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Microplastics and single use plastics: A curse of over consumerism

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

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

Abstract

Human population and waste generation are closely interlinked. According to an estimate by 2050 the global population is projected to reach 9 billion and at the present consumption rates plastic production is projected to cross 1 billion tonnes by 2050.Plastic industry is directly and indirectly involved in greenhouse gas emissions, in Europe alone 4-6% of oil and gas consumption is used to manufacture plastic products.Single use plastics (SUP) like cups, plates, straws, stirrers, bottles, food containers are substantial sources of plastic pollution.Microplastics include primary(Microbeads) and secondary (Fragments generated from plastics). Microplastics impose a great danger to marine and human life through consumption and toxicity.Mass production, consumption of plastics and lack of scientific management of plastic waste has led accumulation of plastics in natural habitats.Which causes entanglement, habitat damage, ingestion of plastic litter and introduction of invasive species.Physiological impact include reduced growth rate,lower or blocked enzyme production,reproductive loss and adsorption of toxicants.Plastic waste is causing serious impact on economy of coastal countries in form of cost of cleanup, reduced fisheries stock and drop in tourism. Creating awareness, sensitization of consumers, effective and stringent policy measures are required to overcome menace of single use plastics and microplastics.

Keywords: *Single use plastics, microplastics, microbeads, toxicity*

1. Introduction

Single use plastics includes plastic item which are intended to be used as once before being thrown away or recycled.Single use plastics are used extensively in cosmetics, packaging,helath care and comsumer goods.Most common single used plastic items are straw pipes,plastic bags, water bottles coffee and beverages container,wrappers,bottle caps,cutlery,stirrers etc (Xanthos and Walker,2017). Microplastics are small pieces of plastics having diameter less than 5 millimeter and larger than 10 nannometer(Thompson et.al.,2004). Microplastics was first reported in 2013 from a fresh water lake (Caruso,2015).Since then microplastics have been reported in aquatic bodies of all continents except Antarctica.Single use plastics make up about 49% of marine beach litter.Daily use products such as mouthwash,handwash,shampoo,conditioners,moisturisers contains extensive amounts of micorplastics.Primary microplastics are directly released in to environment while secondary microplastics originate from degradation of larger plastic items(Barnes et.al.,2009).Microbeads are a type of microplastics having diameter less than 1 mm.Most common source of microbeads are tooth paste and mouthwash.Microplastics have been reported from beaches,sediments,ocean waters,guts of sea creatures and even from faeces of humans(Derraik,2002).Several scientific studies have documented incidence of microplastics in fisheries and aquaculture.Microplastics also act as carrier of hazardous chemicals like flame retardants, pigments, alkylphenols, perfluorooctanoic acid, nonylphenols and propylene (Hermabessiere et. al.,2017). According to an estimate around 4.8 to 12.7 MT of plastic enters the ocean annually and around 300 billion pieces of plastics are floating in arctic ocean (Eriksen et al.,2014).Sectors such as tourism, fisheries,birds,mammals,turtles and shipping is impacted by marine debris and litter. Around 400 million tonnes of plastics is produced annually.Around 50% of all plastic waste produced belongs to single use plastic products and packaging items.Around 5 trillion pieces of plastic weighing around 2.69 lakh tonnes are floating in seas. According to an estimate around 500 million to 1 trillion plastic plastic bags is consumed every year globally. Region wise North east Asia, North American and European region accounts for 26%,21% and16% of global plastic waste respectively.China is largest plastic polluter and United Sates of America(USA) ranks first in per capita production plastic waste.According to an estimate out of top 20 marine plastic waste contributing nations, 16 are middle income countries where less importance is given for scientific disposal of plastic waste.Plastics persist in environment and doesn't get biodegraded easily. Slow break down of plastics takes place due several physical factors such as Ultraviolet(UV) rays, abrasion, wave action and heat.Upon disintegration plastic items can release deleterious chemicals styrene,Benzene,if ingested can damage nervous system, lungs and reproductive system (GESAMP,2016). Apart from that plastic items can block airways and stomach of marine animals who mistakes plastics as food.There is urgent need to improve waste management practices

with suitable incentive based schemes. Development of alternatives in form of Bio based plastics and biodegradable plastics are need of hour. Proper labeling, source segregation and awareness, voluntary reduction strategies, public private partnership and devising ecofriendly alternatives can reduce burden of plastic waste to large extent.

