



Emerging concerns of microplastic deposition in marine life: A review

Shreya R Patil

Assistant Professor in Zoology Veer Wajekar A.S.C. College, Phunde, Navi Mumbai, India

Abstract

Microplastic contamination has emerged as a pervasive and persistent form of marine pollution, attracting increasing scientific attention due to its widespread occurrence and potential biological impacts. These minute plastic particles, originating from both primary and secondary sources, are now detected across all marine compartments, including surface waters, sediments, and deep-sea environments. Marine organisms encounter microplastics through multiple exposure pathways, leading to their deposition in various tissues and organs. Beyond physical accumulation, microplastics interact with toxic chemicals and microorganisms, thereby intensifying their ecological and biological effects. This review critically examines the environmental distribution of microplastics, their uptake and deposition in marine organisms, the resulting biological and ecotoxicological consequences, trophic transfer processes, and potential implications for human health. Emphasis is placed on understanding microplastic–organism interactions in order to assess long-term risks and guide future research and management strategies.

Keywords: Microplastics, marine pollution, bioaccumulation, marine organisms, ecotoxicological effects

Introduction

Environmental Occurrence and Distribution of Microplastics in Marine Ecosystems

Microplastics have become integral contaminants of marine ecosystems due to the extensive global production and indiscriminate disposal of plastic materials. These particles originate either as primary microplastics, intentionally manufactured for industrial or consumer applications, or as secondary microplastics formed through the progressive fragmentation of larger plastic debris. Physical processes such as wave action, ultraviolet radiation, and thermal oxidation, combined with biological activity, continuously transform macroplastics into micro-sized particles, ensuring their persistent input into marine systems.

Once introduced, microplastics are transported by ocean currents and wind-driven circulation, resulting in their global dispersal. Their spatial distribution is governed largely by polymer density and environmental conditions.

Low-density plastics such as polyethylene and polypropylene tend to remain buoyant and accumulate in surface waters and convergence zones, whereas high-density polymers and biofouled particles sink and settle in sediments. Coastal environments often show elevated concentrations due to riverine discharge, urban runoff, industrial effluents, and wastewater treatment plant outputs. Estuaries and mangrove ecosystems act as effective sinks, trapping microplastics within fine sediments and organic matter.

Recent investigations have demonstrated that microplastics are not confined to coastal or surface environments but are also present in deep-sea sediments, polar regions, and remote oceanic gyres. The discovery of microplastics in such isolated habitats underscores their persistence and long-range transport potential, raising concerns about their accumulation in ecosystems previously considered pristine (Cózar *et al.*, 2014; Van Cauwenbergh *et al.*, 2013)^[3, 7].

Table 1: Microplastic Deposition in Major Marine Organism Groups

Marine Organism Group	Common Deposition Sites	Reported Effects
Zooplankton	Digestive tract	Reduced feeding, energy depletion
Bivalves	Gills, gut	Inflammation, oxidative stress
Crustaceans	Gut, hepatopancreas	Reduced growth, behavioral changes
Fish	Gut, liver, muscle	Metabolic disruption, tissue damage
Seabirds	Stomach	Physical injury, reduced fitness

Uptake, Deposition, and Tissue Distribution of Microplastics in Marine Organisms

Marine organisms encounter microplastics throughout their life cycles via multiple exposure routes, with ingestion being the most dominant pathway. Organisms often mistake microplastics for natural food particles due to their size, color, and surface properties. Filter-feeding organisms such as zooplankton, bivalves, and ascidians are particularly susceptible, as they indiscriminately filter large volumes of water and retain suspended particles, including microplastics (Cole *et al.*, 2013)^[2].

In higher trophic organisms, ingestion commonly occurs indirectly through contaminated prey, facilitating the

transfer of microplastics along food chains. In addition to ingestion, microplastics may enter organisms through gill uptake or dermal contact, especially in early developmental stages when protective barriers are not fully developed. Once internalized, microplastics are predominantly retained in the gastrointestinal tract, where they may persist for extended periods.

Smaller microplastics, particularly those in the lower micrometer range, possess the ability to cross epithelial barriers and translocate to other tissues. Studies have reported microplastic deposition in gills, liver, muscle tissue, and even circulatory systems. Tissue distribution is influenced by particle size, shape, surface charge, and

hydrophobicity. Fibrous particles are often retained longer due to entanglement within tissues, increasing the likelihood of localized inflammation and cellular stress (Wright *et al.*, 2013)^[8].

