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MICROPLASTIC IN INDIA A SHODDY AFFAIR

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

ABSTRACT

Small sized fragmented plastic or microplastic contamination is widespread and considered as one of the major problems of aquatic environment. Ability to resist bio-degradation amplifies longevity, long transportation and aggregation, enables microplastics to find their sink in the drinking water. The situation in India is more critical as sources of microplastics are far too many and the high sediment flux in the rivers may easily facilitate the process of fragmentation during typical tropical climate, making the aquatic ecosystem of India extremely vulnerable. Detailed research and careful monitoring activities could bring clearer picture of the scenario and assess the impact of plastics on environment and biota. Some mechanism through which the emissions at the source could be checked or some other ways to reduce and reuse plastic waste or some new novel business solutions are essential to tackle this problem.

Keywords: Microplastic; freshwater; globally distributed; industrial efflux; pollution.

1. INTRODUCTION

Plastics have become omnipresent and a pervasive compelling force of contemporary industrialized world. It has become indispensable because of its exceptional properties in an affordable price. Chemicals such as lead, cadmium and mercury used in production of plastic are toxic and detrimental to human body. When larger plastic wastes are exposed to different environmental conditions it undergoes weathering and leads to formation of microplastics. Microplastics are very small plastic pieces (less than 5 mm long) which are harmful to all types of life forms [1]. Because of their small size, they can penetrate the biological barriers and accumulate in tissues which produce a series of hazardous effects on feeding, growth, reproduction, immunity and genetics [1].

Microplastics have become an alarming concern for living fraternity around the world. The most common

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and concerning reason which makes microplastics threatening is solely because they are not completely biodegradable and have a propensity to accumulate in environment [2]. Researchers have also thrown light on how the microplastics are accumulated in each trophic level (bioaccumulation) and magnify (biomagnifications) [3].

Microplastics have been found in all continents (except Antarctica) out of which Asia accounts for majority of it and Australia least [4]. With over 1.2 billion population and improper infrastructure for waste management, India is one of the world's leading plastics consumers and waste generator, with over 40-45% of its waste remains uncollected and dumped indiscriminately into rivers, lakes, ponds, oceans and seas [5]. Due to rampant disposal and dispersal in aquatic environments plastics and eventually microplastics interfere with marine and freshwater life. India predominantly being a rural country and with less than 40% of its rural population having access to safe drinking water between 2016-2020 [6], uses freshwater sources as the primary source of water for day-to-day activities (bathing, washing utensils and clothes), farming and most importantly, drinking. Clothes, cosmetics, personal care products, plastic bottles, paints etc. have different forms of plastic materials [like - polyvinyl chloride (PVC), polyethylene (PE), polystyrene (PS), polypropylene (PP), and polyethylene terephthalate (PET) etc.] that get accumulated in the water and while fishing gears and other nets used in freshwater bodies are also accumulator of plastic materials [7]. This amounts to microplastics loading in freshwater sources and has serious adverse effects in health. Urban population use relatively less natural freshwater source for day-to-day activities but the rampant industrialization in order to meet the demands of ever expanding population releases toxic waste materials containing plastics into freshwater sources. The plastics dumped under the soil as land fill may reach the groundwater in microplastic form and contaminate drinking water sources for urban population that can have damaging ramifications to health [8]. Indian rivers are fed by tremendous amount of monsoon rains receiving from both South-West and North-East monsoon, leading to flooding and microplastics loading in freshwater sources [9]. Though proper health concerns due to microplastic pollution and accumulation are undeciphered but eventually they will be evident.

The reason for microplastics being omnipresent is owing to its low cost, easy availability and its multidimensional use by human fraternity. If examined, their presence can be traced from the mighty remote Himalayas to the abysmal depths of oceans. Plastics have become an inescapable truth of daily life .Escalating demand for plastic use and soaring plastic wastes cannot be the gospel of life. Remedial measures to overcome and reduce this problem of microplastic pollution are the need of time. Certain countries despite being surrounded by ocean have controlled microplastic pollution effectively through proper awareness and strict directive measures like imposing ban on single use plastics switching to more convenient and natural mode to do away with this invisible threat [10].

