

**MODERN INNOVATIVE TECHNIQUES IN RECYCLING AND  
REUSE OF WASTE PLASTIC**

<sup>1</sup>Saurabh N. Kolhe, <sup>2</sup>Dipesh H. Kaware, <sup>3</sup>Dr. Anurag V. Tiwari

<sup>1,2</sup> Research Scholar, Department of Civil Engineering, Sipna College of Engineering and Technology, Amravati, Maharashtra, India<sup>1,2</sup>, Assistant Professor, Department of Civil Engineering, Sipna College of Engineering and Technology, Amravati, Maharashtra, India<sup>3</sup>

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**ABSTRACT**

Disposal of plastic waste in an environment is considered to be a big problem due to its very low biodegradability and presence in large quantities. Plastic recycling was taking place on a significant scale in India. In Indian cities and villages people use the plastic in buying vegetables as a carry bag, drinking water bottle use of plastic furniture in home, plastic objects use in kitchen, plastic drums in packing and storage of the different chemicals for Industrial use and many more uses. After usage of plastic as it will become part of waste garbage and concrete pollution due to presence of toxic chemicals and it will spread diseases and give birth to uncontrolled issues in society. In current scenario consumption of plastic waste increasing day by day and it is very difficult to manage the plastic waste. There are limited methodologies available for re-utilization of plastic waste again. Such examples are recycling, gasification, hydrogenation. In this paper we will review the innovative technique in recycling of plastic waste in current scenario.

**Keywords:** *Plastic waste, reuse, chemical recycling, mechanical recycling, recycling of plastic products.*

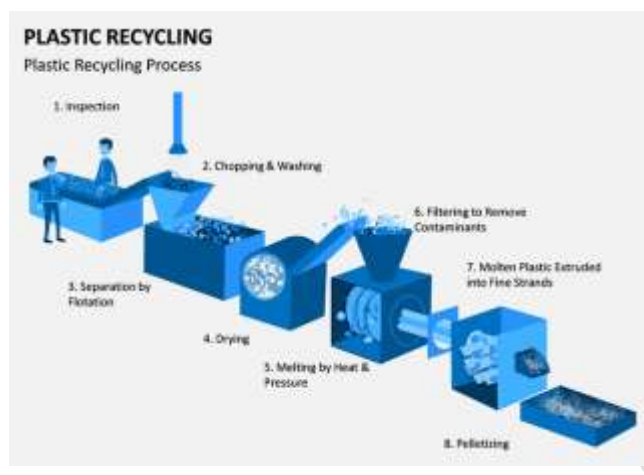
**1. INTRODUCTION**

Plastic is a synthetic polymeric material with a high molecular weight, made from a wide range of organic compounds such as ethylene, vinyl chloride, vinyl acetate, vinyl alcohol and so on. Plastics can be molded into different shapes in its soft form and then it sets into a rigid or slightly elastic form. The basic precursors for the production of plastic materials are obtained from natural gas, coal and petroleum. Owing to the unique properties of plastics such as: light weight, low cost, durability, robust, strength, corrosion resistance, thermal and electrical insulation, versatile fabrication and design capabilities which can easily be molded into assorted products.

As a result of their extensive applications, the production of plastics has been expanded, particularly over the past 60 years. Plastics have significant advantages over other materials (i.e. wood, ceramics, metals, etc.) such as their lower cost, durability and low weight, therefore their extensive applications and disposal leads to numerous environmental issues. Approximately 4% of the world's oil and gas produced is utilized as feedstock for plastics and about 3–4% is used in their manufacturing to provide energy. Plastics contains various types of toxic components as additive, such as di-(2-ethylhexyl)phthalate (DEHP), bisphenol A (BPA), poly halogenated compounds and heavy metals which pose a potential health risk to the humans. The plastics are not readily degraded and are very stable in the ambient environment, their disposal in the environment has currently created a considerable pollution problem.

In these aspects, the management encompasses planning, design and operation of facilities for collecting, transporting, processing, recovering and finally disposing of waste. Waste management and disposal is the most neglected sector in India, and about 90% waste is currently disposal of by open dumping. There are lacks of efficient waste collection segregation and treatment facilities in most part of India, even in the most developed cities.

## **2. RECYCLING PROCESS OF PLASTIC WASTE**



**Fig -1: RECYCLING PROCESS OF PLASTIC WASTE**

### **2.1 Collection**

The first step in the recycling process is always collecting the plastic material that is to be recycled. This step is completely reliant upon businesses, restaurants, and the public to dispose of their plastic waste in the correct place. If plastic waste is disposed of in normal trash bins, it will not be recycled, so it is extremely important to separate common waste and plastic waste.

Additionally, it is ideal for governments to have a recycling collection system that goes to people's houses or businesses to collect the plastic waste. If this is not possible, local collection points for plastic should be easy for the public to access. Making it easy and convenient for people to correctly dispose of plastic waste is paramount in promoting recycling.

### **2.2 Sorting**

After plastics are collected and transported to a recycling facility, the next step is sorting. Machines sort plastics into different areas based upon a multitude of properties that are often dependent upon the recycling facility or what final product is being produced.

