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## **Concerns Regarding “Plastic” Pollution: Reasons, Effects and Needs to Generate Public Awareness**

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### **Abstract**

*Present livelihood devoid of utilization of “plastic” goods is impossible to imagine. Nevertheless, the negative aspects of plastics, including their detrimental effect on life and environment, are paramount. Society is facing a constant threat from the use of plastic products, both during their service life and even long after they are discarded! A full-proof management of plastic wastes is proving to be impossible, primarily due to the non-degradable nature of plastics, as well as, ignorance of humans to abide by the provided rules. This paper reviews the ongoing debates regarding the positive and negative aspects of “plastics”, and their social and environmental impact; and different methods of plastic waste management adopted by different countries, with a special focus on the Indian scenario. Moreover, a discussion on possible solutions and the potential role of mass media in spreading awareness and generating responsibility, specifically among largely ignorant Indian citizens, has been provided.*

**Keywords:** *Mass Awareness, Negative Aspects, Plastics Pollution, Positive Aspects, Society*

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**1. Introduction:** Plastics represent one of the most common materials used in our everyday life, as well as, on a larger world scenario (Spokas, 2008). From common household commodities to big industries products, such as transportation vehicles, electronic goods, medical products and packaging involves utilization of plastics. Major advantages of plastics include low cost manufacturing, processability, durability and environmental stability of products, and extreme light weight. But ironically these positive attributes, resulting in ever-increasing usage of plastic products, have led to almost proportional increase in the generation of plastic wastes. Since, plastics are in general non-biodegradable, therefore, these huge amount of plastic wastes are posing serious threat to

the society, ecology and environment of this planet (Thompson et al., 2009). Although recycling and reuse of plastics is an option to deal with this huge burden of plastic wastes (Rubens, 1992); lack of proper mass education, as well as, failure of the policy-makers and the governments in formulating and implementing sound initiatives is preventing generation of mass awareness regarding this (McDonald and Ball, 1998). Another major problem to consider is that plastics are manufactured from fossil fuels, which are non-renewable and demands cautious use and preservation; yet nearly one-third of plastics used in packaging are discarded after a single use!

In this review, we have tried to portray the various negative aspects of plastics regarding which people should be made aware of, as well as, point out various probable and practical ways of managing plastic wastes, ranging from municipal to individual participation and awareness. Herein we have primarily focused on ways and approaches regarding spread of awareness among people with the help of mass media of all sorts, as well as, highlighted the major roles that the governments can play in this process. However, we have not overlooked the positive aspects of plastics as well. Overall, we have looked at the world’s scenario and then compared it with that of the developing countries, especially the situation prevailing in India, and have tried to find out the most practical solutions and methods these developing countries can implement in future in order to overcome this serious issue.

## **2. Negative aspects of plastic**

**2.1. Plastics in everyday household use:** Most of our daily use products are made of plastics (Fig. 1). These include food and beverage packing, electronics, building products, furnishing, vehicles, toys, medical devices and many other commodities. Most of the modern households receive municipality water via plastic pipes. Most families have non-stick cooking pan often made of Teflon – a soft polymer which can crack into tiny pieces and get mixed with food. Video games, computers, mp3 players and mobile phones are also made from variety of plastics.

At present, the major share of the world’s plastic demand is enjoyed by the thermoplastic type polymers, such as polypropylene (21%), low-density and linear low-density polyethylene (18%), polyvinyl chloride (17%) and high-density polyethylene (15%). These are followed by polystyrene and expandable polystyrene (8%), polyethylene terephthalate (7%, excluding PET fiber) and the thermosetting polyurethane (6%, figures for 2007, Plastics Europe MRG, 2008) (Lithner, 2011).

Polymers are long chain molecules consisting of repeated monomer units and are synthesized by polymerizing the monomers, which are in general derived from non-renewable crude oil. Worldwide, ~4% of the total oil produced gets utilized in the manufacture of raw materials for plastics (British Plastic Federation, 2011; Lithner, 2011). In addition to monomers, initiators, catalysts, and solvents (depending on the manufacturing process) are also used for the polymerization purpose. Furthermore, in transforming the resulting virgin polymer to a finished product with desired properties, it gets blended with a number of different additives, such as plasticizers, flame retardants, heat stabilizers,

antioxidants, light stabilizers, lubricants, acid scavengers, antimicrobial agents, antistatic agents, pigments, blowing agents and fillers. The large variety and diverse nature of the plastic polymers and the additives results in an extremely large variation in the chemical compositions of the different plastic products (Lithner, 2011; Rosato, 1998).

Since polymers are not particularly reactive and their large size limit transport across biological membranes, therefore, they are not generally considered as toxic (Lithner, 2011; Anastas et al., 2000). Nevertheless, polymeric materials often consist of non-polymeric components such as residual monomers, oligomers and other low molecular weight fragments, catalyst remnants, polymerization solvents, and a wide range of additives (Lithner, 2011; Crompton, 2007). Several of these constituents are hazardous to human health, as well as, the environment. For instance, they may be carcinogenic, mutagenic, toxic for reproduction, sensitizing and hazardous to life and environment, with long lasting effects. Since the non-polymeric compounds usually are of low molecular weight and are either weakly bound or not bound at all to the polymeric macromolecules, they or their degradation products can be emitted from the plastic commodity to air, water or other contact media (such as food) (Lithner, 2011; Crompton, 2007; Lau and Wong, 2000; Tsumura et al., 2001; Hammarling et al., 1998; Fantoni and Simoneau, 2003; Fankhauser-Noti and Grob, 2006; Tsumura et al., 2002).