Microplastics as Carriers of Chemical and Biological Contaminants

One of the most concerning aspects of microplastic pollution is their ability to act as vectors for chemical and biological contaminants. Due to their hydrophobic surfaces and high surface-area-to-volume ratio, microplastics readily adsorb a wide range of environmental pollutants, including heavy metals, polycyclic aromatic hydrocarbons, persistent organic pollutants, pesticides, and pharmaceutical residues. These contaminants originate from industrial discharges, agricultural runoff, and urban waste streams.

When microplastics loaded with contaminants are ingested by marine organisms, the conditions within the digestive tract may promote desorption of these chemicals, enhancing their bioavailability and toxicity. This process may exacerbate the biological effects of microplastics beyond their physical presence alone, leading to synergistic toxic effects (Rochman *et al.*, 2013)^[6].

In addition to chemical pollutants, microplastics provide novel substrates for microbial colonization, forming complex biofilms collectively referred to as the plastisphere. These biofilms often harbor diverse microbial communities, including potentially pathogenic bacteria. The transport of such microorganisms across marine environments raises concerns regarding disease transmission and the alteration of native microbial assemblages, further complicating the ecological impacts of microplastic pollution.

Biological and Ecotoxicological Effects on Marine Life

The biological effects of microplastics on marine organisms manifest at multiple levels of biological organization. At the organismal level, ingestion of microplastics can lead to physical blockage of the digestive tract, reduced feeding efficiency, and false satiation, ultimately resulting in energy deficiency. Chronic exposure may impair growth, reproduction, and survival, particularly in species with limited ability to egest ingested particles.

At the tissue and cellular levels, microplastics have been shown to induce inflammatory responses, oxidative stress, and cellular damage. The generation of reactive oxygen species can disrupt antioxidant defense systems, leading to lipid peroxidation, protein damage, and altered enzyme activity. In fish and invertebrates, microplastic exposure has been associated with changes in metabolic pathways, immune suppression, and histopathological alterations in vital organs such as the liver and gills (Jovanović, 2017)^[5].

Sub-lethal effects are of particular concern, as they may not cause immediate mortality but can compromise physiological performance and reproductive success. Over time, such effects may translate into population-level consequences, altering community structure and ecosystem functioning.

Trophic Transfer, Human Health Implications, and Future Research Directions

Microplastics are readily transferred across trophic levels, resulting in their accumulation in higher-order consumers. Predatory fish, seabirds, and marine mammals often exhibit higher microplastic loads due to repeated ingestion of

contaminated prey. This trophic transfer raises significant concerns regarding the entry of microplastics into human food systems through the consumption of seafood.

Although the full extent of human health impacts remains uncertain, potential risks include exposure to toxic additives, adsorbed pollutants, and pathogenic microorganisms. The presence of microplastics in edible tissues of commercially important species highlights the need for comprehensive risk assessment and regulatory frameworks (Galloway, 2015)^[4].

Future research must prioritize long-term exposure studies, standardized analytical methodologies, and investigations into nanoplastics, which may pose even greater biological risks due to their ability to penetrate cellular membranes. Addressing microplastic pollution will require coordinated efforts encompassing scientific research, policy interventions, improved waste management practices, and public awareness initiatives.

References

1. Browne MA, *et al.* Ingested microscopic plastic translocates to the circulatory system of the mussel *Mytilus edulis*. *Environmental Science, Technology*,2008;42:5026–5031.
2. Cole M, *et al.* Microplastic ingestion by zooplankton. *Environmental Science, Technology*,2013;47:6646–6655.
3. Cózar A, *et al.* Plastic debris in the open ocean. *Proceedings of the National Academy of Sciences*,2014;111:10239–10244.
4. Galloway TS. Micro- and nano-plastics and human health. *Marine Anthropogenic Litter*,2015:343–366.
5. Jovanović B. Ingestion of microplastics by fish and its potential consequences. *Integrated Environmental Assessment and Management*,2017;13:510–515.
6. Rochman CM, *et al.* Ingested plastic transfers hazardous chemicals to fish. *Scientific Reports*,2013;3:3263.
7. Van Cauwenberghe L, *et al.* Microplastic pollution in deep-sea sediments. *Environmental Pollution*,2013;182:495–499.
8. Wright SL, Thompson RC, Galloway TS. The physical impacts of microplastics on marine organisms. *Environmental Pollution*,2013;178:483–492.