Thus in this review we discuss the extent of microplastics' contamination in freshwater sources across Indian subcontinent and try to enlighten the possible remedies to deal with this problem.

2. ORIGIN AND ABUNDANCE OF MICROPLASTIC

Creation of new synthetic chemicals in collaboration with competence of mass production has made plastic one of the most available commodity in modern world. Most standard plastics such as polypropylene, polystyrene, PVC and polyethylene terephthalate are non-biodegradable and their increasing aggregation in the environment is a warning to planet.

Small size plastic particles are described as macroplastics as >5 mm, mesoplastics as 5 to >1 mm, microplastics as 1 mm to >0.1 μm, and nanoplastics as 0.1 μm by Lambert et al. [11]. However, generally accepted upper limit size of microplastic is < 5 mm [12] and are a crucial adulterant dispersed throughout freshwater and marine ecosystem and posing notable threat to the living organisms. Microplastics are present in diverse morphologies like beads, fragments, fibers, films. Microplastics can be originated from variety of sources like ingredients in cigarette filters, textile fibers and cleaning items such as sponges and cosmetic care products for personal use and dust from vehicular tires, as well as from larger plastic products released into the aquatic environment through cosmetics, textiles, land application, waste from domestic and industry are degraded down by natural and artificial processes such as photo degradation, biodegradation, mechano-chemical, photo-oxidative degradation, thermal, and catalytic action. Weathering of plastic greatly increases the surface area which has detrimental effect on organisms. Hydrophobic chemicals can be adsorbed on microplastic and desorbed into the digestive system thus increasing bioavailability of pollutants leading to bioaccumulation. Certain microorganisms, such as fungi (Actinomycetes) and bacteria (mutated *Pseudomonas putida*) are capable of breakdown of

larger plastics, specifically thermocol, polycarbonate, low-density polyethylene etc. into microplastics [13]. Microplastics are dispersed in the environment as mishandled wastes that haphazardly adulterate water, soil and air. Environmental contamination by microplastic is augmented by anthropogenic factors, such as low efficiency of urban waste water treatment and application of sewage sludge to fields. Natural factors such as wind, storms and floods contribute to the distribution of microplastic [14]. The concentration of microplastic is measured in items/m^3 (freshwater) and items/m^2 (marine environment). Asia followed by Europe and America are the most polluted continents where as Africa and Oceania are least polluted with microplastic [15].

3. STATUS OF MICROPLASTIC IN INDIA

Microplastic and India: India accounts for about 16% of the world's population sustaining on only 4% of world's freshwater sources. These diminishing freshwater sources are getting polluted with microplastics. Microplastic owing to its ability to withstand biodegradation increases its durability, transportation capability and accumulation and thus sinking in the drinking water.

India being an industrialized nation and in the path of becoming a developed nation is farfetched because there is little or no control on release of industrial efflux on freshwater sources resulting in aggregation of microplastics like low density polyethylene (LDPE), polyethylene terephthalate (PET), polystyrene (PS), polyvinyl chloride (PVC), polyurethane (PUR), polybutylene terephthalate (PBT) in freshwater sources [9]. On the basis of primary techniques like sieving and filtration microplastics in aquatic environment are predominantly classified on their size, shape, colour, and polymer type. Fourier transform infrared spectroscopy (FT-IR) is the most common spectroscopy used to identify polymer of microplastics based on their functional groups. Microplastic studies in India are mostly conducted on surface water and sediment sections of lake and river lacking substantial study in the arena of groundwater [16].

Appearance of microplastic in freshwaters of India is an emergent issue and is very recently explored. The principal source of microplastic contamination in freshwater is fragmentation, degradation and weathering of plastic debris like fishing ropes, pipes, synthetic textiles, it can also occur due to leakage of primary microplastic from cosmetic industries, runoff activities during rain and dry deposits in lakes. Latest studies have estimated that billion microplastics discharge into Bay of Bengal, Brahmaputra and Meghna river [16]. Wind patterns and wind velocity of cyclones and storms and moisture laden winds of South-West and North-East monsoon leads to accumulation and transportation of microplastic.

