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The Impact of Microplastic on Marine Ecosystem

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Abstract: *With the growth in population, waste management is becoming a big issue; nevertheless, recent studies have also revealed another serious issue: marine litter. It was discovered that human-generated waste is accumulating in the marine environment, with high levels of microplastics found in water bodies such as rivers, lakes, seas, and oceans. According to research, UV radiation and cold temperatures assist to break down typical plastic into smaller particles known as microplastics, which then enter the marine environment via runoff.Microplastics are often made of polyvinyl chloride (PVC), polyethylene terephthalate (PET), polystyrene (PS), or nylon, among other materials. With inefficient management, the concentration of these microplastics is increasing at an alarming rate, impacting not just the marine environment but also marine life. Some recent studies have found that the marine environment around urban centres has higher levels of microplastics, and aquatic creatures in these locations have a high accumulation of microplastics in their tissues.Furthermore, it has been claimed that other water pollutants, such as dyes, heavy metals, and other chemicals, can easily bind to microplastics, and that these microplastics act as a carrier of other pollutants in the bodies of aquatic creatures, which then enter the food chain. The current paper gives an overview of microplastics, their fate, and the detrimental consequences on the ecosystem and marine health*

Keywords: microplastics, microbeads, marine biota, marine health

I. INTRODUCTION

Plastic has become a vital component of modern life, with several applications in everyday activities (Jiang et al., 2019, Li et al., 2019, Zhang et al., 2020). According to recent available data, worldwide plastic production is expected to be around 367 million metric tonnes in 2020 (Tiseo, 2021-Statista). Plastic is a synthetic material with several distinct features, including strength, durability, and lightness (Li et al., 2019). Klemeš et al. (2020) and Kosior and Mitchell (2020) report that its unique features have led to its widespread use in several industries, including food, healthcare, and electrical products. However, mismanagement in plastic disposal procedures has contributed significantly to the accumulation of this non-degradable synthetic material in water bodies such as the sea, ponds, rivers, and soil (Chae and An, 2018, Li et al., 2018). Plastic material, like dyes, heavy metals, and organic pollutants, has been found as a harmful component for aquatic organisms (Bhattacharya et al., 2020; Gola as al., 2020; Gola et al., 2017, Jain et al., 2020; Li et al., 2019). Recently, Sivagami et al. (2021) discovered the presence of microplastics in regularly used sea salts; the study also emphasised the issues related with human health.It was projected that 4.8-12.7 million tonnes of plastic were dumped in the oceans, and this figure is growing by the day (Jambeck et al. 2015). The size, shape, density, chemical content, and other characteristics of plastic materials discarded in aquatic bodies vary widely. Microplastic refers to plastic materials with a size between 1 μM and 5 mm (Cole et al., 2011). Furthermore, microplastics found in water bodies are classified into two categories: primary microplastics and secondary microplastics (Auta et al., 2017). Cosmetics, personal-healthcare goods, children's products, insect repellents, and other items are the most common sources of primary plastic. On the other hand, fragmented products created from physical fragmentation, biological degradation, and chemical degradation of large-sized plastic material constitutea significant source of secondary plastics (Sait et al., 2021; Yuan et al., 2020).