Type and amount of exposure of consumers to chemicals released from a plastic material during use varies greatly, depending upon the nature of products they use. For instance, the exposure may come from indoor air, food, water or and skin contact; however in most cases, these individual exposures are not likely to be large enough to result in adverse effects. In practical, the actual/total exposure is the cumulative effect of individual exposures to a whole array of different plastic products and constituent mixture of chemicals that a consumer comes in contact with.

Humans have been detected with chemicals used in plastics (Lithner, 2011), such as phthalate plasticizers, bisphenol A (BPA) and brominated flame retardants (Crompton, 2007; Lau and Wong, 2000; Tsumura et al., 2001; Hammarling et al., 1998; Fantoni and Simoneau, 2003; Fankhauser-Noti and Grob, 2006; Tsumura et al., 2002; Koch and Calafat, 2009; Thomsen, 2010); and these substances have been demanding the primary focus of research on plastic-associated chemicals (Dutta et al., 2014). Some consumer categories are particularly sensitive to hazardous chemicals, for instance infants; and therefore, larger margins of safety are required for them. Baby feeding bottles made of polycarbonate have been banned in Canada (2008) and in the European Union (2011), because of the risk of BPA leaching from such bottle. BPA has been assigned category-1 based on evidence on human effects and high level of concern due to the risk of exposure, within the European Union strategy on endocrine disruption; and is subject to further evaluation for its potential endocrine disrupting properties (Lithner, 2011).

It has been found that most contamination of canned food is caused due to the presence of BPA as a manufacturing substance of the can. Canned vegetables, fish, meat, baby

formula and drinks have been found to contain various levels of BPA concentration during several conducted tests. Heating times and temperature have been detected as the main factors responsible for transportation of BPA into food (Kang et al., 2006). BPA is usually used as an additive in manufacturing plastic baby feeding bottles. These bottles frequently get subjected to hot conditions, such as during sterilization before use (either by placing the bottle in boiling water or by pouring extreme hot water inside the bottle) and also during the process of cleaning after use. This contact of the plastic bottles with extreme heat might result in emission of BPA, which in turn might directly enter a baby’s body with milk. Several studies have clearly indicated that daily use plastic products leach harmful toxics during their use. Especially, and most notably, it has been found that toxic leachates are mainly found in products intended for children like baby bottles, children’s handbags, floating rings, bathtub and squirt toys (Le et al., 2008; Cooper et al., 2011; Vandenberg et al., 2007; Nam et al., 2010).

**2.2. Plastics in general and marine environments:** Plastic wastes when not managed properly, treated as garbage and dumped indiscriminately pose a certain threat to the overall environment (Fig. 2). With the growth of population all over the world, plastic wastes too have increased tremendously. On the other hand, landfills have been overburdened and new sites are hard to find. Hence more and more plastics land on soil and water bodies, thus contaminating both of these resources. Carelessness on part of both the producers and the consumers results in such a menace. Control over plastic pollution seems to be an impossible and unachievable task at the present prevailing scenario.

Plastic marine debris has been a reason of concern for environmental scientists over the last few decades. Two major international conventions have addressed specifically against marine plastic litter “the International Convention for the Prevention of Pollution from Ships, 1973” and “the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters, 1972” commonly known as The London Convention with its 1996 protocol. However, although various surveys have been conducted to find out the harmful effects of plastic pollution on marine biota and animals, as well as, pollution of beaches due to plastic pellet spills, little have been done to prevent the nuisances.

Various birds, turtles, seals, sharks and sea lions get adversely effected by discarded plastics packets, fishing nets, packing loops, as well as, plastic pellets, and in some cases these turns up to be life threatening. One also cannot overlook the fact that discarded plastics on sea beaches and water proves to be an eye sore to the tourists, as well as, locals (Fig. 3). Hence aesthetic value, entanglement, ingestion, suffocation, ghost fishing and formation of an artificial sea floor (due to plastic sinking, which in turn might affect adversely the biota, as well as, reefs) can be summed up to be the harmful effects of plastic wastes on marine and related environments (Pruter, 1987; Laist, 1987; Derraik, 2002; Islam and Tanaka, 2004; Azzarello and Vleet, 1987; Moore, 2008; vom Saal et al., 2008; Yamamoto et al., 2001).

**2.3. Aesthetic value:** For any layman, the nuisance plastic wastes may cause is that which is visible to his eyes. This factor does attract a lot of attention of the media and the public. Plastics are persistent and might take a century long to degrade and break into microscopic pieces. Hence if steps are not taken, they keep on accumulating. Ironically, tourists might avoid such beaches which can negatively affect the economy of the area. So governments are bound to fund beach maintenance, as well as, form strict guidelines regarding waste handling by tourists and locals. Irresponsible plastic littering might cause drains to get clogged, which in turn could result in over flowing of drain water and in the monsoon could result in flooding streets.

**2.4. Human health and safety:** Marine debris can pose as a threat to swimmers, surfers and scuba divers. Medical wastes, such as broken glasses and sharps, can injure people. They can also transmit contagious diseases. Untreated sewage dumping into oceans can have personal hygiene debris which contaminates the water bodies with harmful viruses and bacteria.

