GLOBAL ISSUES OF PLASTICS ON ENVIORNMENT AND PUBLIC HEALTH

Shana Shaji
Government Ayurveda College
Tripunithura, Ernakulam
Kerala, India
Email: shanashaji96@gmail.com

Jerin Jose
Amal Jyothi College of Engineering
Kanjirappally, Kottayam
Kerala, India
Email: jerinjose100@gmail.com

Jeny Jose
Bar-Ilan University
Ramat Gan, Israel
Email: jenyjose53@gmail.com

ABSTRACT

Plastic manufacturing industries are voluminously increasing year by year all over the world. Growing human population and the urge for urbanization are elucidated as the pillar reasons for the high demand of plastics and plastic based materials. Plastic pollution can be considered as the most aggressive environmental issue the society is facing at present. Plastics are also dumped to the river mouth proximities and thus it reaches the marine and aquatic creatures too. This paper summarizes the current scenario of plastic production and its pollutions, types of plastics, toxicity and its environmental impacts of both the human beings and surrounding ecosystem. It also opens a brief view to the single use applications of these plastics in medical and health industry.

Keywords: *Microplastics, toxic additives, health hazards*

I. INTRODUCTION

Plastics and its by product materials are widely used in the modern era due to its varied functional properties and low cost. Extreme toughness, chemical and thermal resistance are the main attractive features of plastics. The usage of plastics is estimated to commence in the year 1950s. It is anticipated that the manufacture and demand for plastics may double worldwide in the upcoming 20 years. As per a statistics of industry, Asia, Europe and USA accounts for the 85% of world's plastic production. Asia contributes to the 80% of plastic leakage to ocean. Plastics can be as hard as rocks, or can be as tiny as threads which can be transported by even a small wind to kilometers long. The presence of plastics can be considered as a significant geological pointer of antropocene. They can be taken as stratigraphic indications in various archeological field by seeing them as current and accurate indicators of earth deposits. United nations have announced the plastic pollution as a worldwide crisis in 2017. This

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made several business establishments to adjust their corporate strategies, preparing for an augmented change to a circular economy. It is expected that an extra 33 billion tonnes of plastics will be further added to the planet by 2050.

Plastics are basically a chain of molecules with each link made up of hydrogen, carbon, oxygen or silicon. They are categorized as thermosets and thermoplastics. Thermosets solidifies while thermoplastics becomes soft upon heating. But thermoplastics return to its normal hardness at room temperature. Thermosets finds applications in construction and automotive applications. Thermoplastic materials are used in medical industry, carpet fibers and so on. Polymers can be naturally derived or synthetic. Synthetic polymers are extreme pollutants. It also acts as carriers of various kinds of chemicals. Plastic particles have been detected in various shapes, concentrations, sizes in biota, other remote locations, agro-ecosystems, food and drinking water. Micro-plastics refers to various plastic debris less than or equal to 1 mm in size. The presence of microscopic plastic debris, or micro-plastics in terrestrial, aquatic and marine habitats were identified from various parts of the world. Table 1 shows the rate of micro-plastic accumulation is various coastal ecosystems. Plastics are versatile, cost-effective, require less energy to produce than alternative materials like metal or glass, and can be manufactured to have many different properties. But, not all current uses of plastics are prudent and sustainable.

Table 1. Micro-plastic accumulations in various coastal ecosystems of the world

References	Location	Level of pollution
[1]	Guanabarabay, Rio de Janeiro, Brazil	1.40 to 21.3 particles/m^3
[2]	Hong Kong, China	3.973 pieces/m^3
[3]	Southern coasts, Sri Lanka	18.06 ± 11.45 items/m^3
[4]	Dutch North Seacoast	54-3146/kg
[5]	Belgium shelf	100-3600/kg

The additives that are added to these plastics for various purposes are of the biggest concern. Polybrominated diphenyl ethers (PBDE), phthalates and bisphenol A (BPA) are to name a few. Continues daily interaction with plastic items allows oral, dermal and inhalation exposure to these chemical components leading to the widespread presence of these chemicals in the human body.

