# Plastic Pollution in India: Sources, Effects & Management

## (भारत में प्लास्टिक प्रदूषण: स्रोत, प्रभाव और प्रबन्धन)

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# Contents

# Microplastics: An emerging environmental problem

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India is home to a diverse range of ecosystems, from the Himalayan Mountains to the Indian Ocean, and from tropical rainforests to arid deserts. However, the rapid economic development and population growth in recent decades have put tremendous pressure on the environment and natural resources. Metro cities around the world are facing several emerging environmental issues that are affecting their residents and ecosystems. According to the Intergovernmental Panel on Climate Change (IPCC) the climate crisis is accelerating at a pace like never before and warned that it is 'now or never' situation to limit global warming to 1.5C. Some of the biggest environmental issues in India right now are Air pollution, Water scarcity, Waste management, Urban heat islands, Loss of green spaces, Climate change, Energy consumption, Biodiversity loss and Microplastic. In this chapter we shall be discussing the Microplastics as an emerging environmental problem.

Microplastics are plastic fragments which are smaller than 5 millimeters in length. Microplastic causes pollution in natural ecosystems. It can enter in Air, soil, or aquatic ecosystems. There are multiple sources of microplastics like domestic wastewater, food packaging industries, cosmetic industries and many other industries which deal with plastic

products. Around 35 % of total microplastic comes to the environment from textile or clothing industries (1). Degradation of plastic generally takes a very long time like hundreds or thousands of years (2). Due to this it has high chances of ingestion by living organisms of different food chains. After its entry inside the body, it can become part of tissues and can cause multiple problems in the functioning of cells and tissues. In terrestrial ecosystems, it has been observed that microplastics can interfere with different food chains and can reduce weight of important organisms like earthworm (3)(4).

Image source: https://blog.uvm.edu/

Microplastics are formed after breakdown and fragmentation of larger plastic items or are intentionally manufactured at a small size for specific purposes. There are two main types of microplastics:

**I) Primary microplastics:** These are intentionally produced and used in various products. They include:

a. Microbeads: Tiny plastic beads used in personal care products like exfoliating scrubs, toothpaste, and cosmetics.

b. Microfibers: Small fibers shed from synthetic textiles like polyester, nylon, and acrylic during washing or regular use.

c. Pellets or nurdles: Pre-production plastic resin pellets used as raw materials in the manufacturing of plastic products.

**II) Secondary microplastics:** These are the result of the degradation and breakdown of larger plastic items in the environment. They are formed by the weathering and fragmentation of plastic products like bags, bottles, containers, fishing gear, and other plastic products.

Both primary and secondary microplastics can have detrimental effects on the environment and wildlife. They can be ingested by aquatic organisms, potentially entering the food chain, and causing various ecological and health risks. Efforts are being made worldwide to reduce the production and release of microplastics into the environment and to mitigate their impacts.

## Microplastics in animals

Microplastics have been found in various animals across different ecosystems, including marine, freshwater, and terrestrial environments. These tiny plastic particles can be ingested by animals through different pathways, leading to potential impacts on their health and well-being.

In marine environments, marine organisms such as fish, seabirds, turtles, and marine mammals are at risk of ingesting microplastics. Filter-feeding animals can mistakenly consume microplastics while feeding on small particles in the water.

In freshwater ecosystems, aquatic organisms like fish and invertebrates can also be exposed to microplastics through contaminated water and sediments.

Microplastics have been found in various species of fish worldwide, including both marine and freshwater fish. Fish can ingest microplastics through different pathways, primarily by mistaking them for food or consuming them indirectly through their prey.

In marine environments, microplastics are often present in the water and can be ingested by filter-feeding fish like mackerel and herring, as well as by bottom-dwelling species.

Additionally, predatory fish that feed on smaller fish or marine organisms could accumulate microplastics through the food chain.

In freshwater ecosystems, fish can be exposed to microplastics through contaminated water and sediment. Studies have detected microplastics in several freshwater fish species, including trout, carp, and perch.

Once ingested, microplastics can accumulate in the digestive tracts of fish, potentially leading to physical harm, reduced feeding efficiency, and negative impacts on reproduction and growth. Microplastics may also cause inflammation in the gut of fish.

Microplastics can act as carriers for toxic chemicals, such as persistent organic pollutants and heavy metals. These pollutants can adhere to the surface of microplastics and be transferred to the tissues of fish upon ingestion, posing additional risks to their health and potentially affecting human consumers if the contaminated fish are consumed as food.

Mitigating the impact of microplastics on fish and other marine life requires collective efforts from governments, industries, and individuals to reduce plastic usage and promote more sustainable practices.

Terrestrial animals may ingest microplastics indirectly by consuming contaminated food or directly if they encounter plastic debris in their habitats.