**2.5. Entanglement and smothering of marine animals:** Animals such as sea turtles, sea lions, seals, sharks, dolphins and others get entangled into abandoned fishing nets, fishing lines, plastic bags, six pack rings, packing strapping bands, etc. These animals firstly get attracted to these plastic items and then get trapped into them and die. At times nets get entangled around the neck of these animals and they die of suffocation or fatal injuries or drownings. It has been reported that olive Ridley sea turtles which mass migrates to lay eggs in the Chilka lagoon coasts of Bay of Bengal often gets entangled in abandoned fishing nets and dies due to drowning (Sahu et al., 2013). Numerous reports of sunken marine debris are found as well, which results due to settling of sediments or other reasons (Fig. 4). This debris, in turn, forms a false floor in the ocean, adversely effecting water and marine plants in the long run.

**2.6. Ghost fishing:** It has often been reported that abandoned plastic nets in water, which remains intact for long periods, continue to trap fishes and animals (Matsuoka et al., 2005; Laist and Wray, 1995). This leads to lesser catch and the trapped fishes gets wasted. Such waste problems were reported regarding 'drift net' fisheries in the south pacific in 1980's. Ghost fishing is not restricted to surface or shallow water. Sea mount fisheries have developed around New Zealand and Tasmania.

**2.7. Ingestion:** Various animals and birds often mistake plastic wastes to be food and eats them, it results to suffocation or internal injury. Animals often eat plastic bags which get trapped in their mouth or organs as a result they stop eating and starve themselves to death (Fig. 5). It often affects their reproductive capacity, at times making them slow to avoid predation. Sea gulls and other birds often mistakes plastic pellets to be food and in turn suffers from internal injury. Sea turtles are severely affected by plastic debris especially by abandoned semi-floating plastic bags which are often mistaken to be jelly fish.

The Olive Ridely turtles during migration in the Bay of Bengal often ingest plastic litters and face serious health issues, which often lead to death. Sea turtles nesting in

beaches of Brazil, Costa dos Conqueiros and Bahia state face similar cases of entanglements and ingestions (do Sul et al., 2011). Over a 21-year period (1958-1979), observations were made of five prion species (*Pachyptila*) cast ashore on exposed beaches near Wellington (southern North Island). Gizzards and proventriculi were removed and examined. Harper and Fowler noted that the lightest birds carried the most pellets and concluded that the proportion of starved beach-cast prions suggested these birds would eat anything resembling food before they died (Harper and Fowler, 1987; Gregory, 2009). They also suggested that prions began ingesting plastic pellets by the early 1960s. Irregular but rapid increases in the percentages of plastic carried in three prion species was found to grow significantly (from <5% to 25%) between 1960 and 1977 (Harper and Fowler, 1987; Gregory, 2009).

**2.8. Habitat destruction and alien invasion:** Sea shores, coral reefs, islands and marine biota can be damaged by plastic marine debris. Discarded fishing nets, loops and fishing lines can destroy fragile aquatic inhabitants, corals and aquatic plants. Plastic debris often sinks into the ocean floor forming an artificial floor which does not let sunlight to penetrate, hence destroying plants lying underneath. On the other hand, it has often been found that floating plastic debris acts as home to entire communities of microbes, which get drifted to different places, and they in turn harm native organisms (Sheavly and Register, 2007).

**2.9. Spillage of plastic pellets:** Accumulation of virgin plastic pellets in different coastal regions also poses various problems. Pellets are initial stage of plastics which are to be transported to different manufacturing companies. Spillage of plastic pellets is mostly accidental. During transportation by ships pellet's containers might suffer leakage which causes pellets to be spilled into the ocean. Even trucks transporting pellets are found to leave behind trails of spills, which ultimately get washed in rain water and through the drainage system finally enter into the ocean. Various reports exist of pellets accumulation in coasts of Northern Gulf of Aquaba, Red sea, New Zealand, Australia, etc (Abu-Hilal and Al-Najjar, 2009; Gregory, 1978, 1991).

**3. Positive aspects of plastics:** The most popular notion among people concerned about environment is “plastics are bad”, “plastics must be banned from society”. But is that the right way to deal with the problem? If one stops and think logically one would realize that plastics are danger to the environment only when some person somewhere has been irresponsibly handling them. So basically the problem lies more with the society and the lack of awareness of properly handling plastics rather than with plastic as a material itself. One solution would be that respective governments take proper and practical initiative to spread awareness regarding the proper handling and proper disposing of plastics. Most importantly governments must set strict codes against the various substance used by the producers as additives during manufacturing so that health issues arising because of leaching of harmful toxics from various plastic products can be avoided. Instructing producers to take responsibility of their products even after use by the consumers is also important. Proper instructions regarding recycling and reusing could ease lots of problem.