Plastics are usually sorted in a few common ways, such as the type of plastic (material it is made with), color of the plastic, or even how it was made. This is important because different types of plastics must be processed in different ways and some recycling facilities are only capable of recycling one type of plastic. If the wrong type of plastic is processed at the incorrect facility it can reduce the efficiency of the whole process and require the entire batch to be sent back again for resorting.

### **2.3 Washing**

Just like with clothes, fruits/vegetables, and many other things, plastics must be washed before they are further processed. The goal of this step is to remove impurities and everything that is not made from plastic.

Most containers and packages have labels, adhesive, or even food residue that must be removed. This non-plastic waste can not be recycled and can cause the final product to have poor structural integrity.

### **2.4 Resizing**

Resizing consists of shredding or granulating the plastic waste into small particles. This increases the surface area of the plastic, making it easier to process, reshape, and transport if needed. Additionally, it gives recycling facilities one last opportunity to remove any non-plastic waste that has made it through the first 3 steps of processing

### 2.5 Identification and separation of plastics

The identification and separation of plastics is when the now small plastic particles are tested to determine their quality and class. The first quality tested is density. This is done by floating the particles in a large tank of water. Particles less dense than water will float and more dense particles will sink. Next their air classification is determined. Air classification is an official term for how thick or thin a particle is. This is done by dropping the particles into a small wind tunnel. The smaller pieces will fly higher up the tunnel and bigger ones will remain lower. Two other features plastics are commonly tested for are their melting point and color. These are determined by collecting and analyzing samples from each batch of plastic particles.

### 2.6 Compounding

The final step in the recycling process is often considered the most exciting because it is when the plastic particles are made into recycled materials usable for future production. Compounding is when the small particles are smashed and melted together into plastic pellets. The pellets can then be used in the production of other plastic products.

## 3. DIFFERENT METHODS OF PLASTIC WASTE MANAGEMENT

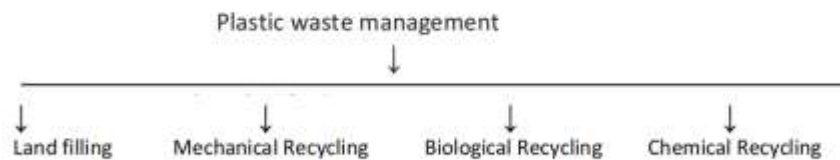


Fig -2: Recycling process of plastic waste

### 3.1 Mechanical Recycling

In this process, only the thermoplastic polymers can be used, because they can be re-melted and reprocessed into end products. The mechanical recycling does not involve the alteration of the polymer during the process. This process is represented by a physical method, in which the plastic wastes will be formed by cutting, shredding or washing into granulates, flakes or pellets of appropriate quality for manufacturing, and then melted to make the new product by extrusion. After the plastic is sorted, cleaned, dried and then directly processed into end products, the quantity of the waste plastic will be dramatically reduced.



Fig -3: Mechanical recycling process of plastic waste

The disadvantages of this method refer to the heterogeneity of the solid waste and the deterioration of product's properties in each cycle which occurs due to the low molecular weight of the recycled resin. It happens because of chain-scission reactions caused by the presence of water and traces acidic impurities and to avoid lowering

molecular weight intensive drying is recommended, the use of chain extender compounds or reprocessing with vacuum degassing.

### **3.2 Chemical Recycling**

This process can be used with mechanical recycling as a complementation. Chemical recycling is defined as the process in which polymers are chemically converted to monomers or partially depolymerized to oligomers through a chemical reaction (a change occurs to the chemical structure of the polymer). The resulted monomers can be used for new polymerization's to reproduce the original or a related polymeric product. This method is able to transform the plastic material into smaller molecules, suitable for use as feedstock material starting with monomers, oligomers, or mixtures of other hydrocarbon compound.

The chemical reactions used for decomposition of polymers into monomers are:

- Hydrogenation
- Glycolysis
- Gasification
- Hydrolysis
- Pyrolysis
- Methanolysis
- Chemical depolymerization
- Thermal cracking

The chemical recycling is not fully developed and for this reason, only a few companies are working on it because this method needs a lot of investment and expert personnel. At this moment, numerous methods are under investigation; for example, the gasification and pyrolysis method is under extensive research to establish the suitable conditions, and the processes that have reached commercial maturity at this moment are glycolysis and methanolysis. For example, PET (polyethylene terephthalate) can be cleaved by some reagents, like water (hydrolysis), acids (acidolysis), glycols (glycolysis) or alcohols (alcoholysis). According to the reagent used, different products are obtained.

