PLASTIC: THE SUBSTANCE YOU CANNOT IGNORE

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Abstract : Plastics have pervaded every inch of space of our daily lives, be it in education, transportation, food, medicine, packaging, clothing, entertainment or household chores. A synthetic material that is inexpensive, easy to produce, light in weight, durable, portable, attractive, strong and versatile, it is virtually an indispensable part of our living. A seemingly simple solution to almost all practical problems, it has brought about a tremendous change in our lifestyles. From water bottles and shopping bags to spectacles and mobile phones, the extensive and convenient use of plastics eclipses the dark secrets that research reveals. Living without plastics is impossible, however in view of the potential dangers that they pose to human life and environment, utmost caution and restriction must be observed in terms of use and disposal of plastic goods and applications.

Key words: benefits of plastic, pollution, disposal, reuses, alternatives.

I. INTRODUCTION

Few substances have been more fascinating, more versatile and more controversial at the same time as the ubiquitous plastic. It is both, the miracle and malady of human experience. Plastics are composed of petroleum- based materials called resins (e.g. polyethylene and polypropylene)-materials that are resistant to biodegradation. The global impact of plastic can be attributed to its low cost, ease of manufacture, relatively unbreakable, its imperviousness to water, a wide spectrum of utility, component in a multitude of products of different scale, ranging from paper clips to spacecrafts.

II. PLASTIC AND ITS INDISPUTABLE BENEFITS

Plastic is a non-biodegradable substance which has made a significant contribution in almost every field of human activity today – agriculture, transportation, piping, electrical and heat insulation, packaging, manufacturing of household and electronic goods, furniture and other items of daily or specific use. According to the newsletter, *Cerc Envis Centre on Eco-labelling and Eco-friendly Products* sponsored by the Ministry of Environment and Forests, Government of India, the world's annual consumption of plastic material has increased from around 5 million tons in 1950s to 100 million tons.

Contribution of plastics to human health is difficult to ignore. Its utility in medicine is immense and elaborate, ranging from products like disposable syringes, blister packing of tablets and capsules, prostheses in joint replacement, bottles for intravenous (IV) fluid, blood bags, catheters, heart valves, body implants to name just a few, have significantly helped in supporting human life. Plastics have contributed towards creating a sustainable, energy efficient, pilfer proof, hygienic and cost-effective packaging of food products like milk, condiments, edible oil, bread and confectionery, rice, wheat flour, snacks and several types of medicines. Plastic packaging of toiletries, cosmetics and countless other consumer products makes it convenient to deliver goods for all sections of people living in urban-rural setups. This has been possible because of the various properties of plastic materials e.g. they are safe and hygienic – inert and chemical resistant, light weight and unbreakable, they enhance shelf-life of products, they are sterilizable and resistant to bacterial and other microbial growth, transparent as well as opaque, they lower fuel consumption and product loss during transportation. The products that reach the consumers are quality assured, hygienic and unadulterated. (Siddiqui & Pandey, 2013).

III. IMPACT OF PLASTIC AS A MAJOR POLLUTANT

Despite all the countless benefits, many plastics products especially comprising of the packaging system such as plastic bags and carry bags are suspect to health, safety and environmental problems. Non-biodegradability of plastics poses a huge waste management problem. Plastic has been a major pollutant of air, soil and water in our fragile eco-system and consequently has harmful effects on individual and collective health, causing serious diseases ranging from cancers, birth defects, suppression of immune system, endocrine disruption, and development problems in children (Pavani & Rajeswari, 2014).
According to Ecology Center, Berkeley, California, in its education on 'Adverse Health Effects of Plastics', plastics also have other hazardous components such as:

- *Tetrafluoro-ethelene*, used in non-stick cooking ware, can irritate the eyes, nose and cause respiratory problems.
- *Acrylic*, used in clothes, contact lenses, dentures, adhesives, articles used to prepare food, diapers, sanitary napkins, and other products, can cause vomiting, nausea, diarrhoea, respiratory difficulties and headaches.
- *Polyvinyl chloride* (PVC), used in packaging, containers, utility items and cosmetics can cause cancer and genetic changes and affect birth. It can also cause bronchitis, skin disease, deafness, impaired vision and problems related to liver and digestion.
- Phthalates, present in emulsions, nail polish, inks, footwear and soft plastic toys among other products, is associated with hormonal disturbances, developmental issues, cancer, reduced sperm count and infertility and weakened immunity.