II. TYPES OF PLASTICS

The broad area of plastics has been classified into seven main types based on their constituents and types of materials used for production.

a. Polyethylene teraphthalates (PET)

They are also called as *'stomach plastics'*. Antimony tri-oxide which is a possible

carcinogen is used as a catalyst for its production and rubber vulcanization. These single use, smooth, transparent and relatively thin PET plastics must be prevented from high temperature exposures so that the leaching of toxic additives such as acetaldehyde, antimony and phthalates can be reduced. PETs are anti-inflammatory and solvent resistant. It is commonly used in the manufacture of soft drink containers, and water bottle production.

b. High density polyethylene (HDPE)

It is the most commonly used petroleum-based plastic in the world-wide. It is resistant to heat. Phthalates and BPAs are not present in the HDPE. But it becomes harmful when it gets a long-time exposure to the sunlight. These waxy and opaque materials are resistant to chemicals and moisture. HDPEs will get softened at 75°C. The soft drinks packed in these plastic containers are safe to drink. Common applications of HDPE include toys and detergent bottles.

c. Poly-vinyl Chloride (PVC)

This strong and tough plastic material is considered highly toxic to human due to the presence of heavy metals, dioxins, BPA and phthalates. PVCs are made flexible by the addition of phthalates. Commencing from the stage of production, usage and disposal, its entire use is reported to be harmful to the environment. But still, the human community prefers the usage of PVC due to its versatility and cost effectiveness. Polyvinyl chlorides (PVCs) are heat resistant polymers. They get softens only at 80°C. PVCs are recycled mainly into composite bins. The health issues related to the continuous exposure and use of PVCs includes liver dysfunction, chronic bronchitis, ulcer, genetic changes, vision failures and skin diseases.

d. Low density polyethylene (LDPE)

They are heat resistant and fragile polymer materials that are commonly used in squeeze bottles and garbage bags. These materials are commonly used in juice packaging and frozen foods. Use of low-density polyethylene is considered safe for the food and beverages industries. These materials will get scratches easily but softens at 70°C. As per the estimates of Environmental protection agency (EPA), 5.7 percent of LDPEs are being recycled in US. Two of the major greenhouse gases (methane and ethylene) are produced when these LDPE materials are exposed to consistent amount of sunlight.

e. Polypropylene

These types of plastics are heavier and stronger than polypropylene. They gets softens at 140°C. These hard and translucent materials find applications in the manufacture of lunch boxes, microwave dishes and so on. It is also used for the packaging of ketchups and beverages.

f. Polystyrene (PS)

Polystyrenes are also a petroleum-based plastic. They are commonly used in packaging and insulating materials. These materials are resistant to salt solutions and alkalis but will be affected with acids and fats. They are generally opaque and glassy rigid. Polystyrenes gets softens at 95°C. It has less water absorption capabilities.

Styrene products are basically hazardous to health. These materials contain carcinogenic substances like benzene. Even a small quantity

exposure of styrene can have hematological, cytogenic or neurotoxic effects in public health. The Table 2 shows the toxicants that are released upon burning of all the above categories of plastics[6].

Table 2. Types of plastics, their toxic contents and health hazards

Type of plastic	Toxic materials/gases released while burning	Health hazards
Polyethylene Terephthalate (PET)	Ethyne, formaldehyde, carbon monoxide, polycyclic aromatic hydrocarbon, Methane, carbon dioxide	Cancerous and mutagenic effects, mild to moderate respiratory irritation.
High-Density Polyethylene (HDPE)	Paraffin, aldehydes, and light hydrocarbons, polycyclic aromatic hydrocarbon, carbon monoxide, olefins	Carcinogenic and mutagenic effects, Mild to moderate respiratory irritation
Polyvinyl Chloride (PVC)	Polycyclic aromatic hydrocarbons, dioxins, chlorinated furans, hydrogen chloride, carbon monoxide	Respiratory tract disorders, birth defects, cancer etc
Low-Density Polyethylene (LDPE)	Paraffin and light hydrocarbons, carbon monoxide, olefins, polycyclic aromatic hydrocarbons and aldehydes	Carcinogenic and mutagenic effects, mild to moderate respiratory irritation
Polypropylene (PP)	Fluorene, methylnaphthalene, biphenyl, polycyclic aromatic hydrocarbons phenanthrene, Naphthalene, pyrene, benzo[a] fluorene, methylphenanthrene, anthracene	Carcinogenic and mutagenic effects, mild to moderate respiratory irritation
Polystyrene (PS or Styrofoam)	Acrolein, polycyclic aromatic hydrocarbons, styrene gas, hydrogen cyanide	Narcosis, neurotoxicity, eye and mucous membrane damage, cancer, and death in high doses
Polyurethane (PU)	Hydrogen cyanide, phosgene, carbon monoxide	Death in high doses