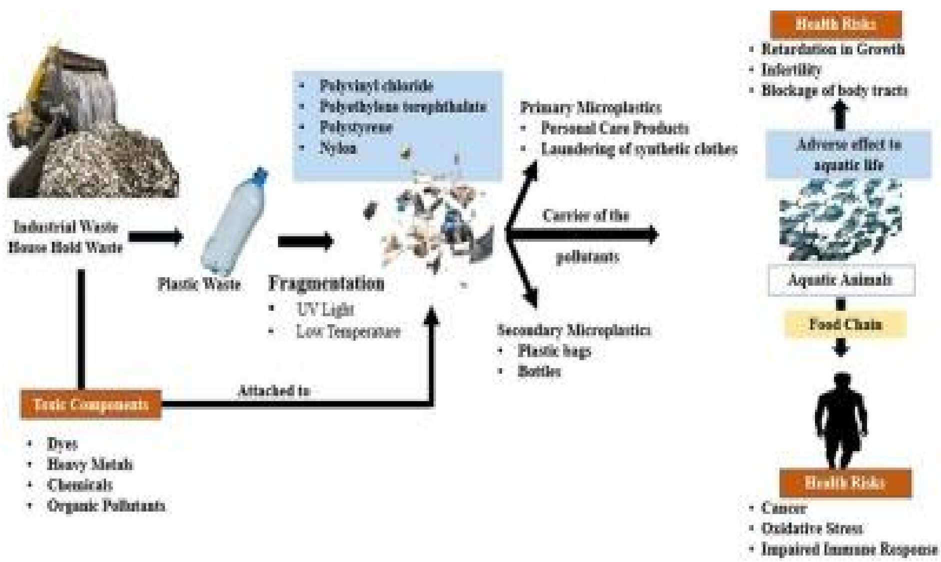
Synthetic materials such as polypropylene, polyethylene, polystyrene, polyvinylchloride, and polyethylene terephthalate are among the most common microplastics discovered in marine water by researchers worldwide. Because of their microscopic size, microplastic poses a greater hazard to aquatic life forms. Furthermore, contamination of these aquatic living species provides an easy channel for microplastic to reach the human body because they function as sea food.

II. THE FATE OF MICROPLASTICS IN WATER BODIES

Multiple human activities, including tourism and municipal and industrial wastewater treatment systems, contribute to the occurrence of microplastics in the maritime environment. Dikareva and Simon (2019), Rochman et al. (2013) discussed the increase in human population and the abundance of microplastic as one of the major factors contributing to the increasing concentration of microplastic in various water bodies such as rivers, ponds, lakes, and seas (Zhou et al., 2018).

III. EFFECT OF MICROPLASTICS ON THE HEALTH OF MARINE BIOTA

These tiny plastic fragments persist in the marine ecosystem, and because of their micron-sized particle nature, they are mistaken for food and ingested by a variety of marine biota, including corals, phytoplanktons, zooplanktons, sea urchins, lobsters, fish, and so on, eventually transferring to higher topic levels. The impact of microplastic on marine biota is a source of concern, as it causes entanglement and ingestion, which can be fatal to marine species. Microplastic fragments are primarily derived from terrestrial sources, putting coastal ecosystems, including coral reefs, at risk owing to pollution. Corals exist in a symbiotic relationship with single-celled algae found in the tissues of coral cavities. The algal association generates energy through photosynthesis. Corals also gain energy by feeding on planktons, which provide critical nutrients required for their growth, development, and reproduction. Coral'microplastic feeding' involves ingestion, retention of plastic pieces, and digestion. The damaging effect of microplastics on corals is the retention of plastic particles in mesenterial tissue, which reduces feeding capability and lowers energy reserves.



Microbial biofilms linked with microplastics may also have a deleterious impact on coral reefs by facilitating pathogen transmission. The first detection of microplastics in scleractinian corals was made in Australia's Great Barrier Reef. Corals eat microplastic pieces at a rate of approximately 50 µg plastic cm^{-2} h^{-1}. These ingested plastic particles were found in the mesenterial tissue within the stomach cavity of corals, which has a deleterious impact on coral health.

Microplastics also harm planktons, which are the most important component of the marine ecosystem. Microplastics penetrate the cell walls of phytoplanktons, reducing chlorophyll absorption. When exposed to microplastics, heterotrophic plankton phagocytose and store these minute plastic pieces in their tissues. Zooplankton (a class of marine invertebrates) play an important role in the marine ecology because they are the major consumers of the aquatic food chain. Zooplanktons have a variety of feeding strategies, including the use of chemo-mechano receptors for prey selection. Microplastics are commonly found in marine habitats and can interact with zooplanktons due to their similar

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size (>333 µm). When exposed to microplastic, zooplankton ingested latex beads, according to experiments28. Another study indicated that zooplankton tend to eat polystyrene beads with dimensions of 1.7-30.6 µm. Centropages typicus, a well-known copepod, ingested microplastics (7.3 µm) and eventually lost their feeding abilities, resulting in a significant impact on their health. When Gammarus fossarum is exposed to poly(methyl methacrylate) (PMMA) and polyhydroxybutyrate (PHB), its growth rate decreases30. In addition, the intake of polyethylene (PE) microplastics by the benthic organism Hyalella azteca reduces growth and reproduction. The microplastics uptake in the marine lugworm Arenicola marina caused a decrease in feeding.

