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A Review of Microplastic Pollution in Marine Ecosystems: Sources, Distribution, Ecological Impacts, and Mitigation Strategies

[1]Manisha Munjewar, [2]Swati Kulkarni, [3]Priya Tayawade, [4]Harish Korde, [5]Sunil Narse, [6]Vaishali Tayade

[1,2,3,4,5,6] Department of Applied Science and Humanities, Shri Shankarprasad Agnihotri college of Engineering, Wardha, India.

[1]manisha24munjewar@gmail.com, [2]swatikulkarni2707@gmail.com, [3]priyatayawade27@gmail.com,[4]harishkorde_23@yahoo.com, [5]narse2011@rediffmail.com,[6]tayadevaishali02@gmail.com

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ABSTRACT

Marine ecosystems worldwide are being impacted by microplastic contamination, which has become a major environmental issue. Plastic particles smaller than 5 mm in diameter are known as microplastics, and they can come from either purposefully produced microscopic plastic particles used in consumer goods or from the breakdown of bigger plastic trash. Microplastics have been found in sediments, oceans, coastal waters, marine life, and even isolated marine habitats. The sources, distribution, ecological effects, trophic transmission, detection techniques, and mitigation measures related to microplastic contamination in marine ecosystems are all thoroughly covered in this review study. The ramifications for marine biodiversity and possible health hazards associated with seafood eating are also highlighted in the study. The build-up of plastic garbage in maritime ecosystems has been mostly caused by rising plastic production worldwide and insufficient waste management systems. Coordinated international efforts are needed to address this problem, including improved waste management, policy changes, technology innovation, and public awareness.

1. INTRODUCTION

Sources of Microplastics Plastic trash fragmentation, synthetic textile fibers, personal care items, industrial plastic pellets, and car tire wear are only a few of the many sources of micro plastics. The deterioration of larger plastic objects such packaging materials, plastic bags, bottles, and abandoned fishing nets is one of the main causes. Another significant source of microplastics is the synthetic fibers that clothing releases while washing. Microscopic fibers released by polyester, nylon, and acrylic fabrics end up in rivers and oceans after passing through wastewater treatment systems [1,5]. Micro plastic contamination is also a result of industrial activities. Resin pellets are used as raw materials in plastic production plants, and unintentional spills during processing and transportation may release these particles into the environment. Furthermore, the usage of micro beads in cosmetics like toothpaste and face cleansers has greatly increased the amount of micro plastic pollution in aquatic habitats [6]

2. Distribution in Marine Ecosystems

Surface waters, coastal areas, the water column, and deep-sea sediments are just a few of the marine environments where microplastics are widely present. Their presence has been documented in nearly every part of the ocean, from densely populated coastal regions to remote and isolated areas such as the open ocean and polar seas. This widespread distribution highlights the persistence and mobility of plastic pollution. Microplastics are transported across great distances by oceanographic processes such wave activity, wind patterns, and ocean currents. Ocean gyres, which are large-scale current systems, can collect floating plastic litter and create high-concentration areas known as "garbage patches." The Great Pacific Garbage Patch is one of these well-known areas. Microplastics have been found even in locations far from direct human activity because of these transport processes [7,8].The physical and chemical characteristics of microplastics, such as their density, size, and form, have a significant impact on their distribution and mobility. Plastics with low densities, such polyethylene and polypropylene, tend to stay buoyant and gather at or close to the ocean's surface. Polyvinyl chloride (PVC) and other high-density polymers are more likely to sink and build up in marine sediments and deeper waters. Microplastic dispersion is influenced by biological and environmental factors in addition to physical characteristics. Biofouling is a significant process that occurs when microorganisms like bacteria, algae, and tiny marine organisms adhere to plastic surfaces. Because of their increased weight, the particles become less buoyant and sink from the ocean's surface to its deeper levels. Moreover, microplastics are not limited to the surface or seabed; they are dispersed vertically throughout the water column. Particles can be moved up and down in the water column by turbulence, mixing processes, and seasonal variations, which makes their distribution extremely dynamic [9,10]. Through a mechanism called biological transport, marine animals also aid in the dispersal of microplastics. Microplastics can spread through the food chain after being consumed by small creatures. The particles may drop to the ocean floor when these species die or expel waste, adding to the buildup of silt. Riverine and coastal input is another significant influence. Rivers play a significant role in the movement of plastic garbage from the land into the ocean. Because of their closeness to cities, industrial discharge, and tourism, coastal zones frequently exhibit higher amounts of microplastics. Microplastics are also dispersed by air movement. The global spread of tiny plastic particles is further aided by the fact that they can be carried by wind over great distances and deposited into marine habitats through dry deposition or rainfall [11,12].

