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Pratyush

Research Scholar,

Department of Environmental

Science, Nalanda Open

University, Bihar, India

Microplastics pollution: An emerging threat to environment

Pratyush

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Abstract

Plastic production has surged dramatically over the past seven decades, making plastics ubiquitous in various industries such as clothing, packaging, and construction due to their cost-effectiveness and versatile properties. However, the environmental and health risks associated with synthetic polymers, particularly microplastics (MPs), have become a major concern. The COVID-19 pandemic exacerbated the issue with increased single-use plastic waste, including disposable masks, contributing to environmental disruption. MPs, defined as plastic particles less than 5 mm, have been increasingly detected in diverse ecosystems, including terrestrial, aquatic, and atmospheric environments. In India, rapid industrialization and inadequate waste management have led to significant MP pollution, with major urban areas contributing heavily to coastal and freshwater contamination. MPs impact marine and terrestrial organisms, entering food chains and posing risks to human health. Despite the growing recognition of this issue, India's role in global MP pollution remains underexplored. This review underscores the urgent need for comprehensive research and improved waste management strategies to mitigate MP pollution.

Keywords: Microplastics (MPs), plastic pollution, environmental impact

Introduction

Everyone may claim that we live in a plastic world since plastic production has increased substantially over the past 70 years on worldwide basis. These polymers are widely used in almost every industry, including clothing, storage, transportation, packaging, and construction, as well as consumer goods. Their qualities, such as low manufacturing costs, adaptability, water resistance, high strength-to-weight ratio, and high thermal and electrical insulation properties, have made them indispensable in modern life (GESAMP 2015) ^[1]. However, in view of identification of the various emerging risks to the environment and human health associated with these synthetic polymers, concern is being raised regarding the massive production and disposal of plastics (Sedlak, 2017) ^[2]. For example, the current COVID-19 pandemic has caused significant environmental disruption due to insufficient use of plastic products. It is thoroughly covered in the review study by de Sousa (2021) ^[3] how a single-use plastic product, such as disposable face masks, might impose varying degrees of issues in our environment. The environment is becoming increasingly vulnerable to the harmful effects of synthetic materials, as evidenced by the deaths of species such as the Magellanic penguin (*Spheniscus magellanicus*) and the release of harmful emissions from the burning of contaminated plastic items. The dispersion and impact of plastic trash, particularly microplastics (MPs), in natural ecosystems have drawn a lot of attention lately. Because of their potential to pose a hazard to the biosphere, they have been recognized as one of the major markers of the anthropocene and added to the list of "Contaminants of Emerging Concern" (CEC) with other chemical pollutants. The term MPs commonly refers to plastic particles whose longest diameter is < 5 mm (Browne *et al.*, 2011) ^[4]. However, recently the term has been suggested to include only plastic particles < 1 mm (Lambert *et al.*, 2014). Above this ranges the plastic particles were termed as mesoplastic (>1 to = 5 mm) and macroplastics (> 5 mm) (Lambert *et al.*, 2014) ^[5]. But at present, the upper limit of MPs is widely accepted to be 5 mm in view of the small size that can be readily ingested by the organisms. Microplastics have been found in soil ecosystems, surface waters, beach sands, coastal sediments, freshwater sediments, and deep habitats. Even rain and snow contain sizable amounts of microplastics, some of which are sometimes imperceptible to the unaided eye.

Corresponding Author:

Pratyush

Research Scholar,

Department of Environmental

Science, Nalanda Open

University, Bihar, India

In fact, there has been a significant build-up of plastic trash in the environment as a result of the extensive use of plastic and the subpar operation of waste management systems, particularly end-of-life collection and capture. Plastic material leakage into the environment is acknowledged as a significant source of pollution.

Microplastic pollution in India

Situated in the southern portion of Asia, India is surrounded by the Arabian Sea in the south west and the Bay of Bengal in the south east and ultimately connects to the Indian Ocean. The country is situated between the latitude 8°4' and 37°6' N and the longitude 68°7' and 97°25' E and has a coastline of 7517 km (Kumar *et al.* 2006) ^[6]. In India, the 8000 km of coastline are home to one third of the country's population. Renowned industrial hubs such as Chennai, Kochi, Kolkata, Mumbai, Visakhapatnam, and Surat are located along the coast and play a major role in the production of plastic waste. These wastes jeopardize coastal ecosystems and resources by finding their way into bays, streams, and rivers and infiltrating the maritime environment. Mumbai, along with other large cities like Kolkata, Chennai, Visakhapatnam, Gujarat, Pondicherry, and Gopalpur, is one of the key cities that discharges a lot of plastic rubbish into the coastal waters on a daily basis (Nanthini *et al.*, 2023) ^[7]. India contributed 8.33 million metric tonnes of plastic pollution yearly, bringing the total to 367 million metric tonnes worldwide in 2021. Polyethylene and polypropylene are widely used in India as microplastics' basic materials. The majority of these materials are produced in Ahmedabad, Mumbai, and Kolkata. There are notable accumulations in Gujarat, Kerala Lake, the Chennai coastline, and the Mumbai beaches. Microplastics have also been found in water samples, with Delhi, Mumbai, and Chennai having the greatest quantities of plastic particles.