Once ingested, microplastics can accumulate in the digestive systems of animals, potentially leading to physical harm, reduced feeding efficiency, and disruption of nutrient absorption.

The presence of microplastics in animals highlights the complex issue of plastic pollution and its widespread impact on ecosystems. It also raises concerns about the potential transfer of microplastics through the food chain, which could ultimately affect human health if contaminated animals are consumed as food.

Addressing the problem of microplastics in animals requires comprehensive efforts to reduce plastic pollution at its source, improve waste management practices, and raise awareness about the consequences of plastic pollution on both wildlife and human beings.

Research has shown that microplastics can be found in the human body, primarily through ingestion and inhalation. These tiny plastic particles, often smaller than 5mm in size, are found in the environment, and humans are exposed to them through various sources, including food, water, and air.

Ingestion: Microplastics can be present in food and beverages due to contamination from plastic packaging, processing, and other sources. When we consume these items, microplastics can be ingested and may accumulate in the gastrointestinal tract.

Inhalation: Microplastics can also be present in the air, especially in urban areas, because of plastic debris breaking down and becoming airborne. When we breathe in polluted air, microplastics can enter our respiratory system.

Once inside the human body, some microplastics may be able to cross the gut or lung barriers and enter the bloodstream, potentially spreading to various organs. The long-term health effects of microplastics in the human body are not yet fully understood, and ongoing research is investigating their potential health risks.

While the presence of microplastics in the human body has been confirmed, the overall impact on human health is still a subject of study and concern. Reducing plastic pollution at the source and improving waste management practices are crucial steps to mitigate the exposure of microplastics to both the environment and human beings.

Microplastics can become embedded in the tissues of organisms through ingestion and respiration process. Some corals like *Pocillopora verrucosa* have been found to ingest

microplastics (5). It takes around 14 days for microplastic to pass through the digestive system of animal while normal digestion period is only 2 days. If it gets enmeshed in the gills of aquatic animals, then removal becomes very difficult.

Important filter feeder animals like bivalves have been shown to ingest microplastics (6). Microplastics reduce the filtration ability of these animals. It causes oxidative stress in the bivalves which can result in impaired ability of the body to detoxify, finally it may result in DNA damage. Even gametes and larvae of bivalves become defective when exposed to microplastics. It also slows down the rate of development of embryo, promotes developmental malformities and decreases rates of fertilization in bivalves. (7)

Zooplanktons ingest microplastics and it also sticks to their appendages and exoskeleton. Like phytoplankton, microplastics emit dimethyl sulfide and hence zooplankton consume them unknowingly. (8)

Microplastics can pass from one trophic level to another when a predator animal consumes its prey having microplastics. In this way it can reach higher trophic levels. Microplastics can absorb chemical pollutants, and these can get transferred to animal tissues along with microplastics. Plastic deposition has been reported in the stomach of many fishes like lantern fish, tuna and sword fish (9).

Microplastics can be present in the food we eat, the water which we drink and the air which we breathe. On average, people consume more than 50,000 plastic particles every year. This number will increase further if we include inhalation also (10). Microplastics were found in many different human tissues studied by students at Arizona State University. (11)

## Pollution of microplastics in India

Microplastics pollution is a growing concern in India, like in many other parts of the world. The extensive use of plastic products, inadequate waste management systems, and the

presence of numerous rivers and water bodies contribute to the spread of microplastics.

India is one of the major contributors to plastic pollution globally, generating a significant amount of plastic waste every year. Improper disposal and inefficient recycling facilities result in plastic debris breaking down into microplastics, which then find their way into rivers, lakes, and oceans.

The presence of microplastics in water bodies poses risks to aquatic life and can potentially enter the food chain, affecting human health. The issue has gained attention from environmentalists, researchers, and policymakers, leading to discussions on ways to tackle the problem.

To address microplastics pollution in India, it's essential to improve waste management practices, promote plastic alternatives, and raise public awareness about the impact of plastic pollution on the environment and human health. Additionally, implementing strict regulations and investing in advanced filtration systems in wastewater treatment plants can help reduce the release of microplastics into the environment.

## Microplastics in rivers of India

Microplastics pollution is a significant concern in Indian rivers due to the widespread use of plastic products and inadequate waste management practices. Many Indian rivers face heavy contamination from plastic waste, which eventually breaks down into microplastics.

The improper disposal of plastic waste, lack of recycling facilities, and limited awareness about the consequences of plastic pollution contribute to the problem. Plastic items discarded on land or in water bodies can gradually degrade into smaller particles, including microplastics, which then find their way into rivers through runoff or direct dumping.

Once in the rivers, microplastics can pose serious threats to aquatic ecosystems. They can be ingested by

aquatic organisms, leading to potential health issues for marine life and, in turn, impacting the food chain.