The detrimental consequences of microplastic ingestion are a reason for concern, particularly among sea birds, as half of the species are endangered, and the toxic effect of plastic pieces has significant effects on their bodies, potentially altering feeding behavior, reproduction, and mortality. Plastic fragments were discovered in the stomachs of six species of sea birds: Phalacrocorax bougainvilli, Pelecanoides garnotii, Pelecanoides urinatrix, Pelecanus thagus, Spheniscus humboldti, and Larus dominicanus, which commonly feeds on fishing nets, waste disposal products, and plastic container. The ingestion of plastic waste by these species is primarily determined by characteristics such as the sea birds' size, weight, and habitat. Spheniscus penguins and Thalassarche albatrosses have modest body sizes, hence their ingestion rates are lower than those of larger marine birds. Fulmarus fulmars, Cyclorhynchus auklets, Oceanodroma, Pachyptila prions, and Pelagodroma consume more plastic waste due to their larger body size and weight. Sharks, whales, seals, sea turtles, and polar bears are also vulnerable to microplastics ingestion in the oceans across the world; for example, the presence of microplastics was identified in the stomach and intestine of the harbor seal, Phoca vitulina. This type of marine mammal is a filter feeder and consequently consume large amounts of microplastics, either directly from ocean water or indirectly by devouring food that has microplastics in its body cavity. The presence of microplastics in the stomachs of sharks in the Sea of Cortez and whales in the Mediterranean Sea demonstrated that the majority of scattered plastic trash gobally eventually ends up at sea, posing a significant threat to marine species. A study on Mediterranean fin whales (Balaenoptera physalus) found significant concentrations of phthalates, indicating the severity of microplastic pollution in the world ocean.

IV. CONTROL MEASURE

The global record of plastic litter entering ocean gyres was projected to be between 4.8 and 12.7 million metric tonnes, and with increased usage of plastic and its products, the total amount of plastic litter available to marine ecosystems is expected to climb significantly by the end of 2025. This major issue was also raised at the "16th Global Meeting of the Regional Seas Conventions and Action Plans", which was held for literate nations, about the global threat of plastic pollution inn marine habitats and the estimated financial damage to the marine ecosystem of around US$13 billion per year. Given the recent trend of ocean pollution caused by plastic litter, there is an urgent need to conduct devoted study that can help to reduce plastic pollution and clean various water bodies around the world. States should take innovative methods to educate the public about the negative consequences of plastic litter in marine ecosystems. It is very important to develop some strong legislative norms and policies that can check the excessive use of plastic things, else the health of the ecosystem would deteriorate in the approaching span of time. There should be a well-established garbage collection system that can monitor the collection of waste containing plastic litter. Efficient management, recycling, and an environmentally suitable disposal method would all contribute to a plastic-free environment. Substantial measures are being developed in poorer nations to combat the use of plastic and related products, such as a complete ban on plastic bags and bottles and a fee for plastic usage. Unfortunately, FMCGs continue to sell their products in plastic packs. Microbeads should be completely banned from cosmetic and other personal care items including toothpaste, face wash, and shampoo. Waste management programmes, such as EPR(extended producer responsibility), that promote the use of manufacturing packaging materials other than plastic for food and beverage packaging, should be encourages. Various governmental and nongovernmental organizations should launch initiatives to raise public awareness about the nocuous and long-term effects of microplastic pollution.

V. CONCLUSION

The presence of microplastics in water bodies is solely attributable to human activity. Microplastics are found in high concentrations in urban water bodies and aquatic species. However, the presence of microplastic in samples from deep marine sediments and the polar zone plainly suggests that this growing pollutant has migrated from its source to another place. Ingestion of microplastic by aquatic living species offers a significant health danger, as well as a variety of additional harmful impacts. New research approaches must be developed for conservation management and to assist various teaching activities aimed at protecting ecosystems from these toxic polymers. The urgent call in this field is to raise public knowledge about the harmful impacts of microplastics. This would encourage numerous ts by products. To reduce plastic input into the ecosystem, the most important strategy is to collect and reuse plastic particles. To avert future threats, the best answer is to stop making it and find alternatives to plastic items.

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