Table.1 Categories of Microplastics (Lusher *et al.*, 2017)

Shape	Terms used
Fragments	Crystal ,powder, granules, flakes
Fiber	Threads, filaments, fibres, strands
Beads	Grain, sphere, microbeads
Foam	Polystyrene, expanded polystyrene
Pellets	Resin pellets, nurdles, nibs

Table.2 Common Single use plastics items

Cotton buds	Cups
Cutlery	Beverage containers
Plates	Bags
Stirrers	Crisp packets
Sticks for balloons	Sanitary items
Food containers	Fishing gear (ALDFG) Abandoned lost or otherwise discarded fishing gear

2. Global production and consumption

Around 8 billion tonnes of plastics have been produced since 1950 generating approximately 6.3 billion tonnes of plastic waste.World produces 400 million tonnes of plastics annually.Presently packaging,textiles,building and construction, consumer products accounts for36%,14%,16% and 10% respectively of global plastics production.About one fourth of all virgin plastics produced and almost 50 % of all plastic waste produced is single use plastics.Most commonly use single use plastics polluting oceans account for around 43% marine litter (Galgani et al.,2015). Huge amounts of micro plastics have been reported from sea, beaches, rivers and soils.According to an estimate globally 1.5 million tonnes of primary microplastics is released in to oceans (Avio,2016).It amounts to 212 grams per capita per person per week.Out of this around 98% is generated from land based sources.Sources of microplastics are littering, sewage sludge,plastiuculture and indiscriminate dumping in landfills.Soils act as permanent sink for microplastics.Microfibers and fragments have been reported from sewage sludge.Microplastics are produced from disintegration of plastics used as protective sheet in plasticulture.If the current scenario continues then there will be around 12 billion tonnes plastic waste in oceans and landfills.China is largest generator of plastic waste producing around 8.8 million metric tonnes per year.Problem of plastics is so grave that it is estimated that about 99% of sea birds have ingested micro plastics and 15% of marine species suffers from entanglement.

Table.3 Sources of Microplastics

Primary Microplastics	Secondary Microplastics
Cosmetics	Tires
Plastic raw materials	Textile
Paint	Paints
Rubber granules	PVC used in building material
Personal care products	Foot wear
	Cooking utensils

3. Impact of single use plastics and Microplastics

Plastics lead to global ecotourism loss worth of 13 billion USD due to aesthetic and economic loss caused by debris and plastic pollution (Ranaud,2014).Single use plastic bags and Styrofoam are very popular as they are cheap, strong and are hygienic but once used they get discarded and take hundreds of year to degrade, contaminate soil and water. Phthalates and Bisphenol A (BPA) are toxins which get leached from plastics and contaminate soil and water (Hartmann et.al,2017).Pthalates get deposited in fat bearing tissues and act as endocrine disrupters.It can also lead to dysfunctioning of reproductive system, inhibition of secondary sexual characteristics and lead to cancer. BPA act as estrogen disrupter and has deleterious effect of placental tissue growth.It can lead to premature birth,still birth,intrauterine problems and preeclampsia.In a study BPA was found to have carcinogenic effect in rodents especially on prostrate glands and urinary tracts (Halden,2010).If current trend of plastic production continues then green house emission by plastic sector will account for 15% of global annual Carbon budget by 2050.In 2012 alone Global plastic production accounted for 390 million tonnes of Carbon di Oxide emission to atmosphere.At present around 150 million tonnes of plastic waste is lying in oceans.Since plastics is made up of additives,plasticizers, stablizers and colourants which are toxic in nature.It is estimated that around 23 million tonnes of additives is present in plastic waste in oceans,which is raising serious concern.Plastics significantly impact maritime economy which includes tourism,fising and shipping industry (Jang et.al.,2014).Apart from direct economic losses there is adverse impact on human health and livelihood, food chains and other environmental factors (Green et. al.,2017).

Table.4 Hazardous chemicals released from microplastics

Hazardous chemical	Used for
Phthalates	Added to improve flexibility. Effect:Endocrine disruption
Bisphenol A	Used in polycarbonate plastics,epoxy resin,PE,PP,PVC. Effect:Endrocine disruption
Flame retardants (Polybrominated Diphenyl ethers)	Used to improve fire resistance in electrical devices. Effect:Endrocrine disruption,teratogenic effect,liver and kidney toxicity
Nonylphenols	Used as stabilizer. Effect:Endrocrine disruption
Trace or heavy metals	Added to plastics as stablizers,anti-oxidants or dyes Effect:Disruption of vital organs

4. Fate and Mechanism of Interaction of Microplastics

Microplastics are released directly in to environment. The fate of microplastics in environment is affected by size, density, shape, and wind and water movement (Depledge,2013).Ocean currents can transport microplastics horizontly and vertically.Environmental conditions such as temperature,ultraviolet radiations and availability of oxygen affect plastic degradation.Biofouling and weathering can also lead to loss of buoyancy(Andrady,2011).Microplastics are reported from sea surface as garbage patch and on sea beach sediments.Waste waters from municipality and effluent from industries contain very huge amount of microplastics.Microplastics have also been reported from agricultural soils.Microplastics reach various trophic levels through ingestion.Microplastics may be egested,fermented or get retention after ingestion.Microplastics can attract hydrophobic chemical from environment.Hence ingesation of microplastics can lead to bioaccumulation of chemicals inside organisms.Small plastics of size ranging from micro to nanno scale can be ingested or taken through gills. Sometimes these tiny particles are mistaken for prey.Microplastics have been found in guts of to hundrededs of marine creatures. In an experiment Blue mussel(*Mytilus eludes*) were found to accumulate polystyrene beads which caused reduction in filtering and production of pseudofaeces.Cole et al.,2011 found significant amount of PCB(Polychlorinated biphenyls) in chicks eating plastic pellets.Plastic debris provides dispersal opportunities for marine organisms which leads to potential invasion of alien species to new environement.Most common species include Barnacles,Hydroids,Mollusks.Several microbial communities are found to grow leading to microplastic fouling.These microorganisms can affect biodegradation and leaching of contaminants (Zettler et al.,2013).Microplastics have been found to cause oxidative stress and inhibit photosynthesis in *Scenedesmus* spp.,it is also found to affect physiology and health of zooplanktons like feeding and reproductive success.Higher mortality rates are observed in copepods with chronic exposure(Bhattacharya et al.,2010,Cole et al.,2013,Lee et al.,2013).The impact on humans by consumption of sea food will depend on retention time of microplastics in gut of seafood like fish, rate of release, degree of translocation from stomach to other body tissues.

