

Utilization of Plastic Waste in Different Forms: A Review

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Abstract:

The Plastic waste has been increased at very fast rate in last few years with the growth of industry. Plastic was originally thought to be a supporter of development but has eventually become the major roadblock. The increased pace of life brought with itself an equal demand for quick commodities. This increase in demand increased the net requirement for plastic and an equivalent amount of waste. Plastic is non-biodegradable and hence comes out to be a big contributor of environmental degradation. This paper discusses about the current situation of plastic in India and concludes with a process to handle plastic waste and further work to reduce the overall burden on the economy.

Keywords —Plastic, Economy, Environmental Degradation, Management of Waste, Pollution

I. INTRODUCTION

In a very short time frame plastic has replaced a large amount of household goods. Along with this change a hidden aspect of “Plastic Pollution” also came into the big picture. The milk containers have been replaced by milk bags, furniture has been replaced by plastic table and chair sets, plastic soft drink bottles and many others have contributed to the ease of life but have also added an equivalent amount of plastic pollution. The major print media network Hindustan Times published an article [1] citing about approximately 11 metric tonnes of plastic being washed offshore a Mumbai beach in yester years. This amount of waste is in itself a reason to find ways to minimise and reduce plastic in India. Plastic pollution proceeds at a slow rate without any sense of smell or sound. The effects of plastic are more lethal than were expected when it was originally discovered.

In the last decade knowingly or unknowingly mankind has added a large amount of plastic in the environment. This untreated plastic has found its way in the soil, water and air when burnt. In many

rural areas, where washing clothes by the river is a regular activity, adds about seven thousand miniscule particles of plastic [2] which if ingested by the aquatic life may result in a leaching of a large amount of chemicals in the biological chain. The following segment highlights the effects of plastic on humans.

It is evident from the previous segments that plastic has many valuable uses however along with it we have become addicted to single use or disposable plastic. These plastics as discussed have severe environmental consequences if not treated well. Plastic waste has become so prominent in our sphere that some scientists suggest it to be used as a geological indicator of the current era in the times to come. Apart from this, there are some other worrying figures. In the recent past, plastic production has increased a lot faster than other materials. A large amount of plastic is derived from chemicals derived from oil, natural gas and coal, which are dirty, non-renewable resources. If the rate at which plastic is produced continues to increase, the plastic industry would account for 20% of the world’s total oil consumption by 2050. It is true, we

need to reduce the production of plastic, but there also exists an utter need to improve the way existing plastic is managed. The plastic bags clog sewers and provide breeding grounds for mosquitoes and pests increase the transmission of vector-borne diseases like malaria among others. The study takes into consideration the fact that plastic has now started to affect the local citizens and thus tends to convert the waste plastic into synthetic paper by segregating and extruding with enhanced fillers. The work that is concealed in the chapters to follow tends to make a synthetic paper by using waste plastic and then tests its properties to check its suitability and feasibility for print ready applications.

II. PLASTIC TYPE & SEGREGATION

Plastics or Polymers as they are commonly referred are divided into two distinct groups:

- **Thermoplastics:** The type of plastic that can be re-moulded and

- **Thermosets/Thermosetting:** The type of plastics that once hardened cannot be moulded repeatedly.

The underlying are a few commonly used plastics along with their properties.

- **Polyethylene-terephthalate (PET or PETE):** Used in soft drink, juice, water, beer, mouthwash, peanut butter, salad dressing, detergent, and cleaner containers. It is a hard, stiff, strong, dimensionally stable material that absorbs very little water. It has good gas barrier properties and good chemical resistance except to strong alkalis (which hydrolyse it).

