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# Plastic Waste: A Review

Anil Pratap Singh[1] and Dr.Angom Sarjubala Devi[2]

[1,2]Department of Environmental Science, Mizoram University,
Aizawl, Mizoram-796004, India

**Abstract**

Plastics are incredible human invention. The indiscriminate use and production of plastic waste has become a serious concern.Around 8 million tonnes of plastics enters in ocean every year. Microplastics are rising in oceans and is being ingested by marine creatures. Certain chemical are added to make plastics more flexible, fire resistant and durable. These chemical are Polybrominated Biphenyls, Bisphenols, Phtahalate esters etc. once released from plastic, upon degradation these chemicals can have serious health implications thereby affecting reproductive, endocrine system and central nervous system. Burning of plastics produce halogens, dioxins and can cause heart disease, respiratory ailments. Unmanaged plastic waste gets littered everywhere destroys aesthetics of place. Utilization in road construction,co-processing, producing Refused derived fuel from plastic waste is being done. Detailed guidelines regarding plastic waste management have been enforced by municipal authorities. Several state governments have banned use of polythene carry bags.Worldwide several initiatives have been taken like ocean clean effort and theme of World environment day-2018 was "Beat the plastic pollution". Although plastics has immense opportunity in health care, transport and energy sector, wise and judicious use of plastics is need of hour.Awareness,sensitization of all stakeholders should be done to ensure plastic waste doesn't exceed carrying capacity of our ecosystem.

***Keywords:*** *Plastic waste, microplastics, co-processing, plastic waste management*

## 1. Introduction

The term Plastics derives its name from a word "Plasticos" which means a substance which can be moulded or reshaped. Plastics are group of polymers having repeating units of Carbon and Hydrogen. Apart from C and H plastics may contain O,N,S,Cl,Si,F may be present (Plastics Europe,2016).Some of the most common polymers present in plastics are Polyethylene, Poly styrene, Polypropylene, Polybutylene, Polyvinyl Chloride, Teflon, Nylon,Polyesters and Polycarbonates.Polymers are abundant in nature. Polymers can be natural or manmade (American chemistry council,2012). Most common natural polymer is DNA(Deoxy ribonucleic Acid) and RNA (Ribonucleic acid).Cellulose, rubber latex, spider silk, hair, horn are examples of polymers. In year 1909 first man made plastic was manufactured and it was commonly known Bakelite.Ryan was the first manmade fibre made from cellulose in 1910.Later on Nylon was manufactured in year 1935(Hans,1993).On the basis of Chemical properties plastics can be divided into two broad category; Thermoplastics and Thermosetting Plastics. Thermoplastics can be heated and reshaped again and again.On the other hand Thermosetting Plastics once formed can't be reshaped, upon heating thermosetting plastics gets deformed. Almost every sphere of human life is touched by Plastics ranging from Mobile phone, batteries, clothing, footwear, food ,drinks, packaging etc.(Selke,2003).Plastic waste is a serious concern as plastics take hundreds of years to degrade. Several environmental issues have arisen due to indiscriminate use and lack of proper plastic waste management.

## 2.Global Plastics production and consumption

Since year 1950 around 8.3 billion Tonnes of plastics have been produced.Out of which around 60% (4.9 billion tonnes) has either been disposed of in landfills or polluted the environment (Mcarthur foundation,2016). Surprisingly only 9% of total plastic waste is recycled in world. If current consumption pattern continues then by year 2050 around 12 billion tonnes of plastics will be produced.In year 2017 world plastic production was around 348 million tonnes.China islargest producer of Plastics in the World (Wilson, 2015).In India around 25,940 Tonnes of plastic waste is produced daily out of which around 40% remains uncollected.Yearly around 1.5 million tonnes of plastic waste is produced in India (CPCB,2016).The average per capita consumption in India is around 11 kg which is well below when compared to USA which is around109 kg per capita per year. Nearly 50 % of total plastic waste compromises of single use plastic items like straws,bottle, spoon,forks,bags etc.According to United Nation's estimate

around 500 billion plastic bags and around 480 billion plastic bottles are consumed every year. If current consumption continues then by year 2050 there will be more plastics in ocean than fish by weight.

