterranean small-spotted catshark (*Scyliorhinus canicula*). Mar. Environ. Res. 155, 104876.
21. Cox, K.D.; Covernton, G.A.; Davies, H.L.; Dower, J.F.; Juanes, F.; Dudas, S.E. (2019). Human Consumption of Microplastics. Environ. Sci. Technol. 53, 7068–7074.
22. Yang, D.; Shi, H.; Li, L.; Li, J.; Jabeen, K.; Kolandhasamy, P. (2015). Microplastic Pollution in Table Salts from China. Environ. Sci. Technol. 49, 13622–13627.
23. Liebezeit, G.; Liebezeit, E. (2014). Synthetic particles as contaminants in German beers. Food Addit. Contam. Part A, 31, 1574–1578.
24. Van Cauwenberghe, L.; Janssen, C.R. (2014). Microplastics in bivalves cultured for human consumption. Environ. Pollut. 193, 65–70.
25. Zettler, E.R.; Mincer, T.J.; Amaral-Zettler, L.A. (2013). Life in the "Plastisphere": Microbial Communities on Plastic Marine Debris. Environ. Sci. Technol. 47, 7137–7146.
26. Hussain, N. (2001). Recent advances in the understanding of uptake of microparticulates across the gastrointestinal lymphatics. Adv. Drug Deliv. Rev. 50, 107–142.
27. Barboza, L.G.A.; Dick Vethaak, A.; Lavorante, B.R.B.O.; Lundebye, A.-K.; Guilhermino, L. (2018). Marine microplastic debris: An emerging issue for food security, food safety and human health. Mar. Pollut. Bull. 133, 336–348.
28. Lupo, C.; Angot, J.-L. (2020). Public health issues related to seafood consumption.. Bull. Acad. Natl. Méd. 204, 1017–1033.
29. Fendall, L.S.; Sewell, M.A. (2009). Contributing to marine pollution by washing your face: Microplastics in facial cleansers. Mar. Pollut. Bull. 58, 1225–1228.
30. da Costa, J.P.; Santos, P.S.M.; Duarte, A.C.; Rocha-Santos, T. (2016). (Nano)plastics in the environment—Sources, fates and effects. Sci. Total Environ. 566–567, 15–26.
31. Browne, M.A.; Crump, P.; Niven, S.J.; Teuten, E.; Tonkin, A.; Galloway, T.; Thompson, R. (2011). Accumulation of Microplastic on Shorelines Woldwide: Sources and Sinks. Environ. Sci. Technol. 45, 9175–9179.
32. Jambeck, J.R.; Geyer, R.; Wilcox, C.; Siegler, T.R.; Perryman, M.; Andrady, A.; Narayan, R.; Law, K.L. (2015). Plastic waste inputs from land into the ocean. Science, 347, 768–771.
33. Mariano S, Tacconi S, Fidaleo M, Rossi M, Dini L (2021) Micro and nanoplastics identification: classic methods and innovative detection techniques. Front Toxicol Available from: https://www.frontiersin.org/article/10.3389/ftox.2021.636640.
34. Oliveri Conti G, Ferrante M, Banni M, Favara C, Nicolosi I, Cristaldi A et al (2020) Micro- and nano-plastics in edible fruit and vegetables. The frst diet risks assessment for the general population. Environ Res 187:109677 Available from: https://www.sciencedirect.com/science/article/pii/ S0013935120305703.
35. Zuccarello P, Ferrante M, Cristaldi A, Copat C, Grasso A, Sangregorio D et al (2019) Exposure to microplastics (< 10 μm) associated to plastic bottles mineral water consumption: the frst quantitative study. Water Res 157:365–371 Elsevier.
36. CONTAM (2016) Presence of microplastics and nanoplastics in food, with par- ticular focus on seafood. EFSA J 14(6):e04501. https://doi.org/10.2903/j. efsa.2016.4501 John Wiley & Sons, Ltd
37. Smith M, Love DC, Rochman CM, Nef RA (2018) Microplastics in seafood and the implications for human health. Curr Environ Health Rep 5(3):375– 386 Springer International Publishing. Available from: https://pubmed.ncbi.nlm.nih.gov/30116998
38. Lithner D, Larsson Å, Dave G (2011) Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition. Sci Total Environ 409(18):3309–3324.
39. Gewert B, Plassmann MM, MacLeod M (2015) Pathways for degradation of plastic polymers foating in the marine environment. Environ Sci Pro- cess Impacts 17(9):1513–1521.
40. Dawson AL, Kawaguchi S, King CK, Townsend KA, King R, Huston WM et al (2018) Turning microplastics into nanoplastics through digestive frag- mentation by Antarctic krill. Nat Commun 9(1):1001.
41. Andrady AL (2011) Microplastics in the marine environment. Mar Pollut Bull 62(8):1596–1605.
42. Cole M, Lindeque P, Halsband C, Galloway TS (2011) Microplastics as contami- nants in the marine environment: a review. Mar Pollut Bull 62(12):2588– 2597.
43. Mato Y, Isobe T, Takada H, Kanehiro H, Ohtake C, Kaminuma T (2001) Plastic resin pellets as a transport medium for toxic chemicals in the marine environment. Environ Sci Technol 35(2):318–324.
44. WHO (2019) Microplastics in drinking-water, Geneva

45. Kwon J-H, Kim J-W, Pham TD, Tarafdar A, Hong S, Chun S-H et al (2020) Microplastics in food: a review on analytical methods and challenges. Int J Environ Res Public Health 17(18):6710.
46. Galafassi S, Campanale C, Massarelli C, Uricchio VF, Volta P (2021) Do freshwater fish eat microplastics? A review with a focus on efects on fsh health and predictive traits of MPs ingestion. Water 13(16):2214
47. Iñiguez ME, Conesa JA, Fullana A (2017) Microplastics in Spanish table salt. Sci Rep 7(1):8620.
48. Diaz-Basantes MF, Conesa JA, Fullana A (2020) Microplastics in honey, beer, milk and refreshments in Ecuador as emerging contaminants. Sustain- ability 12(14):5514
49. Kutralam-Muniasamy G, Pérez-Guevara F, Elizalde-Martínez I, Shruti VC (2020) Branded milks–are they immune from microplastics contamination? Sci Total Environ 714:136823 Elsevier
50. Liebezeit G, Liebezeit E (2013) Non-pollen particulates in honey and sugar. Food Addit Contam Part A 30(12):2136–2140.
51. Mason SA, Welch VG, Neratko J (2018) Synthetic polymer contamination in bottled water. Front Chem:407
52. Kedzierski M, Lechat B, Sire O, Le Maguer G, Le Tilly V, Bruzaud S (2020) Micro- plastic contamination of packaged meat: occurrence and associated risks. Food Packag Shelf Life 24:100489 Elsevier
53. Du F, Cai H, Zhang Q, Chen Q, Shi H (2020) Microplastics in take-out food con- tainers. J Hazard Mater 399:122969
54. Sobhani Z, Lei Y, Tang Y, Wu L, Zhang X, Naidu R et al (2020) Microplastics generated when opening plastic packaging. Sci Rep 10(1):4841.
55. Hernandez LM, Xu EG, Larsson HCE, Tahara R, Maisuria VB, Tufenkji N (2019) Plastic teabags release billions of microparticles and nanoparticles into tea. Environ Sci Technol 53(21):12300–12310.