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A Chapter on Microplastic Pollution in Uttarakhand, India

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ABSTRACT

Microplastics are any form of plastic fragment smaller than 5 mm and are a pollutant which is harmful to the environment we live in. Microplastics come in two different categories: primary (which directly enter the environment) and secondary (from the breakdown of larger plastics). Microplastics are pervasive in the environment and have been found in drinking water, both bottled and tap water, fresh water, food, air, and marine systems.

Emergent contaminants like microplastics are becoming a relatively recent form of pollution in various ecosystems throughout India. The majority of the plastic debris in marine environments—about 80% of it—comes from terrestrial sources and is known to be transported by rivers. Microplastics produced as marine plastic pollution degrades cause climate change indirectly by harming ocean life and directly by emitting greenhouse gases. There are many factors that contribute to the microplastic contamination of groundwater in India, including tourism-related activities, industrial and domestic effluent discharges, fragmentation of poorly managed plastic debris, and riverine leaching. Airborne microplastic contamination also poses a serious threat in India, one of the cities with the worst air quality.

Due to the non-degradable nature of plastic and the fact that it persists in many ecosystems, excessive plastic use is becoming a significant cause of environmental concern, even though India has banned single-use plastics. India, one of the world's top producers of plastic waste, is gradually stepping up its microplastic research. By using evidence from field research and reviewing the available scientific literature, this article aims to present the most recent understanding of microplastic pollution in Uttarakhand's environment.

I. INTRODUCTION

One of the most important environmental issues that we are currently dealing with is plastic. Plastic is widely used in almost every industry, including clothing, storage, transportation, packaging, construction, and consumer goods. They have become essential in modern life due to their characteristics like low production costs, adaptability, water resistance, high strength-to-weight ratios, and high thermal and electrical insulation properties¹. Our ecosystems are

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adversely affected by plastic pollution. In 2019, the global production of plastic was at 370 million tons, with only 9% of it being recycled, 12% being incinerated, and the remaining left in the environment or landfills². India produces about 3.5 million tonnes of plastic waste annually, and over the past five years, the amount of plastic waste produced per person has nearly doubled³. Plastics are being produced and used at an increasing rate, and as a result, they are piling up in the oceans and are by far the most common type of marine debris globally⁴.

While the harm caused by visible litter has been known since the 1980s, interest in the tiniest fractions of plastic pollution, **micro and nanosized** particles, is more recent and has been steadily increasing in both the scientific community and the general public.

Microplastics, as the name suggests, are very small pieces of plastic and are used to distinguish microplastics from larger plastic waste. They are any form of plastic fragment smaller than 5 mm⁵ and are a pollutant which is harmful to the environment we live in. Microplastics come in two different categories: primary (which directly enter the environment) and secondary (from the breakdown of larger plastics). When produced in their original microscopic size, microplastics are categorised as primary, while those that are fragmented from bigger plastic products are categorised as secondary⁶.

Microplastics are pervasive in the environment and have been found in drinking water, both bottled and tap water, fresh water, food, air, and marine systems. Both bottled and tap water may contain microscopic plastic pieces, according to research studies published so far on microplastics in drinking water⁷.

II. MICROPLASTIC: AN ACCELERATOR OF CLIMATE CHANGE

The effects of plastic pollution are also exacerbated by climate change. Micro-plastics eventually make their way into waterbodies, moving from rivers to seas or oceans. The majority of the plastic debris in marine environments—about 80% of it—comes from terrestrial sources and is known to be transported by rivers. Other harmful substances, including DDT and hexachlorobenzene, can travel through microplastics that act as a pollutant transport medium and eventually end up in the bodies of living organisms that consume them⁸. Microplastics produced as marine plastic pollution degrades cause climate change indirectly by harming ocean life and directly by emitting greenhouse gases. Carbon is captured at the ocean's surface and transported deep into the water by microscopic plants (microalgae) and animals (zooplankton), where it can be stored. But according to current studies, microplastic contamination is having an effect on zooplankton and microalgae. Microplastic pollution is contaminating microalgae, which lowers their capacity to sequester carbon through photosynthesis. It also affects

zooplankton's longevity, metabolic rates, and reproductive success. These results thus imply that the ocean's natural carbon sequestration system may be hampered by microplastic pollution⁹.

Oceans as dustbins

Plastics are still being dumped into the ocean through a number of different pathways due to the rapid industrialization, population growth, and economic development, which could lead to associated environmental, economic, and health issues¹⁰. One of the main contaminants in the marine environment are microplastics, which marine organisms mistake for prey and which, when consumed, can be toxic or even fatal¹¹. Between 4.8 and 12.7 million tonnes of land-based plastic waste are thought to have made their way into the ocean¹².