## Table.1 Useful plastics products

| S.no | product | Polymer used (Chemical name) |
|---|---|---|
| 1. | Bullet proof jacket | Polyparaphenylene Trepthalamide (Kevlar) |
| 2. | Aircraft window | Bisphenol A polycarbonate |
| 3. | Nonstick layer on utencils | Polytetrafluoroethylene (Teflon) |
| 4. | Contact lens | Poly methylmetha acrylate |
| 5. | Bottle caps | Polypropylene |
| 6. | Electronic equipment cases | AcrylonitrileButadiene Styrene |
| 7. | Food packing | Polyvinylidiene chloride (saran) |
| 8. | Cushioning foam | Polyurethanes |
| 9. | cutlery | Polystyrene |
| 10. | Riot shields | Polycarbonates |
| 11. | Fire resistant polymer | Phenol formaldehyde (Bakelite) |
| 12. | Adhesive | Polyepoxide |
| 13. | Medical implants | Poly ether ether Ketone |
| 14. | Biodegradable polymer | Polylactic acid |
| 15. | Nylon | Polyamides |

## 3.Microplastics

Microplastics are tiny pieces of Plastics ranging in size from 5 mm to 10nm(Arthur et al. 2009).Global microplastics reaching oceans have been estimated to be around 1.5millin tonnes.Out of total microplastics production globally about 98% comes from land based sources while only 2% is generated fron sea based activities.Microplastics are generated mainly from personal care products such as face wash, tooth paste, facial scrubs.Microplastics have been found in various marine animals fish,birds and mammals (Lusher et al., 2013;Yamashita et al.,2011).Microplastics have been categorised in to two types primary and secondary micro plastics on the basis of their origin.If plastics were originally produced of the size of microplastics then it is called primary microplastics.If microplastics are produced after degradation,fragmentation and weathering of larger plastics items then it is called Secondary Microplastics.Common examples of Primary micro plastics are scrubbers,microbeads,plastic powders present in cosmetic formulations. Microplastics is entering food chain and reaching human through sea food consumption (Koelmans et.al.,2016).

## 4.Bioplastics

Bioplastics is made from raw material derieved from biomass mainly sugars and then proceed in to plastics.This sugar is derieved from corn,sugarcane,sugarbeet or potato.In large quantilies bioplastics is produced from Polylactide acid (PLA) and Poly hydroxyl alkanoates (PHA).On the other hand Biodegradable plastics are plastics which can be broken down by microrganisms (European Bioplastics Factsheet,2016).

## 5.Great Pacific Garbage Patch

Great pacific garbage patch also known as pacific trash vortex is huge collection of debris situated at North Pacific Ocean. It covers approximately 1.6 Million square kilometres.Around1.8 million pieces of plastics have been reported out of which Micro plastics comprises approximately 8% of total debris.The concentration of plastic debris at centre ranges more than 100 s of $Kg/m^3$ while at outer region it is about 1 $kg/m^3$ (Kostigen et al.,2010).

## 6.Impact of Plastics on Environment, Human health and marine life

Around 4 % of world's total oil production is used as feedstock to manufacture plastics. According to Environmental Protection Agency (EPA) for one ounce of PET produced there is release of one ounce of Carbon di oxide. Degradation of plastics leads to emission of green house gases and thus contributes to global warming (Molgaard,1995).Less than 9 % of total plastic waste is recycled hence most of plastic waste end up in landfills or remains openly littered. Here plastics may take 40-1000 yrs to degrade (Moore,2008).Openly littered plastics choke sewage flow and sometimes get mixed in soil leads to loss of soil fertility and deteriorate aesthetics of landscape. Burning of plastics lead to generation of carcinogenic Dioxins which can also act as hormone disruptors (Thomson et al.,2009).If it enters body it can get accumulated in body fats and can get transferred from pregnant mothers to baby via placenta. Burning of plastic waste can lead to heart ailments, respiratory problems, nausea, vomiting, headache etc.Prolonged exposure to

