You Are What You Eat: Bioaccumulation of Microplastics in the Food Chain

Audrianna Torrey

Department of Environmental Science, College of Science, Technology, and Health, Lindenwood University

Abstract

Over the last century, the use and production of plastic has surged as demand for cost-effective alternatives to traditional materials has grown. While plastic has been extremely beneficial in reducing the cost of production while expanding the market, it has also created a global pollution crisis. By 2015, an estimated 6,300 million tons of plastic waste had been generated with nearly 80% accumulating in landfills and the environment. Over the last couple decades, researchers have begun to study the effects of plastic waste and its breakdown into microplastic on aquatic environments. Although not all organisms reside in water, every living-being, including humans, relies on water for survival. The signs of microplastics becoming more common to find within living beings have sparked conversations both within and beyond the scientific community. This review of recent studies and literature on the movement of microplastics focuses on creating a general understanding of how microplastics infiltrate and bioaccumulate through the food chain. By examining how microplastics have made their way through he biosphere, research can highlight the lasting impact of pollution on the environment and human health.

Microplastic definiton chart

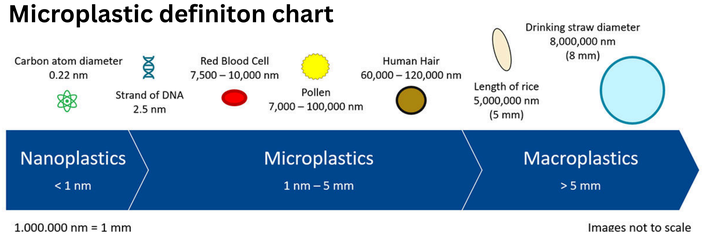


Figure 1. Shows a chart defining the size range of microplastics as well as size comparisons. (Illinois EPA)

Introduction

Since the term “microplastic” was first officially coined by Thompson et al. in 2004, the information around microplastics in the environment has grown (Thompson et al.). What was once a broad category of products and pollutants, microplastics has since been broken into two categories based on point of origin (Schmid et al., NOAA).

Microplastics as the broad spectrum category are defined as any plastic the is between 1nm and 5mm. This range spans the size of a single Lego stud at the largest down to half the size of a strand of DNA (Illinois EPA).

Microplastics are divided int two distinct categories based on origin; primary and secondary. Primary microplastics are the ones purposefully made on a microscopic level. The most common occurrence is the microbeads used in cosmetics and hygiene products, and glitter. Pre-production plastic is often kept in beads or pellets that fall under the microplastic size category. Secondary microplastics are what the majority of the public think about when asked about microplastics. These are the by product of the degradation of larger plastic items. These particles result from the weathering, breaking, or fragmentation of larger plastic materials and include microfragments and microfibers—the types most commonly associated with public awareness of microplastics.

Understanding microplastics’ distribution and effects is vital due to their persistent presence in both marine and terrestrial environments. Their impact on ecosystems, wildlife, and even human health remains a growing concern, as current data on their environmental fate and long-term consequences is limited.

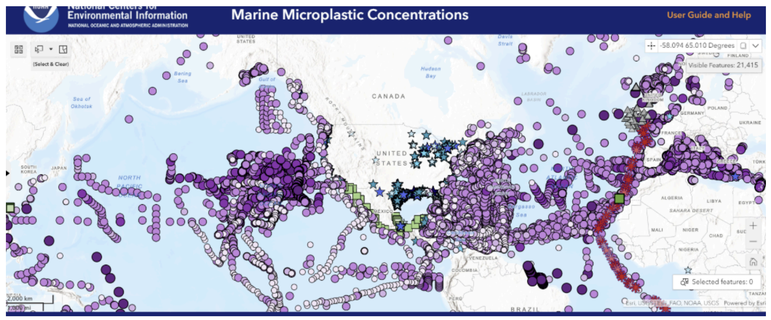


Figure 2. A image copy of the interactive map of Marine Microplastic Concentrations created by the National Centers for Environmental Information within the National Ocean and Atmospheric Association (NOAA).

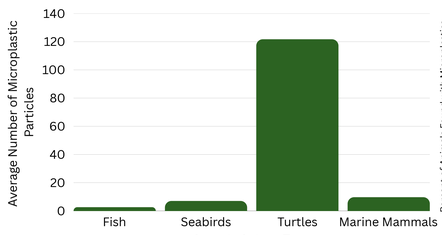
Methodolgy

This study is a systematic literature review examining studies done on the presence and origin of microplastics in the environment and within various trophic levels of the food web. Primary source studies were used to find and support data done during field investi8gations and studies. Secondary sources were used to find relating primary sources an d support he data found. Research and articles published between 2004-2025 were included, as that is the time frame in wh8ich microplastics were defined with the current definition that is being used in this review. Marine environments were the main focus, as the main movement medium for microplastics is water and the main primary consumers of microplastics are the microscopic fauna found in aquatic ecosystems.

Data

Graph 1. Shows the average amount in 132 studies as presented by Ugwu et al. of microplastic particles found in aquatic animals across four broad aquatic animal types: Fish (2.61), Seabirds (7.04), Turtles (121.73), and Marine Mammals (9.71)(Ugwu et al.).

Graph 2. Shows the average percentage of animals in 132 studies as presented by Ugwu et al. found with microplastic particles across four broad aquatic animal types: Fish (41.99 %), Seabirds (50.38%), Turtles (88.17%), and Marine Mammals (59.49%) (Ugwu et al.).