Sources of Microplastics

Inadequate management of plastic waste has led to increased contamination of fresh water and marine environments. Plastic materials represent between 60% and 80% of the waste present in the marine environment and 90% of the waste floating on the seas and oceans. Plastic waste present in the marine environment is a threat to both the environment and marine fauna due to the risk of being swallowed by marine life. Statistics show that at least 267 species worldwide are affected by this problem, including 44% of birds, 43% of mammals, 86% of turtles and various fish species. Humans are most exposed to microplastics (MPs) through food intake, which includes commercially processed fish, seafood tainted with microplastics, sea salt, honey, beer, and culinary ingredients. The majority of these food products are occasionally tainted by pollutants found in the packaging as well as impurities from processing materials. Microplastics come from a range of polymeric materials mixed with various additives manufactured as such or result from the degradation and fragmentation of plastic waste into micro particles. Their behavior in the oceans is similar to that of marine plankton, and they can be ingested by aquatic fauna, being mistaken for small natural prey and consumed by filter-feeding species, such as bivalve mollusks, or adsorbed on macroalgae. These microplastics are potential carriers of chemical contaminants, such as the additives that constitute them and the persistent organic

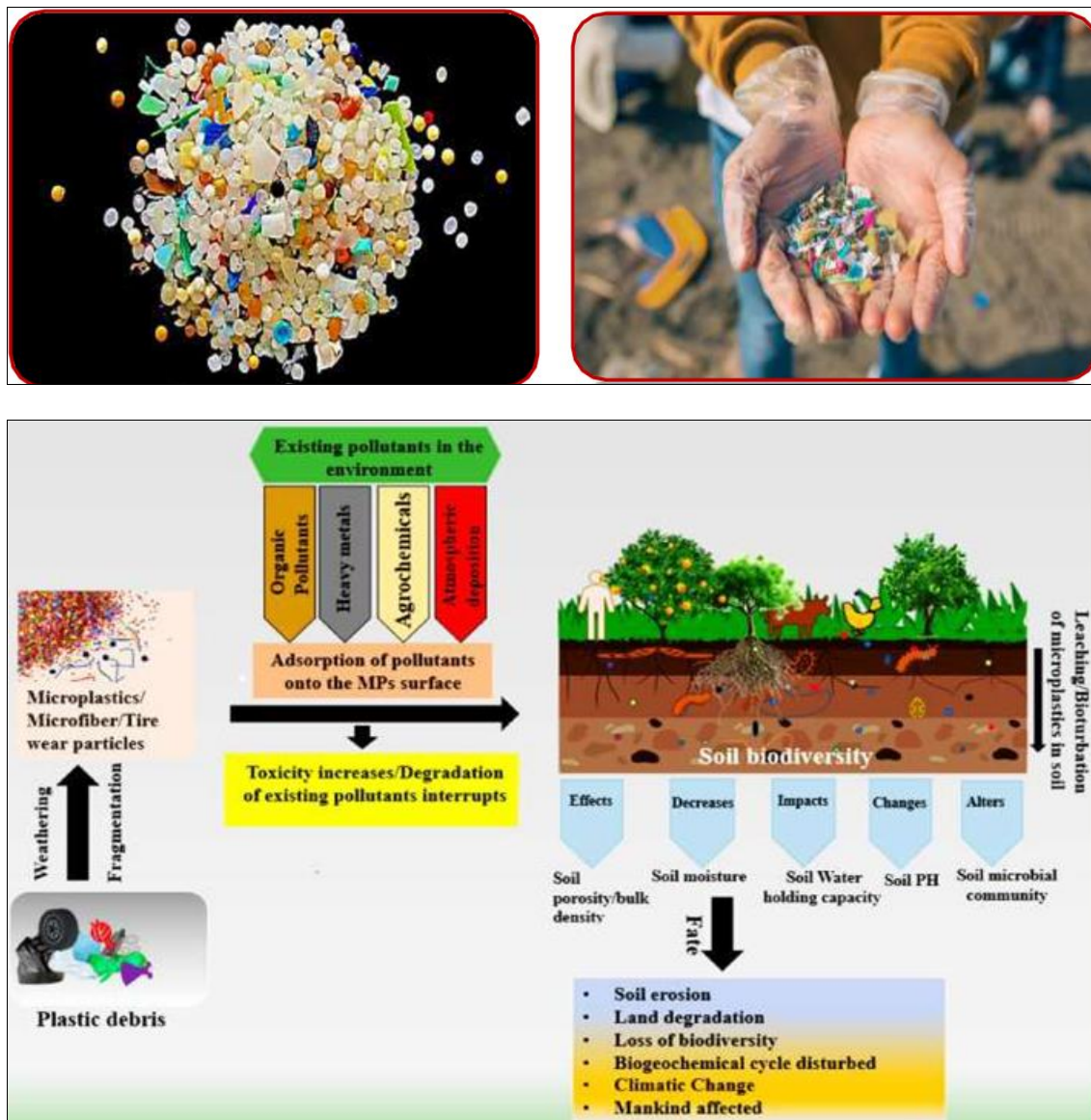
pollutants that are adsorbed and concentrated in them.

