International Journal of Applied Social Science *REVIEW PAPER*
Volume 5 (6), June (2018) : 822-834 ISSN : 2394-1405 (Print)
Received : 26.04.2018; Revised : 07.05.2018; Accepted : 22.05.2018

Enhancing/Improving sustainability of plastic packaging: Modern technologies

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ABSTRACT

Plastic packaging is both a boon to the environment and a challenge. It is lightweight, protects and preserves goods, and as a petroleum-based product, in the current global marketplace, it is cheap. Flexible plastics packaging offers new levels of convenience and freshness, especially in the food industry. Recycling of plastics is one of the foremost steps towards innovation and sustainability in the packaging industry. We know recycling is much better for the environment than committing used items forever to landfill. However, it is also important to know that there is often a limited number of times some materials can be recycled before they are unusable and have to go to landfill. Recycling is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products. Recycling can benefit your community, the economy and the environment (US EPA, 2017). Plastic has fibres a bit like paper, and as it is recycled, the fibres shorten each time. This means plastic can be recycled at least 7-9 times before it is no longer recyclable. A single plastic bottle recycling can conserve enough energy to light an 10W LED bulb for upto 36 hours. Answers to the litter problem will not be found in the increased use of one material such as degradable plastics, over another. The problem is instigated by the behaviour of people and not plastics products. The influence of degradable materials on the recycling of conventional plastics is a concern for recyclers (BPF Recycling Group, 2017). Biodegradable material is different from bio-based material. Plants can also be used to make non-biodegradable plastics (UNEP, 2015). It is projected that 8300 million metric tons (Mt) of virgin plastics have been produced to date. As of 2015, almost 6300 Mt of plastic waste had been generated, around 9% of which had been recycled, 12% was incinerated, and 79% was accumulated in landfills or the natural environment. If existing production and waste management trends continue, roughly 12,000 Mt of plastic waste will be in landfills or in the natural environment by 2050 (Geyer, 2017). It is really confusing for consumers to understand how to recycle plastics. For starters, there are these numbers 1 through 7 each with their own distinct chemical properties, uses, and recyclability. In addition, many manufacturers are including additives so as to color their packaging, resulting in low-grade plastics that cannot be recycled (Media Room, 2016). There appear to be different models in the industry for 'plastic to fuel' generation. The technology basically involves thermochemical depolymerisation, essentially breaking down plastic at 300-500 degrees Centigrade in the absence of oxygen to get the liquid fuel. Any solid residue in the final stage is much like carbon black which can be used in diverse ways. So it is a 'zero-discharge, zero-effluent' plant (Amarnath, 2017).

Key Words : Moderning technologies, Plastic packaging, Environment

How to cite this Article: Chitkara, Surbhi and Goel, Sushma (2018). Enhancing/Improving sustainability of plastic packaging: modern technologies. *Internat. J. Appl. Soc. Sci.,* **5** (6) : 822-834.

INTRODUCTION

These days plastics are the material of choice in packaging for the sectors such as FMCG, food and beverages, pharmaceuticals etc. In India, a large number of household products that are bought for daily use are packaged in plastics. Plastics are used mostly for packaging due to innovative visual appeal for customer attraction and convenience. Furthermore, they improve the hygiene quotient and shelf-life of the products especially in food and beverages segment.

The Indian packaging industry is estimated at over USD 32 Bn and offers employment to more than 10 lakh people across the country through 10,000 firms (Panchal and Karthikeyan, 2016).

Therefore, due to growing expertise in the packaging of F&B, medicinal, home and personal care and other heavy industrial products, plastic packaging segment is expected to capture high demand. The overall packaging industry in India has a massive growth potential and is expected to reach USD 73 Bn in FY 20. The features of plastics make them an ideal packaging material for all industrial or commercial uses. Globally, plastics comprise 42% of packaging with the combination of rigid and flexible plastics.