5. Management options

Common measures to curb menace of plastic waste include partial or complete bans and reduction strategies. Although measures to crub plastic waste exists but lack sincere implementation.Apart from plastics only few countries have done policy intervention to limit microbeads by mostly restricting its use in cosmetics.In June 2014 United Nation's general assembly passed a resolution on marine plastic debris and microplastics for its effective management by limiting sea and land based sources and through effective legislations. World leaders have build a consensus to not only prevent but also reduce marine pollution. Beat the microbead initiative have successfully garnered attention of general public. It helps them check amount of microbeads in their personal care products by scanning the bar code.Honolulu strategy was developed at International Marine debris conference in 2011 to reduce plastic pollution in marine ecosystems. It encompasses several measurs such a market based instruments, implementing policies, regulations, legislations and launching clean sea campaign. European commission have implemented European strategy on plastics 2018 mandates all packaging plastics must be reusable or recyclable by 2030.Compaign named as 'straw wars' was started in London which promotes voluntary commitment to deny use of straws at restaurant and food joints.Container deposit scheme started in South Australia have been a successful environmental legislation to promote recycling and reducing litter.Textile industry can play a leading role by development of textiles that release fewer fibers,prevent breakage of fibers from garments or develop technologies to capture released fibres.Deposit refund scheme can be used for beverage to provide incentives. Single use plastics are generally provided to customers freely which promotes its excessive use.Hence bans and increasing cost of single use items by levy and taxes can deter people and force them to use these items wisely. Items designed and made from fiber like jute

and cotton can be promoted as they can be degraded easily.

Table. 5 Strategies for future

1	Creating after use plastic economy
2	Reducing leakage to natural systems
3	Decoupling plastics from fossil feedstock
4	Adopting circular economy approach in plastic management
5	Sourcing plastics from biomass based feedstock
6	Effective recycling,depolymerization to generate feedstock, developing technology to remove additives
7	Development of biobenign material,superpolymers which has excellent recyclability
8	Establishment of global plastics protocol

6. Research needs and way forward

There is need to investigate comprehensively sources and fate of micro and single use plastics. Apart from marine water, fresh water microplastics need to be monitored. Generating comprehensive data base on micro and single use plastics will help understand environmental impact.Aspects such as intake mechanism and fate of microplastics in biota should be studied under laboratory as well as natural conditions.There is a need to study interaction of microplastics with other contaminants present in environment. Risk assessment framework need to be developed, capacity to detect microplastics by microscopy and spectroscopy need to be improved.Important emerging area of research in field of microplastics are quantification and characterization through reliable and reproducible methods.Creation of standard toxicity tests,analysis of microplastics in water,seafood and soil.Study on sources,fate,transport,degradation,distribution and risk to environment.

7. Conclusions

It is estimated that plastic production is bound to increase four fold by 2050. Plastics are most abundant litter items found in oceans.Both land and sea based activities are responsible for input of plastics in to marine environment.Landfills, dumpsites situated near shores, harbor activities are few land based sources.Indescriminate or illegal dumping,accidental losss, storms are some of the sea based sources of plastic litter. Apart from toxicity and asthetic problems plastic debris also cause navigational problems to shipping industry. Microplastic pollution is bound to increase as an outcome of degradation and fragmentation of plastic waste. Large amount of single use plastics and micro plastics ending up mismanaged in environment because of careless and irresponsible behavior. To reduce this burden proper steps should be taken following circular economy approach.It should start with prevention and reduction of waste, strengthening waste management system and recycling along with safe and controlled disposal of plastics. Introduction of extended producer responsibility (EPR) and Deposit Return Scheme can not only prove effective in reducing plastic litter but also it can create job opportunities. Prevention is most practical solution to reduce microplastic pollution.Microplastics research should focus on scale,fate and impact of microplastics on terrestrial and aquatic ecosystem along with human health.Well developed technologies and methods need to be devised to study sampling,extraction and quantifying microplastics.A multipronged strategy in form of non regulatory measures such as status quo or agreements with industry, new legislations such as levy,taxes,refund schemes and intermediate models in form of product stewardship can help reduce menace of micro and single use plastics to large extent.Goverment should promote research and innovation to find alternatives to plastics, standardization and proper labeling for efficient recycling, involvement of stakeholders in decision making and raising awareness among consumers.

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