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PLASTIC WASTE - A HAZARDOUS CHEMICAL NUISANCE TO ENVIRONMENT: A FOCUS AND REMEDY

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ABSTRACT

Plastics are low molecular weight organic materials, that are non degradable in the natural environment. Generation of plastic waste constitutes a major part of Municipal Solid Waste. This creates a lot of environment pollution, which in turn affects ecosystem and human health. The solution to tackle this dreadful situation lies in following 3R namely Reduce, Reuse and Recycle. Waste plastics can be recycled and used in several ways including construction of roads. The current scenario focuses much on degradable biopolymers, an ecofriendly concept to protect the environment.

INTRODUCTION

Plastics are a subspecies of a class of materials known as polymers. These are composed of large molecules, formed by joining many, often thousands, of smaller molecules (monomers) together. Other kinds of polymers are fibers, films, elastomers (rubbers), and biopolymers (i.e., cellulose, proteins, and nucleic acids). Plastics are made from low-molecular-weight monomer precursors, organic materials, which are mostly derived from petroleum, that are joined together by a process called "polymerization" (College Street, 1997).

Plastics owe their name to their most important property, the ability to be shaped to almost any form to produce articles of practical value. Plastics can be stiff and hard or flexible and soft. Because of their lightweight, low cost, and desirable properties, their use has rapidly increased and they have replaced other materials such as metals and glass. They are used in millions of items, including cars, bulletproof vests, toys, hospital equipment, and food containers.

It is estimated that approximately 4-5 % post-consumer plastics waste by weight of Municipal Solid Waste (MSW) is generated in India (CPCB, 2006). The plastics waste constitutes two major category of plastics; (1) Thermoplastics' and (2) Thermoset plastics. Thermoplastics, constitutes 80% and Thermoset, constitutes approximately 20% of total post -consumer plastics waste. The Thermoplastics are recyclable plastics which include; PET, LDPE, PVC, HDPE, PP, PS etc., however, Thermoset plastics contains Alkyd, Epoxy, Ester, Melamine Formaldehyde, Phenolic Formaldehyde, Silicon, Urea Formaldehyde, Polyurethane, Metalised and Multilayer Plastics etc.

PACKAGING WASTE

Source

Packaging is defined as any material, which is used to contain, protect, handle, deliver and present goods. Items like glass bottles, plastic containers, aluminium

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cans, food wrappers, timber pallets and drums are all used as packaging materials. Among these packaging materials, plastic containers form a major source of pollution owing to its over utilization in wide variety of sectors. Packaging waste can arise from a wide range of sources including supermarkets, retail outlets, manufacturing industries, households, hotels, hospitals, restaurants and transport companies (Limbach, 1990).

POLLUTION PROBLEMS

1. Plastics are non-degradable.
2. It prevents or reduces the seepage of water in to the soil.
3. It clogs / blocks the domestic pipelines and sewage lines.
4. Direct burning of plastics leads to the emission of toxic fumes and gases, which in turn affects human health.
5. Emission of carbon dioxide during burning of waste plastics causes raise in earth temperature. i.e. Global warming (Lakshmanaperumalsamy,2006).
6. Incorporation of synthetic coloring dyes (Azo dyes) to manufacture plastics pose a threatening health hazard to workers and consumers.
7. Continuous accumulation and dumping of plastics, in due course of time reduces cultivable land.

Industrial practices in plastic manufacture can lead to polluting effluents and the use of toxic intermediates, the exposure to which can be hazardous. Better industrial practices have led to minimizing exposure of plant workers to harmful fumes; for example, there have been problems in the past resulting from workers being exposed to toxic vinyl chloride vapor during the production of polyvinyl chloride.

Much progress has been made in developing "green processes" that avoid the use of detrimental substances. For example, phosgene, a toxic "war gas," was formerly used in the manufacture of polycarbonates. Above all many chemical ingredients of plastics were highly carcinogenic. Problems with their use largely result from the presence of trace amounts of non-plastic components such as monomers and plasticizers. For example, the use of polyacrylonitrile for beverage bottles was banned at one time because the traces of its monomer, acrylonitrile, were a possible carcinogen. There has been concern about endocrine disruption from phthalate-containing plasticizers used for plastics such as polyvinyl chloride (PVC) (Gerngross, 2000).