Indian economy being an agrarian one where 50% of the total work force is dependent on agriculture based work owing to high demand in the market, there is a pursuit of high productivity and increase the profit per unit of agricultural input hence excess pesticides are used which are polluting the freshwater sources long with microplastics. It's estimated that world accounts for 6.46 billion tons of plastic [9], due to insufficient waste management. The situation in India is censorious as source of microplastics are superabundant. This can be directly associated with the livelihood of huge Indian population. Microplastics have been recovered from different parts of the country.

- **Vembanad Lake** the largest brackish wetland ecosystem in Southern India. Microplastic particles were retrieved on sampling [17].
- **Dal Lake, Kashmir, India** contains microplastics. The lake serves many people as a means of income, whether they are fishermen, tourist guides or owners of Shikara boats which is attributed as the main reason for microplastic pollution [18].
- Floodplains of two gigantic population sustaining rivers of the world- **Ganga and Brahmaputra** carry microplastics as well as heavy metal pollution. Co-occurrence of microplastic and heavy metals can be attributed to the fact that microplastics act as a vector for heavy metal transportation, the heavy metals adsorb on microplastics, thus with trophic transfer it leads to bioaccumulation of both microplastics and heavy metals [9].

Microplastic pollution in Indian urban industrialized areas are equal to the rural contributes. Availability of safe and drinkable water continues to be an aspiration of rural population in parts of India. Maharashtra State Health Department has stated that 25% of the rural water available is unfit to drink. Traces of microplastic and microbial contamination have been found in the water bodies of rural India [19]. This can be attributed due to discharge of domestic sewage directly or indirectly into water bodies, agricultural run-off during rainy season containing chemical fertilizers and pesticides as well as effluents from agro-based industries and from day to day activities of bathing and washing.

In India, people suffering from different health issues in the coastal region and river banks can be mostly traced backed to microplastic pollution. Toxicity of microplastic creates a colossal modification of environmental compositions, biomagnifications and bioaccumulations in aquatic and terrestrial ecosystems. The abundance and characteristics of microplastics in the aquatic environment, the aquatic biota mistaking them for food, leads to a serious concern both for aquatic organisms and people who depend on them for food. Microplastics are generally found in seafood and copepods which harm their body functions, these microplastic contaminated seafood are a potential threat to human health. It was detected in the gut of the fish species in Tuticorin, the south east coast of India. Polystyrene in the soft tissues of *Pernavirdis* was found in the fishing harbor of Chennai [20].

The presence of heavy metals like Cd, Pb, Hg and Cr in the additives that are used extensively in the manufacture of plastics make microplastics more hazardous to the aquatic environment [21]. To avoid this problem of bioaccumulation the fish should be degutted before consumption.

Data on microplastic pollution is largely inadequate and is mostly confined to the regions of Tamil Nadu and Pondicherry. Extensive coastlines of Andhra Pradesh, Orissa, and West Bengal remain unexplored.

Tackling the unseen:Occurrence, transportation and effect of microplastic pollution has been discussed effectively. It requires better mastery over microplastics for control and removal strategies. Control of microplastics can be divided into three stages- (i) production stages, (ii) application stages and (iii) discharge stages.

(i) Production stage is involved in understanding the inauspicious effects of microplastic. The consciousness about single use plastic bags and microbeads are important sources of microplastic. Inadequate productions will reduce microplastic discharging in aquatic environment. Stopping the spread of microplastic pollution begins with holding the companies accountable who use plastic. While that requires government intervention and laws, proper industrial protocol to incorporate social responsibility, covering all the ethical, legal, and economic dimensions. Using more of biodegradable polymers or bio-based plastics rather than fossil-based plastics may help to limit microplastic pollution to some extent. Though, more detailed study is also needed on the toxicity of those biodegradable polymers or bio-based plastics.

(ii) Application stage strategies and **laws** have been furnished by different governments to lessen plastic applications. The policies involve in banning the sell of plastic bags, charging customers for light weight bags and imposing taxes from manufacturers, for example, Indian Central Government had implemented the "Plastic Waste Management Amendment Rules", 2021 for prohibiting all identified single use plastic items by 2022. Changes in washing behaviors, reduction in detergent dosage and recycling plastics in a sustainable way may reduce microfibers in aquatic environments.