Each grades of plastics has a symbol of easy identification. It will help the layman to understand the type of plastic they are using. Table 3 shows the various symbolic representations of each grade of plastics mentioned above.

Table 3. Various grades of plastics and their symbolic representations

Sl. No	Type of plastic	Symbol
1	Polyethylene teraphthalates (PET)	
2	High density polyethylene (HDPE)	
3	Poly-vinyl Chloride (PVC)	
4	Low density polyethylene (LDPE)	
5	Polypropylene	
6	Polystyrene (PS)	

III. APPLICATIONS OF PLASTICS IN PUBLIC HEALTH AND MEDICAL DOMAIN

Plastics are mostly versatile and light weight. Therefore, they are widely used in throw-away applications. Fifteen percent of the hospital waste in US is from plastics. They saves time in medical field as they can save the period of sterilization[7][8]. The health care professionals have mentioned the easiness of selecting and usage of disposable products. Syringes are an example for the single use applications of plastics in public health. It has now become reusable too. Disposable syringes were in demand during 1980s because it

reduces the risk of the transfer of diseases like hepatitis B and HIV[8]. In the modern era, both reusable and throw away syringes are available in market. Absorbable sutures which are polymer based materials has the capability to biodegrade over a period of time considering the patient needs[9]. As a controlled drug delivery system, polymers are widely used in the pharmaceutical industries. Disposable latex gloves and intravenous (IV) bags and the tubes used in dialysis are examples for inexpensive and single time use of plastic materials. In the total hip replacement procedures in orthopedics, polymethylmethacrylate polymer is used as bone cement[10]. Various structures of biodegradable polymer scaffolds are used in tissue engineering domains too[11]. The microneedle patches for medicine distribution, prosthetics and different types of engineered tissues are also examples for use of plastics in medical field[12].

IV. ENVIRONMENTAL IMPACTS OF PLASTICS

As per the information released by the United Nations environmental program (UNEP), the pollutions due to plastics can have various negative effects on the natural processes and habitats. The ability of the ecosystem to adapt to the climatic changes is also being affected. Increase in the population has demanded the huge need of plastics and plastic products. Plastic bags have a major role in the urban solid waste system. It has resulted in the deterioration of natural beauty, blockage of channels, streams, rivers and animal choking[13]. At the end, it resulted in the breeding of mosquitos and other flies and creation of foul smells. The normal aeration phenomena of soil are affected. This lead to the decreased productivity of agricultural lands[14]. Considering the various issues of plastic bags, various European countries have imposed fees on it. It was aimed to limit the usage and production of plastic bags. These bags are dumped as landfills around the world. It occupies various tons of hectors of land. The drastic effect of plastic bags is that it takes long years for its decomposition. Moreover, various poisonous substances are leached into the soil when these bags decompose due to the effect of sunlight. If it gets burned, lethal materials are released into air resulting in the air pollution too. They emit toxic methane and carbon di oxide (CO_2) into atmosphere during the disintegration stage. These minor quantities of toxic material accumulation in animals and human beings can result in the carcinogenic effects too.

Animals usually confuses the plastic bags for the food and thus consumes them. Thus, it will block the digestive system of them. They are also often drowned and tangled in plastic bags. Animals that are entangled in marine debris may result in infection, mortality, laceration and starvation. Scientists have reported various cases where endangered and big tortoises were seen to be suffocating due to the swallowing of plastic bags in combination with seaweeds[15].