Several studies have highlighted the presence of microplastics in various Indian rivers, including the Ganges, Yamuna, and Brahmaputra, and many others. This pollution not only affects aquatic life but also has implications for water quality and human health, as rivers serve as a significant source of drinking water and irrigation in many regions.

Image source: https://thediplomat.com/

Addressing microplastics pollution in Indian rivers requires comprehensive waste management strategies, improved recycling facilities, and public awareness campaigns to reduce plastic usage and promote responsible disposal practices. Efforts to curb plastic pollution at its source are essential to protect the health of India's rivers and the overall environment.

## Microplastics and microalgae

Microplastics causing potential threat to the living organisms but the mechanisms of their impacts at the molecular level are poorly known. It is true for primary

producers especially algae. In standing water, phytoplankton are basal food supplier to the food webs, oxygen production and biogeochemical cycling, and with rich biodiversity. When plastic interacts with algae, the accumulation of plastic particles can result in reduced photosynthetic capacity of the organism due to the reduction of the amount of light passing to the algae, resulting in reduced survival, and increased oxidative stress.

Algae are one most important primary producer in aquatic ecosystems. Any change/s in algae in the aquatic environment ultimately affect the structure and function of aquatic ecosystems. *Chlorella pyrenoidosa* and *Microcystis flosaquae* are the most widely distributed and common types of algae in freshwater ecosystems. *M. flos-aquae* is the main alga that causes cyanobacteria blooms.

Phytoplankton is a major primary producer in freshwater food chain (12). In freshwater system species richness, diversity, and abundance of phytoplankton play a critical role in maintaining the ecological balance. These indicators also provide necessary information regarding pollution level of particular aquatic ecosystem (12). Previous studies reported that MPs would affect freshwater microalgae in concentration and size-dependent manner (13). Sjollema et al., (2016) observed negative effects of uncharged and negatively charged microplastics of sizes 0.05, 0.5 and 6 µm on three different types of microalgae, *Dunaliella. tertiolecta*, *Chlorella vulgaris* etc. (14). Yokota et al. conducted a literature review that revealed primary producer–microplastic interactions can alter algal growth, photosynthetic efficiency, morphology, possibly via adhesion or transfer of adsorbed pollutants from microplastics. Wang et al., (2020) observed that both pristine and aged polyvinyl chloride microplastics (PVC MPs) would affect the growth rate and chlorophyll content of *Chlamydomonas reinhardtii* (15). Xiao et al., (2020) investigated negative consequences of PS-MPs in freshwater microalgae, *Euglena gracilis* (16). They noted that PS-MPs

(0.1 and 5 µm) strongly suppressed algal growth in a concentration-dependent manner. Zhang et al., (2016) also revealed that PVC MPs inhibited the growth of *Skeletonema costatum* (17). In another work (18), the impact of PS of varied surface charges in *Scenedesmus obliquus.* was assessed. The researchers reported reduced cell viability, photosynthetic efficiency and increased oxidative stress in the cells interacted with polystyrene nano plastics of 200 nm size with different surface charges. But they did not examine the effects of particles with different sizes or concentrations. Liu et al., (2019) reported, PS nano plastics (size: 100 nm) of different charges, (plain, aminated and carboxylated) caused growth inhibition and increase in the oxidative stress in *S. obliquus* (19). But they did not explore the effects of varied sizes of PS nano plastics on microalgae. Similarly, Huang et al., 2019 observed decreased cell viability and photosynthetic efficiency of *S. obliquus* upon interaction with three sizes of PS beads (0.1, 0.5, 1, and 2 µm) combined with different charges of PS (negative, positive and fluorescence tagged). But the size of PS-bead size was limited only to 2 µm. They did not study the effects of larger PS particles.

MPs stimulate oxidative stress in algae. It is noted, 1 µm MPs generated more Reactive Oxygen Species compared to 12 µm MPs. Similar trends have been noticed for superoxide and hydroxyl radical generation too. Larger sizes of MPs tend to trigger lesser amount of oxidative stress than the smaller sized ones because small sizes can penetrate the cell membrane easily (20).

In a recent study, microplastic contamination in sediment and surface water was discovered in Lonar lake, Maharashtra. The lake is third largest natural saltwater lake formed by meteoric impact around 52,000 years ago (21). The impact of microplastic contamination on living organism of in the lake is yet to study.

## Microplastics in coastal areas of India

Microplastics pollution is a growing concern in Indian coastal areas due to various factors. Coastal regions in India are highly populated and experience extensive industrial and commercial activities, leading to increased plastic waste generation. This, combined with inadequate waste management and poor disposal practices, contributes to the presence of microplastics in coastal waters.

Several sources contribute to microplastics contamination in Indian coastal areas:

**1) Urban runoff:** Rainwater can wash microplastics from streets, sidewalks, and urban areas into stormwater drains, eventually reaching coastal waters.