Microplastics in terrestrial systems

With increased consumption of plastic items in our daily lives, their ageing and subsequent fragmentation leads to leaching of MPs in our terrestrial systems. The sources of these MPs can include mismanaged plastic waste, tyre wear and tear, fragmentation of construction and building materials, or aeolian transport of MPs from widespread sources (Patchaiyappan *et al.*, 2020) ^[8]. Concerns regarding particle-induced toxicity and chemically-induced toxic symptoms during leaching are raised by the growing amount of microplastics (MPs) in the environment. Out of the plastic waste, 4.8–12.7 million were dumped in the ocean; the remaining quantity was left on land, indicating a higher environmental burden. Soil organisms are necessary for the drilosphere process to maintain soil fertility. Recent studies suggest that MPs and soil biota may have a negative interaction that has an impact on the behavior and well-being of terrestrial animals (Lwanga *et al.*, 2023) ^[9]. Microplastics (MPs) can enter terrestrial habitats through a number of different channels, including human littering, inappropriate removal of plastic waste, the application of sewage sludge to agricultural land, and landfill disposal. These pathways can impact MPs' fate, retention, occurrence, deprivation, and conveyance. As plastic debris builds up on land, it is discharged into freshwater and marine environments. Additionally, washing textiles generates MP fibres, or microplastics, which damage aquatic life and alter freshwater ecosystem dynamics.

Microplastic in Aquatic ecosystem

Microplastics are found in oceans all throughout the world, acting as a sink for plastic trash. According to studies, they can be found in the water column, biota, beaches, and surface waters. More microplastics are accumulated in water columns due to strong ocean currents. Between 50 and 300 plastic particles per square meter were discovered along Goa's Caranzalem beach during high tide. In Mumbai, India, it was discovered that there were 68.83 particles per square meter, with sizes ranging from 1 to 20 mm. On the beaches of Goa and Chennai, plastic pellets with a particle size of 2.5 mm and ranging in size from 1200 to 3000 were found (Veerasingham *et al.*, 2016) ^[10]. These findings highlight how urgently the global issue of microplastics in seas needs to be resolved. The most recent study found that there has been no discernible change in the concentration of microplastics in the marine environment of the Baltic Sea ecosystem over the preceding three decades, in contrast to the widely held belief that the number of microplastic particles increases with universal plastic production and consumption. In natural settings, the biota's ability to detect microplastics is not restricted. According to the research, human activities may have a direct correlation with the level of microplastic pollution, rather than being simply dependent on global plastic production and consumption. According to recent studies, microplastics can be found in lakes, rivers, and estuaries. However, microplastic particles from freshwater resources in India have not been identified. Microplastics can also enter the environment by dissolving in water columns and leaching from land into water basins. These processes occur more frequently in close proximity to urban and touristic areas that are close to freshwater habitats.



Conclusion

India being one of the major producers of plastic waste is gradually pacing up its research in microplastics. At present, the role of India in global MP pollution is not well understood. India is the second most populous country in the world and has a high population density. Published studies show that microplastics are causing an increasing amount of pollution in India's maritime environment. The lack of scientific solid waste treatment in India is a major barrier to future efforts to reduce plastic pollution. The present article has eventually come to the conclusion that the marine environment in India is far more contaminated with microplastics than it is on average around the world. MP contamination will rise in tandem with the growing demand and manufacturing of plastics, potentially posing a severe threat to the environment. These days, it is crucial to expand research studies at both the laboratory and field scales, paying equal attention to each and every element of the various environmental matrices that include freshwater systems, terrestrial systems, marine systems, atmosphere, human consumables, and related toxicities.

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