Packaging is classified mainly into two types *i.e.* Rigid Packaging and Flexible Packaging. As compared to rigid packaging, flexible packaging is one of the most dynamic and fastest growing markets in India. Flexible packaging expects a strong growth in the future. There has been increasing shift from traditional rigid packaging to flexible packaging due to numerous advantages offered by flexible packaging such as convenience in handling and disposal, savings in transportation costs etc. The packaging segment in India is a combination of both organized and unorganized players ranging from very small players with limited presence to big players with large market share. Demand for this segment is anticipated to grow rapidly across all the players. Also, there is an increasing focus on innovative and cost-effective packaging materials. Thus, the industry players are keeping in track with the changing trends in packaging and making efforts to capture the market with higher technology orientation.

Plastic Packaging Industry in India :

Packaging industry in India grew at a CAGR of 16% during the last five years and touched USD 32 Bn in FY 15. The Indian packaging industry constitutes 4% of the global packaging industry. The per capita packaging consumption in India is very low at 4.3 kgs, compared to developed countries like Germany and Taiwan where it is 42 kgs and 19 kgs respectively. However, in the coming years Indian packaging industry is predicted to grow at 18% p.a. wherein, the flexible packaging is expected to grow at 25% p.a. and rigid packaging to grow at 15% p.a.

Plastics can be used in flexible manner because of its extraordinary properties. Plastics can be made re-sealable, reusable, moulded into desirable shapes, innovatively designed etc. thus resulting in consumer-friendly packaging. This provides ease in handling, disposal, storage etc. Change in packaging trends is observed with the emergence of new products in flexible packaging such as vacuum pouch, high temperature retort pouch, stand-up pouch etc.

In India, large number of FMCG products consumed by the households are packaged in plastics. In 2014, more than 95% of the biscuits, dried processed food items and hair care products, and more than 85% of dairy products, baked goods, laundry and skin care, sold in India were packaged in plastic. Indian markets at present, are dominated by flexible plastics packaging. A gradual shift has been seen from rigid to flexible packaging, due to flexible packages being visually appealing, cheaper and durable.

Flexible packaging can be made either with monolayer or multilayer films of plastics. Multi-layered laminated sheets of plastics mainly include PE, PP, PET, and PVC. Polyethylene (PE) and polypropylene (PP) account for nearly 62% of polymer usage in the flexible packaging industry (Panchal and Karthikeyan, 2016).

Plastic Recycling in India :

Recycling of plastics is the primary step towards innovation and sustainability in the packaging industry. There are nearly 3500 organized and 4000 unorganized plastic recycling units in India. Most of the plastics (PE, PP, PVC, PET and PS) may perhaps be recycled via mechanical route, whereas, engineering plastics, such as PBT, SAN and Nylon, are recycled by selected recyclers.

In India, currently 3.6 Mn Tonnes of plastics is recycled per annum which provides employment to almost 1.6 million people (0.6 million directly, 1 million indirectly). In coming times, the awareness of consumers and support from government is likely to increase the recycling of plastics and increase the magnitude of plastic waste management (Panchal and Karthikeyan, 2016).

Drivers of the Packaging Industry :

The packaging industry is majorly driven by key factors like rising population, increase in income levels and changing lifestyles. Growth prospects of end-user segments are leading to rise in the demand of the plastic packaging industry. Demand from rural sector for packaged goods is being fuelled by the increasing media penetration through the means of internet and television.

India is emerging as the most ideal destination for organized retail in the world. Also, the presence of E-commerce is expanding rapidly and is bringing around a revolution in the retail industry. Increased use of digital retail channels is seen thereby enabling retailers to reach out to customers with less amount of money spent on real estate. Together, organized retail and boom in e-commerce offers huge potential for future growth of retailing in India which in turn is pushing the growth of packaging sector (Auckland Council, 2016).

Indian retail market has attracted and increased the existence of multinational companies. Rising income levels is likewise stimulating the growth of organised retail which therefore increases the demand for innovative and attractive packaging concepts (Panchal and Karthikeyan, 2016).