**2) Rivers and waterways:** As mentioned earlier, rivers in India carry plastic debris, including microplastics, from inland areas to the coast.

**3) Marine litter:** Coastal areas often face direct dumping of plastic waste, including single-use plastics like bags and bottles, which later break down into microplastics.

**4) Shipping and fishing activities:** Coastal areas with busy ports and fishing activities may experience plastic pollution from shipping containers and fishing gear.

The presence of microplastics in coastal waters can have significant implications for marine ecosystems and biodiversity. Marine organisms may ingest microplastics, leading to health issues and potential bioaccumulation in the food chain. Moreover, microplastics can impact water quality and marine habitats, affecting the overall health of coastal ecosystems.

To address microplastics pollution in Indian coastal areas, comprehensive efforts are needed, including improved waste management, strict regulation of plastic usage, increased public awareness about plastic pollution, and promoting sustainable practices in coastal industries and

activities. Collaborative actions from government, industries, communities, and individuals are crucial to protect India's coastal environments from this pervasive environmental issue.

## Methods for preventing pollution caused by microplastics

Preventing pollution caused by microplastics requires comprehensive strategies at various levels, including individual actions, industry practices, and government regulations. Here are some effective methods for preventing microplastics pollution:

1. **Ban or restrict microplastics:** Governments can enact laws and regulations to ban or restrict the use of microplastics in certain products, such as personal care items, cleaning products, and industrial applications. This helps to reduce the direct release of microplastics into the environment.

2. **Avoid products with microplastics:** We should opt for products that do not contain microplastics, such as facial scrubs, toothpaste, and cosmetics. Look for natural alternatives like products with exfoliants made from apricot kernels, salt, or sugar.

3. **Reduce single-use plastics:** Minimize your use of single-use plastic items such as bags, straws, and bottles. We should opt for reusable alternatives like cloth bags, stainless steel or glass bottles, and metal or bamboo straws.

4. **Choose natural fibers:** When buying clothing, prefer natural fibers like cotton, wool, or silk over synthetic materials like polyester, nylon, and acrylic. Synthetic fibers shed microfibers more easily during washing.

5. **Proper waste disposal:** Ensure that plastic waste is disposed of correctly in recycling bins or waste collection points. Avoid littering to prevent plastic items from ending up in water bodies and eventually breaking down into microplastics.

**6. Support initiatives and policies:** Support organizations and initiatives that work to reduce plastic pollution and promote sustainable practices. Advocate for policies that regulate and reduce microplastic use and pollution.

**7. Educate and raise awareness:** Educate yourself and others about the harmful effects of microplastics pollution and the actions that can be taken to reduce it. Raise awareness in your community and encourage others to join the cause.

**8. Industry innovation and best practices:** Encourage industries to adopt sustainable practices and invest in research and development for alternative materials that are less harmful to the environment.

**9. Promote alternative materials:** Encourage the development and use of eco-friendly alternatives to plastic products. This includes biodegradable or compostable materials that break down more easily and are less harmful to the environment.

**10. Improve waste management:** Establish efficient waste management systems that reduce the likelihood of plastic waste ending up in the environment. Implement recycling programs and educate the public about proper waste disposal.

**11.Upgrade wastewater treatment plants:** Upgrade existing wastewater treatment facilities to include advanced filtration systems capable of capturing and removing microplastics from wastewater before it is discharged into water bodies.

**12. Implement microplastic-reducing technologies:** Explore and implement technologies designed to capture and remove microplastics from the environment, such as floating booms and skimmers in rivers and harbors.

**13. Encourage sustainable fishing practices:** Reduce the use of plastic-based fishing gear and promote the adoption

of sustainable alternatives. Abandoned fishing nets and gear are a significant source of microplastic pollution.

**14. Support research and monitoring:** Invest in research to better understand the sources, distribution, and impacts of microplastics pollution. Continuous monitoring is essential to assess the effectiveness of prevention measures and adapt strategies accordingly.

**15. Consumer awareness and education:** Educate the public about the issue of microplastics pollution and empower consumers to make informed choices. Promote responsible consumption and discourage the use of products containing microplastics.

**16. Industry responsibility:** Encourage industries to take responsibility for the entire life cycle of their products, including the potential generation of microplastics during production, use, and disposal. Encourage sustainable production and product design.

**17. International cooperation:** Address microplastics pollution as a global issue, promoting international collaboration to share knowledge, best practices, and technologies for prevention and mitigation.

**18. Support clean-up efforts:** Fund and participate in clean-up efforts to remove plastic waste and debris from the environment, preventing larger plastics from breaking down into microplastics.

By implementing a combination of these methods, we can make significant progress in preserving our environment and protecting ecosystems from this persistent and harmful form of pollution.

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