REMEDIES TO CURE POLLUTION

The popular 3 R slogans, which mean Reduce, Reuse and Recycle, can be adapted to tackle this problem.

Reduce, Reuse and Recycle

Reduce

Over utilization of plastics and its derivatives can be minimized or reduced by using plant based biodegradable materials for packaging and as containers. For example jute bags can be a very good alternative instead of polythene bags.

Reuse

Once used materials should not be thrown as waste, in contrast it can be reused to an optimal level. For example it can be used as containers for nurseries, for making artificial ponds, bunds so as to retain water for various agro based works, as roof materials etc.

Recycle

Recycling of plastics is desirable because it avoids their accumulation in landfills. While plastics constitute only about 8 percent by weight or 20 percent by volume of municipal solid waste, their low density and slowness to decompose makes them a visible pollutant of public concern.

Over 1.5 million pounds of plastic bottles were recycled in 2000, representing a four-fold increase in the amount of plastic recycled the previous decade. Nonetheless, the capacity to recycle bottles appreciably exceeds their supply by about 40 percent, so local governments and environmental groups need to encourage greater participation in this practice among consumers (Arlington, 2001).

Profitable operations are currently in place for recycling polyethylene terephthalate (PET) from bottle sources and converting it into products such as fibers. Polystyrene (PS) is another potentially recyclable polymer.

The initiative to popularise a simple technology using waste plastic to lay roads has received a shot in the arm with the Central Pollution Control Board (CPCB) approving it for wider application. In Tamil Nadu, the District Rural Development Agency (DRDA) had laid 1,200 km of plastic roads in 28 districts.

Recycled Materials

Plastic materials and uses in road construction

Six main types of resins are used to make plastic products in the US:

1. PET, polyethylene terphthalate, from 2-1 soda bottles.
2. HDPE, high-density polyethylene, natural, from 1 gallon milk jugs, grocery bag.
3. HDPE, high-density polyethylene, colored, from bottles.
4. PVC, polyvinyl chloride, various bottle, pipes, flooring.
5. LDPE, low density polyethylene, from film and trash bags, rigid containers.
6. PP, polypropylene, from some food containers, battery cases, medical containers.
7. PS, polystyrene, from carryout containers, some food containers, vitamin bottles.

It will be ideal for roads that have to bear the brunt of continuous rainfall, like those in Mumbai. According to officials, though the technology has proved to be beneficial, it can be adopted nation-wide only with the approval of the Central Road Research Institute (CRRI).

Plastics recycling units

Several plastic recycling units are established nation wide including states such as Tamil nadu (588), followed by Gujarat (365), Karnataka (302), Kerala (193) and so on (Stein, 1992).

Process of Road laying using polymer- aggregate - Bitumen mix

The plastic waste (bags, cups, Thermocole) made out of PE, PP, & PS are separated, cleaned if needed and shredded to small pieces (passing through 4.35mm sieve). The aggregate (granite) is heated to 170oC in the Mini hot Mix Plant and the shredded plastic waste is added, it gets softened and coated over the aggregate. Immediately the hot Bitumen (160oC) is added and mixed well. As the polymer and the bitumen are is the molten state (liquid state) they get mixed and the blend is formed at surface of the aggregate. The mixture is transferred to the road and the road is laid.

Salient features of the polymer-waste-bitumen mix Road

- Road strength is twice stronger than normal roads;
- Resistance towards water stagnation i.e. no pot holes are formed;
- Less bleeding during summer;
- Burning of plastics waste could be avoided
- It doesn't involve any extra machinery;
- It doesn't increase cost of road construction; and
- It helps to reduce the consumption of bituminous mix vis-à-vis reduce cost.
- A low-cost, simple technology
- Spot utilization of waste plastic
- Rain-proof, long-lasting roads
- Higher load-carrying capacity

Other uses of plastic

Several communities and states have examined and utilized plastics for other uses related to highway and road construction, including fences or sign posts, sign blanks, barricades, delineators or cones and plastic timbers, tables, and benches.