Plastics have several positive aspects, such as (a) low manufacturing costs and long life, which in the developing countries enable affordability of plastic products; (b) food packaging all around the world depends on plastics, as it can be air tight and thus can prevent contamination; (c) light weight of plastics enables long distance transportation cost of plastic products affordable. For instance, glass bottles got replaced by PET bottles largely owing to these factors. Nowadays packed drinking water is much in vogue and use of plastic bottle packaging has provided people access to clean drinking water anytime anywhere; (d) medical products made out of plastics are worth mentioning; for example, syringes, blood bags, pipes and tubes, etc. have helped medical science in many aspects; (e) bioplastics, which are plastics found in nature, are naturally degradable; hence plastics made of renewable sources can be a solution to lot of problems in relations to plastics made out of fossil fuels; (f) biodegradable plastics are those which can be degraded by micro-organisms, further studies in this field is needed which one day would enable large scale treating of plastics by micro-organisms inside enclosed surroundings; and (g) quite recently it has been found out in India that plastic wastes in its molten state, paired with crumb rubber, can be safely deposited off in making pavements (Rokade, 2012). It decreases the cost of making pavements as well it is an excellent way of managing the waste plastic menace. A 25 km road was laid in Bangalore, India, as a test and it has been proven that the road is superior in its smoothness, uniformity and was crack resistant in comparison to plastic free roads. Adding the polymer modified bitumen has increased the road's moisture, as well as, heat resisting capacity. It is an economical way of managing waste plastics instead of dumping them into landfills or incinerate which would in turn emit toxics into environment; (h) a recent study has proven that hypothermia (extreme low temperature) in new born babies can be avoided by placing them in low density polyethylene bags right after their birth without the risk of causing hyperthermia. Hypothermia is a prevalent risk to new born babies in developing, as well as, developed countries. Hypothermia occurs in tropical climate as well (Gregory, 1991). A controlled trial was conducted at the tertiary University Teaching Hospital in Lusaka, Zambia. Pre-term and extremely low birth weight infants were placed in the plastic bags within ten minutes of birth, which resulted in the babies gaining normal body temperature within an hour. The study was approved by the institutional review boards of University of Alabama at Birmingham, Oregon Health and Science University and University Teaching Hospital in Lusaka, Zambia (Leadford et al., 2013). Plastic bags have been used for this purpose in the developed counties; however, it awaits introduction in the developing counties, where it can potentially serve as a low cost alternative to conventional methods.

**4. Plastic waste management:** Plastics wastes have been posing serious threats to the environment for many decades, but the present situation is more serious than ever before. Plastic production has undergone a tremendous boost over the last few decades, since plastics have become a necessity; thus resulting in an almost proportional increase in the generation of plastic wastes. The implementation of the three 'R's (reuse, reduce and recycle) were aimed to deal with the enormous plastic waste problem, but it never has the

desired effect. However, proper implementation and strict laws can bring a change in people's behavior and perspective.

Thermoplastics are the most used plastic type and it is mainly used in packing foods and other goods. Although most of it gets discarded after single use, they can be properly collected and recycled to form new products. It has been found that approximately over 67 million tons of plastic wastes get produced from discarded packaging in the European Union, which amounts to about one third of all municipal solid waste (Klingbeil, 2000; Song et al., 2009). In the United Kingdom, among the 10.4 million tons of packaging waste produced annually, 18% is plastic (DEFRA 2007). Most importantly discarded plastic wastes are the major cause of litter which during monsoon can block drains and cause flooding (Gregory, 2009; Song et al., 2009). Plastic wastes are persistent and they attract a lot of attention, plastic litter acts as an eye sore and it is difficult to manage, hence plastics are viewed as a major concern in solid waste management. The United States generates a total of 11 million tons of plastic wastes annually (EPA, 2003), which amounts to 11.1% of annual municipal solid waste (Siddique et al., 2008).

**4.1. Recycling:** Recycling of plastics is thought to be the most important solution in plastic waste management (Achilias et al., 2007; Dodbiba et al., 2008; Oku et al., 2000). But along with its usefulness there are various limitations. If one considers recycling rates of plastics around the world one finds that in comparison to the waste generated only a negligible part of it can get successfully recycled. Firstly, plastics have many different kinds of additives in them, so it is impossible to find uniformity in quality of plastic wastes. This causes a primary hindrance in waste plastic recycling. The first step in this case is to sort out plastics according to its category; however, it is a labor intensive job and the expense would be much higher than desirable. Secondly, most of municipality plastic wastes are unclean and contaminated; hence it proves to be a barrier in recycling. Moreover, some of the plastic wastes are found to have undergone various degree of degradation as well.

Unlike metals, plastics degrade after recycling; hence the term down-cycling is also used at times. In various instances it has been found that the logos and numbers emblazoned in the surface of plastic bottles and packets are confusing and not proper. The Seattle Times reported in 2007 that according to the United States Environmental Protection Agency, U.S recycles less than 6% of plastic wastes in comparison to 50% of paper, 37% of metals and 22% of glass recycling. According to the American Chemistry Council, among plastic wastes PET bottles have the highest recycling level i.e. 24%. According to Consumers Union, polyvinyl chloride, a plastic causing health concerns, has a recycling rate below 1% (Watson, 2007).

The environmental protection agency of the United States has made various studies regarding the content and quantity of municipal solid wastes, and has found out that among these plastics are the only materials which under certain conditions can be transformed from waste to energy. This can thus result in the most cost effective, as well as, an effective alternative to recycling huge quantities of plastic wastes (Lea, 1996).



PET, as a material, was originally exploited and patented by DuPont during their search for new fiber forming polymers (Sinha et al., 2010). PET also represents a type of plastic which gets extensively used in bottled drinks and water. PET is non-biodegradable and resistant to atmospheric degradation; hence it becomes difficult to manage the huge amount of PET wastes. Since most of PET gets used in manufacturing food or drinking container; hence single use discarding is done in 90% of cases. To recycle, PET also faces similar problems of collection and sorting. While the PET bottles can be recycled, the caps of the bottles are not made out of recyclable material. In most cases PET bottles collected from municipality solid wastes are contaminated by dirt or other pollutants; while on the other hand, most of the bottles undergo a certain level of degradation, making sorting and categorizing more difficult. However, PET can be recycled to procure energy through incineration. Most of PET, worldwide, is recycled to produce electricity or energy in any other form. In the United Kingdom and the United States, three quarter of collected PET items are used to manufacture fibers for carpets, apparel and bottles. Mechanical recycling and methanolysis are the two methods generally adopted for this purpose (Al-Salem et al., 2009). In Japan, a council for PET bottle recycling has been established in 1993, which promotes mechanical recycling of PET bottles in the municipalities of Tokyo (Council PET, 2005) (Al-Salem et al., 2009). The United States has a much lower level of collection rate of PET bottles in comparison to Europe. Germany, Italy, France, Spain and the United Kingdom have a very high rate of recollection of PET bottles; in 2009 the collection rate of these countries being around 68%. On the other hand, in 2009, Brazil had recollected around 262 tonnes of PET bottles with 55.6% of recollection rate (Associação Brasileira da Indústria do PET, ABIPET 2011); while in Japan in 2008, a total collection of 445 tons of PET bottles was reported, which rates around 77.9% (Japan 2011) (Welle, 2011).

