



Plastic waste management: Indian Perspective

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Abstract

Plastic waste has increased dramatically as a result of the widespread use of a variety of plastic products. As part of our lifestyle, we must raise knowledge of their applications and regular management. Plastics are being used more and more in our daily lives these days. For example, companies that produce food, beverages, cosmetics, pharmaceuticals, and other goods must package their final goods for safe and effective distribution to the public. Polymerisation or polycondensation is a biological process used to make plastics. If plastic garbage is not properly handled and managed after usage, it can have a number of negative effects on the environment. In the developing country like India massive use of plastic and dumping the waste plastic has become challenge for sustainable living. Numerous landfills have been produced by the careless disposal of rubbish on the fringes of towns and cities. This review aims to discuss challenges and possible solution for the increasing plastic waste.

Keywords: Thermoplastic, Thermoset, plastic waste, management strategies

Introduction

The increased used of plastic products in packaging during the recent years has posed a severe threat on the environment. Plastic waste may be termed to the plastic that is discarded after use. The volume of solid trash is continually rising due to population growth, developmental activities, lifestyle changes, and socio-economic factors. An extensive range of synthetic or semi-synthetic polymerisation products are collectively referred to as plastic. They consist of organic condensation or addition polymers and may also include other materials to enhance functionality or cost-effectiveness. According to India's population and per capita consumption, an estimated 15722 tonnes of plastic garbage are produced daily. Polymers made from natural materials that are typically referred to as "plastics" are few in number. In the presence of an appropriate catalyst, these polymers break down into monomers like styrene, vinyl, propylene and ethylene. Different types of plastics are then created by chemically polymerising these monomers¹. Plastic waste management is a critical issue in India, where the rapid increase in population and living standards has led to a significant rise in plastic production, consumption and waste generation. Despite the existence of regulations like the Plastic Waste (Management and Handling) Rules, 2011, the management of plastic waste remains unscientific and chaotic, posing severe environmental and health risks.

Categories of plastics

Plastic may be categorised in primarily into two types

A. Thermoplastic, or recyclable plastic: Thermoplastics are materials that repeatedly become softer when heated and harder when cooled. They are capable of being melted down to create new plastic products. Paraffin wax is comparable to thermoplastics. When heated to room temperature, they become flexible and mouldable; when cooled, they become thick and rigid once more, retaining their new shapes. Approximately 80 percent of the plastic used in Europe is thermoplastic. These include

- a. Polyethylene Tetrphthalate (PET)
- b. Polypropylene (PP)

- c. Poly Vinyl Acetate (PVA)
- d. Poly Vinyl Chloride (PVC)
- e. Polystyrene
- f. Low Density Polyethylene (LDPE)
- g. High Density Polyethylene (HDPE)

B. Non-Recyclable Plastics (Thermoset) : However, due to their complicated molecular designs, thermosets are not appropriate for frequent heat treatments. During the first stage of manufacture, thermosetting materials develop a structure that resembles a thinly woven network. In contrast to thermoplastics, these materials cannot be recycled into new goods. Electronics and automobiles both make extensive use of thermosets. Various compounds known as additives can alter the characteristics of plastics. These include

- a. Epoxy
- b. Bakelite
- c. Polyester
- d. Urea-Formaldehyde
- e. Melamine

History of plastic waste management in India

The first systematic attempt to control plastic waste in the Indian market was the Plastic Waste (Management and Handling) Rules, 2011 (PWMH Rules, 2011), which marked the beginning of the development of plastic waste management in India. The primary goal of these regulations was to enhance the management of municipal plastic trash by encouraging collaboration between local waste pickers and municipal authorities to ensure effective waste collection. Lack of proper guidelines restricted the implementation of this rule.

Considering the issues, the government introduced the Plastic Waste Management Rules, 2016 (PWM Rules, 2016), replacing the PWMH Rules, 2011. The updated regulations placed a stronger emphasis on recycling, segregation, and reducing the use of plastic in an effort to improve the regulatory framework.

In February 2022 the Guidelines on EPR for Plastic Packaging were added to Schedule II of the PWM Rules, 2016, while the Plastic Waste Management (Amendment) Rules, 2018 further improved the regulatory environment. These regulations reinforced the ban on some single-use plastic products and established a robust Extended Producer Responsibility mechanism, strengthening the compliance regime with effect from July 1, 2022.

Plastic Waste Management (Amendment) Rules seek to solve persistent problems that manufacturing and plastic packaging industries encounter giving practical solution .

Current Scenario of Plastic Waste in India

India generates approximately 15,722 tons of plastic waste daily, with 70% of plastic consumption converted into waste. This waste is often dumped haphazardly, leading to clogged drains, groundwater pollution, and air pollution from burning plastics. Recycling efforts are largely informal, relying on outdated technologies, and focus primarily on high-value plastics like PET bottles, while low-quality plastics are neglected.

There is a significant potential for recycling in the present waste composition, which is hardly utilised. Paper, plastic, metal, and glass make up the majority of waste materials, and typically 15% of them can be recovered from the waste stream for additional recycling. Of the waste material, only 30 to 50 percent must end up in landfills because the remaining 35 to 55 percent is organic trash that can be turned into compost³.

