JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# AN INTEGRATED APPROACH TO PLASTIC WASTE MANAGEMENT; WITH SPECIAL REFERENCE TO BENGALURU CITY

**ROHIN RUTVIK SARANA**
Project Centric Learning Student, Jain Deemed-to-be University, Bengaluru
**PRAJNA PAI**
Project Centric Learning Student, Jain Deemed-to-be University, Bengaluru
**DR PATCHA BHUJANGA RAO**
Professor of Commerce & Coordinator-Project Centric Learning, Jain Deemed-to-be University, Bengaluru

**ABSTRACT**

The natural qualities of plastics, such as their inertness, low bulk densities and little risk of contamination is the result that encourages for appropriate packing of materials. All around the country, but especially in urban areas, plastic bottles, sachets and packaging of food have become very common. The packaging revolt was not supported by an effective plastic waste management strategy, leaving many cities covered with plastic debris, leading to terrible visual issues and other issues with community health.

Most wealthy nations now have plastic recycling programmes in place as a result of rising environmental consciousness and declining landfill capacity. The study addresses the potential for programmes to manage plastic trash in Bengaluru where it is considered that unless long-term corrective actions are adopted for the management of plastic trash, the rate at which the ecosystem is deteriorating now is likely to continue.

**Keywords:** Plastics, packaging, recycling, plastic waste management.

## INTRODUCTION

Recycling plastic waste is one of the key goals of waste management since it enables the use of resources already present in waste, which helps to conserve primary resources and lessens the environmental effect of all processes that prepare primary resources for use in the creation of commodities and/or items. In order to enable recycling, items must be designed to be recyclable, collected end-of-use materials (often referred to as waste), processed to make intermediate secondary materials that can replace primary materials, and then actually used to create new products.

One of the main objectives of waste management is recycling plastic waste because it allows for the utilisation of resources already present in waste, aids in the conservation of primary resources, and reduces the environmental impact of all processes that prepare primary resources for use in the items. Items must be made to be recyclable in order for recycling to be possible. End-of-use materials must also be collected, processed to create intermediate secondary materials that can replace primary materials, and then used to make new products.

A thorough understanding of the situation is necessary to enable the optimization of a system that responds to the question posed in the title of this article because the processes involved and opportunities available differ greatly depending on the material to be recycled and the type of waste being examined, as well as the prevalent waste management structures available. One waste stream that calls for more investigation is plastic rubbish, as is the case with this special issue of Waste Management Research.

It is crucial that all practicable steps be taken to prevent plastic trash from entering the environment, ending up as litter, and causing all the unwanted negative consequences on the ecosystems without using the resource potential (Velis, 2014). According to Rujni-Sokele and Pilipovi (2017), bio-based plastics may help, but they may also make things worse because the term "bio-based" does not always equate to "bio-degradable." So, the first priority should be to stop the generation of plastic garbage. Additionally, the greatest amount of resource recovery should be done. But uncertainty looms into as to what extent should plastic garbage has to be recycled, and when should energy production take precedence over material recovery. In addition to technological considerations, economic, ecological, organisational, and social factors must be taken into account when addressing this issue. The product design and the developments in processing technology clearly have an effect on the technological viability. The processing equipment that can be used is significantly influenced by financial factors. As a result, there is a direct connection between technological viability and the financial border criteria. Although the basis of recycling systems often consists of technical solutions, it is important to remember that all technical processes involve passing.

More specifically, according to Feil et al., lesser output is produced by eliminating impurities and improve the final product's quality (2017). Output streams of greater quality usually leads in higher prices for these goods. Economically addressing, the extra processing costs must be more than offset by the greater end revenues. Other restrictions on technology also exist. For instance, the stabilisers used to create polyvinyl chloride, such as lead, cadmium, and other chemicals, cannot be eliminated (PVC).Stopping the use of harmful plastic additives, designing waste collection systems properly to keep impurities out of the recycling stream, and optimising technical recycling processes to at least partially remove contaminants are all necessary to improve the quality of current plastic waste and prevent adverse health effects from these types of contaminants (see Pieber et al., 2012).

## TYPES OF PLASTICS AND THEIR MAJOR APPLICATIONS

The following list includes the numerous plastic varieties and the main applications for each:

**THERMOPLASTICS:** These kinds of plastics soften when heated, may be moulded or shaped under pressure whilst in the plastic state, and solidify and hold the shape or mould when they are cooled. Here ARE SOME TYPICAL THERMOPLASTICS ALONG WITH THEIR APPLICATIONS AND CHARACTERISTICS.