**4.2. Incineration:** Incineration of plastic waste and energy recovery from the process is a favorable way. Incineration of municipal solid waste along with district heating system is quite common in northern Europe. In Sweden, a high level of material recycling (37%) and biological treatment (12%) is done. Household wastes (about 47%) are generally incinerated with waste-to-energy conversion, producing heat and energy. In many countries, wastes to energy consumption are mainly used to produce electricity; however, biogas, heat and power is also produced in many places (Sverige, 2008a, 2008b; Fjärrvärme, 2009).

Since gross calorific values (GCV) of most commodity plastics are comparable to or higher than that of coal (Eriksson and Finnveden, 2009; Davis and Song, 2006), therefore incineration with energy recovery is a prospective option (after removing all recyclable elements). For example, petrochemical carbon, already having a high value use, can result in a more eco-efficient option than burning the oil directly, when reused as a fuel in incineration (Song et al., 2009; Miller). It has been demonstrated from trials conducted by the British Plastics Federation (BPF, 1993) that modern waste-to-energy plants were capable of burning plastic wastes (including chlorinated plastics, such as PVC) without releasing dangerous or potentially dangerous emissions (Song et al., 2009).

**4.3. E-waste management:** E-waste, electronic waste or waste generated from electronic and electrical equipments, is a very fast growing problem to be dealt with (Fig. 6). With the advancement of technology in a fast pace, more and more electrical equipments are becoming obsolete and being discarded. It is estimated that in 2004, 315 million PC's became obsolete in the United States alone (Lakshmi and Nagan, 2011). E-wastes are composed of many harmful substances to environment and human being. On the other hand, it is profitable in managing e-wastes as valuable metals such as iron, gold, copper, etc. can be obtained, even though in lieu of great health cost. After metals, plastic dominates the composition of e-wastes. In 1991, Larry Summers, the then chief economist of world bank, stated that e-wastes could easily be exported from developed countries of the world to underdeveloped and developing countries in Africa, India or China without causing much nuisance owing to the fact that these underdeveloped countries have much land to spare for the dumping of such waste and they have more serious problems to deal with other than e-wastes. Since then these developing countries have found huge rising amounts of international and domestic wastes to deal with (Widmer et al., 2005; Nnorom and Osibanjo, 2008; Osibanjo and Nnorom, 2007).

Experimentation with e-wastes plastics have been done in India and it has been proved that no major changes occur in concrete with the implementation of e-plastics as a coarse aggregate and no compromise occur in the strength and the effectiveness of concrete. It also proved that e-plastics have much greater utilization benefit if used in this manner (Lakshmi and Nagan, 2011). With more awareness, this could be a very effective way of e-plastic management. Other than that reusing and recycling is recommended.

On May, 2012 Indian ministry of environment and forest has passed new e-waste handling rules; however, since then the implementation has been both effective, as well as, ineffective. Eventually though importing of e-wastes had been banned in India, but it has been finding its way into the country in an illegal way (Agarwal, 2012).

Extended producer responsibility is now thought to be an effective way of waste management. Organization for economic cooperation and development defined it as an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of the product's life cycle, including its final disposal (OECD, 2001) (Widmer et al., 2005). This shifts the responsibility of waste management away from the municipality and also the costs of treatment and disposal are included in the product's price. Legislators are increasingly adopting this method in various wastes management including e-wastes (Widmer et al., 2005).

**4.4. Medical waste management:** According to World Health Organization (WHO), medical wastes are wastes generated by health care activities, which includes a broad range of materials from huge needles and syringes to soiled dressings, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, medical devices and radioactive materials. Poor management of healthcare wastes potentially exposes healthcare workers, waste handlers, patients and the community at large to infection, toxic effects and injuries, and

risks polluting the environment. It is essential that all medical waste materials are segregated at the point of generation, appropriately treated and disposed off safely (WHO).

It has been found that medical wastes are defined differently by different nation; however in this paper we are concerned only about plastics in medical wastes. The amount of wastes in hospitals or clinics depends upon the approximate number of patients admitted or treated in a day. Everyday medical wastes (plastics) include: gloves, surgical goggles, medicine and injection vials, feeding tubes, drain tubes, fluid bottles, disposable syringe, plastic disposable aprons, disposable oxygen masks, blood bags, etc. Most of these are disposed following the regulation applied; improper disposition may lead to contamination. Most countries have different colored plastic bags in which certain category of medical wastes are to be disposed, then they are transported to the waste treatment sites situated either in the hospital perimeter or elsewhere. These wastes then get incinerated or decontaminated following different treatment procedures available.

The United States Environment Protection Agency has passed the regulatory “clean air act” revised in 1995, regarding incineration of medical wastes, as it often leads to harmful toxic emissions. In 1988 The Medical Waste Tracking Act was enacted.

In European countries, excepting Italy, classification and disposal of medical wastes is regulated by ordinances (Mühlich et al., 2003). The United Kingdom has strict regulatory act regarding medical waste handling and they fall under “health and safety legislation” as well as “hazardous waste regulation, 2004”.