## **4. INNOVATIONS TO UP-CYCLE PLASTIC WASTE**

### **4.1 Plastic Roads**

Plastic roads are made entirely of plastic or of composites of plastic with other material. Plastic roads are different from standard roads in the respect that standard roads are made from asphalt concrete, which consists of mineral aggregates and asphalt. Most plastic roads sequester plastic waste within the asphalt as an aggregate. Since plastic roads are a relatively new idea, construction processes vary. In Jamshedpur, India, roads are created from a mix of plastic and bitumen. In Indonesia roads are also being built using a plastic-asphalt mix in many areas including Bali, Surabaya, Bekasi, Makassar, Solo, and Tangerang. These roads are made from recycled plastics, and the first step in constructing them is to collect and manage the plastic material. The plastics involved in building these roads consists mainly of common post-consumer products such as product packaging. Some of the most common plastics used in packaging are polyethylene terephthalate (PET or PETE), Polypropylene (PP), and high- and low-density polyethylene (HDPE and LDPE). These materials are first sorted from plastic waste. After sorting, the material is cleaned, dried, and shredded. The shredded plastic is mixed and melted at around 170<sup>0</sup>C. Hot bitumen is then added and mixed with the melted plastic. After mixing the mixture is laid as one would with regular asphalt concrete.

In India, 703 km length of National Highways have been constructed using waste plastic. Ministry of road Transport and Highways has issued guidelines for mandatory use of waste plastic in periodic Renewal with hot mixes and in wearing coat of service road on national Highways within 50km periphery of urban area having population of more than 5 lakhs. Use of plastic waste in construction of road protects the environment from adverse impact of waste plastic.

#### **4.2 Eco-Bricks**

An ecobrick is a plastic bottle packed with used plastic to a set density. They serve as reusable building blocks. Ecobricks can be used to produce various items, including furniture, garden walls and other structures. Ecobricks are produced primarily as a means of managing consumed plastic by sequestering it and containing it safely, by terminally reducing the net surface area of the packed plastic to effectively secure the plastic from degrading into toxins and microplastics. To enable the production of ecobricks at minimal environmental cost, the Global Ecobrick Alliance promotes low-technology methods that do not require capital, fuel, electricity, or specialized equipment. Typically, producers use a wood or bamboo stick to manually pack plastic into the plastic bottle. Any size of transparent polyethylene terephthalate (PET) plastic bottle can be used to make an ecobrick. The bottle and the packed plastic are clean and dry to prevent the growth of bacteria. Plastic is cut or ripped into small pieces then packed little by little, alternating between adding the plastic and compacting it, layer by layer. The bottle is rotated with each press to ensure the plastic is evenly compacted throughout the bottle. This helps prevent voids and that the packing reaches the requisite solidity needed for building block applications. Completed ecobricks are packed solid enough that they can bear the weight of a person without deforming—a density range between 0.33 g/ml and 0.7 g/ml. Maximizing density minimizes the flammability of the ecobrick while increasing its durability and re-usability.

#### **4.3 Refugee Shelters from plastic**

The number of refugees and homeless persons in the world have been increasing. This raises the need for coming up with affordable housing solutions. Researchers from University of Bath have been working with plastic engineering company Protomax to design and test reusable shelters. The material used for the shelters is called Storm Board and is made up of recycled waste plastic. Such low-cost and easy-to-construct housing will be more and more in demand in the coming days and can indeed be part of a solution to the big plastic waste pandemic.

#### **4.4 Plastic made from wood**

Plastic Timber is a plastic form of timber (lumber) made of virgin or recycled plastic. It is made of 100% plastic, compared with wood-plastic composite timber. Widely employed in outdoor decking, it is also used for molding and trim and garden furniture such as park benches. Manufacturers claim plastic lumber is more environmentally-friendly and requires less maintenance than wood/plastic composites or rot-resistant wood. Unlike wood-plastic composite timber, plastic timber is 100% recyclable after its original intended use. Plastic lumber is composed of virgin or waste plastics including HDPE, PVC, PS and PLA. The powder or pellets are mixed to a dough-like consistency at roughly 400 °F (204 °C) and then extruded or molded to the desired shape. Plastic timber works like wood - it can be shaped, drilled, and cut using conventional woodworking tools. At the same time, it is waterproof and resists all types of rot and mold, although it is not as rigid as wood and may slightly deform in extremely hot weather. Plastic lumber is not sensitive to staining from a variety of agents. A major selling point of this material is it doesn't need to be painted and is overall low-maintenance. It is manufactured in a variety of colors, and is widely available in grays and earth tones.

## **CONCLUSIONS**

The various recycling technologies of plastic waste presented in this paper. Recycling, Reusing and decreasing single life polymeric materials will certainly benefit the current situation. Though plastics is very useful in modern civilization and provides us with various useful articles, it serves as a serious threat to our environment. So, we should try our level best to reduce, reuse and recycle plastic whenever possible to reduce the level of environment pollution caused by plastics. In mechanical recycling only thermoplastic polymers can be used. Chemical recycling complements mechanical recycling and can be a more sustainable solution than incineration or landfill of plastic waste. It arrives at the conclusion that chemically recycled plastics cause significantly lowers CO<sub>2</sub> emission than those produced from primary fossil resources. Plastic waste management has assumed great signification in view of the urbanization activities. Plastic will also increase the melting point of the bitumen. The use of this plastic in road construction is an innovative technology which not only strengthens the road but also increases the road life. Ecobricks certainly offer a readymade solution to the immediate problems posed by plastic. They are a hugely powerful tool for cleaning up local areas, educating schools and communities, and creating structures that will stand the test of time. Waste management is an important issue that needs government action quickly.

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