

Advances in Commercial Biodegradable Products in India: Alternatives to Plastics

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Abstract: *The ancient tradition of preservation of nature in India got disrupted by the mass production of goods that flooded the Indian market after the industrial revolution. Plastic is an example of a pollutant that is visible in developing nations such as India, where garbage collection systems are often inefficient or non-existent. Countries with low recycling rates, also have trouble properly collecting discarded plastics. Indian economy relies on shipping goods in packaging using plastics that are used only once, before being discarded contributing to a significant amount of waste. This article addresses the current efforts by select companies that are addressing the alternatives to plastics.*

Keywords: plastics, biodegradable, renewable, eco - friendly, sustainable

1. Introduction

Traditionally, Indian society is deep - rooted in preserving nature. A verse from Rig - Veda says, “Thousands and hundreds of years if you want to enjoy the fruits and happiness of life, then take up systematic planting of trees” [1]. Indian society firmly lives by the motto of reuse, recycle and refuse, the three principles of sustainability. Indians rarely throw away things. A plastic container is reused for storing essentials or groceries. Heavy - duty plastic bags are reused several times. A scrap vendor ‘raddiwala’ buys old newspapers which are made into envelopes or bags. These bags are often used to keep groceries by storekeepers to hand out purchased goods. In this manner, plastic, iron, brass, and even old electronics are recycled.

Banana leaves have been used for many centuries as a serving plate. These leaves are rich in antioxidants called polyphenols and can prevent several lifestyle diseases. Banana leaves have waterproof quality. The leaves have a waxy exterior and hence they are easy to clean as dust does not stick to them. It is for this reason that even now, restaurants use banana leaves for serving food in southern India.

Kulhad is a baked soil clay cup that has been used for generations in India. These cups are natural, and the surface is not glazed. Kulhads are biodegradable and hence the reason why they are thrown away straight after you use them. They are designed to rapidly dissolve into the ground leaving absolutely no waste behind.

World War II necessitated a great expansion of the plastics industry in the United States, as ‘industrial might’ proved as important as military success. The need to preserve scarce natural resources made the production of synthetic alternatives a priority. Plastics provided those substitutes. Nylon, invented by Wallace Carothers in 1935 as a synthetic silk, was used during the war for parachutes, ropes, body armour, helmet liners, and more. Plexiglas provided an

alternative to glass for aircraft windows. A Time magazine article noted that because of the war, “plastics have been turned to new uses and the adaptability of plastics demonstrated all over again” [2]. During World War II plastic production in the United States increased by 300%.

After the discovery of plastics in the early 20th century, they pervaded all aspects of society. From plastic - filled pillows, toothbrushes, keyboards, and containers to store food, it is impossible to go through a day without encountering plastic of some kind. We are becoming increasingly aware; our widespread adoption of plastics has not been without consequences for our health and the environment. Plastic pollutes our landscapes, oceans, air, and bodies.

What are plastics?

Plastic is a synthetic or naturally occurring polymer that can be easily moulded and shaped under heat and pressure. This property is known as plasticity, hence the name of this material. Moreover, plastic is chemically stable, lightweight, water and shock - resistant, has low thermal conductivity, and has good insulation properties. This adaptability, plus a wide range of other properties, such as being durable, flexible, and inexpensive to produce, has led to its widespread use.

Polymers are big molecules formed by chemically connecting a series of simpler units called monomers, thus creating a chain - like structure. The process of combining these monomers (e. g., ethylene gas) by heat and pressure is called polymerization. Depending on the purpose, polymers can have numerous properties, such as reflectivity, impact resistance, brittleness, translucence, ductility, and elasticity [3].

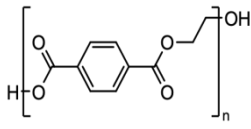
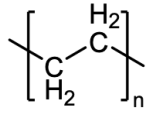
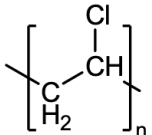
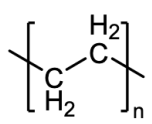
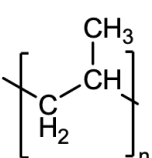
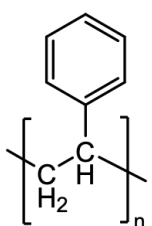
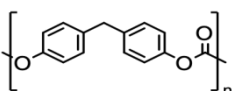
Most modern plastics are derived from fossil fuel - based chemicals like natural gas or petroleum [4]; however, recent industrial methods use variants made from renewable materials, such as corn or cotton derivatives [5 - 6].