**Polyethylene terephthalate (PET):** Common characteristics include being tough and clear, having good strength and stiffness, being resistant to chemicals and heat, and having good oxygen and carbon dioxide barrier capabilities. ii. Because it is fire resistant, it is utilised in packaging, soft drink and mineral water bottles, garment fibres, films, food containers, transportation, building, and appliance industries, among other things.

**High density polyethylene (HDPE):** Common characteristics include great chemical resistance, good processability, excellent crystalline, melting point (130-1350C), and excellent water vapour barrier qualities. ii. Used to make films (carrying bags), pipes, injection-moulded goods (storage bins, caps, buckets, mugs), and blow-moulded goods (a variety of containers, water bottles).

**Polyvinyl chloride (PVC):** It has the following qualities: 1. Versatility; 2. Energy conservation; 3. Adaptability to shifting conditions; 4. Durability; 5. Fire resistance. ii. It is utilised in sectors like construction, packaging, healthcare, agriculture, and transportation. Additionally utilised in the production of furniture, footwear, household appliances, films and sheets, bottles, and wires and cables.

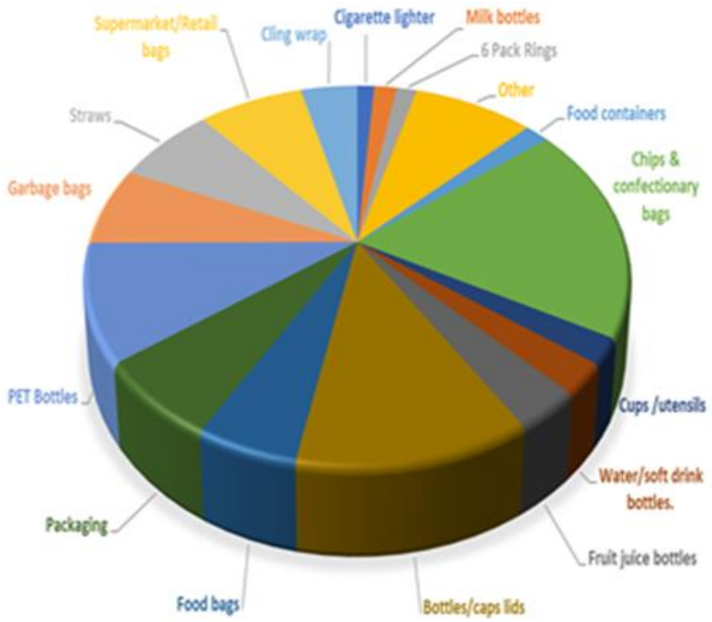
**Low density polyethylene (LDPE):** Low density, semi-crystalline nature, low melting range, low softening point, good chemical resistance, outstanding dielectric properties, low moisture barrier, poor abrasion and stretch resistance are some of the characteristics of LDPE. It is utilised in the production of carrying bags, sturdy bags, nursery bags, and tiny squeeze bottles. Additionally utilised for wire and cable insulation and milk packing.

**Polypropylene (PP):** Low density, great chemical resistance, environmental stress resistance, high melting point, strong process ability, dielectric characteristics, low cost, and creep resistance are some of the qualities. ii. Used to make furniture, home goods, luggage, toys, hair dryers, fans, and other items like bottles, medical containers, pipes, sheets, straws, and films.

**Polystyrene (PS):** Among polystyrene's characteristics are: i. Glassy surface, transparent to opaque, rigidity, hardness, high clarity, and sensitivity to fats and solvents. ii. Used to make circuit boards, plugs, sockets, switch plates, coil forms, housings, and other electrical and communication equipment. Used to create toys, wall tiles, baskets, cutlery, dishes, cups, tumblers, dairy containers, and other items.

**Others plastics:** In addition to these six, there are numerous additional types of plastics that are frequently utilised in the engineering industry. Examples include nylon, acrylonitrile butadiene styrene (ABS), and polycarbonate (PC).