Recycling Plastic Packaging :

Plastic is one of the most popular and important materials used in the modern world. However, its popularity is part of the massive problem and reason why plastics should be recycled. Instead of throwing them away, polluting the land and water bodies, we can optimize the lifespan of plastics by recycling and reusing them.

Plastic recycling refers to the process of recovering waste or scrap plastic and reprocessing it into useful product. Due to the fact that plastic is non-biodegradable, it is essential that it is recycled as part of the global efforts to reducing plastic and other solid waste in the environment (Rinkesh, 2015).

Recycling targets are set on the basis of tonnes, and plastic is a very light material. Some councils prefer to collect heavier waste than plastic packaging. However, the number of councils offering the collection of various recyclables has been increasing steadily. Recycled plastic packaging are used to manufacture a wide variety of new products. These are used to create all sorts of items, such as packaging, bags and complements, car components, furniture, building materials, paint pots and even kerbstones (Rinkesh, 2015).

The vast majority of monomers used to make plastics, such as ethylene and propylene, are derived from fossil hydrocarbons. None of the commonly used plastics are biodegradable. As a result, they accumulate, rather than decompose, in landfills or the natural environment. The only way to permanently eliminate plastic waste is by destructive thermal treatment, such as combustion or pyrolysis. Thus, near-permanent contamination of the natural environment with plastic waste is a growing concern. Plastic debris has been found in all major ocean basins (Barnes, 2009).

Largest market of plastic is packaging, an application whose growth was accelerated by a global shift from reusable to single-use containers. As a result, the share of plastics in municipal solid waste (by mass) increased from less than 1% in 1960 to more than 10% by 2005 in middle and high-income countries (Geyer *et al*., 2017). At the same time, global solid waste generation, which is strongly correlated with gross national income per capita, has grown steadily over the past five decades (Wilson, 2015).

Global production of resins and fibers increased from 2 Mt in 1950 to 380 Mt in 2015 (Plastics Europe, 2006). Today, China alone accounts for 28% of global resin and 68% of global PP&A fiber production (Plastics Europe, 2016). Bio-based or biodegradable plastics currently have a global production capacity of only 4 Mt and are thus not considered in calculations (European Bioplastics, 2017).

On average, we find that non-fiber plastics contain 93% polymer resin and 7% additives by mass. When including additives in the calculation, the amount of non-fiber plastics (defined as resins plus additives) manufactured since 1950 increases to 7300 Mt. PP&A fibers add another 1000 Mt. The largest groups in total non-fiber plastics production are PE (36%), PP (21%), and PVC (12%), followed by PET, PUR, and PS (<10% each). Polyester, most of which is PET, accounts for 70% of all PP&A fiber production. Together, these seven groups account for 92% of all plastics ever made.

Packaging is the major plastics consuming sector, followed by consumer products and the construction industry (Mutha *et al*., 2006). Approximately 42% of all non-fiber plastics have been used for packaging, which is predominantly composed of PE, PP, and PET. The building and construction sector, which has used 69% of all PVC, is the next largest consuming sector, using 19% of all non-fiber plastics (Geyer *et al*., 2017).

Most of the packaging plastics leave use the same year they are produced, whereas construction plastics leaving use were produced decades earlier, when production quantities were much lower. For example, in 2015, 42% of primary non-fiber plastics produced (146 Mt) entered use as packaging and 19% (65 Mt) as construction, whereas non-fiber plastic waste leaving use was 54% packaging (141 Mt) and only 5% construction (12 Mt). Similarly, in 2015, PVC accounted for 11% of non-fiber plastics production (38 Mt) and only 6% of non-fiber plastic waste generation (16 Mt) (Geyer *et al*., 2017). By the end of 2015, all plastic waste ever generated from primary plastics had reached 5800 Mt, 700 Mt of which were PP&A fibers (Mutha *et al*., 2006).

There are essentially three different options for plastic waste:

First, it can be recycled or reprocessed into a secondary material. Recycling delays, rather than avoids, final disposal. It reduces future plastic waste generation only if it displaces primary plastic production. However, because of its counter factual nature, this displacement is extremely difficult to establish. Furthermore, contamination and the mixing of polymer types generate secondary plastics of limited or low technical and economic value.