The success and dominance of plastics starting in the early 20th century have caused widespread environmental problems, due to their slow decomposition rate in natural ecosystems. Most plastic produced has not been reused, either being captured in landfills or persisting in the environment as plastic pollution. Plastic pollution can be found in all the world's major water bodies, for example, creating garbage patches in all of the world's oceans and contaminating terrestrial ecosystems [6].

Classification of plastics

Plastics are usually classified by the chemical structure of the polymer's backbone and side chains. Important groups classified in this way include acrylics, polyesters, silicones, polyurethanes, and halogenated plastics. They can also be classified by their physical properties, including hardness, density, tensile strength, thermal resistance, and temperature. Plastics can additionally be classified by their resistance and reactions to various substances and processes, such as exposure to organic solvents, oxidation, and ionizing radiation [7].

Table 1: Types of plastics

Group No.	Types of plastic	Structure	Applications
1	Poly terephthalate (PET)		PET is mostly used for food and drink packaging purposes due to its strong ability to prevent oxygen from getting in and spoiling the product inside.
2	High density polyethylene (HDPE)		HDPE is made with long unbranched polymer chains and is much stronger and thicker than PET. It is used for making milk jugs, recycling bins, agricultural pipes, playground equipment etc.
3	Poly vinyl chloride (PVC)		In its rigid form, PVC is largely used in the building and construction industry to produce plumbing pipes (drinking and wastewater). It can also be mixed with other substances to make it softer and more flexible and used in wiring and electrical cable insulation.
4	Low density polyethylene (LDPE)		The polymer is thin and has a more flexible design and is characterized by low - density molecules, giving this resin a thinner and more flexible design. It has the simplest structure of all plastics, making it easy and cheap to produce. Used in plastic bags, six - pack rings, various containers, dispensing bottles, and most famously for plastic wraps.
5	Polypropylene (PP)		PP is hard and sturdy, it can withstand high temperatures and is found in Tupperware, car parts, thermal vests, yogurt containers, disposable diapers etc.
6	Polystyrene (PS)		Polystyrene (Styrofoam) is highly inflammable and dangerous as it can leach harmful styrene, in disposable take - out containers.
7	Polycarbonates (PC)		If plastic cannot be identified in the six types above - mentioned, then it will be included in group number 7. Polycarbonates are commonly used for eye protection in the creation of lenses for sunglasses, sport, and safety goggles.

Biodegradable plastics:

Poly lactic acid (PLA) is an example of a bioplastic that is used to make shopping bags, transparent cups, 3 - D printing material, and other products. Because it can be derived from plant material such as corn sugar, potato, or sugar cane, it can reduce the demand for fossil fuels used to make conventional plastics.

PLA is recyclable, biodegradable, and compostable. But that does not mean that the ocean or any other natural environment can easily handle it. The term "bioplastics" is used for two things: bio - based plastics (plastics made at least partly from the biological matter) and biodegradable plastics (plastics that can be completely broken down by microbes in a reasonable timeframe, given specific conditions). Not all bio - based plastics are biodegradable, and not all biodegradable plastics are bio - based. And even

biodegradable plastics might not biodegrade in every environment.

For biodegradation, PLA needs industrial composting conditions, including temperatures above 136 degrees Fahrenheit. It needs to be properly managed and routed to specialized industrial composting or recycling facilities. Under the right circumstances, microbes can turn the material into carbon dioxide and water within a couple of weeks. However, if it becomes littered or dumped, PLA sticks around for much longer. When pure PLA ends up in seawater, it does not seem to biodegrade at all. [8]

Recycling plastics for road construction.

"Plastic Roads" consist of modular, hollow, and prefabricated road elements made from consumer waste plastics. Most plastic roads consist of waste plastic used to replace bitumen mixed with recycled asphalt. This type of material is sometimes referred to as Plastic Asphalt [9].