- Bisphenol A (BPA), a potentially toxic chemical used in hard plastics such as reusable water bottles, baby bottles, sippy cups and linings of aluminum cans, interferes with the body's natural hormonal messaging system. Environment California Research & Policy Center, reports in the *Science for Environment Policy*, November 2011, attribute breast and uterine cancer, increased risk of miscarriage, and decreased testosterone levels to BPA. Other studies report early puberty and development of obesity and diabetes.

In the USA, plastics constitute 20% of the municipal solid waste and at the global level its production is estimated at 100 million tons annually. In supermarkets customers are habituated to pick a bag for every commodity they pick. Plastic bags have a great economic advantage over paper bags. A standard plastic grocery sack costs one cent against a paper bag that costs four cents, he said. So plastic bags go to schools and colleges, homes and offices, picnics and parties, on tours and pilgrimages and still millions of others simply end up polluting the planet. They fly in the breeze, flutter from trees, clutter streets, choke drains, float on rivers adrift to high seas, litter open spaces and fatally block the digestive tracts of animals (Roach, 2003).

"Once in the environment, plastic takes hundreds of years to breakdown. As they decompose, tiny toxic bits seep into soils, lakes, rivers, and oceans", said Vincent Cobb, an entrepreneur in Chicago, Illinois, who sells reusable bags as a viable alternative and launched the Web site *http://Reusablebags.com* to educate the public (Gogte, 2009).

IV. Impact of Plastics on soil

Plastics have a strong presence in the environment. They accumulate in landfills and also in soils where factories are located. Plastics can get into the soil and aquatic systems through a number of ways but most importantly they get widely dispersed and transported by wind from landfills. Working with soil e.g. in agriculture releases particles into the air that can be inhaled by workers and others nearby. Micro particles may lodge in the lungs, and chances are that contaminants could be absorbed into the bloodstream (Wallström, 2003). However, the risks to human health and terrestrial ecosystems from the use of plastic polymers and products still needs to be assessed (Lithner, Larsson & Dave, 2011; Rillig, 2012; Rocha-Santos & Duarte, 2015). Almost no studies have been conducted on the fate of plastics in soil. Studies conducted by Zheljazkov (2005), reveal that addition of polythene granules reduced soil pores size, which may have negative effect on the nutrient intake by the root of plant. This is confirmed by a research undertaken by Atuanya, Aborisade & Nwogu (2012) to study the impact of plastic enriched composting on soil structure, fertility and growth of maize plants. They found that the higher the plastic granules the more was its negative impact on growth of the plants.

V. Consequences of Plastics in water

David Barnes, a marine scientist with the British Antarctic Survey in Cambridge, England, who studies the impact of marine debris, says that nearly 80 per cent or more of the waste accumulating on land, shorelines, ocean surface or sea bed is plastic. The most common items of which are plastic films, such as carrier bags, that are easily blown by the wind, discarded fishing equipment and food and beverage packaging (Barnes, Galgani, Thompson & Barlaz, 2009). According to a study reported in the journal Environmental Research 2008, by oceanographer and chemist Charles Moore, of the Algalita Marine Research Foundation-California, about 44 percent of all seabirds eat plastic, apparently by mistake, sometimes with fatal effects. And 267 marine species swallow plastic bags, which when waterlogged resemble jellyfish (Barry, 2009) and (Lutcavage et al., 1997 as cited by Moore, 2008). U.K.'s Marine Conservation Society, a national environmental nonprofit organisation, too reported that more than a million seabirds and 100,000 mammals and sea turtles die globally each year from entanglement in, or ingestion of, plastics. Seabirds mistake raw plastic pellets spilled from container ships for fish eggs. Plastic sheeting has even been found in the stomachs of dolphins and whales. To tackle the environmental havoc caused by plastic bags, Ireland, Taiwan, South Africa, Australia, and Bangladesh have heavily taxed or banned their use outright. Several others including England and some U.S. cities, are considering similar action (Gogte, 2009).