Second, plastics can be destroyed thermally. Although there are emerging technologies, such as pyrolysis, which extracts fuel from plastic waste, to date, virtually all thermal destruction has been by incineration, with or without energy recovery. The environmental and health impacts of waste incinerators strongly depend on emission control technology, as well as incinerator design and operation.

Finally, plastics can be discarded and either contained in a managed system, such as sanitary landfills, or left uncontained in open dumps or in the natural environment (Mutha *et al*., 2006).

The Indian recycling industry belongs to the so-called 'informal sector' which, according to the International Labour Organisation (ILO) definition, comprises production units which typically operate at a low level of organization. Most of these recycling units have very low fixed capital (for machinery, etc.) and are generally run as small family businesses. Informal enterprises are usually not registered and thus evade rules and regulations, e.g. tax laws, minimum wage laws, accounting and workplace safety (Vishwanath, 2001).

Process of Plastic Recycling :

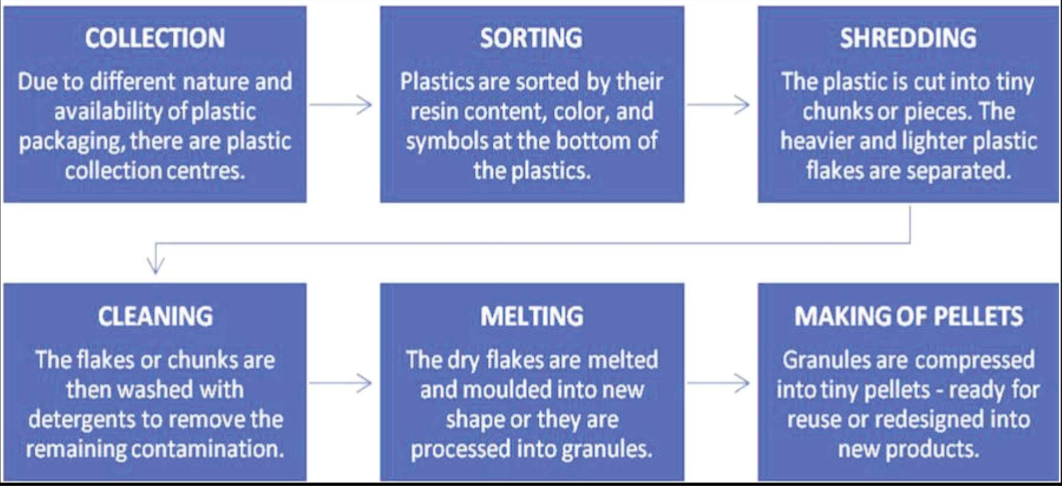

Fig. 1 : Plastic Recycling Process

Advantages of Recycling Plastics :

Provision of a Sustainable Source of Raw Materials :

Recycling plastics provides a sustainable source of raw materials to the manufacturing industry. Once the plastics are recycled, they are sent to manufacturing industries to be redesigned and converted into new shapes and used in different appliances.

Reduces Environmental Problems :

Since majority of plastics are non-biodegradable, they pose a high risk to the people and the environment. They can block sewer lines, drainages and other waterways leading to blockages and unwanted pileups. Also, when compared with the processes of producing virgin resins, recycling processes produce less carbon dioxide.

Reduces Landfill Problems :

The best method of waste management is waste prevention. Recycling plastics minimizes the amount of plastic being taken to the ever-diminishing landfill sites. Instead of misusing the land for garbage disposal, it can be used for human settlement, agriculture or other important economic activities.

Consumes Less Energy :

Recycling plastics requires less energy as compared to making the plastic from scratch. This saves energy and that energy can be diverted to other important things in the economy. The process of manufacturing plastic using natural raw materials is expensive and time consuming compared to the recycling process.

Encourages a Sustainable Lifestyle among People :

Recycling can be an opportunity to create local jobs in collection, sorting, communications, administration and reprocessing. The reprocessing can be undertaken locally, regionally or beyond, and thus boosting the living standards of people.