Plastic roads were first developed by Rajagopalan Vasudevan in 2001 [10]. Plastic Road consists of an asphalt mix incorporating plastic waste. The installation of plastic roads first comprises the collection of waste plastics, including plastic carry bags, cups, soft and hard foams, and laminated plastics. These are then cleaned by washing, shredded to a uniform size, melted at 170°C then blended with hot aggregates and bitumen. This unique mixture is thereafter used, as a main component, in the eventual construction of a plastic road [11].

So far, no large - scale, systematic approach has been employed to build roads entirely of plastics in any country. In India, Chennai has been experimenting with plastic roads since 2011. Chennai has used nearly 1, 600 tons of plastic waste to construct 1, 035.23 kilometres length of roads in recent years. Several other cities such as Jamshedpur, Indore, Surat, and the state of Meghalaya have constructed plastic roads from waste/recycled plastic using this technology [12]. Now, India has almost 33, 700 km of plastic roadways, which means every 1 km of road uses one million plastic bags [13]. However, it must be noted that as of 2021, only 703 km of National Highways were constructed using plastic roads [14].

Alternatives to Styrofoam and other forms of plastics

Of all the plastics, Styrofoam is a non - recyclable single - use plastic. It is most widely used all over as a packaging material and therefore also manufactured in huge quantities i. e., 10 million metric tons/year. As there is no easy, cost - effective way to recycle it, and most of it is discarded post its use, thereby establishing itself as one of the world's biggest pollutants. The afterlife of Styrofoam packaging can be seen as being dumped on the land, floating in rivers and oceans, or getting burnt in dump yards, causing disastrous levels of air, water, and land pollution. This section describes a few innovative businesses emerging out of India.

Ecoville

Ecoville company was initiated with the vision of building a sustainable future and protecting the environment by revolutionizing the building and construction materials industry [15].

This company is providing a cost - effective substitute to real wood that is not only created with recycled plastic but is also a recyclable material itself thereby making the products environmentally conscious. This company is manufacturing doors and panels that are built to last. Its quality does not deteriorate in the long run with the material being water - resistant, termite - resistant, powder - free, and borer free. These features of the product make it an excellent substitute for wood.

Edible utensils:

Two women entrepreneurs who wanted to contribute to society, particularly after the 'Swachh Bharat Abhiyan' (a country - wide campaign initiated by the Government of India in 2014) are the brain behind this venture. The utensils on which the food is served play a major role in the evolution of the food and packaging industry. This company is manufacturing edible utensils/cutlery which contain no plastic, are bio - degradable, and result in zero waste [16].

Edible cutlery is a new concept where the cutlery can be eaten after consuming the food or drink. Edible cutlery is made in the form of spoons, forks, soup spoons, and ice cream sticks. The ingredients used for manufacturing these are normal food components like millet. Edible Cutlery can be made to impart taste and texture using different flavours and colours with food ingredients of plant origin. The edible cutlery can withstand contact with liquid and is suitable for all climatic conditions and remote areas.

Envigreen

Envigreen Biotech India Private Ltd produces India's first 100% biodegradable substitute for plastics [17]. Envigreen products can be used in all walks of life and can be a 100 percent substitute for plastic. Envigreen manufactures products that are made from natural starch, vegetable oil derivatives, and vegetable waste. These products are non - toxic to the environment, animals, and plants. Envigreen contains no conventional plastics at all. Envigreen is on a mission to make the world plastic free with operations in the Middle East and South - East Asian countries.

Dharaksha Ecosolutions

Dharaksha Ecosolutions is an environmentally conscious start - up specializing in biodegradable packaging material [18]. A Delhi - based company, Dharaksha prevents the burning of agricultural waste by creating biodegradable and sustainable alternatives for packaging material that eliminates the usage of chemically derived Styrofoam. This material is cost - competitive and has already been used by well - established companies such as Dabur, Kraft Packaging, and Barosi.

2. Conclusion

Fossil fuel - based plastics are causing widespread environmental problems due to their slow decomposition rate in natural ecosystems. As a society, there is a great need to come up with commercially viable biodegradable products as an alternative to plastics.

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