III. MICROPLASTICS AS ENVIRONMENTAL POLLUTANTS IN INDIA

India's plastics industry is rapidly expanding, with Western India as the country's largest consumer (47 percent), with significant consumption in the states of Gujarat, Maharashtra, Madhya Pradesh, Daman and Diu, Chhattisgarh, and Dadra and Nagar Haveli¹³. Due to the non-degradable nature of plastic and the fact that it persists in many ecosystems, excessive plastic use is becoming a significant cause of environmental concern, even though India has banned single-use plastics. Significant risks to living things are posed by microplastics, major pollutants that are widely dispersed throughout freshwater and marine environments in India¹⁴.

Microplastic fibres have been identified in 25g as well as other samples taken around the Indian Ocean. The Vembanad Lake Microplastic Pollution Study is the initial report on the presence of microplastics in lake sediments that come from India, and the study discovered that the most prevalent type of plastic was low-density polyethylene microplastic, which was found in the lake sediment pollution at 18. Global modelling studies rank the Ganges River as the second-largest contributor to ocean plastic pollution¹⁵.

Microplastics shapes can be used to determine where they came from¹⁶. According to the research conducted by Veerasingam et.al¹⁷ (2020) Fibers, fragments, pellets, films, and foams have all been found in India's environmental matrices. According to studies conducted on both the east and west coasts of India, fibres and fragments were the most common shapes of microplastics'. According to the physical characterization of microplastics, secondary microplastics, such as fragments, fibres, films, and foams, were the majority of the microplastics discovered in India rather than primary microplastics, such as pellets.

IV. PLASTIC POLLUTION IN UTTARAKHAND

According to a survey conducted by the Uttarakhand Environment Protection & Pollution Control Board (UEPPCB) in 2016–17, Dehradun, the state capital, is the city that contributes the highest percentage of plastic waste. As per the survey, the state capital's waste is growing by 327.9 tonnes per day and will eventually reach 584.051 tonnes per day¹⁸. Haridwar is in second place with 236.5 tonnes per day, and over the course of the given period, it will rise by 368.363 tonnes per day.

The effects of plastic pollution, which is known to be a major cause of environmental change worldwide, have been documented not only in marine species but also in terrestrial fauna. A study found that plastic was present in the diets of Asian elephants (*Elephas maximus indicus*), in the forests of India's Uttarakhand state. Using samples of Asian elephant faeces as a proxy for ingestion, the study located, described, and quantified visible plastic and other anthropogenic waste in areas where humans frequently live. The presence of non biodegradable waste, plastic particles, and other hazardous and toxic anthropogenic waste in the diet of Asian elephants indicates the widespread use of plastic¹⁹.

A significant source of income in mountainous areas is tourism. As per the research conducted by Sundriyal et al. (2018), for every peak tourist season examined, the entire stretch of the Dehradun-Mussoorie road was discovered to be covered with used plastic bottles, empty wrappers from chips and biscuits, and empty cartons of juice on both sides of the road. This shows that littering is not just limited to the edges of the town. And it is clear from the fact that plastic waste-producing items like water bottles, packaging materials, etc. are widely used throughout the town²⁰. Shivpuri, Rishikesh, and Haridwar are some of the other well-liked tourist destinations in Uttarakhand. Haridwar and Rishikesh are well known for their religious significance. Both of these locations are overcrowded, and numerous construction projects are in progress to accommodate the daily increase in population²¹, which are the prime sources of pollution. The Ganga River flows through the Himalayan Valley, emerging onto the Gangetic Plain at the holy city of Haridwar from the mountainous Rishikesh region²². Haridwar and Rishikesh are a part of the Ganges network, and with more than 0.12 million tonnes of plastic released into marine ecosystems annually, the Ganges network ranks second among the world's plastic polluting catchments and is one of 14 continental rivers that receive more than a quarter of all waste generated worldwide. The river collects macro, meso, and microplastics from various sources along its journey and carries them to the sea²³.

V. A STUDY ON MICROPLASTIC POLLUTION IN DEHRADUN

Field observations are taken as part of the study from the cleanup drives conducted by the Dhirenuma Social Welfare Foundation (DSWF) as part of the ongoing initiative "mission clean doon." The amount of microplastic was significant at each and every site where we conducted clean-up operations.

The littering behaviour of individuals is rising day by day. Everything that seems to be useless is thrown away directly into the environment, which includes both degradable and non-biodegradable items.