**Thermosets:** Materials classified as thermosetting are those that, once hardened, cannot be remoulded or softened by heat. Unsaturated polyester, epoxy, polyurethanes, phenol, melamine, and urea formaldehyde are all included. These substances cannot be recycled. The management of plastic garbage must be organised so that the plastic waste produced by various sources is appropriately handled.




| | |
|---|---|
| Cigarette lighter | 1.20% |
| 6 pack rings | 1.40% |
| Milk bottles | 1.60% |
| Other | 8.50% |
| Food containers | 1.70% |
| Chips & confectionary bags | 18.60% |
| Cups /utensils | 2.20% |
| Water/soft drink bottles. | 2.60% |
| Fruit juice bottles | 3.40% |
| Bottles/caps lids | 11.90% |
| Food bags | 5.20% |
| Packaging | 6.70% |
| PET Bottles | 10.00% |
| Garbage bags | 6.70% |
| Straws | 7.00% |
| Supermarket/Retail bags | 7.40% |

The various sources of plastic waste are shown in Figure 1.

## PLASTIC WASTE IN BENGALURU

An estimated 20% of the 4000 tonnes of municipal solid trash produced in Bengaluru is plastic, according to estimates. Despite a general prohibition in place since 2016, the **Bruhat Bengaluru Mahanagara Palike** (BBMP) still has trouble controlling plastic pollution. The Karnataka State Plastic Association estimates that each month, each person in the city consumes about 16 kilogrammes of plastic. In addition to the 83 registered units in Bengaluru, there are 33 registered units outside of Bengaluru. Around 49056 tonnes per annum (TPA) of low-value plastic is supplied to cement plants. There are about 73584 TPA available for recycling. According to the regulations, marking and labelling are carried out. The director of municipal administration has conducted 8357 raids who broken the rules. And nearly a fine of Rs. 88,77,318 has been collected and roughly 2205 tonnes of prohibited plastic have been seized. Other than Bengaluru BMP, 283 local bodies have filed their annual reports to Karnataka State Pollution Control Board (KPCB).

## CONVENTIONAL TECHNOLOGY FOR THE MANAGEMENT OF PLASTIC WASTE

Recycling, landfilling, and incineration are the three main components of conventional technology for managing plastic trash.

### RECYCLING OF PLASTICS THROUGH ENVIRONMENTALLY SOUND METHODS:

Plastics recycling needs to be done in a way that reduces pollutants throughout the process, improving process efficiency and energy conservation. Primary, secondary, tertiary, and quaternary technologies for recycling plastic have been categorised.

**Primary** recycling is turning trash or waste into a product that has properties akin to the original.

Processing discarded plastics into items with properties different from those of original plastic products is known as **secondary** recycling.

In **tertiary** recycling, common chemicals and fuels are made from plastic debris that has been either sorted from or added to the municipal garbage stream.

By burning or incinerating the used plastics, **quaternary** recycling recovers their energy. India does not employ this method.

**STEPS INVOLVED IN THE RECYCLING PROCESS ARE:**

The following steps make up the recycling process are :

**Selection** of the wastes that can be recycled must be chosen by the recyclers.

**Segregation:** According to the standards outlined in the BiS requirements, the plastic trash must be separated (IS:14534:1998)

**Processing**; The pre-consumer trash must go straight into recycling after selection and segregation. It is required to wash, shred, aggregate, extrude, and granulate post-consumer trash (used plastic garbage).

**Landfilling:** Although landfill construction area is becoming scarce in some nations, landfilling is still a common method of waste disposal. There are long-term risks of groundwater and soil contamination by a few additives and plastic product breakdown, which can turn into constant organic pollutants. A well-managed landfill site results in limited immediate environmental harm beyond the effects of collection and transportation.

**Incineration:** The need to landfill plastic trash is reduced by this procedure, but there are concerns that dangerous compounds could be discharged into the atmosphere as a result of this process. Dioxins, furans, and polychlorinated biphenyls pose a harm to the environment when mixed plastic trash contains PVC and other halogenated additives, for instance. It's crucial to choose the right incinerator. Although it is unlikely to be carried out in a regulated manner to bring down the pollutants from off-gas, such as dioxins and furans, to desired levels. Thus, it is typically not preferred to use this way of managing plastic garbage. The expense of treating the gases is typically more than the energy gained.

Any incineration issue can be solved by modern incineration technology without harming the environment and, in many situations, by recovering the calorific value of the trash being burned. Trash incineration facilities have the ability to use highly contaminated plastic waste collected from various waste streams for energy recovery. This recovery system's cost is regarded as the highest of all the available options. It is important to keep in mind that burning plastic garbage could produce dangerous pollutants like dioxins and furans, which is highly undesired, when considering incineration as a solution.

## RECENT TECHNOLOGIES FOR THE MANAGEMENT OF PLASTIC WASTE

Here is a list of current technologies for managing plastic garbage;

**Polymer Blended Bitumen Road:** For the successful building of flexible roads in various locations throughout India, the method of road laying employing waste plastics has been developed.