toxic fumes can lead to kidney and liver damage. Burning of polystyrene cups and plates produces styrenewhich can damage eyes and mucous membrane.Anually on average 8 million metric tonnes of plastic waste reaches ocean. According to a study there are about 15-51trillion pieces of plastics present in ocean. About 90% of trash found in oceans is plastics(Erikson et al.,2014;Cozar et al.,2014).A study conducted by NOAA (National oceanic and atmospheric administration) concluded that plastic kill about 1,00,000 marine animals each year.Plastic causes entanglement, suffocation, strangulation or starvation of Marine life.Scientists have found plastics to impact turtles,whales,seabirds,corals,jelly fish as marine animals injests plastics mistaking them for food (Lusher and Thomson.,2013).The floating plastic particles can easily get colonized by microbes(Carson et al.,2013).Plastics contain harmful chemicals such as Bisphenol A, Melamine formaldehyde, Pathalates, Flame retardants which may get released upon dissociation in gut of marine animals or simply get accumulated and passed on to next trophic levels (Horn et al.,2004). Small plastics micro beads look like fish eggs and are eaten by marine reptiles, birds,fish and jelly fishes. Recently a study conducted by Philipp Schwabl at Medical university of Vienna found on average 20 particles of micro plastics per10 grams of excreta. These plastic particles could affect immune responses and lead to release of toxic chemicals in gut (https://www.theguardian.com).

## 7.Plastic waste management

Rapid economic growth, rising middle class and aspiration of people have led to rise in per capita expenditure of country. As society consumes more and more there is consequent generation of waste. According to CPCB solid waste generation in India amount to about 62 million tonnes per year.Out of total solid waste generated 40-60% is organic while plastic account for 8-10%.There is rise in per capita waste generation at the rate of 1.33% per year. According to CPCB(2016) Indian generates about 25940 tones of plastic waste per day.Out of which around 40% of plastic waste remains uncollected.In India Packaging Industry is growing at the rate of 18% and is expected to reach 72.5 Billion by year 2020.According to Plastic Infrastructure Report Total consumption of Plastic in India in year 2017 was 12.8 Million Tonnes.In India per capita plastic consumption is 11 Kg/yr.By year 2031 total plastic production in country will be around 31.4million tones per year (Indian centre for Plastics in Environment,2006).Globally at present total plastic production is 8.3billion metric tonnes. According to a study conducted by CPCB and CIPET about 94 % of the plastics generated in country is recyclable.Out of this HDPE(High Density Polyethylene) and LDPE(Low Density Polyethylene) accounts to 65%,PP (Polypropylene) amounts to about 10% ,PET(Polyethylene Terephthalate) and other categories amounts to about 8.5% of total plastic waste produced. In India lare chunk of plastic waste comprises of packaging material, multilayer pouches, sachets, polybags etc. Household plastic waste is major source of plastic waste in India (Narayan,2001).In India plastic waste is being managed through utilization in cement clins as alternate fuel, in construction of road, attempts have been made to produce fuel from plastics and Plasma pyrolysis technology. Recycling of plastic is being done through environmentally sound manner. Recycling of plastics includes primary, secondary, tertiary and quaternary recycling (Subramanian,2000).In Primary recycling processing of a plastic waste is done convert it in to a product with same characteristics like original product. Secondary recycling converts plastics into materials with different characteristics like that of original plastics product. Tertiary recycling involves the production of chemicals and fuels from plastics waste. Quaternary recycling retrieves the energy content through burning and incineration of waste plastics (Scheirs,1998).

Table.2 Status of use of plastics carry bag in different states (CPCB,2016)

| s no | state | status |
|---|---|---|
| 1. | Assam | Complete ban |
| 2. | Chattisgarg | Complete ban |
| 3. | Jammu& Kashmir | Complete Ban |
| 4. | Karnataka | Complete Ban |
| 5. | Nagaland | Banned |
| 6. | Orissa | Complete Ban |
| 7. | Punjab | Complete ban |
| 8. | Uttar Pradesh | Complete ban |
| 9. | Uttarakhand | Complete ban |
| 10. | Maharashtra | Partial Ban |
| 11. | Manipur | Partial Ban |
| 12. | Meghalaya | Partial Ban |
| 13. | AndhraPradesh | Partial Ban |
| 14. | Goa | Partial Ban |
| 15. | Gujrat | Partial Ban |
| 16 | TamilNadu | Partial Ban |
| 17 | Jharkhand | Partial Ban |