The non-biodegradable "plastic" is the one that is dominant. And the types of plastic vary based on their composition. That includes **Polyethylene Terephthalate** (used in fizzy drinks and water bottles; salad trays; high density polyethylene milk bottles, bleach, cleaners and most shampoo bottles), **Polyvinyl Chloride Pipes** (used in fittings, window and door frames (rigid PVC); thermal insulation (PVC foam) and automotive parts), **Low Density Polyethylene** (used in carrier bags, bin liners and packaging films), **Polypropylene** (used in margarine tubs, microwaveable meal trays, also produced as fibres and filaments for carpets, wall coverings and vehicle upholstery) and **Polystyrene** (used in yogurt pots, foam hamburger box and egg cartons, plastic cutlery, protective packaging for electronic goods and toys). Insulating material in the building and construction industry)^{24,25}.

The size of the plastic also varies. Secondary microplastics that are formed as a result of the breakdown of larger plastics are found everywhere. Leaving them exposed to the environment has a negative impact, and it is challenging to remove them from the soil.

Sources and types of waste

Human actions act as the primary source of waste found littered everywhere. Inappropriate behaviour like throwing waste away intentionally and unintentionally creates the problem. Tiny packets and fragments of roadside are found along the roadside. Packeted items such as snack packets, juice covers, chocolate covers, straws, and pan covers are much more prevalent. These are found disposed of in an improper way. Proper disposal of waste is very essential. Littering them in the environment has many negative consequences. Throughout the clean up drive, we found it very difficult to separate the small fragments of plastic, and it is very challenging. Many are deep inside soil that has started to degrade. The degradation boosted the formation of microplastics that are too small and inseparable.

Another issue that is apparent is the improper disposal of medical waste. There are plenty of

plastic tablet covers, needles, and other medical wastes seen. In addition to endangering the environment, these hazardous wastes also endanger people and animals. The animals are discovered to be consuming the waste. Other types of waste include food waste that has been wrapped in plastic, plastic bottles, clothing, and covers. The waste that has accumulated along the river banks will once more be carried by the river to the oceans.

Impact on soil and aquatic ecosystems

Plastic waste makes up the majority of the waste. Most plastics fragment or breakdown into microplastics. This affects the soil, water and animals. In soil, the plastic fragments are broken into small pieces and form microplastics. This can affect the soil texture and interrupt soil biota²⁶. Recent studies have demonstrated that soil-dwelling organisms can easily consume microplastics once they are present in the soil, potentially affecting their fitness and survival²⁷. Bandowet al.²⁸ also reported that the presence of HDPE microplastics caused the pH of the soil to decrease. Thus, microplastics can alter the soil's biophysical characteristics. Due to inadequate landfill interment systems, the accumulated terrestrial plastic eventually finds its way into the water systems²⁹. When plastic is released into the environment, it can be carried by the wind, washed from land to surface waters by rain, particularly with stormwater runoff, and carried in freshwater and seawater^{30, 31, 32}. Household, commercial, and other plastic waste act as a source that may enter the marine system directly or through other water bodies, increasing its amount and affecting aquatic life³³. Macroscopic plastic acts as the secondary source of microplastic through the process of fragmentation. The long-term effects of MPs can be transmitted to higher levels of the food chain, having a detrimental effect on the organisms. The effects of microplastics vary depending on the type, concentration, and species of the organism.

VI. CONCLUSION

Due to the non-degradable nature of plastic and the fact that it persists in many ecosystems, excessive plastic use is becoming a significant cause of environmental concern, even though India has banned single-use plastics. Microplastics are pervasive as a result of their persistence and long-range transport, particularly with regard to the abrasion and fragmentation of heavier plastic objects and materials made of synthetic polymers. Global recognition exists for the harmful effects of single-use plastic waste on marine environments as well as terrestrial ecosystems. It has become a significant environmental challenge that all nations must address to reduce pollution from single-use plastics.

The Indian government has made determined efforts to reduce the pollution brought on by single-use plastics that are left lying around. With effect from September 30, 2021 and

December 31, 2022, respectively, the Plastic Waste Management Amendment Rules, 2021 also forbid the manufacture, import, stocking, distribution, sale, and use of plastic carry bags with a thickness of less than 75 microns. On February 16th, 2022, the Guidelines on Extended Producers Responsibility on Plastic Packaging were also published by the Ministry of Environment, Forest, and Climate Change as Plastic Waste Management Amendment Rules, 2022. The government has been making efforts to raise awareness about the need to stop using single-use plastics. The implementation of rules and regulations together with public awareness can have a positive impact on the environment. This can create a behavioural change in the people and the society.

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