Any sort of effort aimed at saving the environment is therefore significant. In order to keep our environment clean, reduce landfills, provide a sustainable supply of plastics to manufacturers, it is important to recycle plastics (Hannequart, 2004, Rinkesh, 2015 and BPF Recycling Group, 2017).

Identifying Plastics :

To identify plastic packaging materials, the BPF recommends the use of a coding system devised by the American Society of the Plastics Industry (SPI).

The well-recognized 'chasing arrows' symbol we see on plastic containers and products does not mean the product is recyclable. The little number inside the triangle tells the real story.

Within each chasing arrows triangle, there is a number which ranges from one to seven. The purpose of the number is to identify the type of plastic used for the product, and not all plastics are recyclable or even reusable. There are numerous plastic-based products that cannot break down and cannot be recycled.

Understanding the seven plastic codes will make it easier to choose plastics and to know which plastics to recycle. For example, water bottles that display a three or a five cannot be recycled in most jurisdictions in the US. A three indicates that the water bottle has been made from polyvinyl chloride, a five means that it's been made of polypropylene, two materials that are not accepted by most public recycling centres (Eartheasy, 2012).

Table 1 : Resin identification codes

SPI Resin Identification Code	1	2	3	4	5	6	7
Type of Resin Content	PET	HDPE	PVC	LDPE	PP	PS	Other

Here are the seven standard classifications for plastics, and the recycling and reuse information for each type:

PET (Polyethylene Terephthalate) :

PET is one of the most commonly used plastics in consumer products, and thus readily available recyclable material at this time. It is intended for single use applications. PET plastic is difficult to decontaminate, and proper cleaning requires harmful chemicals.

PET is most commonly used for one and two litre clear soda bottles, as well as some bottles containing liquor, liquid cleaners, detergents, and antacids. The used plastic is crushed and then shredded into small flakes which are then reprocessed to make new PET bottles or spun into polyester fiber. This recycled fiber is used to make textiles such as fleece garments, carpets, stuffing for pillows and life jackets, and similar products. Products made of #1 (PET) plastic should be recycled but not reused.

HDPE (High-Density Polyethylene) :

HDPE is the most commonly recycled plastic and is considered one of the safest forms of plastic. It is used to make milk and juice bottles, water jugs, base cups for some plastic soda bottles, as well as bottles for laundry detergent, fabric softener, lotion, motor oil, and antifreeze.

HDPE plastic is very hard-wearing and does not break down under exposure to sunlight or extremes of heating or freezing. For this reason, HDPE is used to make picnic tables, waste bins, park benches, bed liners for trucks and other products which require durability and weather-resistance. Products made of HDPE are reusable and recyclable.

PVC (Polyvinyl Chloride) :

PVC is a soft, flexible plastic used to make clear plastic food wrapping, cooking oil bottles, teething rings, children's and pet's toys, and blister packaging for numerous consumer products. It is commonly used as the sheathing material for computer cables, and to make plastic pipes and parts for plumbing. Because PVC is relatively impervious to sunlight and weather, it is used to make window frames, garden hoses, raised beds and fences.

PVC is named the 'poison plastic' because it contains numerous toxins which it can leach throughout its entire life cycle. It should not be reused for applications with food or for children's use.

LDPE (Low-Density Polyethylene) :

LDPE is often found in shrink wraps, dry cleaner garment bags, squeezable bottles, and the type of plastic bags used to package bread. The plastic grocery bags used in most stores today are made using LDPE plastic. LDPE is considered less toxic than other plastics, and relatively safe for use. It is currently being recycled by some of the major retail. When recycled, LDPE plastic is used for plastic lumber, landscaping boards, garbage can liners and floor tiles. Products made using recycled LDPE are not as hard or rigid as those made using recycled HDPE plastic. Products made using LDPE plastic are reusable, but not always recyclable.

