

Environmental Plastic Pollution

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Abstract

Plastic pollution is an emerging threat to human well being and Environmental health. Due to mismanagement of plastic waste and irresponsible consumer behavior huge mass of plastic waste is entering environment. In aquatic ecosystems like oceans, rivers and lakes plastic waste leads to entanglement, ingestion and suffocation of birds, fish, turtle, mussels and crustaceans. Upon disintegration plastics get broken down into various shapes. These smaller items like micro plastics are ingested by invertebrates and various marine life forms. Plastics have been proven to cause stress, injuries, bioaccumulation, tumor formation, disruption of immune response and metabolic functions. Apart from that plastics lead to revenue loss in tourism sector of the magnitude of 13 billion US Dollars. Around 4-8% of global oil and natural gas stock is used to manufacture plastics directly or indirectly. Further polymerization process is highly energy intensive leads to generation of approximately 400 million tonnes of greenhouse gas emission. Around half of global population is living within boundary of 60 km near sea, plastic debris destroys scenic and aesthetics of oceans. Plastic pollution leads to socioeconomic and environmental losses. Solution to present problem can be achieved through concerted means of stringent legislations, enhancing collection and recycling, suitably substituting plastics with biodegradable alternatives, raising public awareness and taking up cleanup measures.

Keywords: Plastic pollution, microplastics, bioaccumulation, awareness

1. Introduction

Plastic is present everywhere. It is so ubiquitous that it has become symbol of Anthropocene era. Nearly half of all plastics produced is Single use plastics. In year 2015 approximately 381 million tonnes of plastic was produced. Till 2015 about 8.3 billion tonnes of plastic have been produced since 1950, out of which around 6.3 billion tonnes of plastic waste was created (Geyer et al., 2017). Around one million plastic bottles are sold per minute and five trillion plastic bags are used every year. Most common plastic waste items are cigarette butts, bottles, bottle caps, grocery bags, wrappers, straws, stirrers etc. About 8 million tonnes of plastic waste enter World's ocean every year (Jambeck et al., 2015). Major transport of plastic trash from land to sea is

done by rivers which serve as conduits for plastic waste to oceans from major cities of the world. Around 90% of the plastic waste that enters oceans is carried by rivers namely, Niger, Nile, Indus, Ganga, Brahmaputra-Meghna rivers system, Amur, Mekong, Hsiang, Changjiang, Zhujiang (Schmidt, 2017). Since most of plastic are non biodegradable hence it may persist in environment for centuries. If current trends persists then by 2050 there will be more plastics than fish in the world oceans. The worrying fact is that out of total plastic waste produced from 1951-2015 only 9% is recycled, 12% safely incinerated and rest 79% was either openly dumped, landfilled or littered in environment (Geyer et al., 2017). Marine plastic pollution is rising and Microplastics has become a cause of concern. Around 5 trillion pieces of plastics of varying size weighing about 250000 tonnes is present in oceans. Microplastics adsorb toxins like persistent organic pollutants, lead to growth of biofilm of harmful microbes like *E. coli* and are being ingested by marine creatures (Andrady, 2011). Recycling is most suitable option in plastic waste management (Hopewell et al., 2009). Landfilling produces leachate which may contaminate groundwater, incineration releases toxic gases and greenhouse gases. Plastic waste prevention and reduction, promoting reuse and judicious use through creating social awareness and arising consumer awareness can greatly help deal with plastic menace. Collection, segregation, transportation, storage, processing and disposal of plastic waste should be strengthened.

2. Plastic debris

Marine debris is discarded, disposed off, abandoned solid material in coastal or marine environment. About 50% of total plastic produced is buoyant. As plastics are cheap, durable, light, once thrown away in open gets washed away and reach water bodies (Kershaw et al., 2011). Huge mass of abandoned and discarded plastics constitute plastic debris of varying size. Plastic debris is becoming a serious threat to world's marine and aquatic ecosystems. It leads to ingestion, entanglement, suffocation of hundreds of

marine creatures. Floating plastics is main component of marine litter.

2.1 Microdebris: Commonly called as nurdles. Size ranges from 2-5mm. Mainly produced from cosmetic, cleaning products like scrubbers.