Challenges in Plastic Waste Management

- 1. Uncontrolled Dumping:** Landfills on city outskirts are poorly managed, contributing to environmental degradation. Empty food packets, bottles, and other trash are everywhere in public spaces due to the human tendency to leave trash behind. Instead of taking the trash home, the public would rather throw it out in the open. It might occasionally be the result of overcrowded dustbins or a lack of dustbins in public areas. The issue also arises when there are irregular pickup schedules.
- 2. Non-Biodegradable Nature:** Plastics remain in the environment for years, causing long-term damage. One of the hardest aspects of plastic's environmental impact is disposing of it. Its strength and resistance to decomposition are two of its most important characteristics, but they are also the cause of one of its biggest issues with regard to plastics disposal. Because the majority of plastics are not biodegradable and are derived from fossil fuels, their disposal presents challenges.
- 3. Failure to pick up from open areas:** In the absence of routine garbage collection, most individuals dispose their trash in open spaces, creating a hot zone that draws more waste and causes it to accumulate. The pickup from these hot spots is inconsistent, which not only causes eye pain but also poses a health risk.
- 4. Informal Recycling Sector:** Lack of advanced recycling technologies and segregation practices limits the efficiency of recycling. Recycling becomes problematic since the majority of the collected plastic garbage is combined with organic waste. The material's cost of segregation is extremely high. It is challenging to separate different types of plastic in India because the majority of segregation is done by hand, mostly by the unorganised sector, which causes issues when recycled.
- 5. Hazardous Effects:** Plastics release toxic substances like styrene and vinyl chloride, affecting human health and the environment. The environment in India is severely degraded by plastic waste. It blocks rivers, causing monsoon-season floods in cities. The durability of plastic is severely hampered by the inability of natural creatures to break down the synthetic chemical bonds in the material. Plastic that has been buried in a landfill remains unaltered for many years. Plastics release harmful chemicals into groundwater, which then trickles down into lakes and rivers. Additionally, plastic leakage pollutes the soil and efficiently deposits microplastics there. Because plastic waste does not break down rapidly, it often floats in the ocean for years, lowering the oxygen content of the water and affecting marine life. The microplastic that enters the ocean is consumed by a variety of marine animals, leading to the death of larger fish, birds, and mammals. The plastic is then ingested by even tinier creatures, and ultimately even humans. One common way to dispose of plastic waste is to burn it, which releases dangerous dioxins and furans into the air.
- 6. E-commerce and increased Packaging Waste:** Packaging waste has increased as a result of India's e-commerce industry's explosive expansion, which has been fuelled by the Covid-19 pandemic. As per the India Brand Equity Foundation, the country's e-commerce business is anticipated to grow from USD 38.5 billion in 2017 to USD 200 billion by 2026. This expansion is correlated with a rise in the use of plastic packaging materials, such as polybags, bubble wrap, and air pillows. Since many of these items are hard to recycle, they frequently wind up as litter or in landfills.

Management strategies for plastic wastes

In order to help the public dispose of plastic waste after use, local authorities, social groups, and government municipalities have put in place various policies and environmental safety laws. Landfills, recycling, incineration, and bioremediation are a few of these waste management techniques that have scientific foundations. The purpose of these techniques is to maintain a clean environment and proper disposal of plastic waste.

The Conventional and new technologies that may be used for the management of plastic are

Conventional Techniques: 1. Recycling 2. Incineration 3. Land filling

Innovative Disposal Techniques : 1. Polymer Blended Bitumen Road 2. Plasma Pyrolysis Technology (PPT) 3. Conversion of Plastics Waste into Liquid Fuel 4. Co-processing of Plastic waste in Cement Kiln

Conventional methods:

1. Recycling

There are four broad categories of plastic recycling technologies:

Primary recycling involves turning garbage or junk into a product that has characteristics similar to the original.

Secondary recycling is the process of turning discarded plastics into goods with different properties from the original plastic items.

In tertiary recycling, plastic debris is either separated into separate waste or included in the municipal waste stream to manufacture basic chemicals and fuels.

Quaternary recycling uses incineration or burning to recover the energy content of the scrap plastics. India does not employ this procedure.

Following steps are involved in recycling :

Selection -The waste materials that are appropriate for recycling must be chosen by the recyclers.

Segregation- The codes specified in the BiS recommendations (IS:14534:1998) must be followed for sorting plastic garbage.

Processing- The pre-consumer trash must be recycled straight after selection and segregation. Used plastic waste, also known as post-consumer waste, needs to be cleaned, shredded, agglomerated, extruded, and granulated.

2. Incineration

Although this procedure reduces the amount of plastic garbage that needs to be dumped in landfills, there are concerns that potentially dangerous substances could be discharged into the atmosphere. For instance, mixed plastic garbage typically contains PVC and halogenated additives, which increases the risk of dioxins, furans, and other polychlorinated biphenyls being released into the environment. The selection of incinerators is crucial. However, it is unlikely to be carried out in a precise way to bring the pollutants from off-gas, such as dioxins and furans, down to desired levels. Therefore this method is not preferable one.

