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# MICROPLASTICS AS AN EMERGING ENVIRONMENTAL HAZARD

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## ABSTRACT:

Microplastic contaminants pose a hazard to ecosystems and biodiversity on Earth. Microplastics (particles with a diameter of 5 mm with no lower limit) are employed in pharmaceuticals, personal care items, and industries due to the gradual fragmentation of huge plastic containers and goods or production in small sizes. Microplastics can be found in the air, on land, in marine environments, and even in food that people and animals eat.

One of the main challenges facing our governing body, research experts, and citizens is the impossibility of completely eliminating all microplastic pollution from the oceans. Cutting down the plastic flow is the essential solution to lowering trash and pollution, and such a strategy might have great relevance. This study gives a detailed investigation of the numerous facets of microplastics, spanning their composition, kinds, features, sources, health hazards, and environmental implications. Additionally, it explores methods for understanding the dynamics of microplastics in marine ecosystems, with an emphasis on preventing their incorporation into all levels of the food chain.

Their perseverance and release of chemicals and additives employed in the production of plastic products might have a domino effect on all living things worldwide. MNPs migrate and disperse from one environmental compartment to another due to the natural interconnection of the terrestrial, aquatic, and atmospheric compartments.

**Keywords:** Microplastic, Environment hazard, Marine ecosystem, Health hazards.

**Introduction:**

One of the 21st century's most urgent environmental issues is microplastics. These pollutants, which are defined as plastic particles smaller than five millimetres, have permeated every part of the earth, including rivers, oceans, soil, air, and even the food we eat. Economic activity, public health, and biodiversity are all seriously threatened by their widespread presence. Microplastics are very difficult to detect, manage, and regulate because they are almost invisible to the human eye, in contrast to larger plastic debris. India's large population, fast industrialization, and high plastic product consumption have made microplastics a growing concern. Although the laws controlling plastic pollution have improved over time, microplastics are still a problem that is not fully addressed. This paper investigates the legal issues raised by microplastics in India, evaluates the state of regulations, looks at pertinent case law, and makes suggestions for a more robust legal system.

There are several sources of microplastics. They fall into the following categories:

- **Primary Microplastics:** These are tiny, purposefully made plastic particles that are present in toothpaste, cleaning supplies, cosmetics, and industrial abrasives. Through industrial discharge and wastewater, they directly enter the environment.
- **Secondary microplastics** are produced when larger plastic objects, like bottles, bags, and packaging materials, break down as a result of environmental factors like wind, water erosion, and ultraviolet (UV) radiation. These plastics break down into tiny particles over time, contaminating soil, water, and the atmosphere.

Numerous studies conducted in India have confirmed the presence of microplastics in seafood, drinking water, and even table salt. The World Health Organization (WHO) has expressed concern about microplastics in drinking water, pointing out that these particles may contain pathogens, heavy metals, and hazardous chemicals. The risks are significant enough to call for immediate regulatory action, even though the full scope of the health implications is still being investigated. For example, microplastics have been discovered in fish, prawns, and crabs in coastal states like Kerala, Tamil Nadu, and Andhra Pradesh, raising serious concerns about seafood contamination. Eating such tainted food exposes people to known endocrine disruptors like bisphenol A (BPA) and phthalates.

In addition to indirect pathways like the food chain, microplastics found in the environment can enter the human body directly through inhalation, water consumption, and skin contact.

The objective of this analysis is to thoroughly assess the possible health risks associated with microplastic exposure in light of the growing concerns regarding microplastics as a new environmental and public health concern. Additionally, a growing number of researchers have evaluated the presence of MPs in the tissues of organisms or attempted to investigate the interactions between MPs and other environmental contaminants. Together with other coupled contaminants, MPs are extremely vulnerable to ingestion by organisms due to their small size. Various abiotic and biotic processes specific to aquatic environments, such as photodegradation, mechanical fragmentation, chemical and thermal degradation, and biological processes, cause these changes. The efficacy of each mechanism varies based on the kind of polymer and the surrounding circumstances.<sup>1</sup>

### **Ecosystem health and Restoration:**

The impact of plastic pollution varies via population. Communities that are marginalized and reside close to industrial centres, waste disposal sites, or unofficial recycling hubs are frequently disproportionately exposed to microplastics in the air and water. Without access to legal or political remedies, these populations endure cumulative health burdens, such as respiratory conditions, endocrine disruption, and contaminated food and water sources. Resolving this disparity needs to be a strategic and moral top priority. These vulnerable populations can be safeguarded by justice-centred environmental health policies, which also foster long-term social resilience.