2.2 Mesodebris: Small granule having shape of cylinder or disc have maximum diameter ranging from 4.76mm-200mm.

2.3 Macrodebris: Particle size is larger than 20 mm. Includes discarded fishing nets, grocery bags etc.

Table.1 Categories of plastic depending upon its size

Category	Diameter
Nannoplastics	<.0001 mm
Microplastics	.00001-4.4mm
Mesoplastics	4.76-200 mm
Macroplastics	> 200 mm

3. Causes of plastic pollution

3.1 Overuse of single use plastic items: Since plastic items are light weight, cheap and easily available, people tend to over consume them. Once used plastic items are thrown away.

3.2 Throw way culture: People are very often not sensitized to reuse and recycling. Once used instead of keeping it for future use or giving it to someone, people simply throw it away.

3.3 Less recycling: In developed countries amount of plastic waste recycled is around 10%. In India around 60% of plastic waste is recycled. Recycling is mainly done in informal sector. In country like India where around 25,000 tonnes of plastic waste is being generated every day, there is huge opportunity for job creation and income generation in recycling sector.

3.4 Improper disposal: Very often people don't segregate green and dry waste. Mixed waste is very hard to recycle and is not economical. Various municipalities don't have enough space for safely disposing plastic waste. Hence plastic waste is either not collected or burned in open. Also there are very few municipalities indulged in incineration and energy recovery from plastic waste.

3.5 Lack of awareness: Sensitization of general public towards menace of plastic waste is not being undertaken regularly by authorities. Even educated class is not aware of importance of source segregation, waste minimization, avoidance, integrated waste management, reuse reduce and recycling. Plastic packaging has become a marketing tool to promote consumerism. People like to flash plastic shopping bags when they go for shopping.

4. Sources of plastic pollution

Plastic waste is generated from variety of sources mainly from industrial, commercial and residential activities. Industrial waste is produced due to

processing, manufacturing, and packaging activities. Automotive industries produce plastic waste like spare parts, fan blades, bumpers, seat covers and grill etc. In industries during construction phase pipe and fittings, sheets and waste tiles, electrical switches, cable sheath, screens are generated. In commercial areas workshops, supermarkets, wholesalers generate reasonable amount of plastic waste mostly comprising of packaging material. Hotels and restaurants produce plastic waste in form of bottles, straws, wrappers and packaging materials. Residential area like colonies, housing societies, apartments, and park generate plastic waste mainly due to littering and non segregation of waste at source. Around 80% of plastic getting in to world's oceans come from land based sources. Important land based sources are water and sewer discharge, tourism, fishing, illegal dumping and industrial activities. Important sea based activities responsible for generating plastic litter are commercial fishing, boating, shipping industry, oil and gas exploration activities.

Table.2 Sources of plastic waste

Ocean based sources	Merchant ships, cruise liners, ferries
	Naval and research ships
	Tourist boats and yacht
	Offshore oil and gas exploration and extraction facilities
	Fishing vessels
Land based sources	landfills
	sewage
	Industries
	Tourism

Table.3 Common items found in plastic waste

Food wrappers, containers, pouches, covers,
Water, cold drink Bottles and container cap
Grocery bags, carry bags, chips packets
Straws and stirrers
Beverage bottles, juice bottles
Films and foams
Discarded white goods like plastic furniture, bucket, mug, television stand, computer items like key board etc.
Plastic cutlery and utensils

5. Great Pacific Garbage Patch

It is huge assemblage of marine debris covering approximately an area 1.6 million square kilometers. It is situated between Hawaii and California. The patch comprises of tiny bits of micro plastics very often not visible to naked eye, making a sea water

look like cloudy soup. About 80% of debris that have accumulated in these patches comes from land based sources (Leberon et al., 2018). Plastics are major component of debris present in garbage patch. More than 1.8 trillion pieces of plastics afloat weighing more than 80,000 tonnes, which concentration levels ranging from 10 kg per meter cube to more than 100 kg per meter cube. Main components of plastic present in garbage patch are discarded fishing gear (nets and rope), Polyethylene and Polypropylene (Eriksen 2014).

6. Impact of plastic waste on environment

Once dumped openly plastic waste contaminate our rivers, streams, oceans, air and soil. Burning leads to release of toxic gases and chemicals like dioxin, recycling if not managed properly leads to several environmental and occupational hazards. During production process of plastics benzenes, xylenes and ethylene oxides are released which are known to cause birth defects, cancer and immune disorders.