Some remedies to control microplastics are –

- **Change in doing laundry**- the polyester is a cheap and versatile material popularly used in making t-shirt or yoga pants but clothing made from this plastic is one of the biggest sources of microplastic pollution in the world as well as in India. A single load of laundry can release more than 1 million microplastic fibers into the environment.
  Remedies- filters can be installed in a washing machine that catches microplastics. Traditional mode of hand washing reduces the microplastic pollution. Decreasing the amount of detergent in laundry led to substantial decrease in microfibers.
- **Buy clothes from natural materials-** instead of garments made of plastic; seek out brands that only use natural resources such as cotton, silk, wool, hemp and linen. Use of polyamide fabric with glycidyl-methaacrylate-modified pectin may reduce microplastic released by 90% on washing.
- **Stop using single use plastics-**buying reusable water bottle, tote bags for groceries, and multi-use straws.
- **Use public transportation-**as cars move on roads the tires break down and shed plastic particles due to wear and tear which accumulate in air.
- **Use of plastic free cosmetics-**lotions and skin creams often include plastic to promote absorption, while toothpastes and exfoliators often contain microbeads.

(iii) Discharge stage-after releasing microplastics into aquatic environment it becomes difficult to separate owing to their miniature size and very low concentration. Wastewater treatment plays a noteworthy role in controlling microplastic discharge into aquatic environments. Before tertiary treatment 88% of microplastics were removed and after tertiary treatment 97% were

removed [22]. Different removal technologies were used like-

Filtration-is used to separate solid plastic particles.

Density separation-isolation of microplastics from sediments, lighter microplastics float in upper layer.

Coagulation-due to small size suspended microplastics form unstable colloid on addition of coagulant for physical separation.

Agglomeration-formation of macromolecular networks can sustainably remove microplastics by hydrolysis and condensation.

Adsorption removal- removal of microplastics by using Zn-Al layered double hydroxide (LDH).

Oil film separation- for microplastic removal it is a hydrophobicity based method.

Froth flotation- achieved through a selective adherence of bubbles on target materials.

4. CONCLUSION

This society becomes increasingly plastic reliant since the initiation of commercial production began in 1950 [23]. Owing to their versatility, stability, light weight and low production costs have fueled global demand. The present estimation states that amount of microplastic in water bodies are predicted to double by 2030 [24]. Around the world, human produces an estimated 300 million tons of plastic waste every year, and at least 3.5% of it ends up in our water bodies [25].

Microplastic pollution sources can be traced back to products like tea bags, cloth washing and glitter. These pose a risk of trophic transfer in aquatic biota via ingestion, bioaccumulation and biomagnifications [3].

Recent studies have made us realize that we inhale and ingest microplastics round the clock during our daily lives. A study in 2019 by researchers at the University of New Castle found that "globally people might ingest an average of 5g plastic every week-equivalent to a credit card" [26]. The impact of this diet in our body is still poorly understood.

Chemicals used in plastics have, however been linked to a range of health problems including cancer, heart disease and poor fetal development, it can also cause oxidative stress, inflammation and respiratory problems [27]. One more concern is that plastics could carry pathogens which bind themselves to different materials. Though the proper health concern due to microplastic accumulation in human body is potentially undeciphered but sooner or later the consequences will be in front of our eyes [27]. Actions should be immediately taken in countries around the world and immediate ban should be imposed on single-use plastic products to get rid of this apparent miniature threat which with subsequent time can jeopardize the environmental harmony between biotic communities throughout the world. So plastic is not just a problem of the health of our environment but really a problem that concerns our own health.

Microplastic pollution should be dealt with concern and proper measures should be taken to control it at both individual and authoritative levels. We as individuals can cut down unnecessary use of plastic and shift more towards sustainable products. International concerns should be raised to discuss in global forums about the potential threat and possible measures to control this unforeseen threat. A strong governing body with international participation should be created immediately to overcome this grim situation as well as harsh retribution should be introduced in order to reform this potentially invincible threat in the name of microplastic.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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