Among plastic ingredients utilized in 2002, PET comprised the largest amount with 42 percent, HDPE a slightly lesser amount with 33 percent, and other plastics with 25 percent. Generation rates provide data on the actual amount of waste that is generated by households and commercial properties. A national study by the American Plastics Council estimates that 200 pounds of glass and 35 pounds of plastics are generated per household per year.

Degradable plastics

Degradable polymers may have limited use in the reduction of litter and production of flushable plastics. Degradation leads to the loss of most of the potential energy content of plastics that might be recovered by trash-to-energy procedures.

Trash to energy

A method of plastic disposal with more positive environmental implications is burning and recovering the energy for power generation or heating. However, it is possible to construct a "high-tech" incinerator designed to operate at appropriate temperatures and with sufficient air supply that these problems are minimized. Remaining toxic substances in fumes may be removed by scrubbing, and studies have shown that no significant air pollution results.

Biopolymers & Bioplastics

Biopolymers are present in, or created by, living organisms. These include polymers from renewable resources that can be polymerized to create bioplastics. Bioplastics are plastics manufactured using biopolymers, and are biodegradable. Biopolymers and bioplastics are not new products. Henry Ford developed a method of manufacturing plastic car parts from soybeans in the mid-1900s. However, World War II sidetracked the production of bioplastic cars. Today, bioplastics are gaining popularity once again as new manufacturing techniques developed

through biotechnology are being applied to their production.

The main work in this field at present is on the polysaccharide alginate, which has several commercial applications. Due to its gelling, water-binding, and viscosity-enhancing properties alginate is widely used in foods and has other industrial applications as different as in textile printing and welding rods. It is also used for medical purposes, such as encapsulation of cells (Gimmestad, 2003).

Alginate over-producing mutants of *Pseudomonas fluorescens* and their genes involved in the production of the polymer were extensively studied. In addition to *Pseudomonas fluorescens, Azotobacter vinelandii* is also employed for mass production of alginate, the degradable polymer (Ertesvag, 1998).

Condensation polymers like cellulose, produced by bacteria have properties similar to polyethene. Polyhydroxybutyrate (poly-3-hydroxybutanoate) and Polyhydroxyvalerate (poly-3-hydroxypentanoate) (PHV) are polyesters produced by a number of different bacteria (*Alcaligenes* spp., *Pseudomonas* spp.) are used as food storage material, an effective alternative plastic packaging material.

Microbial Cellulose

Cellulose is the earth's major biopolymer and is of tremendous economic importance globally. Among the bacteria, one of the most advanced types of purple bacteria is the common vinegar bacterium, *Acetobacter*. This non-photosynthetic organism can procure glucose, sugar, glycerol, or other organic substrates and convert them into pure cellulose (Brown, 1976). *Acetobacter xylinum* is Nature's most prolific cellulose-producing bacterium.

Uses of microbial cellulose

- The unique gel-like property of microbial cellulose makes this an attractive food base.
- Used in audio speaker diaphragms.
- As a liquid loaded pad for wound care
- As binding material in papers, it adds great strengths and durability to pulp, which in turn integrate in to paper.
- Mass-produced in bioreactors by fermentation method, the brand name is Cellulon.

Polyhydroxybutyrate

The microbial polymer poly-3-hydroxybutyrate (PHB) and related poly-hydroxyalkanoates, such as poly-3-hydroxyvalerate and poly-3-hydroxyoctanoate, are unique biodegradable thermoplastics of considerable commercial importance (Edwin Daves, 1988).

Specialty polymers

Natural polyesters are "biocompatible" and can be used to make surgical thread and for other medical applications; if left behind in the body, they will easily be degraded with no harmful effects. The properties of PHB-PHV blends are such that they could replace polypropene for many applications.

CONCLUSION

A recent study of all the energy costs of processing and transporting polymers made either in plants, or by bacteria, found that the amount required was very much greater than needed for producing plastics from petrochemicals - so much so that as long as our energy is derived from non-renewable resources, they will greatly increase carbon dioxide emissions. Once an alternative energy supply is in place (solar, biomass, fusion, etc.) these biopolymers are likely to come into their own. Let us join hands to preserve our mother Earth by following 3R slogan and better shift to biodegradable polymers to step in to a healthy, clean and green world in days to come in.

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