**Co-processing of Plastic waste in Cement Kiln:** Municipal solid waste(MSW) which includes plastic waste is produced in many cities and towns. It is alarming that the dumping of plastic garbage is contributing to a variety of issues, including the contamination of drains, the infertility of the land, careless burning that endangers the environment, and the leaching of plastic into the soil and groundwater. Being non-biodegradable, plastic debris is left lying around in most cities and towns, giving them a distasteful appearance. On a per capita basis, the nation produces 15,342 tonnes per day(TPD)of plastic garbage per day .

To get rid of plastic waste disposal problems, Central Pollution Control Board (CPCB) in association with M. P. Pollution Control Board has taken initiative to use the plastic waste in cement plant at ACC Kymore (Katni, M. P.). The stack monitoring results, revealed that emission values are found below the standard set for Common Hazardous Waste Incinerators. After getting encouraging results, CPCB has granted permission to many cement plants to co-process the hazardous and non-hazardous (including plastic) waste in their kilns after trial burns.

**Co-processing of plastic waste as an Alternative Fuel and Raw Material (AFR):** Co-processing refers to the use of waste materials in industrial processes like making cement, lime for steel, or other huge combustion facilities. Co-processing demonstrates the substitution of primary fuel and raw materials with waste-recovery industry and waste-derived materials. Trash materials are referred to as alternative fuels and raw materials, such as plastic waste utilised in co-processing . The co-processing of plastic trash may have benefits for both the cement industry and the municipal authorities in charge of waste management. On the other side, cement companies can reduce their use of fossil fuels and raw materials, resulting in a more environmentally friendly manufacturing process. Another benefit of the recovery process utilised in the current facility is the elimination of the requirement to spend money on other plastic waste management strategies and to secure land filling.

**Co-processing of Plastic waste in Cement Kiln:** Utilizing used plastic in cement kilns as a substitute fuel is one of the most efficient ways to recycle plastic waste for energy recovery. There are initiatives that aim to transform plastic into new energy sources in addition to recycling plastic for the creation of new products and energy efficiency. Crude oil, which serves as the raw material for fuel production, is used to make plastic. Therefore, some scientists are working to refine waste plastic back into crude oil so that it may be used to power engines again. By using this technique, used plastic waste is not only put to good use but also contributes to the preservation of the planet's limited reserves of crude oil.The high temperatures used in cement kilns allow even some types of plastic trash that are polluted with harmful substances like pesticides and other hazardous elements to be used without increasing emissions into the air or water. Such disposal does not necessitate sorting or cleaning. Low-end plastic garbage, which poses a challenge to waste management, might be the cement industry's main source of energy. The whole amount of plastic waste produced in India today could be disposed of by cement kilns there at a 10% replacement rate, with the added benefit of using less coal, a fossil fuel, in the process.

**Plasma Pyrolysis Technology (PPT):** A technique known as plasma pyrolysis combines the pyrolysis process with the thermochemical features of plasma. Plasma pyrolysis technology can be used to get rid of all kinds of plastic trash because to its intense and flexible heat producing capacity.

**Process Technology:** The plastic trash is initially fed into the primary chamber of plasma pyrolysis by a feeder at 850 C. The waste material separates into higher hydrocarbons, carbon monoxide, hydrogen, and methane, among other gases. Gases from the pyrolysis and waste plastic are drained into the secondary chamber by an induced draught fan. The gases from pyrolysis are burned in this chamber while too much air is present. Due to a high voltage spark, the combustible gases catch fire. The secondary chamber's temperature is kept at 1050 C. The combustion of the hydrocarbon, hydrogen, and carbon produces harmless carbon dioxide and water. The risk of oxic gas production is eliminated by maintaining the conditions. Over 99% of organic waste is converted into harmless gases like CO2 and H2O. Bacillus stereothermophilus and Bacillus subtilis are among the stable bacteria that are killed by high plasma conditions. Right away. Segregation of the garbage is not required because extremely high temperatures ensure that all forms of waste are treated equally.

**Conversion of Plastics Waste into Liquid Fuel:** It is not difficult to use this technology. It may accept a wide variety of polymers as feedstock, including ones that are difficult to recycle, unclean, or unsorted. The material can be purchased in large pieces and then cut into smaller pieces before being used, but recent developments have made it possible to insert larger pieces of plastic straight into the system. With a forklift, garbage is loaded into a hopper to begin the process. The materials that can be loaded include agricultural film, medicinal packaging, product packaging, component holders, and plastic automobile bumpers. Once the hopper is inside the reactor, natural gas is burned to produce heat and launch the process.