6.1 Soil/beaches Main contributor to soil plastic pollution is illegal dumping of solid waste, sewage sludge and agricultural activities. Plastics is extensively used as mulching and in green houses in agricultural activities. PE mulching is being replaced by biodegradable alternatives but due to incomplete breakdown small plastic fragments are generated in soil. Upon replacement of plastic covering in green house, plastic is left loose, is an important source of plastic litter in soil. Sometimes plastic residue is burnt leading to contamination of soil. Composting is also perceived as source of micro plastic litter in soil. A study conducted in Italy found average 4.9% plastics contamination in manure (Novamont, 2018). Microplastic contamination is 4-32 times more on land than that on oceans. Plastic removal by raking process destabilises the shore and enhances coastal erosion. Raking also destroys nesting sites of turtles and seabirds. Plastic waste disposal on land severe environmental problems like making soil infertile, release of greenhouse gases, leaching of heavy metals to ground water. Indiscriminate littering of plastics on land reduces percolation and aeration in soil.

6.2 Water: Once discarded plastic reach in to soil and water. Very often plastic waste blocks sewage system creating a flood like situation. In aquatic systems plastic block sunlight hence reduces photosynthesis. Surface of plastics leads to formation of biofilms (Zbyszewski and Corcoran, 2011). Microorganism present in biofilms produce foul odor and release toxic chemicals. Water blockage due to plastic debris leads to breeding of mosquitoes and other vectors. Plastic waste generated on land reaches sea through rivers. In oceans plastic remain for long periods and gets

accumulated at remote location such as mid ocean gyres, shipping routes, population centers on islands (Morritt et al., 2014).

6.3 Air. Solid waste containing plastics is very often burnt in open which leads to air pollution. Burning of plastic waste releases toxic chemicals like Poly chlorinated biphenyls, dioxin, mercury, furans etc (Forrest et al., 1995). Burning of plastic waste increases susceptibility to respiratory ailments heart disease and damage to nervous system. Incomplete combustion of plastic waste containing PE, PP, PS leads to formation of carbon monoxide, dioxins, carbon black, pyrenes etc.

6.4 Human Health: Plastics contain various chemical with toxic potential. PVC and PS have been found to release toxic chemicals in environment which causes cancer and hormonal imbalance. These polymers are also broken down by heat, UV rays and mechanical action. During polymerization process certain chemical known as additives are added to give plastics a desired property. One such additive is Bisphenol-A (BPA), is a endocrine disruptor and mimics oestrogen, increases chances of prostate cancer, breast cancer, obesity, lowers sperm count and increases chances of miscarriage (Melzer et al., 2011). Phthalates (1,2 Dibenzenecarboxylic acid, 2-ethylhexyl phthalate) are used as plasticizers to make plastic more flexible. Phthalates are proven to have anti androgen activity, induce allergies and obesity. Polybrominated diphenylesters (PBDE's) are used as flame retardant. Exposure to PBDE's hampers development of nervous and reproductive system. BPA and Phthalates tend to concentrate in body tissues. BPA also leach from landfill and contaminate groundwater, rivers, streams harming fish and other aquatic life. Heavy metals such as Cadmium (Cd), lead (Pb), nickel (Ni) present in children toys, mobilephones pose a risk to human health (Mudgal et al., 2011).

6.5 Marine life

Entanglement: Abandoned or lost fishing net commonly known as Ghost fishing, packing loops, rope are chiefly responsible for entanglement of marine creatures (Barnes & Milner, 2005). Entanglement can lead to serious injury or wound, drowning, make it more vulnerable to predators and can also lose ability to catch prey. Scientists think decline in population of Hawaiian Monk seal and Northern fur seal is due to entanglement (Derraik, 2002). Microplastics is being ingested by filter feeders, deposit feeders and detritivores mistaking them for food. Around 400 species have been found to ingest or getting entangled, killed or injured in plastic debris. In a study it was found that 7 turtle species and two third of all sea birds have ingested plastics at some part of time. According to

UNEP (2006) plastic waste causes up to a million sea birds and 100000 marine mammals. Laist (1997) in a study reported around 267 different species which were found to suffer from plastic debris, it includes 86% turtles, 44% sea birds and 43% of all marine mammals. Sedentary creatures like corals are damaged and suffocated by plastic waste and leftover fishing nets plastic debris transfers harmful invasive species to non native environment.