Of the beach garbage alone, more than 90% constitute plastic. Plastic has displayed a long shelf life, yet recent study has shown that in water, plastic disintegrates at much cooler temperatures in a matter of months. Research reveals that degrading plastics are leaching into the seas potentially toxic chemicals such as styrene monomer a carcinogenic substance and Bisphenol A, which affects the reproductive systems of animals (Barry, 2009).

Barry (2009), also reported the work of Katsuhiko Saido, a chemist with the College of Pharmacy at Nihon University in Japan and his team, who collected water samples from the U.S., Europe, India, Japan, and elsewhere and has presented the findings at a meeting of the American Chemical Society in Washington, D.C. They found derivatives of polystyrene, a common plastic used in disposable cutlery, Styrofoam, and DVD cases, among others. Once Styrofoam, for example, breaks down, the tiny polystyrene components being heavier than water start to sink, polluting the entire water column. The toxic chemicals that these plastics release also attach themselves to other chemicals such as those found in pesticides and synthetic substances present in the water. They are known to induce endocrine malfunctioning, disrupting the reproductive, developmental, and immune systems of animals e.g. 'the masculization of female polar bears, egg development in male flatfish, and spontaneous abortions and declines in seal populations.'

Thompson, R. (2004), a senior marine ecology lecturer at the University of Plymouth and his team collected sediments from beaches, estuaries, and shallow waters in U.K and found widespread microscopic fragments of nylon, polyester, and seven other types of plastic. As smaller contaminated organisms like plankton that ingest the microparticles of plastic get eaten by higher organisms, which in turn are eaten by still higher animals causing serious biomagnification along the food chain, the concentration of pollutants at each level gets increased greatly implying serious consequences for us at the top (Viviena, Bodiguelb, Charmassonc, Loizeaud, Duvale… Cossag (2012).

According to Moore (2008), since half of the world's human population lives within 50 miles of the ocean, lightweight plastic trash, finds its way into the ocean while moving through innumerable habitats, causing eight complex problems en route, e.g. fouling beaches…

destroying coastal nurseries… entangling marine life with e.g. 'ghost nets', killing innumerable sea turtles, marine mammals and commercial species through drowning, strangulation, dragging, and reduction of feeding efficiency… killing seabirds which ingest plastic items that mimic natural food, preventing survivors to store body fat, vital for migration and reproduction... altering the species composition of sessile organisms due to slow biodegrading petroleum-based plastic polymers … affecting the food web through the ingestion of xenoestrogens and persistent organic pollutants (POPs) from pellets of plastic resin/fragments of plastic by invertebrates that pose a health hazard through biomagnification… sinking floating consumer plastics, due to grains of sand trapped in their seams and seriously affecting inhabitants of the sediments and inhibit gas exchange possibly through the interference with CO2 sequestration… fouling vessel intake ports, keels and propellers and endangering the lives of the crew working to free the debris and also causing economic losses through significant damage to vessels.

VI. Effects of Plastic Emissions in the Air

The Report of the Berkeley Plastics Task Force, April 8, 1996, states that the manufacture of plastic uses large amounts of energy and resources and generates toxic emissions and pollutants. The presence of these substances such as ethylene oxide, benzene and xylene just to mention a few, in the atmosphere accelerates global warming. People are exposed to these chemicals not only during manufacture of plastic goods but also while using plastic packages. Burning of domestic waste containing plastics under open-fire low temperature conditions, the waste plastics that they contain contribute to smoke generation and infuse toxic gases and decomposition products of plastics into the smoke which can potentially cause an extremely health hazard and environmental concerns.

VII. Disposal of Plastics

Presently, only three methods of disposing plastic are routinely used on a large scale: landfill, incineration and recycling. However, each of these techniques has disadvantages and drawbacks. Landfill and incineration, both lead to the release of dangerous secondary pollutants into the environment, and landfill also has an additional drawback in the requirement of large portions of land space (Webb, Arnott, Crawford & Ivanova, 2013).

