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Sources and Impact of Microplastic Pollution in Indian Aquatic Ecosystem: A Review

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Abstract

Microplastics are major pollutant distributed widely throughout the Indian marine and freshwater are posing a significant risk to living organisms. World economic forum's estimation, the world's oceans will be filled with more plastics than fishes by weight by 2050. The extreme production and use of plastics being lead to plastic waste disposal, and the plastic degrade to microplastic. The growing amount of microplastics will continue to increase microplastic pollution in aquatic environments. Today, it is a major environmental problem because microplastics are less than 5 mm in size and associated with other pollutants that can be accumulated on the body to make health problems and lead to death. Microplastics are directly ingested by organisms from polluted water or indirectly through the contaminated food web. The effects of microplastics are wide-ranging, impacting marine life, fisheries, economics, tourism, plants, marine aesthetics, and human health. This paper review focuses on the microplastic sources, pollution, and its impact in the Indian aquatic environment.

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Introduction

Microplastic pollution is a developing environmental problem in aquatic fields. Global production and consumption of plastics have continued to rise and the problem is that most of us use and then toss way more plastic than we need. Plastic treating is the pillar of the economy in most of the advanced economies and several plastics machinery manufacturing units in India are plus and their consumption in the year 14-15 about 14 MMT.[1] Plastics industry produces and exports a wide range of raw materials that contribute to 40-50% of the total waste material[2] however, 1 million plastic bottles are purchased per minute, most of which aren't recycled.[3] Worldwide production and consumption of plastics have continued to rise and the problem is that most of us use and throw away more plastic than we need. The Indian plastics industry has the enormous potential of growth[4] and its usage was increased day by day leads to dumping of plastic

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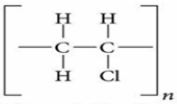
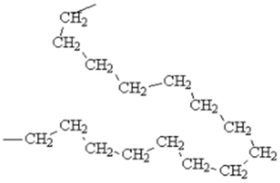
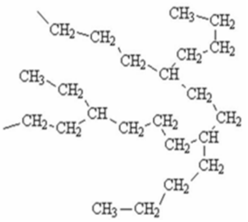
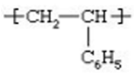
waste into the environment make huge pollutions. Deep Indian Ocean flooring is already loaded heavily with 4 billion fibers per km^2 [5] and in India, the people were consuming about 117 micrograms/ year, if the average rate of salt consumption is 5 grams/ day.[6] Accumulation of plastic debris identified by FTIR spectroscopy as, polystyrene, polyester, polyurethane, nylon, and glass wool in the intertidal sediments of the world's largest ship-breaking yard.[7] The occurrence of microplastics in sediments[8,9] and plastic debris leaving in the Indian Ocean.[10] India is the most important country contributing to huge environmental pollution by dumping plastic waste in landfills and oceans every year.[11]

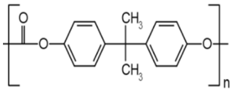
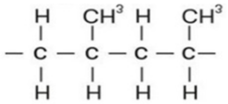
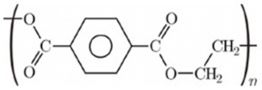
Microplastics are formed from the degradation of plastic[12] and the weathering of plastic greatly increases its surface area and subsequently, altering the chemical behavior of the plastic also increasing their contamination with dangerous pollutants that are present within the aquatic environment. Microplastics are collected from the beaches of Goa[13] and the sediments of Vembanad Lake in India.[14] The accumulation of microplastic in organisms through the food chain and their impact deleteriously effect in the biological system of aquatic and terrestrial organisms. Plastic debris from beaches across Mumbai[15] and bioaccumulation of microplastics in marine animals also well documented.[16] Human health is harmfully affected by the accretion of microplastics with other toxicants in the food chain while traveling through the environment.[17]

Sources of Plastic

The presence of plastic in the aquatic environment is due to different anthropogenic activities mainly reaches from the terrestrial source.[18] Human population using oceans as their household dustbins[19] and the plastic litter accumulation on beaches in Mumbai.[15]. Synthetic fibers are very much harmful to the aquatic environment and the sources of plastic fragments in the aquatic environment are mainly the discharge of wastewater as well as runoff water from domestic and industrial wastes.[20]