PP (Polypropylene) :

Polypropylene plastic is tough, light weight and has excellent heat-resistance qualities. It serves as a barrier against moisture, grease and chemicals. The thin plastic liner seen in a cereal box is polypropylene. PP is also commonly used for disposable diapers, plastic bottle tops, margarine and yogurt containers, potato chip bags, straws, packing tape and rope.

Recycled PP is used to make battery cases, brooms, bins and trays. #5 plastic is today becoming more accepted by recyclers. PP is considered safe for reuse.

PS (Polystyrene) :

Polystyrene is an inexpensive, lightweight and easily-formed plastic with a wide variety of uses. It is most often used to make disposable styrofoam drinking cups, take-out 'clamshell' food containers, egg cartons, plastic picnic cutlery, foam packaging and so on. Recycling is not widely available for polystyrene products. Most collection services will not accept polystyrene, which is why this material accounts for about 35% of US landfill material. While the technology for recycling polystyrene is available, the market for recycling is small. However, awareness among consumers has grown and polystyrene is being reused more often.

Other (BPA, Polycarbonate and LEXAN) :

Number 7 plastics are used to make baby bottles, sippy cups, water cooler bottles and car parts. BPA is found in polycarbonate plastic food containers often marked on the bottom with the letters 'PC' by the recycling label #7. Some polycarbonate water bottles are marketed as 'non-leaching' for minimizing plastic taste or odor, however there is still a possibility that trace amounts of BPA will migrate from these containers, particularly if used to heat liquids.

A new generation of compostable plastics, made from bio-based polymers like corn starch, is being developed to replace polycarbonates. These are also included in category #7, which can be confusing to the consumer. These compostable plastics have the initials 'PLA' on the bottom near the recycling symbol.

The plastics industry has conformed to regulations by applying the required codes to consumer products, but it is up to individuals to read and understand the codes. By understanding these simple classifications, we can best use plastics to our advantage while minimizing the health and disposal issues that may otherwise arise (Holmes, 2017).

Toxicity and Health Hazards of Different Plastics :

The possibility of hazards from new polymers and modifications to old products has been increasing with the expansion of the plastics industry. Plastics pose a great risk to the environment. The most toxic plastics are #7, #3 and #6, while those that may be somewhat safer include #1, #2, #4 and #5.

The exact detailed chemical composition of plastic materials is known only from information provided by manufacturers. A declaration of conformity according to EC regulation no. 10/2011 is required to ensure the safety of plastic materials in contact with foodstuffs. This regulation established a positive list of monomers and additives which are authorized for use in plastic materials. Some substances are subject to restrictions and/or specifications according to their toxicological data.

PET :

PET is considered safe, however, Non-Intentionally Added Substances (NIAS) not listed in the regulation such as breakdown products from monomers and additives and/or impurities found in initial polymerization reactants may be present in a PET bottle wall. It can actually leach the toxic metal antimony, which is used during its manufacture.

Shotyk *et al*. (2006) found unambiguous evidence of Sb (Antimony) leaching from PET containers by studying 63 brands of bottled water coming from Canada and Europe. Comparisons with analyses of the pristine groundwater and the same water available in glass bottles, in which there is no antimony, have confirmed that water is polluted by PET containers. It also found that the longer a bottle of water sits on a shelf, in a grocery store or your refrigerator - the greater the dose of antimony present. It is believed that the amount of antimony leeching from these PET bottles differs based on exposure to sunlight, higher temperatures, and varying pH levels.

Brominated compounds have also been found to leach into PET bottles. Bromine is known to act as a central nervous system depressant and can trigger a number of psychological symptoms such as acute paranoia and other psychotic symptoms.

HDPE :

HDPE, which is considered a low-hazard plastic, has been found to release estrogenic chemicals. The study by Yang *et al*., entitled "Most Plastic Products Release Estrogenic Chemicals: A Potential Health Problem That Can Be Solved," found that BPA-free products often contain other chemicals that have estrogenic activity (EA). Almost 95 per cent of all plastic products tested were positive for estrogenic activity, meaning they can potentially disrupt your hormones and even alter the structure of human cells, posing risks to infants and children. In this particular study, even products that claimed to be free of the common plastic toxicant bisphenol-A (BPA) still tested positive for other estrogenic chemicals.