Table 1: Classes of plastics that are commonly encountered in the marine environment.

Plastic Class	Empty Cell	Specific Gravity	Percentage production#	Products and typical origin
Low-density polyethylene	LDPE LLDPE	0.91–0.93	21%	Plastic bags, six-pack rings, bottles, netting, drinking straws
High-density polyethylene	HDPE	0.94	17%	Milk and juice jugs
Polypropylene	PP	0.85–0.83	24%	Rope, bottle caps, netting
Polystyrene	PS	1.05	6%	Plastic utensils, food containers
Foamed Polystyrene				Floats, bait boxes, foam cups
Nylon	PA		<3%	Netting and traps
Thermoplastic Polyester	PET	1.37	7%	Plastic beverage bottles
Poly(vinyl chloride)	PVC	1.38	19%	Plastic film, bottles, cups

3. Impact on Marine Organisms

Numerous marine species, including plankton, fish, mollusks, crabs, seabirds, and marine mammals, have been shown to consume microplastics. Because plastic particles are microscopic and resemble natural prey, many species confuse them for food. After being consumed, microplastics can build up in an organism's digestive tract and result in internal injuries and intestinal blockages. Furthermore, the presence of plastic particles may lower calorie intake and feeding efficiency, which would ultimately impact development and reproduction. Additionally, hazardous substances including pesticides, heavy metals, and persistent organic pollutants can be transported via microplastics. When consumed by marine creatures, these pollutants may cling to the surface of plastic particles and penetrate their tissues, possibly leading to toxicological consequences [10, 13].

4. Microplastics in the Marine Food Chain

Across trophic transfer, microplastics can pass across marine food webs. Zooplankton and other small organisms directly consume microplastic particles from saltwater. After being eaten by larger predators like fish and invertebrates, these creatures enable microplastics to progress through the trophic levels. Concerns regarding human exposure to microplastics through fish intake are raised by this transmission. Microplastic particles have been found in economically significant fish and shellfish species in a number of studies, indicating that humans may consume trace amounts of plastic particles along with marine food items [11,12,13].

5. Detection and Analytical Methods

To find and measure microplastics in environmental samples, scientists employ a variety of analytical methods. Visual microscopy, Raman spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), and scanning electron microscopy are common techniques. These methods aid in determining the concentration levels, particle size distribution, and polymer composition of marine water, sediments, and biological tissues. Researchers' capacity to track microplastic pollution in marine ecosystems has greatly increased thanks to developments in analytical technologies [14,15].

6. Management and Mitigation Strategies

Effective waste management techniques and legislative changes are necessary to reduce microplastic pollution. Reducing single-use plastics, improving recycling systems, and waste segregation are crucial steps in keeping plastic trash out of marine habitats. A number of nations have passed laws prohibiting microbeads in cosmetics and encouraging the use of biodegradable substitutes. Environmental education initiatives and public awareness campaigns are crucial in promoting sensible trash disposal and consumption habits. Long-term solutions to lessen microplastic contamination in aquatic environments could come from technological advancements like better wastewater filtering systems and the creation of biodegradable polymers [16,17].

7. Future Research Directions

The long-term ecological effects of microplastic pollution should be the main focus of future research. To assess the effects on human health, ecosystem functioning, and marine biodiversity, more research is needed. Addressing this environmental issue will require developing sustainable materials and enhancing the infrastructure for managing plastic garbage worldwide. To lessen the impact of plastic pollution on the environment, governments, businesses, and scientific communities must work together internationally [2,18].