Implementing the OSH-inspired One Health approach, interventions at critical phases of the microplastic lifecycle can dramatically reduce environmental pollution and downstream exposure across species. Source reduction strategies, such as restricting the discharge of microplastics from synthetic fabrics, tires, packaging, and industrial processes, directly prevent the entry of new particles into air, water, and soil systems. Environmental monitoring allows for the identification of pollution hotspots, the assessment of temporal patterns, and the early detection of new problems in addition to source control. Targeted treatments can be informed by this data. Additionally, measures like feed management and habitat preservation that target

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<sup>1</sup> Davi R. Munhoz et al., *Microplastics: A Review of Policies and Responses*, 14 *Challenges* 88 (2025), <https://www.mdpi.com/2079-9721/14/3/88>

livestock, wildlife, and aquaculture systems assist reduce the bioaccumulation of microplastics and associated contaminants, lowering the dangers to the environment and human health.

The communities most affected by plastic pollution frequently have useful ecological knowledge as well as workable waste management and resource stewardship techniques. Local and indigenous communities, particularly those that rely on subsistence or coastal economies, can provide vital information about fishing, water management, and land use. Through participatory governance models, policymakers should encourage active communication with these communities. Incorporating these perspectives enhances cultural sensitivity, legitimacy, and ultimately the effectiveness of interventions. By putting these tactics into practice, direct exposure is decreased and ecosystem resilience is increased. Interventions support biodiversity, nutrient cycling, and overall ecosystem services by preserving functional ecological compartments and preventing microplastic accumulation. This creates a feedback loop that improves ecological and public health outcomes by stabilizing the environmental conditions that support animal and human populations.<sup>2</sup>

### **Distribution of Microplastics and Their Potential Risks to the Human Health:**

It is widely known that people are exposed to MPs through ingestion of dust, water, and food particles as well as inhalation of airborne particles. To put things in perspective, it is estimated that each year, humans ingest between tens of thousands and millions of MP particles, or several milligrams per day. In both children and adults, atmospheric MPs can enter the respiratory system and build up in the pulmonary tissues. The respiratory system allows inhaled MP particles to enter the human body and reach the alveoli. MPs can avoid and stay in the pulmonary depths for a long time because larger particles are blocked by mucociliary clearance in the upper respiratory tract, which includes the nostrils, nasal cavity, mouth, pharynx, and larynx. Both ingestion and inhalation expose humans to marine MPs. According to age and gender, some people are thought to consume between 39,000 and 52,000 MPs annually.

When airborne inhalation is considered, MPs rise to between 74,000 and 21,000 particles. Members of parliament could travel up to 95 km and visit more remote locations by using atmospheric conveyance. MPs can be ingested by humans in a number of ways, such as by

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<sup>2</sup> Lynn L. Bergeson, L. Claire Hansen & Carla N. Hutton, *Microplastics in 2025: Regulatory Trends and Updates*, Nat'l L. Rev. (Sept. 4, 2025), <https://natlawreview.com/article/microplastics-2025-regulatory-trendsand-updates>

eating edible fruits and vegetables. discovered that, with a median of 223,000 p/g of MPs, apples had the highest level of contamination. A study conducted in China found that MPs are more common in aquatic species. This suggests that the health risks associated with commercial fish and bivalves sold in urban markets are higher than those associated with fish and bivalves exported from other nations. Oxidative stress, inflammatory responses, and metabolic issues may be harmful to health due to the molecular pathways that interact with MP particles. These consequences could be harmful to one's health. MPs, which range in diameter from 5 to 20  $\mu\text{m}$ , have been found to accumulate in the liver and kidneys of rodents, according to toxicological tests carried out by Deng et al.<sup>3</sup>

The FSSAI is committed to guaranteeing that consumers have access to wholesome and safe food. Gathering trustworthy data unique to India is crucial given the worldwide concerns around microplastics in food. In order to safeguard the public's health, this research is to determine the degree of microplastic contamination in Indian food and provide guidance for the creation of sensible laws and safety requirements. Inflammation and changes in their metabolic profiles result from this buildup. It was found that MPs smaller than 20  $\mu\text{m}$  could pass through biological membranes. There is evidence that exposure to MPs in experimental animals is associated with a number of diseases, despite the fact that plastics were once thought to be safe materials.<sup>4</sup>