Landfills:

One main drawback of landfills from the point of view of sustainability is that none of the materials used in the production of plastic are recovered i.e. the material flow is linear rather than cyclic. The hazards of landfills are ultimately the toxic seepage (leachate) which not only contaminates precious soil and ground water (Hopewell, Dvorak & Kosior, 2009) but the water mass also impedes the flow of ground water.
Plastics may take up to 500 years to decompose (Cho, 2012), hence very often the garbage in the landfills are set on fire. Direct burning of plastics leads to the emission of toxic fumes and gases, which in turn affects human health. Emission of carbon dioxide during burning of waste plastics causes raise in earth temperature resulting in global warming (Anand, Ramanujam, Kulothungan, Sharanya, Murugalakshmi, & Bhuvaneswari, 2008)

Incineration**:**

By all means we should avoid burning plastics. Incineration releases synthetic carcinogens into the environment including dioxins. From the studies conducted by Nkwachukwu, O.I., Chima, C.H., Ikenna, A.O. et al. (2013), and citing Pilz, Brandt & Fehringer (2010) they state sometimes the energy recovery of plastic waste in MSW incinerators can result in a net increase in CO2 emissions due to substituted electricity and heat production. Therefore, if all incineration activities do not have suitable filter system traps for released toxic substances, they will pollute the atmosphere, soil and groundwater. There is also the environmental burden of disposing off ashes and slag. Flue gas cleaning residues for example often have to be disposed off as hazardous waste because they absorb toxic compounds. There is a huge cost involved for these activities depending on the alternatives, e.g. the existing power generation mix and the risk of open-air burning or landfill fires.

Recycling:

Plastics are made from crude oil derivatives or natural gas, making high demands on non-renewable fossil fuel. According to Protecting Our Universal Investment (POUI), 22nd July, 2011, the amount of oil needed to produce a plastic bottle is enough to fill a quarter of the bottle. According to the Stanford University Recycling Center, recycling one ton of plastic not only saves 16.3 barrels of oil but also 5,774 kilowatt-hours of electric energy. Siddiqui & Pandey (2013), are of the opinion that besides saving energy, plastic can be prevented from leaching into groundwater and spilling into lakes, rivers and oceans. All the same, recycling puts plastic back into the market and eventually into the environment and finally end in landfills. Recycling has proved the reduction of oil usage, energy recovery as fuel, reduction of carbon dioxide emissions and the quantities of waste requiring disposal. Hence, advances in technology and systems for the collection, sorting and reprocessing of recyclable plastics are creating new opportunities for recycling. With the combined actions of the public, industry and governments, it may be possible to divert the majority of plastic waste from landfills to recycling over the next decades (Hopewell, Dvorak & Kosior, 2009).

Though recycling appears to address the environmental concerns of landfill and incineration, the process is relatively inefficient because the polymer keeps diminishing in quality. The process is also not cost-effective, and subsequently, there is less incentive for investment in recycling facilities. Moore (2008) explains that it is difficult to separate composites and mixed plastic waste into various plastic types that require different reprocessing technologies. So also, since many thermoplastics melt at temperatures not far above the boiling point of water, contaminants are not driven off during remanufacture. Citing Brandrup (2003), he says that the price of recycled plastic

materials often exceeds the price of virgin plastic resin. Because of contamination, recycled plastics is rarely used in true 'closed-loop' recycling. e.g. a layer of virgin plastic must be added onto the recycled material for food contact applications. Plastic bags are often used to make plastic 'wood', rather than more bags.

The Annual Report (2011-12) on Implementation of PWM, Website Material on Plastic Waste Management, Central Pollution Control Board, also states that though plastic waste is mostly recyclable, recycled products are more harmful to the environment as they contain additives and colours. The recycling of a virgin plastic material can be done 2-3 times only, because after every recycling, the plastic material deteriorates due to thermal pressure and its life span is reduced. Hence recycling is not a safer and permanent solution for plastic waste disposal.

Home Reuse:

It's tempting to wash and reuse your plastic utensils at home, but the utensils are designed to be used once only and may degrade with repeated washing and reuse. Plastic utensils are made from *polystyrene*, which is not biodegradable and can last as long as centuries before it finally breaks down in landfills. However, Ingham (2011), a food science professor at the University of Wisconsin, says that "Upon exposure to detergents and hot water, the plastic material can begin to degrade, allowing chemicals to leach into foods and beverages.". Hence plastic cutlery e.g. should be used only when absolutely necessary.