- **Di-2-ethylhexyl phthalate (DEHP):** DEHP is a colourless oily liquid that is soluble in fat and not soluble in water. It is not volatile so does not vaporise readily into the atmosphere. It is an endocrine disruptor that mimics the female hormone oestrogens. It has been strongly linked to asthma and allergies in children. It may cause certain types of cancer and it has been linked to negative effects on the liver, kidney, bone formation, and body weight. In India and internationally, DEHP has been banned since 1999 from use in plastic toys

and is unsafe for children under the age of three. Note: Internationally, DEHP, BBzP, and other dangerous phthalates have been banned from use in plastic toys since 1999. In India however, a complete ban was seen since 2018. A phthalate declaration is required when producing and using the same to comply that no phthalate is part of the product or process.

- **High-density-polyethylene (HDPE):** HDPE is used in opaque containers used for storing milk, water, juice, bleach, detergent and shampoo. In some cases garbage bags, yogurt and margarine tubs and cereal box liners may also be made of HDPE. Considered a safer plastic till now, researches about the risks associated with this type of plastic are still under process.

- **Low-density polyethylene (LDPE):** LDPE is used in grocery store, dry cleaning, bread and frozen food bags, most plastic wraps, and squeezable bottles (honey, mustard). It doesn't have negative effects on the human life cycle but research about the risks associated with this type of plastic is in progress.

- **Polyvinylchloride (V or Vinyl or PVC):** PVC can be seen in toys, clear food and non-food packaging (e.g., cling wrap), some squeeze bottles, medical tubing, and numerous construction products (e.g., pipes, siding). PVC has been described as one of the most hazardous consumer products ever created. It is used for softening of di-(2-ethylhexyl)-phthalate (DEHP) or butyl benzyl phthalate (BBzP). It is also recommended that PVC should be avoided contact with nasal tracts as it has a leaching capability thus causing damage to the intrinsic networks inside the body. In the manufacture of materials containing chlorine, including PVC and other chlorinated plastic feed stocks dioxin is released in the process as per the given chemical reaction.

- **Dioxin:** Dioxin is a widely known human carcinogen. It is also the most potent synthetic carcinogen ever tested in laboratory animals. A characterization by the National Institute of

Standards and Technology of cancer causing potential evaluated dioxin as over 10,000 times more potent than the next highest chemical (diethanol amine), half a million times more than arsenic, and a million or more times greater than all others. Thus while working with phthalates and chlorinated bases special care needs to be taken.

- Polypropylene (PP):** It is used in ketchup bottles, yogurt and margarine tubs, medicine and syrup bottles, straws and other opaque plastic containers, including baby bottles. It is a soft and easy to mould material which is thermoplastic in nature. It has a low heat requirement and hence is easy to manufacture and reproduce.
- Polystyrene (PS):** The manufacturing of styrofoam containers, egg cartons, disposable cups and bowls, take-out food containers, plastic cutlery, and compact disc cases all are done with polystyrene as the base. It has the basic property of leaching styrene and is an endocrine disruptor mimicking the female hormone estrogen, and thus has the potential to cause reproductive and developmental problems. The longterm exposure by workers has shown brain and nervous system effects and adverse effects on red blood cells, liver, kidneys, and stomach in animal studies. Styrene is also present in cigarette smoke and car exhaust. Styrene migrates significantly from polystyrene containers into the container’s contents when oily foods are heated in such containers.
- Polycarbonate (PC):** Polycarbonate is used majorly for storage container and automobile headlamps. In some cases it is used to make covers of compact discs and cell phones or computers parts. Polycarbonate has the property to break down bisphenol. It has been noted in various studies that there exist a number of adverse effects from low-level exposure to bisphenol. It may lead to chromosome damage in female ovaries, decreased sperm production in males, early onset of puberty, various behavioural changes,

altered immune function, and sex reversal in frogs.