### **Microplastic waste management:**

The potential number of MPs contributing to environmental toxicity was identified through a sensitivity analysis of the CF and different scenarios involving the release and clearance of various MPs during wastewater treatment. Demetrious et al. evaluated different methods for managing material recovery plant leftovers using life cycle assessment (LCA). The authors evaluated the environmental performance of the residual waste from the material recovery plants using an LCA that models the potential effects of acidification, climate change, eutrophication, and photochemical oxidation. Sensitivity analysis was used to identify various waste fractions of the residual waste composition at material recovery facilities. The data

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<sup>3</sup> Abhijeet Das & Satchidananda Mishra, Tackling the Microplastics Pandemic: The CLEAN Framework as an Integrated One Health Approach for Global Environmental and Public Health, *Green Tech. Resilience & Sustainability* (2026), <https://doi.org/10.1007/s44173-026-00031-1>

<sup>4</sup> Lakshita Singh, FSSAI Acts on Microplastic Contamination in Food, *Impact & Pol'y Rsch. Inst. (IMPRI)* (Aug. 29, 2024), <https://www.impriindia.com/insights/fssai-acts-on-microplastics-in-food/>

showed that landfills had the lowest gas emissions, regardless of whether credits offset power consumption or the carbon accounting methods used to estimate biogenic carbon dioxide.

Waste collection is the first step, which can be completed through post-separation or source collection (by customers). Since source collection is less costly and lessens waste contamination, it is advised. Waste disposal options include curb side collection, buy-back or drop-off centres, and door-to-door (D2D) waste collection with or without fees. These options range in customer convenience. Economic incentives to boost recycling rates can be beneficial, like buy-back programs that give consumers a certain amount of money for each package or weight, or detrimental like D2D collection fees that change based on waste type and weight or the use of intelligent trash cans. However, assessing charge values is a delicate process because effective rates could promote illegal dumping or MP burning. However, low fees won't have much of an impact on waste separation or consumption.

There is alternative, the most advanced recycling technologies that can bridge these gaps and get around the limitations imposed by the plastics present in different waste streams. This includes solutions for tertiary recycling, where plastic is transformed into monomers or feedstocks through thermochemical processes. Other approaches to chemical recycling are also being researched, such as solvent-based dissolution, which maintains polymer structure, and depolymerization, which breaks polymer bonds with chemicals.<sup>5</sup>

### **Global Control Measures and Efforts by International Organizations, Regional Unions, and Associations:**

A detailed examination of laws pertaining to plastics and microplastics revealed several laws created to deal with plastics dumped in landfills. To cover all types of plastics, these laws need to be strengthened and reviewed. A review of governance strategies for managing MPs in marine ecosystems revealed a lack of community participation in monitoring and conservation, which is primarily due to the lack of citizen science and co-management initiatives by important stakeholders. Additionally, no standardized management strategy has been implemented. In order to guarantee the decrease and reuse of plastics, the laws mainly relied on prohibitions, levies, and volunteer efforts.

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<sup>5</sup> Chaity, Need for Microplastics Regulation in India, *Int'l J. L. Mgmt. & Human.* 4257 (2024), <https://ijlmh.com/wp-content/uploads/Need-for-Microplastics-Regulation-in-India.pdf>

The review suggested a closed loop strategy that integrates current laws to influence consumer behaviour, facilitate plastic redesign and recycling, and assess the impact of those that end up in landfills in order to determine the efficacy of current legislation and direct the creation of new laws on MPs and single-use plastics. The pollution of agricultural land caused by MPs, which is mediated by sewage and fertilizers coated in plastic, has received little attention in MP policies. This calls for the implementation of legislation that will guarantee food quality assurance as well as the creation of policy and governance-based measures that will stop the contamination of agricultural fields and other potentially hazardous substances that MPs may carry. It is anticipated that the actions will shield people from MPs and PTEs.

The EU has developed a high-level plan for sustainable SS management by its member nations after realizing that sewage sludge (SS) is a significant contributor to the degradation of agricultural land. International communities have received figures from the United Nations (UN) that illustrate the detrimental effects of ocean plastic pollution on marine life and, consequently, on humans who rely heavily on it for their livelihood. These figures are provided by the UN to help nations make decisions. In order to guarantee effective waste management and offer ecologically beneficial alternatives, the UN resolution on tackling single-use plastic product pollution was developed in response to all member nations' inadequate management and recycling of plastic trash. Less than 9% of the 9 billion MT that have ever been created are recycled. If waste management and plastic consumption continue as they are, 12 billion MT of plastics will be released into the environment by 2050, the majority of which will originate from plastic packaging.<sup>6</sup>

### **NGT Initiatives on Microplastic Regulation:**

India's National Green Tribunal (NGT) has taken important steps to address the problems with microplastics and their effects on the environment and human health. The NGT acknowledged in February 2024 that microplastics can enter blood cells and pose major health hazards. They also called for rigorous adherence to environmental standards and started a study to determine whether current enforcement measures needed to be modified. After learning about the problem in July 2024, the tribunal ordered the Department of Environment and the Kerala State Pollution Control Board to look into microplastic contamination in Ashtamudi Lake.