## 8.Salient features of Plastic waste management rules-2016

PWM rules apply to every waste generator, local body, Gram Panchayat, manufacturer, Importers and producer. The minimum thickness of plastic carry bags made up of virgin or recycled plastics cannot be less than 50 micron. Plastic carry bags made up of recycled plastics should not be used for carrying or storing food or drinks. Responsibilities of Municipal urban and rural local bodies have been fixed. Recycling of plastic waste should comply Indian Standard: IS 14534:1998 while carry bags made up of compostable plastics shall comply IS: 17088:2008.Proper labelling in form of name, registration no and thickness of carry bag should be provided. State pollution control board and pollution control committee,Secretary In charge of urban development department of state and concerned gram panchayats have been designated as authority to enforce provisions of PWM Rules at various levels (PWM Rules MoEF&CC,2016).

## 9. Recent developments

A group of scientists from United States,United Kingdom, Brazil have engineered a enzyme which can digest Polyethylene Trephthalate (PET).This enzyme have been derived from PETase a natural enzyme found in *Ideonellasakaiensis* (http://www.sci-ews.com).A fungus *Aspergillus tubingensis* have been reported bt Kew botanical gardens to degradepolyester polyurethane (PU) Recently scientists from University of Limerick have developed a technology known as SerPET through which plastic bottles can be converted in to various consumer goods such as luggage,sailing and sports equipments.Thus by converting plastic bottles in to self reinforcing polymer (SRP)through serPET can help reduce volumes of plastic waste and prevent plastic waste load in landfills.Squid protein extracted from teeth present on the arms of Squid can be processed in to eco-friendly biodegradable plastics (Abdon et al.,2019). Caterpillars of wax worm have been found to breakdown polyethylene by Frderica Bertochini at Institute of Biomedicine and Biotechnology of Canterbria in 2017.Scientists from Beihang University from China isolated bacteria which can degrade PET from plastic eating moth larva. Mikael Hedenqvist, Professor at KTH Royal Institute of Technology has developed a technology to produce plastics from renewable feedstock such as wheat gluten. Soy, wheat, corn, oat, potatao, cotton, oil, milk, feather, wool, silk can provide suitable feed stock to produce protein plastics. Sourcing feed stock from renewable sources rather than non renewable sources can greatly reduce our dependence on fossil fuels and can enhance sustainability.A study published in Journal of the Science of Food and Agriculture reports that suitable combination of starch, protein, glycerol can form films with same strength and flexibility like that of plastics. Research is going on in to produce liquefied waste plastics as raw material for fossil fuel refining. Researchers of Indian Institute of Technology(IITG) have developed biodegradable plastics for the first time in India.

## 10.Ocean clean-up efforts

A 20 million ocean clean project has been launched between California and Hawaii to collect trash. The ocean clean up system consists 600 meters long floater above surface of water and 3 meters deep skirts below. Floater helps the system afloat while skirt prevents plastics from escaping.The system is carried passively by currents. Floating system will capture from small pieces to larger debris.The ocean clean-up project targets to capture up to 50% of plastics in the area within 5 years (https://www.theoceancleanup.com).

## 11.Conclusion

Plastic waste is a grave concern for present and future generations.According to a report three out of ten rivers which carry approximately 90% of plastic waste are present in India which are Ganga, Indus and Brahmaputra. Ganga carries approximately 1,10,000 tons of plastic waste to bay of Bengal. Scientists have even recorded certain chemicals derived from plastics in eggs of birds found in remote areas of arctic and marina trench.Plastic in ocean gets broken down to minutes particles of micro and nanno scale and enter marine food chain through zooplanktons and subsequently reach higher trophic levels.Large plastic pieces often fill stomach of fishes, sea birds, turtles and can make them starve to death.Once these microplastics are ingested by marine animals,toxic pollutants such as Bisphenols phthalates may get released and reach top consumers of trophic chain.Plastics waste production is projected to reach 400 million tonnes by 2025 due to rising population and economy of developing countries.Hence there is need to strengthen plastic waste collection, recycling and disposal system. Biodegradable and Bio plastics is seen as an alternatives to plastics but reuse reduce and recycling is

paramount in plastic waste reduction strategy. Apart from creating awareness, people need to sensitized though suitable programmes with the help of digital and print media and bring change in attitude and perception regarding waste generation and management.

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