Though most of the developing countries have successfully implemented regulation regarding medical wastes management, but still in some countries situation is grim. Lack of proper waste treatment facilities is a problem faced often in developing countries. Here careless disposal may lead to mass contamination of diseases, which get spread through soil, air, water, animals and rodents.

**5. Plastics: the Indian scenario:** India has the second largest population in the world. Presently India’s population have crossed a billion (2012 – World Bank, U. S. census bureau). Hence, it is expected that India has a vast consumer market for plastic, which results in similar amount of plastic wastes to be dealt with. The Central Pollution Control Board of India states that India produces approximately 6 million metric tons of waste annually and this amount has been increasing yearly. This has led, in recent years, in implementation of various rules regarding the production of environment friendly plastics, banning of certain plastic bags and products, as well as, rules regarding management of plastic wastes.

**5.1. Implementation of laws by the government:** The central government of India, along with the ministry of environment and forest, has passed the draft of rules in relation to the plastics (manufacture, usage and waste management) in 2009, and this gazette was made available to the public in the same year. These rules include definitions and clear statement of authorities responsible for waste management (as state pollution control boards regarding

states and pollution control committee regarding the union territories). It sets protocols for marketing and labeling of plastics, manufacturing, as well as, pricing of plastic bags made available to consumers by retailers, and most importantly rules to be followed regarding plastic waste management. There shall be state level advisory body formed by the state governments to look over proper implementation of the rules and all states and union territories are to submit annual report to the central pollution control board (the ministry of environment and forest notification, New Delhi, 4<sup>th</sup> Feb, 2011).

An annual report of year 2011-2012 was published by the central pollution control board on the implementation of plastic waste management in accordance to the above mentioned law passed in 2009. A standard procedure was formed following which the state pollution control bodies were to submit their report. 2011 was the first year when annual reports by several states were submitted to the central pollution control board, but the overall responses of the states have been unsatisfactory. Some states have provided incomplete results, whereas many states were unable to submit any report. Therefore, various doubts were reported, and hence, further clarifications were to be provided to the states. On the other hand, reports were received that in many states proper implementation of the rules were not carried out and indiscriminate sale of banned plastics were rampant (website material on plastic waste management, central pollution control board, Delhi, June, 2013).

**5.2. Water and land pollution:** India is the home to some of the most polluted rivers of the world, the mother of all being the Ganges. The Ganges or Ganga is the holiest river of the Hindus, and apart from that majority of the population depends on this river directly or indirectly. It is well-known that all of the generated sewages from household and industries get dumped in the river indiscriminately and in most of the cases they are untreated (Fig. 7). Plastic poses to be the latest threat to rivers or any fresh water source in the country. Plastic contaminates the water, spreading diseases and also threatens the life of animals, birds and fishes. Several reports can be found where domestic animals like cows have ingested plastics from open dumping sites. In November 2009, the government of India had declared Ganges as the national river and had set a “National Ganga River Basin Authority (NGRBA)” to look into the well-being of the river. This came in addition to the Ganga Action Plan, which is being carried out for decades. The exclusive work of these authorities is to make Ganga pollution free. The Uttar Pradesh government has banned selling of plastics around 2 km radius of Ganga in 2011, the ban is done in accordance to NGRBA. Strict implementation of this law is to be carried out (Verma, 2011).

Plastic littering is a major nuisance of the country. It leads to soil contamination, as well as, it chokes drain outlets, river beds, etc., ultimately leading to over-flowing and flooding of drain water during monsoon. Most of the landfills are home to municipal wastes beyond its capacity, where wastes are dumped without segregations of plastics or any other materials. Rag pickers roam around such places and collect plastics and papers from the dumping grounds and in the process get exposed to various contamination and dirt. Last year (2013), the Supreme Court of India, on receiving report from central pollution control

board, said steps should be taken in places where implementation of the laws regarding plastic waste management are not taking place and state governments are unable to submit annual reports. According to the central pollution control board, India generates 56 lakh tonnes of waste annually and among it 60% of wastes are collected and recycled but the rest (i.e. 6137 tonnes of waste) remain uncollected and pollute the environment. The Supreme Court had also said that indiscriminate dumping of city wastes in villages has to be stopped and laws are to be formed by the central pollution control board regarding the handling of wastes by the municipalities (Mahapatra, 2013).

**5.3. Plastic waste management:** For a developing country, India recycling nearly 45% of plastic wastes (ministry of environment and forest) is quite high. But the process of recycling are much back-dated, and the infrastructure of recycling plants does not always comply with the required standard. In India, municipality wastes are generally collected without segregation and they are dumped in open dumping grounds or landfills. This gets followed by manual segregation and sending to plants where recycling are done manually, due to the availability of cheap labor in the country. The recycled plastics then get cleaned, shredded, melted and finally made into new products. Each time these plastics undergo the process, the quality of the material degrades; hence it is more aptly known as “down-cycling”. So at times when recycled plastics are reused, virgin plastic is added to them in order to maintain certain quality of the finished product (Begum, *Plastics and environment*, Centre of Excellence in Environmental Economics, Madras School of Economics.).