- Others:** It includes the new, safer, biodegradable bio-based plastics made from renewable resources such as corn and potato starch and sugar cane. The development of such plastic resins however is in its initial stages. The usage ratio in India for some of them is as under:

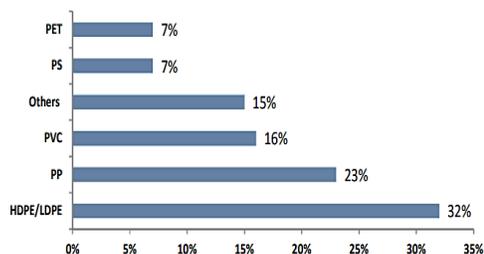


Fig 1: Ratio of Plastic usage in India [Source: Central Pollution Control Board, TOI]

III. EFFECT OF PLASTIC ON HUMANS

●**Groundwater Pollution:** As highlighted above, minuscule fibres of acrylic, nylon, spandex, and polyester are shed on each cycle of cloth wash. In a report submitted by an independent body of the United Nations around 700,000 microscopic fibres of plastic can be released into the environment for each cycle of wash using a washing machine[2] The use of technology has given us an ease but at the same time the effects of this ease on the environment are quite significant. In a similar manner, if we calculate the amount of fibres that may be released while washing a single synthetic jacket it amounts to 1.7 grams of micro fibres which are often displaced unnoticed.

●**Air Pollution:** In their research work, Verma[3] et. al, stated about a large amount of gases being released during the incineration of plastic waste. In India, around 12% of municipal solid waste is plastics [4]. Since the waste management in India is contractual and based on the number of truck load carried by them, illegal dumping isn’t far from being a common practise. This illegal dumping when taken into consideration releases toxic gases like dioxins, furans, significant amounts of mercury and other

polychlorinated biphenyls into the atmosphere. In some of its worst forms, burning of Polyvinyl Chloride [PVC] liberates lethal halogens and pollutes the air. The direct impact of which is seen in the form of climate change. Polystyrene used in the manufacture of disposable cups and other utensils, when burnt releases bases of styrene which harm the Central Nervous System [CNS]. The hazardous brominated compounds are proven carcinogens and mutagens. Dioxins have the capability to settle on the crops or enter into the waterways eventually finding a way into our food chain and hence the body system.

•**Landfills:** In India, a large number of artificial mountains can be observed to be present. These are basically a cluster of waste accumulated in landfills. On analysing, we find approximately 13.1% is contributed by plastics[4] In their report, Press Information Bureau [5], indicated that the current amount of plastic waste in landfills is approximately 1.03 billion tonnes. The amount of plastic if spread on a single place would require approximately 42 full size football stadiums to be evenly spread. In the Northern Capital Region alone waste accounts to a combined height of 167m.[5]

•**Upsetting of Food Chain:**Plastic has the capability of being absorbed in its micro structural form. These have a negative effect on the health of people who consume them for their energy requirements. In India a large population is a consumer of sea food. This sea food may contain certain amounts of absorbed plastic and when consumed either indirectly or directly may result in sickness or in worst forms death. This imbalance by sudden or gradual decrease in number of specie will affect the others dependent on them leading to an overall upsetting of food chain.

IV. CONCEPT OF 3R & A SHIFT TO 5R

As discussed in the previous segments, plastic can now be seen in every aspect of our lives and brought along with itself an equivalent amount of plastic pollution. In the current census, around 8.12 million tonnes of plastic waste enters the oceans surrounding the Indian subcontinent and as the

estimates suggest by the year 2050, the amount of plastic in the oceans will weigh more than all the aquatic life combined [6]. In our study, we found significant traces of plastic inside animals. In the worst forms, choking and cuts by fishing nets were common in the species. In a major share, plastic chokes the land of its natural ability to nurture the sown seed. In their study, Genuis [7] observed traces of bisphenolA (BPA) in the blood samples of 90% infants and 95% of the adults when they were tested. In a similar work, Cho[8] found tiny bits of plastic fibres (smaller than the width of a human hair) during microscopic investigations of honey, sugar, beer, processed foods, salt and bottled water. It is evident from the above cases that plastic is proving to be a burden on us and affecting the quality of our lives. It is very much required to think of alternatives or to convert the plastic in its processed form to something that’s not only sustainable and also biodegradable. One such approach is proposed in the segment that follows. In their report Press Information Bureau had highlighted that India alone generated 72 million tonnes of waste in the year 2019[5]. This figure increases at a rate of 4% annually, thus adding approximately 3 million tonnes each year. This research paper not only takes the concept of 3R and refreshes it but also proposes two additional steps to manage plastic waste. The concept of 3R is discussed in Table 1

