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Plastic Waste Management: A Review

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Abstract

Due to ever increasing production waste plastics is becoming a major stream in Municipal solid waste. It is a major constituent of Municipal solid waste apart from food and paper waste. Due to lack of effective plastic waste management most of plastic waste is neither collected nor disposed in appropriate manner. Hence it causes adverse effect on human health and environment. Plastic waste blocks drainage system causing floods in cities and upon degradation releases green house gases in landfills. Once produced fate of plastics is to become a litter item as plastics can be recycled only few times. Also recycling reduces its strength and utility. Energy recovery is suitable option if recycling is no longer viable.Coventional technologies like co-processing in cement kilns, utilization in road construction, disposal techniques like land filling and incineration is being coupled with emerging technologies like Plasma pyrolysis, conversion of plastic waste in to fuel, to effectively manage plastic waste.

Keywords: *waste, waste management, litter, recycling, disposal*

1. Introduction

The world has witnessed phenomenonal growth in plastic production in recent times.Plastics have high strength to weight ratio,can be shaped in to various forms, water resistant, light,durable and cheap. These properties have led to substitution of traditional substances like concrete, glass, metals, woods, natural fiber and paper (NEERI, 1996). Due to unscientific management and ineffective legislation Plastic waste has become a challenge for human well being. Burning of plastic waste releases toxic gases like Carbon Mono- Oxide, Chlorine, Hydrochloric acid and carcinogens like Dioxin, Furans, Amines, Nitrides, Styrene, Benzene, Acetaldehyde and toxic metal like Lead and Cadmium (Chanda and Roy,2000). Openly dumped and littered plastics present an unaesthetic look and pose several environmental problems. At present plastic waste is being managed through Incineration, Plasma pyrolysis technology, converting plastic waste in to fuel, utilization in road construction and as a alternate fuel and raw material in cement clins. Several new approaches are being fallowed such as changes in product design, shifting to biobased and biodegradable alternatives, better waste management systems which improves collection efficiency and recycling rates, clean up and remediation activities to collect plastics from environment (ICPE,2007).

2. Waste Management Hierarchy

Waste is a substance which is designated to have less or negligible economic value. Technically waste is material that may lack primary economic value but possess secondary intrinsic value. To ensure environmental sustainability waste prevention, reduction, minimization and treatment is huge challenge. The most common approach is waste prevention, substitution and waste minimization. In the waste management strategy waste prevention is considered as most viable option. Waste minimization can be achieved through proper designing minimum use of packaging material and toxic contents (Banerjee and Srivastava, 2009). Source reduction is followed by Reuse where product is utilized for new or existing purpose without undergoing physical change. While recycling involves processing. Depending upon type of plastics it may be or may not be recycled. Resource recovery, Incineration and land filling are least preferred options in hierarchy of management of plastic waste. In a waste management hierarchy all options can play significant role and integrated waste management strategy should focus on combination of techniques and approaches to handle various waste streams.

Table.1Components of Plastic waste management system

Legislations	Policy,Laws,rules,Act
Institutions	State and central government, Pollution Control Boards Pollution control committees, Municipal authorities
Financial mechanisms	Levies, Local taxes, state taxes, Grants and subsidies from central government
Technology and Infrastructure	Transport,treatment,recycling and disposal techniques like Incineration, Plasma pyrolysis, RDF,coincineraion, coprocessing
Stakeholders	Waste generators, consumers, producers, waste managers

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3. Generation

Plastics and polymer industry in India is growing at a rate of 10% (compound annual growth rate).The production has grown from 8.33 million metric tonnes in 2010 to13.4 million metric tonnes in 2015.It is being projected that if annual growth rate continues at 10.5% then by 2020 plastics and polymer production in country will reach 22 million metric tonnes.Plastic production is mainly comprising of polyolefins such as polyethylenes, polypropylenes and polystyrenes.Major Plastic producers in India are Bharat petroleoum,Reliance industries,Indian oil corporation,Gas authority of Indian Limited etc.The average per capita consumption of plastics in India is approximately 11kg which is very low as compared with developed countire like USA where average per capita consumption is around 109 kg.According to Central Pollution Control Board(C.P.C.B.) approximately 25940 tonnes of plastic waste is being produced per day.Pastic waste comprises around 8-10% of total municipal solid waste. Highest producer f plastic wastein India is Delhi, Kolkata fallowed by Ahmedabad.In India out of total plastic waste around 60% is recycled. Recycling is mainly done by informal sector.Indian consumes about 13 million tones of plastic products each year out of which 9 million tones of plastic waste is produced every year.