3. Land filling

Although this is a conventional method of waste disposal, several nations are running out of territory for landfill construction. A properly managed landfill site causes less immediate environmental damage than the effects of collection and transportation, but there are long-term risks of soil and groundwater contamination from a few additives and degradation from plastics products, which can become persistent organic pollutants. One major disadvantage of landfills from a sustainability perspective is that none of the raw materials needed to make plastic are recovered; instead, the flow of materials is linear rather than cyclical.

Innovative Disposal Techniques

1. Plasma Pyrolysis Technology (PPT)

A technique called plasma pyrolysis combines the pyrolysis process with the thermo-chemical characteristics of plasma. All kinds of plastic trash can be disposed of using plasma pyrolysis technology because of its extreme and adaptable heat generating capabilities. Plastic waste is first fed by a feeder into the main chamber of plasma pyrolysis, which is heated to 850⁰C. The waste material separates into higher hydrocarbons, hydrogen, methane, and carbon monoxide, among other substances. The secondary chamber receives the pyrolysis gases and plastic trash that are drained by an induced draft fan. The pyrolysis gases burn in this chamber when there is too much

air present. The high voltage spark causes the combustible gases to catch fire. The secondary chamber's temperature is kept at 1050⁰ degrees Celsius. Safe carbon dioxide and water are produced by the combustion of the hydrocarbon, hydrogen, and CO. There is no chance of harmful gases forming because of the conditions that are kept in place. It converts almost 99 percent of organic waste into non-toxic gases (CO₂, H₂O). *Bacillus stereo thermophilus* and *Bacillus subtilis* are among the stable bacteria that are immediately killed by the high plasma conditions. Since extremely high temperatures ensure that all waste kinds are treated equally, waste segregation is not required.

2.Polymer Blended Bitumen Road

This approach is being successfully used to develop flexible roads by laying roads utilising discarded plastics in different locations in India.

3.Co-processing of Plastic waste in Cement Kiln

Using plastic trash as an alternative fuel in cement kilns is one of the best ways to recycle it for energy recovery. In addition to recycling plastic to create new goods and save energy, several programs try to convert plastic into new energy sources. Crude oil is used to make plastic and is also the raw substance used to make fuel. Therefore research is on to convert waste plastic back into crude oil so that engines can run on it again. Using this technique not only helps to reuse discarded plastic, but it also preserves the planet's limited supply of crude oil. Using this technique not only helps to reuse discarded plastic, but it also preserves the planet's limited supply of crude oil. Even plastic garbage tainted with harmful chemicals like pesticides and other hazardous materials can be used in cement kilns due to their high temperature, which prevents higher emissions into the air or water. Cleaning or segregation are not necessary for this kind of disposal. Waste from low-end plastics, which poses a waste management challenge, could supply the cement industry with essential energy.

4.Liquid Fuel

The process of turning plastic waste into liquid fuel is not particularly complex. A wide variety of polymers, including unclean ones, can be used as feedstock. Although the material can be broken up into smaller pieces before being used, recent developments have made it possible to insert larger plastic pieces straight into the system. Waste is loaded into a hopper using a forklift to begin the process.

Plastic automobile bumpers, gasoline tanks, product packaging, component holders, agricultural film, and pharmaceutical packaging are among the materials that can be loaded. Once in the reactor, the hopper is burned to provide heat and initiate the process. The plastic hydrocarbons are now broken down into shorter chains of molecules with the aid of a catalyst. The process is maintained and heat is produced using the off-gases that will not be collected as fuel. As the process proceeds, the fuel oil and diesel are collected after condensing from a gaseous form into a liquid condition. Temporary gasoline tanks are used to hold them. An automated system controls the procedure.

Zero Waste Concept

The goal of zero waste is to recover all resources from the waste stream and avoid and eliminate waste through the systematic design and management of products and processes. Attempting to reduce waste has spread over the world, inspiring design modifications that enable product disassembly and recycling. Zero waste simply means that a product produces no undesired or needless trash at any point during its life cycle. method is becoming more and more well-liked as a best practice. In addition to encouraging product recycling, its goal is to reorganise the design, manufacture, and distribution of goods in order to stop waste from ever starting.

Materials in a zerowaste city circulate in a cyclic manner, meaning they are used repeatedly until they reach their optimal level of use. Circular cities ensure that no materials are underutilised or wasted. As a result, products are recycled, repurposed, sold, or redistributed within the system when their useful lives are over. When repair or

reuse are not feasible, they are recovered or recycled from the waste stream and used as inputs, which eliminates the need to extract natural resources.

Conclusion

A multifaceted strategy combining the government, citizens, and non-governmental organisations is needed to handle plastic garbage in India. Advanced recycling technology, creative disposal techniques, and source segregation can all greatly lessen the negative environmental effects of plastic trash. In order to promote sustainable practices and environmental consciousness, public awareness campaigns and education are crucial. A cleaner and healthier future can be achieved by India by implementing a zero waste strategy.

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