TABLE I
3R CONCEPT

Reduce	Reuse	Recycle
- Minimize resources first	- Based on think before you	- Conversion of waste
- Most effective step	recycle or dispose	- Convert Old → New
- The hardest step for humans	- Increases object life,	- Requires energy & other resources
- Based: monetary & psychological notions	- Prevents old resources from entering the waste stream.	- Needs storage of waste
		- If recycle output cycle is not as fast → Landfills

Apart from these three steps, two additional steps are proposed as under for waste management in India.

1. **Recovery:** This step involves a second thought about the waste after processing. In this process the waste that cannot be recycled any further is recovered by finding a way to produce energy or new material by processing the waste

2. **Rehabilitation:** The ash or dust obtained after recovery is then taken to the landfill to be slowly decomposed and return to nature without damaging the environment. This method can not only reduce the waste to a very small amount but can also give way for waste to be handled effectively.

V. LIMITATIONS

The proposed concept adds two more steps to allow more amount of waste volume to be handled in each sequence. In essence, the main aim should be to reduce the production of waste since the very beginning but when the generation of waste can no longer be avoided, the items should be reused. Recycling should be followed only when the items are such that they cannot be reused. In this process the waste is melted, chopped or formed into a new product that might suffer a decrease in quality. The decrease of quality in recycled materials, as well as the energy and resources needed to recycle waste, are two of limitations of current waste handling process. The last limitation is on the process of rehabilitation, because even when the ash or dust is in much smaller quantity than the original waste, it cannot be nullified completely.

It is evident from the previous segments that plastic has many valuable uses however along with it there are many severe environmental consequences if not treated well. Plastic waste has become so prominent in our sphere that some scientists suggest it to be used as a geological indicator of the current era in the times to come [6]. A large amount of plastic is derived from chemicals derived from oil, natural gas and coal, which are dirty, non-renewable resources and the current rates will result in plastics taking 20% of the world's total oil consumption by 2050 [6]. It is true, we need to reduce the production of plastic, but there also exists an utter need to improve the way existing plastic is

managed. As per the reports of CPCB [5] a very low percentage of 9% of all plastic waste ever produced has been recycled. Out of this 9%, 12% has been burnt, while the rest 79% has found its way into landfills, dumps or the natural environment. In India, where drainage network is not well developed, plastic bags clog sewers and provide breeding grounds for mosquitoes and pests and increase the transmission of vector-borne diseases like malaria among others. The research work takes into consideration the fact that plastic has now started to affect the local citizens and thus proposes two additional steps to the conventional 3R concept. The two additional steps not only reduce the amount of waste to its minimum but also added a scope of second consideration for the discarded waste to give them a new lease of life by utilizing the energy concealed within them.

VI. CONCLUSIONS

- A study on the initial types of plastic used in conversion of plastic to paper has been missed out by directly using PET.
- No research work on the opacity factor and light scattering with variable additive enhancement ratio has been observed [above 20% as previously used].
- Thickness and bulk properties analysis has been missed out in the studies till date.
- No research work on the effect on the strength and bonding of the paper sheet with variable filler content and variable raw material has been found.

VII. SCOPE OF FURTHER WORK

This research paper leaves a scope for further work on the analysis of waste generated in India and its further utilisation to result in additional steps to the proposed concept. Furthermore, work can be done to reduce the load on rehabilitation to its minimum so that the dust and ash generated can be further minimised. Additional work can be done to find alternatives to plastic to result in cleaner and plastic free environment.

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