The plastic hydrocarbons are now broken down into shorter chain molecules with the aid of a catalyst. The off-gases that won't be used as fuel are used to generate heat and maintain the process. Condensing from a gaseous to a liquid state, fuel oil and diesel are produced and collected throughout the process. They are put into makeshift fuel tanks. An automated system manages the process.

## PROBLEMS RELATING TO PLASTIC WASTE

### LAWS AND THEIR IMPLEMENTATION

Plastic Waste Management Rules (PWR), 2011, were introduced under the Environment Protection Act, 1986, to address the rising rates of plastic waste disposal and to ensure its scientific management. The regulations' replacement for the framework that entrusted responsibility for managing plastic trash to the urban local body (ULB) is "multi-layered plastic that is neither recyclable or not energy recoverable or with no other use. Second, Section 15-which deals with the cost of carry bag - has been left out. Before, it was mandatory for merchants who sold plastic bags to register with their individual urban local bodies and pay a charge every year. Thirdly, in order to create a centralised registration system, the new regulations require brand owners and producers who operate in more than two states to register with the Central Pollution Control Board (CPCB). A state-level monitoring committee was established because, despite the guidelines' attempts to lessen the plastic scourge, some concerns still exist. By establishing minimum thickness requirements and requiring shops to charge a price for each plastic bag distributed, the regulations further addressed the issue of carry bags.

The untreated manifestation of Extended Producer Responsibility (EPR) The Plastic Trash Management Rules 2016 replaced the rules from 2011 and were far more thorough in their attempt to solve the problem of plastic waste. Regulations in this version Government and business must work together to create models for efficient and long-lasting EPR adoption. The 2016 rules' unique concept of the EPR lacked specifics, though. Similar detail is required for the EPR for managing plastic trash as is for e-waste in the "Implementation Guidelines for E-waste." Real-time evaluations of manufacturers, plastic supply and demand, and state-by-state mapping are required in order to create EPR targets that are both practical and answerable. Pilot EPR solutions for low-hanging fruits like the fully recyclable PET must also be prioritised and investigated.

Municipalities may look at some of the Goa state's successful models, which include the following actions: expanded the scope of its use and coverage to include plastic importers and rural areas in the supply chain. Additionally, the required minimum thickness for plastic carry bags was raised from 40 to 50 microns. The justification for this had a double-edged effect, not only would the recyclability quotient rise, but an increase in the manufacturing cost would discourage stores from giving out bags for free. A collect back system had to be implemented, and the regulations required producers and brand owners to develop a strategy in conjunction with local organisations.

Municipalities could combat the problem of plastic trash with the help of this Extended Producers Responsibility (EPR) approach. In order to improve local governments' financial situation, the EPR also calls for the collection of a fee from manufacturers and importers of plastic carry bags and multi-layered packaging. As a result, local dairies have partnered with residents to pay them a set amount for returning clean, empty plastic milk bags to the booths where they are sold. Tie-up with Tetra Pak (company) for a buyback of plastic waste management systems. empty packs.

The Plastic Waste Management (Amendment) Rules 2018 are an updated version of the 2016 regulations. The latter has been modified in a number of significant ways, including three. In the rules, it is first noted that the phrase "non-recyclable multi-layered plastic" is used in Section 9(3). Further, India might look into other effective models already in place in other nations, where manufacturers assume responsibility for the end-of-life of the product by sponsoring plastic waste management initiatives.

## CONCLUSION

Managing plastic garbage has become increasingly relevant in today's world. Numerous programmes are being carried out in India to decrease the effects of plastic garbage. Recycling is one such technique for the management of waste from plastic products. It makes more and more sense from an environmental and financial standpoint, and current trends demonstrate that more and more plastic waste is being recovered and recycled. Future technological, economic, and societal challenges are anticipated to make the gathering of recyclable waste and the replacement of virgin resources difficult.

Recycling used plastic trash is an effective strategy to boost the polymer industry's environmental performance, especially when combined with initiatives to expand the specification and use of recycled grades as substitutes for virgin plastic. Reusing old plastic waste is a good way to improve the environmental performance of the polymer sector, especially when done in tandem with efforts to increase the specification and use of recycled grades as virgin plastic substitutes.

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