Other than recycling and incineration, although incineration is avoided in India as it emits harmful toxins such as chlorinated dioxins and furans are emitted which might cause serious health issues (website material on plastic waste management, central pollution control board, Delhi, June, 2013), plastic wastes are used in laying pavements, as well as, manufacturing of energy, oil and mixed with concrete to achieve better results. Bitumen added roads are laid in Bangalore as a test which have proved that, bitumen (a substance acquired from waste polymers) when added to make pavements increases the road’s durability and longevity. Plastic wastes are often used in co-processing, i.e. the use of plastic waste as a substitute to fossil fuels. This is often used in factories requiring large source of energy and this process helps in reducing cost of manufacturing, as well as, in the preservation of non-renewable resources (website material on plastic waste management, central pollution control board, Delhi, June, 2013). Further plastic wastes are broken down in high temperature reactors into monomers, also known as de-polymerization, and in the process liquid RDF, gases and sludges are formed. These can be reused as economical fuels (website material on plastic waste management, central pollution control board, Delhi, June, 2013).

The ministry of environment and forest has laws regarding the thickness of plastic bags allowed. Generally no retailers are to provide plastic bags free of costs to the consumers; rather a price is fixed to be charged. This step has been adopted to encourage reusing of plastic bags (Ministry of Environment and Forest, Notification, New Delhi, Feb 14, 2011.).

However in most of the places, especially in the suburbs, one can find plastic bags being used in abundance during transactions.

All manufacturing and recycling factories of plastics are required to obtain valid registration to carry their work from respective state authorities, and they must follow rules passed by the ministry of environment and forest. All plastic items should have proper labeling, and this is mandatory. But the problem faced by common people lies in the fact that the labeling, most of the times, proves to be confusing, as clear instructions are not provided. People who are poor, illiterate or semi-illiterate (which comprises the majority of India's population) do not understand the relevance of the labeling. Thus, basic instructions of reuse, reduce and recycle do not reach to the teeming masses of the country.

**5.4. Medical waste management:** The ministry of environment and forest has passed rules regarding handling of biomedical wastes in 1998. Concern regarding medical wastes arose since plastics occupy a large portion of it. Generally in India medical wastes are dumped in different color-coded bins inside plastic bags, which are then collected by workers and then transported to treatment sites. Biomedical wastes are not to be mixed with any other types of wastes, and untreated wastes are to be transported to the treatment site only in vehicles allotted by the government. Biomedical wastes are to be properly labeled and then various methods are to be used for treating the wastes, like incineration; and while doing so standard procedures are to be maintained so that harmful toxin emission gets minimized. Other methods, such as autoclaving, microwaving and deep burial, are also used (Ministry of Environment and Forest, Notification, July 20, 1998).

But the above mentioned rules of the government are unable to properly handle the huge amount of medical wastes. Huge population of India leads to overcrowding of hospitals, especially the public funded ones; hence it becomes difficult to handle such huge amount of generated wastes. Lack of awareness is a big factor. Hardly any hospitals have trained workers who handle such wastes and hardly protective clothes are used while handling medical wastes by the workers; hence they become prone to contamination. Moreover, in some cases, color-coded segregation of medical wastes is not performed. The Ministry of Environment and Forest has revised the rules in 2011, keeping in view all the shortcomings, and it is now known as "biomedical waste (management and handling)".

**5.5. E-waste management:** It is a continuing trend of the developed countries to export e-wastes to developing countries for years. Out of 40 million metric tons of e-wastes produced globally each year, 13% of it gets recycled in developing countries (population reference bureau). Much of e-wastes of Europe and America are exported to India (Wooddell, 2008). Though the government of India, after notification by the ministry of environment and forest, has passed e-waste laws in May, 2012, little changes have taken place since then. According to a study made by "the associate chambers of commerce and industry of India" in co-ordination with another organization, over 95% of e-wastes generated by the country are handled by private dealers and most of the wastes are dismantled rather than recycled (Ghosal, 2013). But the major concern is that the children

are mainly involved in doing the job of dismantling, without proper precaution and without any knowledge of the harmful consequences to their health. “The associate chamber of commerce and industry of India” reported this year that approximately 4.5 lakh children are involved in activities related to e-wastes in the country. Leaving out the imports, India produces 12.5 lakh metric tons of e-waste each year (Ghosal, 2013). On the other hand, imports of e-wastes from other countries at present happen both legally and illegally. Availability of cheap labor is the primary factor behind this. Since many valuable substances can be recovered from e-wastes, it is mostly done manually by the labors in the back yards; hence, known as back yard recycling. Most of the private dealers provide no infrastructure or safe environment to handle such wastes. After the dismantling, the leftovers, which are toxic to health and environment, are dumped untreated. The other factor is disposing of e-wastes in most developed countries are costly hence they prefer exporting them in countries of Asia and Africa. A ban on importation of e-wastes was proposed, but it was cancelled due to some unknown reason by the government; and instead license was provided for further importation of e-wastes (Agarwal, 2012).

**5.6. Mass media: a tool to spread awareness of the plastic menace:** India has the second largest population in the world. Keeping in mind of the dangers plastic waste is posing to the country, finding out proper ways to deal with the problem is an absolute necessity. Strict legislation and implementation of laws by the government is the most effective way to deal with the problem. But the foremost thing to be kept in mind is that the general public should understand the impact that careless handling of plastic has on the environment and human health. Only through involvement and awareness people would abide by the laws. If people do not understand the relevance and reasons behind the laws, it would be hard for the government to force people behaving responsibly.

In the twenty first century media is the most easily available tool to spread awareness among common citizens. Various types of media being radio, television, print media (newspaper, magazines, books, leaflets, etc) and the most happening social media can be used as effective tools to spread awareness among the masses. Local municipalities could conduct surveys in respective areas as well.

