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Hazards Of Plastic & Its Substitute Bioplastic—The Future

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Plastic, the wonder material of the 20th century has awarded every aspect of life primarily because of its sociability and relative lightness. It is an important and of modern life and used in different sectors, such as packaging, building materials, consumer products and much more. Each year about 100 million tons of plastics are produced worldwide. Ever ever, plastic's non-biodegradability poses serious environmental and health problems.

Hazards of Plastics

Most of today's plastics or synthetic polymers are produced from petrochemicals. As conventional plastics are persistent in the environment, improperly disposed plastic materials are a significant source of environmental pollution, potentially harming life. The plastic sheets or bags do not allow water and air to go into the earth resulting hi reduced soil fertility, preventing degradation of other normal substances, depletion of underground water source and danger to animal life. In the seas too, plastic rubbish from ropes and nets to the plastic bands from beer packs choke and entangle marine mammals.

The extensive use of plastics therefore leads to the consequence that plastic residues are found all over the planet, potentially harming wildlife and littering the remotest places. The majority of ordinary plastic products will remain for centuries or more, since they are composed of huge and unbreakable molecular polymer chains. In addition the additives used in processing plastics results in the presence of substances that are a serious health hazard (Table 1).

Table 1. Health impacts of different plastics

Type of Plastic	Usage	Health Impacts
Polycarbonate (Bisphenol A)	Baby feeding, bottles, optical lenses, CDs/DVDs, water bottles	Endocrine disruptor
Polystyrene (PS) (Bisphenol A)	Packaging for take away foods, disposable utensils and foam packaging	Endocrine disruptor, a known carcinogen
Polyvinyl chloride (PVC) (pthalates)	Coating on copper wires, rain proof sandals and many more	Endocrine disruptor, a known carcinogen, affects the reproductive system, causes respiratory disorders
HDPE, LDPE	Polybags and crates for soft drinks	A known carcinogen, damaging to the liver and the nervous system
Polyurethane (PU)	Foam used for cushioning in mattresses and pillows, automobile seats	Asthma, reduced sperm quality, heart disorders
Polyethylene terephthalate (PET)	Soft drink and mineral water bottles	A known carcinogen, affects the reproductive system
Polypropylene (PP)	Drinking straws	Affects the central nervous system, causes cardiovascular disorders and can aggravate diabetes or hypertension

Source: No immunisation against plastics. Health and Environment Newsletter. January-February 2003. New Delhi: Centre for Science and Environment.

The disposal of plastic waste is a growing problem. The plastic carry bag, often made of thin plastic, best symbolizes all that is wrong with the growing plastic culture. The carry bag is considered to be the chief cause of choked drains. The accumulation of plastic in municipal waste poses serious problems in the management of waste. Municipal waste cannot be incinerated because of the presence of plastic in it. Burning of waste releases dioxin, a class of 75 chemicals, which is carcinogenic and causes birth defects and other serious ailments.

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PVC (polyvinyl chloride) is the most commonly used plastic in India (28% of all plastics). It is in the slippers that we wear, stationery used in schools, to the buildings and offices. One of the main additives in PVC is phthalates, which lend PVC its inherent physical characteristics. Even a teether in a child's mouth or a soft plastic toy releases phthalates. Phthalates bond loosely with the polymer chains and can easily leach out, leading to severe consequences, such as hormonal imbalance, systemic disorders, decline in sperm count in men and cancer. Polystyrene (PS), another commonly used plastic for packaging food and making thermocol cups leaches another toxic chemical, bisphenol A, a building block. It causes hormonal imbalance and diverse types of cancers. Polycarbonates (PC), used for making babies' bottles, and most refilled jars of water dispensers can cause severe systemic disorders in children. Other types of plastics, such as polyethylene terephthalate (PET), used to package soft drinks and water bottles, high density polyethylene (HOPE), used in manufacturing cooking oil containers; low density polyethylene (LDPE), which is a vital component in plastic bags and polypropylene (PP), used to make caps for containers, all impact public health in various ways. Beginning with the fetus in the womb, toxic effects of plastics manifest themselves with an array of ailments at every age.

The per capita consumption of plastics in the world and India are 19kg and 2.7 kg, respectively. Plastics in solid waste streams in the world and India are 7% and 0.5%, respectively.

To minimize the problems of pollution by plastics, recycling of all plastic products would be ideal. Recycling % of plastics in the world and India is approximately 20% and 60%, respectively. In India, this 60% recycling includes, 3% landfill and 8% incineration. However, such a complete recycling of plastic material is difficult to achieve, since recycling facilities are not available everywhere or are too remote and the population compliance too poor to be cost effective. This leads to the emerging need, to find biodegradable substitutes to plastics.

Biodegradable plastic substitutes

Biodegradable plastics are derived from renewable raw materials. These plastics can be made from abundant agricultural/animal resources, such as cellulose, starch, collagen, casein, soy protein polyesters and triglycerides. They degrade over a period of time if exposed to san and air. Large-scale use of these would help in preserving non-renewable resources like petroleum, natural gas and coal and contribute to the problems of waste management

Bio plastics, such as for carry bags, should degrade rapidly at the end of their useful life while retaining their mechanical properties during use. A biodegradable material will ultimately breakdown into carbon dioxide and water ard biomass within a specific time As compostable material it must also contain no toxic materials, the breakdown time must be less than 12 weeks and the resulting compost must not impede plant growth.

There are three essential criteria for biodegradation of plastic.

1. They must disappear and leave no visible trace;
2. This disintegration must occur in a reasonable timeframe (e.g. 3 months or 6 months); and
3. They must not leave behind any toxic residues.