Table.1 Plastic consumption in various sectors

Sector	Percentage
Packaging	43%
Infrastructure	21%
Automobile	16%
Agriculture	2%
Others	18%

Table.2Fate of plastics since 1950-2015

Total production	8.3billion tonnes
Total plastic recycled	9 %
Total plastic incinerated	12%
Total plastic entering landfill or environment	79%

4. Collection Efficiency

Waste collection, storage and transportation is a major activity of Municipal authorities. Urban local bodies spend approximately 500-1000 rupees for collection and transport of 1 tonnes of municipal waste. Of about totoal plastic waste produced approximately 60% is recycled in India.Waste collection involves primary and secondary collection. Primary collection includes collection of waste from residential and commercial areas. After collection taking waste to storage depot or taking it directly to disposal site. Secondary collection involves collection of waste from community bins, waste storage depots and then transferring it to processing sites or to disposal facilities (Narayan 2001).

Table.3 Major Items present in Plastic waste

Category	Examples
Polyethylene terephthalate (PET)	Water bottles,textile fibre,peanut butter jars, pillow and sleeping bag fillings, food jar
Polyvinyl chloride (PVC)	plumbing pipes, seat covers, shoe soles,cables
High-density polyethylene (HDPE)	Milk, juice, cream and Shampoo bottles, packaging
Low-density polyethylene (LDPE)	Sheets,garbage,Trash, Shopping, grocery bags, packaging materials
Polypropylene (PP)	medicine bottles, Straws, car batteries, Bottle caps, disposable syringes, car bumpers, chips packets
Polystyrene (PS)	Pharmaceuticals, Disposal cups, cutlery, packaging foam
Polycarbonate (PC)	electronic items, mobile phone covers, hard disc covers, key boards, mouse and defense tools and equipments
Nylon	Fishing nets, clothing, ropes

5. Recycling of Plastic waste

Plastics are made up of different kind of polymers having different chemical properties. The plastics can be grouped in two broad categories namely Thermoplastics and Thermosetting Plastics. About 80% of total plastics are Thermoplastics and can be remolded on application of heath hence can be efficiently recycled. Examples of Thermoplastics are LDPE, HDPE, PET. On the other hand Thermosetting Plastics when applied heat loses flexibility and gets converted in to hard and rigid substance (Aguado et al.,2007).Plastic recycling is largely unorganized in India. Of about total plastic

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waste produced approximately 60% is recycled in India. The steps involved in recycling are sorting, washing, shredding, identification and extruding. Managing and recycling plastic waste is not only environmental friendly but also economically beneficial. Mechanical recycling involves melting of old plastic and using it to make new products. Mechanical recycling involves collection, sorting, washing, grinding, filtering and extruding. Chemical recycling also called as Feedstock recycling involves depolymerization and complete breakdown. It involves pryolysis, Hydrogenation and gasification.

Table.4 Types of Plastic Recycling (Matthews, 1993).

Category	Method
Material/ Mechanical recycling	Recycling to make raw materials and plastic products it includes Shredding,molding,sheeting
Chemical/ Feedstock recycling	Monomerization Gasification Liquefaction
Thermal/ Energy recovery	Cement clins power generation RDF(Refuse derived fuel) RPF(Refuse paper and plastic fuel

6. Disposal options

Landflling: Land filling is not considered as best suitable option for waste management. It is a carefully designed structure present below and above ground.Landfilling is a strategy to isolate waste from surrounding environment, to keep it dry and slow down its decomposition, prevent contamination of ground water and adverse effect on human health. The waste dumped in landfilled is compressed to reduce its volume and covered with soil. Since most of the plastics are non biodegradable, plastic waste remains in landfill without breaking down.Also landfills require a large amount of space.Upon leaching plastic may release Harmful toxins like Bisphenol-A and Phthalates.

Incineration: Incineration is an alternate method to landfilling.It is one of the waste to energy technologies.Upon incineration plastic waste is converted in to Carbon di oxide,water ash,flue gas, residues of Hydrochloricacid,sulphur and other volatile compounds are found.

Plasma Pyrolysis Technology (PPT): PPT involves combination of pyrolysis technique with thermochemical properties of plasma.Pyrolysis Leads to breakdown of plastic waste in to its monomers by thermal breakdown at 300-400 ^{0}C in presence of catalyst such as Aluminium oxide in absence of oxygen.Upon pyrolysis plastic waste produces diesel like substance. In plasma pyrolysis plastic waste is heated to 850^{0}C in a feeder chamber lacking oxygen and leads to dissociation of plastic waste in to Carbon monoxide, Hydrogen and Methane. After first stage in secondary chamber temperature of about 1050^{0}C is maintained, having excess air,burns hydrogen,CarbonMonoxides and hydrocarbons leading to production of water and Carbondioxide (USEPA,1990).