Table 1: Chemical structure of plastic

Plastic	Abbreviation	Chemical Structure
Poly vinyl chloride	PVC	
High density polyethylene	HDPE	
Low density polyethylene	LDPE	
Polystyrene	PS	

Polycarbonate	PC	
Polypropylene	PP	
Polyethylene terephthalate	PET	

Plastic affectedly throughout aquatic environments also is now a convenient place to dispose of and it will be one of the most challenging ecological threats for the next generation. Different types of plastic like[21] polyethylene,[22] polypropylene, polystyrene, polyvinylchloride, polyethylene terephthalate,[23] polycarbonate,[18] high-density polyethylene, and low-density polyethylene[22] (Table 1) that polluted the aquatic field. Polypropylene has a dominating position and their consumption increases which leads to environmental pollution.[24] Based on their sizes plastics are Macro plastics (≥ 25mm), mesoplastic (<25 mm- 5mm), microplastic (<5mm-1mm), mini- microplastic (<1mm-1μm) and Nano plastic (<5μm). Microbeads are composed of polyethylene, polypropylene, and polystyrene beads are used in skincare and cosmetic products.[18]

Degradation of Plastic

Plastic is directly released into the aquatic environment through cosmetics, textiles, land application, waste from domestic and industry. The microplastics are originating from the degradation of plastic occurs due to natural and artificial processes such as photo degradation, biodegradation,[23] mechano-chemical, photo-oxidative degradation, thermal, and catalytic action.[25] Weathering of plastic greatly increases its surface area. Consequently, the reaction sites at which the sorption of dangerous toxic pollutants can occur is potentially increased, thereby altering the chemical behavior of the plastic and increasing their contamination with dangerous pollutants that are present within the aquatic environment.

Microorganisms such as fungi, bacteria, and actinomycetes are involved in the degradation of natural and synthetic plastic[26] into microplastic as well as biodegradation of plastic polyethyleneM,[27] thermocol cups,[28] and bacteria is a major factor for degrading polythene.[29] Report of low-density polyethylene degradation by induced mutations in *Pseudomonas Putida*[30] and the maximum fouling was observed on polycarbonate during the initial three months.[31]

Microplastics as Pollutants

Microplastics are less than five millimeters in size they have been detected on the surface of every aquatic field because of improper usage and disposal of microplastics that pollute the freshwater and marine systems. Plastic can be encountered in two forms: large plastic wastes also small plastic particulates below 5 mm in size named microplastics,[47] and it originating from the degradation of larger plastic.[14] A major source of plastic pollution in the aquatic environment from industrial sources. Plastic litter reported alongside the beaches of Karnataka,[21] Caranzalem beach sands, Goa,[48] resin pellets from Chennai and Tennakkara Island49 and the debris in Great Nicobar.[50] The impact of the 2015 flood makes the occurrence of microplastic pellets along the Chennai coast, India[51,52] and the microplastic resin pellets in sediments around Agatti Island[53] also the beaches of the southeast coast of India.[54]

Microplastic is in pellet, fragment, fiber, film, and foam forms and Nano plastic is less than 1μm. Fiber forms of microplastic are isolated from 25g and samples around the Indian Ocean[55] and marine debris pollution along Marina Beach, Chennai.[56] Microplastic pollution in the Vembanad lake study is the first report from India on microplastic particles in lake sediments. The low-density polyethylene microplastic reported from the lake sediment sample has been recognized as the dominant type of plastic[14] and technique was used for counting debris at the sea of Malacca and the Bay of Bengal.[57]