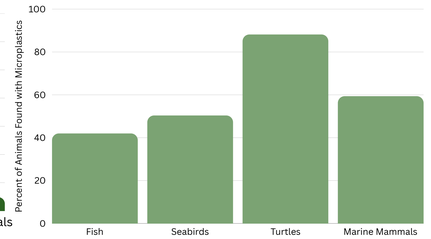


Table 1. Shows the spread of information across the main sources used for this review. This table compares the type of microplastics studied, the type of aquatic environment, the studied impact, the key findings of the studies, and the trends that were noticed by each study.

Source	Type of Microplastic	Location/Environment	Impact on Marine Life	Key Findings	Significant Trends
Thompson et al. (2004)	Primary & Secondary (microbeads, pellets, fibers)	Oceanic waters	Ingestion by marine organisms (e.g., fish, turtles) leading to internal injuries and potential for biomagnification	Microplastics accumulate in the ocean, impacting marine life, especially small fish and plankton	Increase in oceanic microplastics since industrialization
Borrelle et al. (2020)	Secondary (fragmentation from larger plastics)	Coastal ecosystems, open ocean	Trophic transfer through food chain (e.g., fish to humans)	Forecasts that plastic waste will surpass efforts to mitigate pollution by 2040	Projected increase in microplastic concentrations in marine environments
Saeedi (2024)	Primary (microbeads, pre-production pellets), Secondary (weathered plastics)	Coastal waters, beaches, deep sea	Direct ingestion and physical damage to fish and marine mammals	Microplastics affect digestion and reproduction in marine organisms	Studies show increased microplastic concentrations in urban coastal areas
Schmid et al. (2021)	Primary (synthetic fibers, beads), Secondary (plastic waste breakdown)	Urban environments, rivers, oceans	Disruption of gut microbiota in marine organisms	Rising concern over microplastic impact on marine biodiversity and ecological health	Rapid accumulation in river systems leading to ocean pollution
Yu et al. (2018)	Primary (plastic pellets), Secondary (weathered plastic debris)	Coastal sites along southeastern U.S.	Ingestion by fish species, with potential for bioaccumulation in higher trophic levels	Microplastics found in a variety of coastal ecosystems, affecting benthic and pelagic organisms	Coastal contamination remains a significant issue with high microplastic concentration
NOAA (2024)	Primary (microbeads, synthetic textiles), Secondary (fragmentation)	National parks, beaches	Ingestion by marine invertebrates (e.g., mollusks, crabs) and fish species	Quantification of microplastic presence in U.S. coastal national parks	Significant presence of microplastics in recreational beaches and marine protected areas
Illinois EPA (2025)	Both primary (pellets) and secondary (fragments, fibers)	Freshwater lakes and rivers	Harm to aquatic ecosystems, potential for entering the human food chain via fish consumption	Reports of microplastics in drinking water systems and freshwater ecosystems	Increase in microplastic concentrations in freshwater systems with urbanization

Discussion

The rapid emergence of microplastic pollution has become a global issue with impacts across not only aquatic environments but also terrestrial enviroments and human health. The research in this study highlights the massive impact of the presence of micropltics in the environment, specirfically aquatic environemtents. As observed by Thompson et al. (2004) and Schmid et al. (2021), both primary and secondary microplastics are prevalent in marine and freshwater environments, showing that since Thompson et al. first defined microplastics, the impact has only grown negatively.

The growing concern over microplastic ingestion by marine organisms is evident in the work by Saeedi (2024) and Yu et al. (2018), who demonstrated that microplastics are ingested by a variety of marine species, including fish and invertebrates, disrupting their digestive systems and, in some cases, affecting reproduction and survival. These findings are consistent with the broader narrative of ecological degradation outlined by Borrelle et al. (2020), which predicts that the global efforts to reduce plastic waste will fall short of addressing the growth in plastic pollution over the next few decades.

As plastics degrade into smaller particles, they enter the food web, where they can accumulate and potentially reach human consumers through seafood, as highlighted by Schmid et al. (2021).

The extent of the imapct in the United Statesw is shown by the data collected by NOAA (2024) on the spread of microplastics across both recreational and conservation areas. Such widespread contamination is compounded by the presence of synthetic fibers, microbeads, and pre-production pellets, which are found across beaches, rivers, and national parks. This highlights the need for a comprehensive approach to managing plastic waste and preventing further accumulation in vulnerable ecosystems.

While studies like those done by Ugwu et al. (2021) and Saeedi (2024) provide valuable insights into the risks associated with microplastic ingestion, there are still some gaps between the data collected and useful methods of removal.

Conclusion

The findings presented in this study emphasize the need for both national and international concern. While progress has been made since 2004, in the identification and impact of microplastics; current research indicates that the amount of microplastics will continue to outpace current relief efforts (Borrelle et al., 2020). The increase of ingestion of microplastics raises serious concerns for both aquatic ecosystems and the organisms that rely on them.

Efforts to reduce plastic pollution moving forward must include efforts to reduce the production and maximize effective waste management to reduce the opportunities of microplastics moving into the environment.

As Yu et al. (2018) and Thompson et al. (2004) highlight, the rising concentrations of microplastics in oceans and freshwater systems necessitate immediate action to protect aquatic life and prevent the broader ecological and health risks posed by these pollutants. More sustainable practices of the production, waste management, and recycling of plastic products will reduce the opportunities for further environmental degradation of plastic and ensure the health and safety of future populations.

Citations

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