India is proud of its diversity, nearly each state has its regional language. Although hindi is the official language (along with English), but a vast majority of Indian population doesn't understand these two languages. If television advertisements or short educative pieces could be telecasted in between popular programs in regional languages and newspaper articles highlighting these environmental issues could be published, it would be a very effective way to spread awareness.

Knowledge gap is an issue to deal with. Most people are unaware of recycling plants existing in the country; they are generally unaware to what happens to the plastic wastes once it is taken to the municipality dumpsites. Generally people has a misconception that plastic is bad, and it is difficult to recycle; but in reality it is no more difficult in recycling than paper or glass. If surveys are conducted through questionnaires consisting of simple

questions, an idea could be formed of the level of awareness of the common masses. Then government can work according to the findings. India has vast number of people who have minimum to no education; hence the best way to reach to them would be through television and radio. Radio programs are important ways of spreading awareness in rural regions.

Social media is the most happening thing presently, its popularity is huge, and it is the best possible tool to reach out especially among young people. This is the most easy and cost effective way of spreading awareness among people near and far, instantly. Facebook, twitter and so many more social networking sites and applications (apps) are hub of information and connectivity. Spreading awareness through these sites can add a little color to the otherwise serious issue of “plastic pollution”, and make it more attractive to the younger generation.

Government of India has made the labeling of all plastic mandatory, but the problem is that most people are not aware of the labeling and not sure what the labels mean. Proper explanation of the relevance of this is important. Until and unless people are made aware of ways of handling plastics properly, the present scenario of the country would not change.

The education system is another important way to spread awareness among children. In this regard, government can make environmental education mandatory. If relevant details regarding responsible use of plastics are taught to children from the very initial stages, then they will grow up with the habit of proper handling of plastics and would have the basic knowledge about the dos and do nots.

**6. Conclusions:** Keeping in mind that in the present world life without plastics is impossible, most importantly plastic products are affordable and are proving to be a boon to the economically backward class; hence, banning or taking any harsh step against plastics products is not the solution. Rather solution to deal with the ever-increasing plastic wastes can be found with the co-operation between the plastic industry, the government or legislation and most importantly by the involvement of common men for which spreading awareness is the foremost necessity. Science is trying to develop the quality of plastics, so that, it could be biodegradable, easily recyclable and less harmful to the environment.

We have found that most studies are done regarding marine plastic pollution, as sewages land into rivers, which finally drains into oceans. But equal importance should be given to freshwater and land pollution caused by plastics. India is home to some of the most polluted rivers of the world. The holy Ganges is choking in plastics, and thus causing adverse effect to marine animals, fishes, as well as, the large number of people who depend on the river for water source.

Discrimination between developed and underdeveloped countries, where underdeveloped countries are seen to be cheap dumping sites, has to be stopped. Governments, in such cases, have the most important role to play in banning the importations or exportations of such wastes. Developing countries, such as India, have less developed infrastructure to properly handle plastic wastes. Indian government must invest to the cause and make sure



that the concerned laws get implemented strictly. Educating the people and spreading awareness regarding proper handling of plastic wastes should be a top priority of the government.

Finally, few newspaper reports concerning the positive and negative aspects of plastics have been presented in Figs. 8 and 9.

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**Figures:**

**Figure-1:** Some commonly found household plastic commodities.



**Figure-2:** Uncontrolled and unregulated dumping of plastic wastes.



**Figure-3:** Discarded plastics on sea beaches and water – an eye sore to the tourists and locals.



Picture source: <http://cdn.coastalcare.org> and <http://static.guim.co.uk>

**Figure-4:** Settling of plastic wastes on sea floor.



Picture source: <http://coastalcare.org>

**Figure-5:** Cows feeding on plastic wastes.



**Figure-6:** E-wastes – a very fast growing problem to be dealt with.



**Picture source:** <http://prajyotmainkar.files.wordpress.com> and <http://images.nationalgeographic.com>



**Figure-7:** Dumping of plastic sewage in the Ganges.



**Figure-8:** Certain positive aspects of plastics recently reported in print media.

**Plastic waste as industrial fuel: New plan may hold garbage fix**  
Corpn, Voluntary Groups To Start Pilot Project in Zone 13 From October

**LONG WAY TO GO**  
An expert committee on Delhi, India, is determined to secure a 20% waste conversion by 2015 and will make the recycling and self-reliance to recycle.

**In tiger land, hosp made of bottles**  
Monotek Chakraborty  
Gosaba: Remote Gosaba — infamous for its village of women widowed by malaria — will now be on the global map for an entirely different reason. It will have Asia's first hospital built entirely of sand-filled plastic bottles and fishing nets instead of brick and iron rods.

**Bio-medical waste disposal success story offers hope**  
The success of the project in the disposal of bio-medical waste in the village of Gosaba, West Bengal, is a model for other villages in the state.

**Sponge-like plastic to soak up CO<sub>2</sub>, reduce pollution**  
London: Scientists have developed a sponge like plastic that soaks carbon dioxide (CO<sub>2</sub>) and might ease its transition from polluting fossil fuels towards new energy sources, such as hydrogen. The material — a relative of the plastics used in food containers — could play a role in cutting CO<sub>2</sub> emissions, and could also be integrated into power plant smokestacks in the future.

**Bottles cut building cost by 60%**  
The Bangalore's waste made of plastic bottles is now being used in construction.

**Don't litter, trade plastic for cash**  
Pollution Control Board Plans To Pay You For Handing Over Plastic Waste

**LINGERING DEVIL**  
The success of the project in the disposal of bio-medical waste in the village of Gosaba, West Bengal, is a model for other villages in the state.

Figure-9: Certain negative aspects of plastics recently reported in print media.