PVC :

PVC plastic contains toxic chemicals including DEHP *i.e.,* di(2-ethylhexyl) phthalate), a type of phthalate used as a plastics softener. Of the world production of additives, PVC alone accounts for 73% by volume, PP and PE account for 10%, and styrenes account for 5%. Many additives including Phthalate plasticizers used to make PVC flexible, and lead heat stabilizers used to prevent degradation of PVC during processing are hazardous for human health and the environment. Soft and flexible plastic flooring, such as vinyl or padded play-mat floors for kids, might be made from toxic PVC.

LDPE :

LDPE is another plastic that is considered a low hazard as it does not contain BPA, it may pose risks of leaching estrogenic chemicals, similar to HDPE.

PP :

PP is said to have a high heat tolerance making it unlikely to leach chemicals, at least one study found that PP plastic ware used for laboratory studies did leach at least two chemicals.

PS :

Polystyrene is structurally weak and ultra-lightweight, it breaks up easily and is dispersed readily throughout the natural environment. Chemicals present in polystyrene have been linked with human health like damaging nervous system, causing reproductive system dysfunction and cancer. Temperature has been found to play a role in how much styrene leaches from polystyrene containers, which means using them for hot foods and beverages (such as hot coffee in a polystyrene cup) may be worst of all.

Others :

It's difficult to know for sure what types of toxins may be in #7 plastics, but there's a good chance it often contains BPA or the new, equally concerning chemical on the block in the bisphenol class known as Bisphenol-S (BPS).BPA and BPS are endocrine disrupters, which means they mimic or interfere with your body's hormones and disrupts your endocrine system (Murphy, 2001, Yang *et al*., 2011 and Lithner, 2011)

Waste to Energy: Producing Fuel out of Plastic Waste :

This technology does not need plastic waste to be sorted, washed or cleaned. High quality crude polymer oil (hydrocarbon mixture) can be extracted out of any kind of plastic waste. Most of the post-consumer waste plastic ends up in the landfill. Plastic waste bought at Rs. 10/kg can deliver Rs. 40-50/kg worth of fuel. This fuel is sold at refinery prices for traditionally sourced fossil fuels, hence there is complete uniformity between this hydrocarbon oil and traditional fuel products (Merchant, 2014).

There appear to be different models in the industry for 'plastic to fuel' generation. Most of the plastic to energy technology use catalysts and some rare chemicals to convert plastics in fuels (Tandon, 2014). The technology basically involves thermochemical depolymerisation – essentially breaking down plastic at 300-500 degrees Centigrade in the absence of oxygen to get the liquid fuel. Some gases generated during this process are reused for heating. Any solid residue in the final stage is much like carbon black which can be used in diverse ways. So it is a 'zero-discharge, zero-effluent' plant (Amarnath, 2017).

The proposed plant by Paterson Energy in Mathura, plans to generate about 2,500 litres of oil per day with the average price estimated at about Rs. 40 per litre. The primary objective of a plastic fuel plant is waste management. There are many industries which generate lot of plastic waste. For instance, Sriperumbudur belt, a major automobile hub near Chennai, generates about 70-80 tonnes of plastic waste daily. Paper mills using recycled paper as raw material generate huge plastic waste from multi-layered and coated paper. A 300 tonne/day de-inking plant that converts used paper to paper pulp will generate about 15-20 tonnes of waste plastic (Venkatesh, 2017).

When plastic is converted into fuel, it is not necessary to remove some of the impurities like resins and dirt. Because this process is not done on polymer to polymer basis. Thus, largely eliminating the need for cost-intensive, environmentally polluting pre-processing that characterizes traditional plastics recycling. Also, the rate for recycling in India is really high. The rag-pickers end to focus on the collection of waste containers that are heavy and not the other forms of plastic waste. Collecting 10 kg of plastic waste is time consuming and thus most of the lighter plastic waste is not picked up.