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<sup>6</sup> Sameh S. Ali et al., *Microplastics as an Emerging Potential Threat: Toxicity, Life Cycle Assessment, and Management*, 12 *Toxics* 909 (2024), <https://pmc.ncbi.nlm.nih.gov/articles/PMC11728610/>

Additionally, in March 2023, the NGT directed several government agencies to evaluate a Central Pollution Control Board (CPCB) study on microplastics and make the required adjustments.

The tribunal ordered rapid actions, such as regulating personal care and cosmetic goods that contain microplastics and designing and manufacturing products that produce them. The Central Institute of Petrochemicals Engineering and Technology, the Indian Council of Medical Research, the CPCB, and other pertinent entities must work together to develop these solutions. Furthermore, on August 13, 2024, the NGT ordered that the Punjab Pollution Control Board be included in negotiations about solid waste management at the vegetable market, or sabzi mandi, in Ludhiana. The Punjab Mandi Board, the Municipal Corporation of Ludhiana, and the deputy commissioner of Ludhiana were also parties to the case.<sup>7</sup>

### **Recommendations:**

This should begin with establishing a dedicated legal framework that clearly defines microplastics and governs their production, usage, and disposal, while also enhancing existing plastic waste management laws. Strict limits must be placed on microplastic use in personal care products, cosmetics, industrial abrasives, and synthetic materials. Improving waste management infrastructure is crucial, including promoting waste segregation at the source, expanding recycling systems, and encouraging advanced recycling techniques like chemical recycling and depolymerization to curb secondary microplastic formation. Industries should be mandated to adopt cleaner production methods and install filtration systems to prevent microplastics from contaminating water and air. The adoption of technological advancement should be used to identify the microplastic and their consequences should be analysed and address the possible solution to overcome it. Nationwide monitoring and research programs should be bolstered through partnerships between regulatory agencies and research institutions to produce accurate, India-specific data on microplastic contamination in food, water, soil, and air. Public awareness and community involvement must be promoted to encourage responsible consumption and waste handling. Special attention is needed for marginalized communities near industrial areas, waste sites, and informal recycling centres, as they face higher exposure risks. An integrated One Health approach linking environmental, animal, and human health can

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<sup>7</sup> Plastic Waste Management (Amendment) Rules, 2024, Drishti IAS (Daily News Analysis), <https://www.drishtiiias.com/daily-updates/daily-news-analysis/plastic-waste-management-amendment-rules2024>

facilitate holistic strategies against microplastic pollution. Finally, India should actively engage in international collaborations and align its policies with global efforts to reduce plastic pollution, strengthening governance mechanisms worldwide.

**Conclusion:**

Microplastics have become a major environmental and public health challenge in the 21st century, with their widespread presence in water, soil, air, food systems, and living organisms highlighting the severity of plastic pollution and its lasting impacts. In India, factors such as rapid industrialization, population growth, and increased plastic consumption have exacerbated the problem. Microplastics arise from primary sources like cosmetics and industrial products, as well as from the breakdown of larger plastic items (secondary sources).. Research increasingly reveals microplastics in seafood, drinking water, table salt, and agricultural products. Exposure to these particles is linked to health issues such as inflammation, metabolic disorders, endocrine disruption, and respiratory problems. Additionally, microplastics can carry harmful chemicals, pathogens, and heavy metals, amplifying health risks. Environmentally, they threaten biodiversity, disrupt ecological balance, and contaminate food chains.

While India has implemented measures to curb plastic pollution such as banning single-use plastics and enlisting regulatory bodies like the Central Pollution Control Board (CPCB) and the Food Safety and Standards Authority of India (FSSAI) microplastics remain insufficiently addressed. Legal awareness has grown through judicial actions by the National Green Tribunal (NGT), yet the lack of a dedicated regulatory framework, limited monitoring, and inadequate public involvement continue to impede effective management. To combat microplastic pollution, a multifaceted strategy is essential, incorporating robust legal frameworks, enhanced waste management, focused scientific research, and active community engagement. Timely action is critical to prevent further accumulation of microplastics in ecosystems and humans, safeguarding environmental sustainability, food safety, and public health.

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