The waste and accumulated solid waste plastic bags in the marine areas are contributing to strong issues in economic development. These bags trapped in the coastal lines pave ways to unfavorable effects on the tourism. Lower earnings and hostile effects on tourism are adverse effects that follows the effect[16]. These entrapped coastline plastic bags have an adverse effect on fishing, shipping

infrastructure and aquaculture. The leaching of chemicals to the water bodies must also be considered as a problem of plastic materials and bags. From most of the literature studies, it is understood that the single-use plastic containers, bags, and materials are the leading causes of environmental and socio-economic problems. If these single-use plastic materials can be reduced, about 40 percent of the world's plastic problems can be controlled.

The adverse effects of plastics can be found in agricultural and terrestrial environments also. It is responsible for the dilapidation of agricultural land and atmosphere[17]. Also, these plastic pollutions can be further transmitted to the aquatic environs too. It has been studied that 80% of the world's plastic wastes present in the ocean basically originates from land and other terrestrial enviorns. The dumping of plastic based materials will end up in the degradation of biotic and abiotic matters. Chlorinated plastic materials has a special capability to leach out the toxic chemicals into soil and thereafter to the various surrounding aquatic systems. Harmful colorants, heavy metals, plastic additives and plasticizer can leach into the environment thereby resulting in the contamination of soil and water. These dumped and unrecyclable polymer fibers and micro-plastics were understood to be detectable from soil and sewage even after five years[18][19]. The hazardous greenhouse gas Methane is also pushed out during the microbial biodegradation of plastics to the atmosphere.

V. EFFECT OF PLASTIC DEBRIS/FIBERS ON ANIMALS

The terrestrial and aquatic animals are severely affected due to the dumping of plastics. Coral reefs are getting damaged by the plastic products and other types of nets along the sea beds[20]. Health risks were reported in line with the entanglement of plastic fibers on marine lives. Literatures have reported this matter for around 243 species of terrestrial and aquatic animals so far. As these animals are not capable to untangle themselves and escape, it leads even to the death of them. Marine animals often get confusion regarding plastic materials and jelly fish. Sea turtles are the major victims of this issue as they prey mainly on the jelly fishes. An analogous situation is happening in the case of sea birds too. They often gets confused with microplastic materials for fishes and cuttle fishes. They mistakenly prey on them and gets entangled within the plastic materials. These synthetic fibers while ingesting causes physical damage and obstruction in bird's digestive system. It further pave ways to malnutrition, starvation and finally to death. Ingestion of plastic debris is more commonly reported in literatures than the entanglements. If the animals are poisoned by toxic constituents from plastics, the food articles used for the consumption of humans are also affected.

VI. SCOPE FOR FUTURE WORK

Certain matters can be considered while designing the plastics for the future works. Some of them are as follows.

1. As a first step, all plastic materials must be labelled for its longevity matters. Through this the public community can identify and use the plastics as per the appropriate needs and also by considering the life of the plastic material.

2. Edible plastics can be an alternative for the materials which are currently in use for the food packaging industry.
3. 'Development of safer, smarter and multi-purpose plastic materials for the future' should be the major aim of all the plastics researchers across the globe.
4. The current day plastic products and plastics of known health issues must be banned all over the world by the joint collaboration of world leaders and United nations. Eg. Diethylhexylphthalate (DEHP) from food and medical equipments.
5. More biodegradable polymers must be developed for almost all applications. More investments must be made in this field of research.
6. Carbon neutral and non-toxic monomers which are non-petroleum based must be developed for the long run and sustainability of public and environmental health.
7. Changes in manufacturing and consumption patterns of plastics needs to be considered.
8. 5R rule must be a guiding principle for all the people in the case of plastic usage and consumption; Restrain, Recycle, Reuse, Reduce, Rethink.

V. CONCLUSIONS

1. To minimize the plastic waste all around the world, the major thing to consider it to minimize its use. It should start from each one of us.

2. The combined efforts of pricing, levying fines and the legislation has successfully prevented the short-time use of plastics all over the world.

3. It is very necessary to think about how these plastic materials can be re-used and recycled before going for a complete disposal of them.

4. Conducting awareness programs and educating the people even from infant stages is an effective way to curb the unhealthy littering and disposal of plastics.

5. Use of eco-friendly alternative bags made out of fabrics, natural fibers and papers can be an effective solution for a better future.

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