Gasification: It is thermo chemical process and involves partial oxidation of plastic waste.As a result of gasification a gaseous mixture containing Carbon monoxide and hydrogen is produced.This gaseous mixture is known as Syngas.Syngas can be utilized for lighting,cooking, heating.

Pelletization:Improves consistency, storage and handling of plastic waste. Calorific value and combustion characteristics improve due to pelletization.The process of pelletiztion involves segregation, crushing, solidification to produce briquettes.Pelletization alters physical properties of waste. Waste plastic pellets are being used in cement clins and coal fired power plants.

Co-Processing: Coprocessing techniques utilize plastic waste as alternate fuel and raw material (AFR) and as in industrial processes such as Cement kilns, power stations.By co processing of plastic waste, cement manufacturers and power plant operators can save fossil fuels and hence can achieve more ecologically efficient production.

RDF/Liquid Fuel: Plastic waste is converted to fuel by catalytic pyrolysis.In specially designed reactors, in absence of oxygen random depolymerization takes place leading to breakdown of plastic waste in to monomers.

Road construction: Plastic waste is shredded to a definite size of 2-4 mm.This shredded plastic waste is added to stone aggregate (granite and ceramic) and bitumen and heated to 160-170 ^{0}C.Bitumen blended roads with plastic are more durable with fewer potholes. At present there is 21000 miles of plastic bended roads in India. Approximately 1 tonne of plastic waste is utilized for constructing 1km of highway (width 3.75m).Utilization of plastic waste considerably saves plastic waste reaching environment and enhances petrochemical conservation (Ismail and Hashmi,2008).

7.Plastic waste management in Aizawl city

The Aizawl Municipal Corporation (AMC) is governed by the Mizoram Municipalities Act, 2007 which lays down the legal and administrative framework for day today functioning and governance, jurisdiction and lays down rules and procedure for functioning AMC. The corporation is headed by elected leadership from the wards within the geographic jurisdiction of the corporation boundaries.The solid waste management in Aizawl city is primarily the responsibility of Aizawl Municipal Corporation (AMC) (The Mizoram Municipalities Act, 2007). AMC looks at all aspects of waste management – collection, storage and disposal of waste. Sanitation wing of AMC headed by Sanitation officer takes up the responsibility of management with Engineering Department helps in the obtaining the vehicles, gadgets,tools,equipments and building necessary facilities like landfill site, etc. In the organisational structure of Aizawl Municipal Corporation, the Sanitation Officer is responsible for waste management and sanitation in the administrative areas of AMC. Under sanitation wing whole area has been divided into 19 wards with each ward having local councils. Local council headed by chairman. Each local council is responsible for management and handling of solid waste.

8. Constraints in Management of plastic waste

Local governments face enormous challenge in providing waste management services. Collection and transportation contributes to approximately three fourth of total expanse in solid waste management services. There are numerous health hazards associated with handling of contaminated plastic waste. Waste once disposed in landfills becomes prone to leaching and hence contaminate ground water and soil. Collection, segregation, Transportation, treatment and disposal is highly inadequate leading to poor state of health and environment. Key issues are limited door to door collection, lack of awareness and willingness to participate among public, unavailability of enough funds, non segregation of waste at source and lack of scientific processing, recycling and disposal technologies (Chaturvedi,2000).

9. Conclusions

Social and psychological aspect of plastic waste management is highly neglected hence identifying nature, magnitude, extent of underlying causes of plastic waste generation should be studied.LCA (Life Cycle Assessment) should be used to estimate environmental impact of plastics at each stage of processing, production and disposal. Sound and reliable data is lacking which is hindering effective policy formulation on plastic waste management. Generating energy from plastic waste, waste avoidance and recovery can be good option. Institutional and regulatory factors should be designed in such a way that facilitate resource recovery and does not impede recovery and recycling. Local governments should try to phase out single use plastic items in a progressive and time bound manner. Dedicated means of disposal and recovery through EPR (Extended Producer Responsibility) and PS (Product Stewardship) should be applied through appropriate policy instrument. Waste prevention and better management through Green design should be promoted as it facilitates retrieving of secondary raw materials. Green designing also helps to reduce toxicity of raw materials without compromising quality and utility of products. Plastic recycling provides an effective opportunity to dispose plastics in environmentally sound manner as recycling has huge potential for income generation and prevention of green house gas emission.Thre is a need to establish commercial level resource recovery and recycling plants.

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