In India, municipalities need to develop controlled waste stream, which they can own and work with private sector partners to process. The only barrier to growth is ensuring a predictable access to supply of plastic waste (Tandon, 2014). The government needs to invest and own the plastic refuse because it is the primary beneficiary (Merchant, 2014).

Degradation of Plastics :

Plastic degradability is another area of growing concern in waste-management terms. The plastic polymers can be degraded in the environment by four mechanisms: photo degradation, thermo-oxidative degradation, hydrolytic degradation, and biodegradation by microorganisms.

The natural degradation of plastic begins with photo degradation due to the UV light from the sun which provides the activation energy required to initiate the incorporation of oxygen atoms into the polymer, leading to thermo-oxidative degradation. In this step, the plastic becomes brittle and breaks into smaller pieces until the polymer chains attain adequately low molecular weight to be metabolized by microorganisms. The microorganisms convert the carbon of the polymer chains to carbon dioxide or incorporate it into biomolecules, but this process will take at least 50 years (Grigore, 2017). Also, most plastic polymer types are resistant to biodegradation, i.e. degradation by microorganisms. Two such polymers are polyethylene and polypropylene, which are extremely resistant to biodegradation (Nicholson, 2006). According to Andrady (1998), In a polyethylene polymer only 0.1% of the carbon will be transformed into CO_2 per year by biodegradation under ideal laboratory exposure conditions. There are a few biodegradable plastics which have a limited, but growing share in the existing plastic market. However, not all of these are completely biodegradable in the natural environment (Lithner, 2011).

Biodegradable and Degradable Plastics :

Degradable plastics including biodegradable ones are commercially available and are used in the packaging of fruits and vegetables. Solutions to the litter problem will not be found in the increased use of one material such as degradable plastics, over another. The problem is caused by the behaviour of people and not plastics products. The impact of degradable materials on the recycling of conventional plastics is a concern for recyclers. Even a perceived risk of recycled material containing biodegradable/degradable material can prevent its use especially in long term applications (BPF Recycling Group, 2017).

Why don't we use more compostable or biodegradable material? :

Biodegradable plastics are blends of petroleum-based polymer resins and renewable sourced resins. Biodegradable plastics have some additives added to them to enhance the degradation process and usually degrade in 10 to 15 years. These require composting and waste management facilities. The Indian bioplastics industry has a long way to go in terms of production, raw materials, and technology (Frost and Sullivan, 2009).

Today, commercial biodegradable plastics are offered on the market by an increasing number of manufacturers. Those most common materials can be classified into the following groups:

- Starch-based plastics
- Polylactide-based plastics (PLA)
- Polyhydroxy alkanoate-based plastics (PHB, PHBV)
- Aliphatic-aromatic-polyester-based plastics
- Cellulose-based plastics (cellophane)
- Lignin-based plastics

Apart from the polymers, plastics contain other materials or additives and this combination determines their processing options and the product's final properties. These other materials include stabilization additives, lubricants, pigments, different fillers, and others. For biodegradable plastics, it is very important that all additional components are biodegradable as well. The standards for compostable plastics require the testing of all additives (e.g. inks and colors) to ensure they do not have a negative effect on the compost (Krzan, 2012).

Good environmental practice requires us to use the least material, then to reuse or recycle by recovering material/energy from the products after they are used. However, if compostable or biodegradable materials get into the recycling stream, this can have detrimental effects, rendering the recyclate unusable. For this reason, where compostable material is used, it is important that this risk is recognised and managed (Rinkesh, 2015).

List of Abbreviations :

ASTM: American Society for Testing and Materials
BPF: British Plastics Federation
CAGR: Compound Annual Growth Rate
EPA: Environmental Protection Agency

F & B: Food and Beverages
FICCI: Federation of Indian Chambers of Commerce and Industry
FMCG: Fast Moving Consumer Goods
ILO: International Labour Organisation
PPA: Polyphthalamide
SPI: Society of the Plastics Industry
UNEP: United Nations Environment Programme

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