State of Microplastics in the Marine Environment, Existing Trends, and Future Perspectives.

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1. Plastic pollution

The first evidence of tiny plastic fragments in the open ocean was found in the 1970s. The global toll of plastic pollution has reached up to 367 million metric tons. Plastic and its debris have accumulated in marine and coastal environments as a result of the persistent and intense release of these pollutants into the environment by anthropogenic activities. There is no question that improper disposal, rising production, and ineffective management of waste pose a threat to many potential impacts on these environments. High quantities of these plastic particles are infiltrating our food chain as more microplastics pollute our marine environment and are consumed by the marine species that thrive in our waters.

2. Pakistan's Scenario

In Pakistan, the coastal residents and the Indus River have discharged about 0.2 million tonnes of plastic debris into the Arabian Sea. One of the most heavily plastic-polluted waterways in the world is the Indus Waterway. In Pakistan, 6,000 industrial producers contribute to the production of 0.6 million tonnes of plastic. Regrettably, plastic products make up 65% of rubbish in Pakistan, and an increase of 15% per year is anticipated. It is challenging to predict

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how much plastic will eventually be poured into the ocean in a developing nation. Owing to Karachi's trash, Pakistan has had severe problems managing its urban waste. In any scenario, by 2050, more plastic is anticipated to be deposited into the ocean, Indus stream is as of now dumping 100000 tons of plastic squander into the Arabian Sea each year.

3. Types and characteristics of Plastics

Despite the fact that defined size of these microparticles has changed from study to study over the past ten years. The term **"microplastic"** refers to fragments with a diameter of less than 5 mm. According to their source, microplastics (MP) can be classified as secondary or primary. Small-sized synthetic polymers are the main type of microplastics. In numerous processes, such as chemical formulations, sandblasting media, product maintenance, and the manufacture of synthetic clothing, they serve as fibrous microplastics. Another primary plastic material that was utilized in cosmetic and healthcare products is microbeads. They are less than 2 millimeters in size and are made of polyethylene (PE), polypropylene (PP), and polystyrene (PS) beads. Primary producers of secondary microplastics include environmental processes like hydrolysis, photodegradation, thermo-oxidative degradation, and biodegradation. Secondary microplastics are the fragmented product of macro or meso plastics.

On the surfaces of water bodies, near-shore beaches, and water bottom sediments, microplastics are unevenly distributed. The significant microplastic pollution of coastal waters is generally attributed to the intensity of anthropogenic activities. Depending on the type of plastic, the microplastics that studies generally report come in a variety of sizes, shapes, colors, and densities.

Microplastics are produced under a variety of environmental conditions, which causes them to have an uneven surface, an irregular

shape, and numerous variations like aged microplastics. Microplastics are frequently associated with crude oil, iron oxides, organic contaminants, and even viruses as polluter substances.

4. Current threats to marine life by microplastics

Loss of aesthetic appeal, disruption of tourism and marine-related economies (e.g., aquaculture, power generation, fishing, shipping), and casualties of marine life are all well-known effects of large-scale plastic debris. Microplastics can significantly affect marine life because they can float away during shipment and enter the ocean via boats and ships. These tiny plastic particles can travel through the ocean floor and wind up marine life. In contrast, although both macroplastics and microplastics can transport pathogens and release plasticizers or additives, microplastics are even more toxic due to their large surface area-to-volume ratio. It can adsorb and desorb toxic contaminants and quantitatively bioaccumulate more toxic contaminants.

Marine microplastics effects numerous aspects of marine fish and food chain. The toxic effects of the microplastics on fishes and other aquatic organisms may include a reduction in food intake, a delay in growth, oxidative damage, abnormal behavior, reduction of growth and development, an effect on feeding and behavioral ability, toxicity to the reproductive system, toxicity to the immune system and genetic damage.

Because of their size, these tiny pieces of plastic remain in marine ecosystems and are mistaken for food by a wide variety of marine organisms, including corals, phytoplankton, sea urchins, lobsters, and fish. Plankton, the most important building block, are also affected by microplastics. Cholesterol levels in marine organisms change with the consumption of micro and nano plastics.

The threat posed by microplastic to an organism will be determined by the likelihood that it will overlap with or come into contact with MPs in its natural environment. It is anticipated that there will be the greatest overlap between microplastics and marine life in the shelf sea zones as there are high levels of biological production and significant concentrations of microplastics due to its close proximity to terrestrial pollution sources.

Many studies have been done in past five years on the effects of MPs on crustaceans like daphnia magna, artemia salina etc. these studies showed that MPs intake resulted in bioaccumulation of microplastics in gut in crustaceans. There have been reports of detrimental effects on feeding behavior, reproduction, growth, development, and lifespan. Concentration, shape, size, and age are a few variables that have been observed to affect the bioavailability of microplastics to zooplankton.

Various organisms in the aquatic environment would not only ingest microplastics, either intentionally or unintentionally but they would also be transferred indirectly from low to high trophic levels via aquatic food chains and ultimately end up in humans. Although seafood is recognized as a source of microplastics contamination in the human diet, a number of researches confirm the presence of microplastics in seafood. Consumption of this contaminated food by humans causes the bioaccumulation of MPs in their bodies and poses different health effects.

5. Future Perspectives

The stability of microplastics, when combined with contaminants such as heavy metals shall be considered for future studies. This data will also help to investigate the combined effects of microplastics with other contaminants on the organisms especially

zooplankton as there is very less data available on combined exposure till now.

Further studies can also be done to examine whether the adsorbed chemicals or heavy metal on MPs are desorbed into organisms/s body or they remain adsorbed. The transformation of microplastics in the presence of different contaminants shall also be kept under consideration as it can lead to change in toxicity

More research should be carried out on the accumulation of microplastics and the relation of their toxicity with the physical characteristics of marine organisms. Moreover, the transfer of microplastics in the food chain and ultimately to humans shall be studied in detail.

The removal of microplastics is one of the leading issues nowadays. As there is a lot of data that confirms the microplastics and their negative impacts on the environment but there is very scarce data on the removal of microplasitcs, therefore more research should be carried out in this domain.

Furthermore, future initiatives to limit plastic pollution should concentrate on ending it at the source in order to decrease the number of microplastics entering the marine environment. This could involve activities like making people knowledgeable about the negative effects of plastic pollution, encouraging the use of reusable and biodegradable materials, and putting laws and policies in place to cut down on plastic waste and encourage recycling. Research is also required to create more efficient management strategies to lessen the effects of microplastics on the marine environment and to better understand the concerns of microplastics on marine life.