Table.4 Marine species with documented record of Entanglement and ingestion (Laist, 1997)

Species	Entanglement record	Ingestion record
Sea turtles	86%	86%
Sea birds	16%	36%
Marine mammals	28%	23
Fish	34%	33%
Seal/sealions	79%	7%
Manatees/Dugongs	25%	25%
Baleen whales	60%	20%

Table.5 Species for which entanglement record is maximum

Scientific name	Common name
<i>Collorhinus ursinus</i>	Northern fur seal
<i>Chelonia mydas</i>	Green turtle
<i>Zalophus californianus</i>	California sea lion
<i>Eubalaena glacialis</i>	North Atlantic right Whale
<i>Fulmarus glacialis</i>	Northern Fulmar
<i>Caretta caretta</i>	Loggerhead Turtle

7. Strategies to reduce plastic pollution

7.1IWM: Integrated waste management system relies on cradle to grave approach. Right from extraction of raw material, production of finished products, generation of waste, storage, collection, transportation, processing, recycling, energy recovery and disposal. It is a holistic approach which focuses on waste prevention, waste reduction, enhance recovery and safe environmental friendly disposal.

7.2Zero waste concept: It includes reuse, reduce, recycling, waste minimization, ecolabelling, ecodesigning and extended producer responsibility. Zero waste approach is inspired from TQM (Total quality Management) concept used in industrial production. In waste management scenario zero waste concept intends to achieve zero discharge, zero atmospheric damage and zero material waste. Its main objective is to create a smart system which

utilizes resources in waste stream to create wealth and employment.

7.3Circular economy approach: The conventional linear approach involves produce, use and dispose. Generally goods are made from raw materials, sold, used and then discarded as waste. On the other hand circular economy approach in waste management involves extraction of maximum use value even after a product becomes a waste and then safely returning to earth's system. Circular economy intends to eliminate waste by maximum utilization of resource. So circular economy focuses more on biobased, biodegradable, renewable alternatives, enhanced energy recovery, increasing utilization rate by improving access and ownership and extending products lifespan.

7.4Changes in Product design: Sourcing raw materials from renewable sources like biomass instead of fossil fuels, creating products which requires less packaging, products which are made from recyclable materials and not releasing harmful chemical in environment, products which are reusable can greatly reduce burden of plastic waste in environment

7.5Better management system: Instead of municipal authorities alone being responsible for waste management, public participation and community engagement in decision making, ownership and responsibility for waste management should be encouraged. Latest technological advancements and techniques should be implemented in plastic waste management.

7.6Effective legislations: Central pollution control board and state pollution control boards have already formulated waste management rule but effective implementation is lacking at ground level. There is lack of funds, proper training and motivation among waste management professionals. The legislation on waste management should incentivize recycling reuse, processing and value addition.

Table.6 Alternatives to plastic usage

1.	Replacement of plastic bags with jute bags or paper bags
2.	Avoiding single use items such as bottled water, straw, plastic cups and plates
3.	Purchasing toys made from natural materials such as clay instead of plastics
4.	Avoiding packaged frozen foods instead prefer to buying fresh foods
5.	Promoting biodegradable and biobased plastics
6.	Selecting disposable and recyclable products
7.	Labeling of plastic polymers and imposing heavy taxes
8.	Extended producer responsibility, Deposit return scheme, Green chemistry
9.	Raising public awareness

8. Conclusions

Plastics have positively transformed our daily lives. Plastics bring many societal and technological benefits but indiscriminate use and improper disposal have led to transforming this incredible human invention into a disaster. Some of the problems arising due to plastic waste are accumulation of plastic waste in landfills, open littering in natural environment, contamination of soil and water bodies, air pollution due to burning, leaching of toxic compounds, toxicity due to ingestion and entanglement of marine life. According to a report 15% of species suffering entanglement and ingestion are on IUCN Red list species. Most common use of plastics is packaging which is discarded after use. As plastic production consumes significant portion of fossil fuels which is around 4 percent. Our fossil fuel reserves are finite in long term overconsumption is not sustainable. Recycling of plastic and resource recovery is suitable option as it reduces environmental impact caused due to mining, quarrying, oil and gas drilling and deforestation. Recycling also reduces emissions of CO₂, SO₂, NO_x. Changing consumer behavior through creating awareness and sensitization of community so as to reduce overall volume of plastics consumed and substitution with less harmful alternatives should be promoted. Focus should be on using renewable alternatives to packaging like jute or cotton, providing better waste management services, strict implementation of waste management legislations.

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