Ecology Center is a nonprofit organization located in Berkeley, California, in the article, 'The Problems with Plastics' cautions against using plastics which can contain thousands of possible additives that manufacturers are not required to disclose. Plastics leach depending on the conditions (light, heat) and the additives used. Hence it recommends avoiding plastics when possible, particularly in toys, products for children, and products that come in contact with food or drink. Studies found that repeated re-use of plastic bottles increases the chance that chemicals will leak out of the tiny cracks and crevices that develop over time. One form of plastic *(polyvinyl chloride/PVC*) can leach hormone-disrupting chemicals into the liquids that are stored in them and another type (*polystyrene/PS*) which is used to make Styrofoam articles such as disposable cups and plates can leach *styrene*, a probable human carcinogen, into food and drinks as well as enter the body with food and accumulates in fat tissues. It can also cause irritation in the eyes, nose and throat.

Mikkelson (2003) also warns against freezing water in plastic bottles or drinking water from bottles left in the car must be avoided as dioxins are released from plastic either way. Dioxins are highly poisonous and known to cause cancer, especially breast cancer. On the other hand, though most experts agree that the amount of BPA that could leach into food and drinks through normal handling is probably very small, there are concerns about the cumulative effect of small doses.

From a study made by Sax (2010), bottles made from *polyethylene terephthalate*, also known as PET or PETE, for water, soda, vinegar and juice bottles, may be safe for one-time use. Studies indicate re-use may leach DEHP—another probable human carcinogen. *Polyethylene* is also found in disposable glasses, shopping bags, chewing gum and toys.

VIII. Curbing the Plastic Menace

Research has been focusing much on degradable biopolymers, an ecofriendly concept to protect the environment. However, a recent study of all the energy costs of processing and transporting polymers made either in plants, or by bacteria, shows that the amount required was far greater than that of producing plastics from petrochemicals. So as long as our energy is derived from non-renewable resources, carbon dioxide emissions will greatly increase (Anand et al., 2008).

The best way to overcome the deadly and lasting danger of plastic pollution is to reduce or avoid it altogether whenever and where ever possible. But when left with little choice, old plastic containers can be used for nurseries to plant kitchen gardens, for making artificial ponds, bunds so as to retain water for various agro based works, as roof materials etc. (Anand et al., 2008). A variety of instructional materials could be prepared to enhance the teaching-learning situation and experiential learning. Creative ways of safely reusing plastics several times before discarding them needs to be a norm for daily living.

The best way to heal the body of any toxin, is to nourish it with adequate nutrition. The body has amazing abilities for detoxification if it enjoys optimal health. Vegetable (at least 3-4 servings a day) and water intake are crucial. Chlorella is a very simple and effective alga, a wonder food that helps with the excretion of a variety of chemicals. Glass and steel are the safest alternatives. Use cloth bags for shopping and natural fiber clothing, bedding and furniture.

IX. Conclusion

Plastics with their countless benefits and banes to humankind, are undoubtedly here to stay. It is for humankind to evaluate and analyze the current approaches to production, use and disposal of plastics. There is a need to revisit the type of checks and balances that need to be in place to ensure sustainability and to address concerns for wildlife and ecology. While we have considerable knowledge about many of the environmental hazards, and unprecedented quantum of data… with respect to its effects on air, soil and water, on flora and fauna as well as on human health, many concerns and uncertainties remain. The search for solutions calls for a collective effort holding every individual accountable for responsible use and disposal of plastics. This accountability has to stem from a consciousness that is sown in the minds of young children in their formative years. We can then groom a generation of well informed and responsible citizens who care about the environment and strike a balance between development and conservation. Educationist have the duty to enlighten the minds of learners to find innovative ways of maximizing the uses of plastic by mandating the 3 Rs: Reuse, Reduce, Recycle and possibly the fourth R, 'Refuse'. This may seem a simple formula but it must be religiously followed whenever and wherever possible. Bruce Burton said, "When I consider the tremendous consequences of small things, I am tempted to think that there are no small things".

Governments, policymakers and industries have the obligation to invest in green chemistry and material reduction by designing products that can be manufactured through reusing and/or end-of-life recycling. Desired standards and targets need to be set, appropriate product labelling defined to inform and incentivize change in behaviour and mindset, and relevant funding academic research and technological developments must be ensured (Thompson et al., 2009).

The following words of Richard Thompson sums it all up, "Every single piece of rubbish has an owner, and every single person can make a tremendous difference with a small beginning of taking responsibility to be more careful in the way we use and dispose off plastic."

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