Conclusion

Globally, marine ecosystems are increasingly at risk from microplastic pollution. Marine life, food webs, and even human health are all impacted by the build up of small plastic particles in seas. A mix of better waste management techniques, legislative restrictions, technological advancements, and higher public awareness is needed to address this problem. It is feasible to lessen microplastic contamination and save marine habitats for future generations by implementing sustainable practices and consuming less plastic [18,19].

References

[1] Andrady, A. L. (2011). Microplastics in the marine environment. Marine Pollution Bulletin, 62(8), 1596–1605.

[2] Thompson, R. C., Olsen, Y., Mitchell, R. P., et al. (2004). Lost at sea: Where is all the plastic? Science, 304(5672), 838–838.

[3] Cole, M., Lindeque, P., Halsband, C., & Galloway, T. (2011). Microplastics as contaminants in the marine environment. Marine Pollution Bulletin, 62(12), 2588–2597.

[4] Law, K. L., & Thompson, R. C. (2014). Microplastics in the seas. Science, 345(6193), 144–145.

[5] Browne, Mark A., et al. “Accumulation of Microplastic on Shorelines Worldwide: Sources and Sinks.”Environmental Science & Technology, vol. 45, no. 21, 2011, pp. 9175–9179..

[6] Fendall, Lisa S., and Mary A. Sewell. “Contributing to Marine Pollution by Washing Your Face: Microplastics in Facial Cleansers.”Marine Pollution Bulletin, vol. 58, no. 8, 2009, pp. 1225–1228..

[7] Cózar, Andrés, et al. “Plastic Debris in the Open Ocean.”Proceedings of the National Academy of Sciences, vol. 111, no. 28, 2014, pp. 10239–10244..

[8] Eriksen, Marcus, et al. “Plastic Pollution in the World’s Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea.”PLOS ONE, vol. 9, no. 12, 2014, e111913..

[9] Hidalgo-Ruz, Valeria, et al. “Microplastics in the Marine Environment: A Review of the Methods Used for Identification and Quantification.”Environmental Science & Technology, vol. 46, no. 6, 2012, pp. 3060–3075.

[10] Wright, Stephanie L., Richard C. Thompson, and Tamara S. Galloway. “The Physical Impacts of Microplastics on Marine Organisms: A Review.”Environmental Pollution, vol. 178, 2013, pp. 483–492.

[11] Farrell, Paul, and Karen Nelson. “Trophic Level Transfer of Microplastic: Mytilus edulis (L.) to Carcinus maenas (L.).”Environmental Pollution, vol. 177, 2013, pp. 1–3..

[12] Setälä, Outi, Viveka Fleming-Lehtinen, and Mika Lehtiniemi. “Ingestion and Transfer of Microplastics in the Planktonic Food Web.”Environmental Pollution, vol. 185, 2014, pp. 77–83..

[13] Rochman, Chelsea M., et al. “Ingested Plastic Transfers Hazardous Chemicals to Fish and Induces Hepatic Stress.”Scientific Reports, vol. 3, 2013, 3263.

[14] Hidalgo-Ruz, Valeria, et al. “Microplastics in the Marine Environment: A Review of the Methods Used for Identification and Quantification.”Environmental Science & Technology, vol. 46, no. 6, 2012, pp. 3060–3075..

[15] Shim, Won Joon, Seung-Kyu Hong, and Sang Hee Eo. “Identification Methods in Microplastic Analysis: A Review.”Analytical Methods, vol. 9, no. 9, 2017, pp. 1384–1391.

[16] Xanthos, Dirk, and Tony R. Walker. “International Policies to Reduce Plastic Marine Pollution from Single-Use Plastics (Plastic Bags and Microbeads): A Review.”Marine Pollution Bulletin, vol. 118, no. 1–2, 2017, pp. 17–26.

[17] GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). “Sources, Fate and Effects of Microplastics in the Marine Environment: A Global Assessment.” Reports and Studies No. 90, 2015.

[18] [18] Galloway, Tamara S., Matthew Cole, and Ceri Lewis. “Interactions of Microplastic Debris throughout the Marine

[19] Ecosystem.”Nature Ecology & Evolution, vol. 1, 2017, 01