Table 2: A list of microbes reported degrading various types of plastics

Plastic	Microorganisms	References
Low-density polyethylene	**Bacteria**	
	Streptomyces sp.	32,33
	Pseudomonas sp.	34,35
	Bacillus spp	34,35,36
	Staphylococcus sp.	34,35
	Acinetobacter baumannii	37
	Kocuria palustris	38
	Bacillus pumilus	
	Bacilus subtilis	
	Fungi	
	Aspergillus clavatus	39
	Rhizopus oryzae	40
	Penicillium oxalicum	41
	Penicillium chrysogenum	
	Aspergillus nidulans	34,35
	Aspergillus flavus	
	Aspergillus terreus	42
	Aspergillus sydowii	
	Actinomycetes	
	Streptomyces KU8	34
	Streptomyces KU5	
	Streptomyces KU1	
	Streptomyces KU6	
High-density polyethylene	**Bacteria**	
	Arthrobacter sp.	43
	Pseudomonas sp.	
	Bacillus sp.	44
	Pseudomonas sp..	
	Fungi	
	Penicillium oxalicum	41
	Penicillium chrysogenum	
Poly vinyl chloride	**Bacteria**	
	Streptomyces sp.	32
	Fungi	
	Trichocladium sp.	45
	Chaetomium sp.	
Polypropylene	**Bacteria**	
	Pseudomonas sp.	46
	Vibrio	
	Fungi	
	Aspergillus niger	

Chemicals and other contaminants are carried by microplastic[58] so they can cause a combined effect on organisms. Plastic is mixed with several addictive to improve performance that additive chemicals[59] carrying other contaminated materials end up within the body of an organism who consume it.[60] Microplastic fragments reach coastal and marine environments that accumulated on organisms that are facing hazardous problems.[61,21,7]

Consequences of Microplastics

Microplastic is highly toxic to the environment and the pollution by them make a direct and serious threat to freshwater and marine environments. In India, people suffering from different health issues due to the impact of microplastic. Toxicity of microplastic create an alteration of environmental structure, biomagnification and bioaccumulation in aquatic and terrestrial organisms threatened to ecosystem functions. Microplastic found in several types of food and the majority of the reports have been studied their occurrence in seafood and copepod was ingest microplastics, which leads to damages their body functions,[62] it was detected in the gut of the fish species in Tuticorin, the Southeast coast of India.[63] Microplastics contaminated seafood could lead to a potential threat to human health.[64] In this context, polystyrene in the soft tissues of Perna viridis was found in the fishing harbor of Chennai India.[65]

The ingestion of microplastics by an aquatic organism has been widely studied in both fields[14] and laboratory.[30] Plastics were accumulated in the rumen of ruminants leading to ruminal impaction, recurrent tympany, indigestion, and other adverse health effects.[66] Accumulation and fragmentation of plastic debris in the environment[67] and benthic invertebrates from the coastal waters of Kochi.[16] The microplastics ingestion in the marine *Arenicola marina* caused an ultimate weight loss, decrease in feeding ability and, also reported that the ingestion of polyethylene microplastics in benthic organisms Hyalella azteca leads to a decline in the development and reproduction process.[18]

Microplastic effect on human health due to the consumption of fish68 and ingested polyethylene plastic transfers dangerous chemicals to fish, suffers from liver toxicity and pathology[69] and its lasting effects in marine organisms which results in harm to their cells and tissues.[19] High-density polyethylene and low-density polyethylene[22] microplastics are an endocrine disruptor. Polyvinylchloride is the most harmful form of plastic contains bisphenol A, lead, mercury, dioxins, phthalates, and cadmium that can in puberty, neurological functions, immunity, cardiovascular health, breast cancer, prostate cancer, and even metabolic disorders. Microplastic and that even breast-feeding mothers are contaminating their babies with bisphenol A from plastic. Ecotoxicological effects of microplastic on biota show that microplastics exposure triggers a wide variety of toxic effects from feeding disruption to physical ingestion, reproductive actions, variations in liver physiology[70] and the cattle affected with plastic foreign bodies.[71]

Conclusions

In this review paper the microplastic pollution and its impact in a developing country like India has been detailed. Microplastic is less than 5mm size and a carrier of other toxic chemicals that make a harmful effect on the fresh and marine aquatic system. The literatures in this review says the sources and distribution of plastic are highly observable problems in India through anthropogenic activities and also the plastics are degraded through biodegradation, photodegradation, mechano-chemical, thermal, and catalytic action to form microplastic. The abundance and different composition of microplastic were reported in Indian water bodies as pellet, fiber, fragment, film, and foam forms that accumulate on organisms make consequences. Also, these microplastics when present in the aquatic organisms enter into the human through food web resulting in several disorders hence, there is a need for a serious concern on the microplastic pollution through scientific researches.

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Conflict of Interest

The authors do not have any conflict of interest.

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