Types of degradable plastics

Degradable plastics are classified according to

- The way they degrade, for example whether they require the actions of microorganism (i.e. are biodegradable), or whether they require heat, ultraviolet light, mechanical stress or water in order to break down.
- The materials they are manufactured from for example whether they are made from natural starch polymers, from synthetic polymers or from a blend of a conventional polymer with an additive to facilitate degradation

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Table 2. Types of degradable plastics as per the degradation properties

Type	Degradation conditions
Biodegradable plastics	Decompose into carbon dioxide, methane, water, inorganic compounds or biomass predominantly by enzymatic action of microorganisms, and can be measured by standardized tests, in a specified time, reflecting available disposal conditions.
Compostable plastics	Degrade under composting conditions. They must break down under the action of microorganisms (bacteria, fungi, algae), achieve total mineralization (conversion into carbon dioxide, methane, water, inorganic compounds or biomass under aerobic conditions) and the mineralization rate must be high and compatible with the composting process.
Oxo-biodegradable plastics	Undergo controlled degradation through the incorporation of 'prodegradant' additives (additives that can trigger and accelerate the degradation process). These undergo accelerated oxidative degradation initiated by natural daylight, heat and/or mechanical stress, and become brittle in the environment and erode under the influence of weathering.
Photodegradable plastics	Break down through the action of ultraviolet (UV) light, which degrades the chemical bond or link in the polymer or chemical structure of the plastic. This process can be assisted by the presence of UV-sensitive additives in the polymer.
Water-soluble plastics	Dissolve in water within a designated temperature range and then biodegrade in contact with microorganisms.

Bioplastics-the future

Biopolymers, or polymeric materials produced by living organisms are the future alternative to the current biodegradable plastics. These are 'truly' biodegradable and can be generated using renewable resources, such as microorganisms or plants. Many microorganisms synthesize polymers. More than a hundred species of bacteria are known to synthesize and store aliphatic polyesters for future use as an energy source. While being naturally biodegradable, these polyesters are also thermoplastic capable of being extracted and formed into fibres similar to any other polyester.

Polyhydroxyalkonoates

Polyhydroxyalkonoates (PHAs) are microbial polyesters that have received considerable attention as biodegradable alternatives to conventional plastics. Many species of bacteria accumulate PHAs as energy storage compounds in response to nutritional stress. Presently, the bacterially produced polymers are not cost-competitive with nonbiodegradable plastic polymers derived from petroleum. By genetically engineering crop plants to produce PHA, a less expensive source of these polymers could become available. Some PHA polymers are commercially valuable as biodegradable plastics.

Polyhydroxybutyrate

Polyhydroxyburyrate (PHB) is a PHA produced in *Ralstonia eutropha* via a three-enzyme biosynthetic pathway consisting of β-ketothiolase, acetoacetyl-CoA reductase, and PHB synthase. PHB production in plants was first demonstrated in *transgenic Arabidopsis thaliana* (L.) Heynh. Poly-B-hydroxybutyrate is tolerated by plants if it is synthesized in chloroplasts and PHB levels ranging between 0.1 and 14% DW have been reported with minimal effects on plant growth. Although various approaches for producing PHB in plants have been reported, most of these utilize *Arabidopsis.*

Similar genes to synthesize PHB have been identified in microorganisms that can utilize palm oil. A research group is trying to identify the genes capable of producing a unique polymer blend of two different polymers by utilizing palm oil in *Pseudomonas* sp. so that transgenic plants can be produced for high biomass production.

Poly β-hydroxybutyrate-co-β-hydroxyvalerate

Copolymers of hydroxybutyrate and hydroxyvalerate, including poly B-hydroxyburyrate-co-6-hydroxyvalerate (PHBV), form plastics having good mechanical qualities and have been commercially marketed. Several articles pertaining to the applications, manufacture, and properties, including biodegradability, of PHBVs have been published. The pri deterrent to widespread use of PHBVs has been and remains the high cost of these plastics compared to conventional plastics, regardless of the potential benefits to the environment. Various efforts have been made to incorporate low-value materials into PHBVs to reduce their overall cost.

Recently, production of PHBV was achieved in the seed of oilseed rape *(Brassica napus* L.), using *Ralstonia eutropha* genes demonstrating that it is possible to produce PHA in crop plants.

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Plants producing PHA at levels compatible with growth could be used for multiple purposes to increase overall crop value. Production of bioplastics in alfalfa leaves could *be* combined with use of alfalfa for feed and energy. In such a system, alfalfa leaves could be harvested to produce PHB, leaf by-product could be processed into a feed, and, stems could be used for producing either electricity by gasification or ethanol by fermentation.

Transgenic plant producing the biodegradable plastic polyhydroxybutyrate (PHB). The PHB granules are visualised by epifluorescence microscopy as foci of red fluorescence.

Metabolix, an American company, has already produced natural plastics through fermentation of plant sugars and oils using microbial biofactories.

Conclusion :

Biodegradable plastics have to be tested for there real value in terms of pollution caused to the environment during manufacture , type of products released upon break down and its effects. For example , paper that seems to be an innocent and obvious substitute contribute maximally to a biotech resources depletion during manufacture and processing and to the greenhouse effect on desecration so paper bags are good option only if they are used more than once conventional plactics are less harmful if they are re used and recycled in fact three ‘R’ for county like India are : REDUSE REUSE and RECYCLE. By this article we can say the future as a biodegradable plastics substitutes in place of harmful plastics .

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