Assessment of Plastic Waste Generation and Eco-Friendly Management: A Review

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Abstract— *Since the invention and inception of plastics in our daily life, the continuous use of the product has increased causing harmful effects to the environment and human life. Now the time has come to awake and be aware of the use and management of plastics in our daily life. The current scenario reveals that plastic consumption has increased in our daily life activities, whether it be food as packaging items, cosmetics, plastic bottles, polythene, and pharmaceutical sector, and other manufacturing and production sectors for efficient and safe delivery of the items. The synthetic plastic production process and degradation of used products, if not managed properly, show adverse impacts on the environment. The reuse and recycling of plastic products seem to be the best strategy, however, depends on the product, technique applied and rate of decomposition. In the present circumstances, the use of bio-plastics is a better alternative, as they are safe, eco-friendly, biodegradable, without harming the living components of any ecosystem. Moreover, the potentiality of microorganisms to degrade the bio-plastic wastes has opened a new forum on reuse, recycling, and processing of plastic waste management. This comprehensive review aims at the generation of plastic waste, their impact on human life and the environment, reducing and recycling techniques, the significance of biodegradable plastics, and their decomposition using microorganisms. Moreover, the problems and challenges that occur during the production and degradation of plastic waste are more important to minimize the impact for sustainable development.*

***Keywords*— Plastic pollution, recycle and reuse, ecofriendly management, microorganisms.**

I. INTRODUCTION

Plastic wastes (PW) have emerged as a major problem causing adverse impacts on the environment and human health. Plastic production starting from 1950, about 6.3 BT of plastics produced worldwide up to 2018, however only 9% is recycled and 12% is incinerated (Alabi et al.,2019). Plastic pollution most visible in developing countries, with improper waste collection systems compared to developed nations, remains a troubling process, especially in the collection of discarded plastics (Parker, 2019). Plastics as an integral part of our life appear in various products of daily use, responsible for carbon emission affecting the ecosystem cycle and becoming a great threat to human health (Filiciotto, & Rothenberg, 2021). Plastic waste is responsible for causing an impact on climate change which otherwise affects genes, species and the whole biome (Pandey et al, 2016 a). It was observed that landfill disposal of plastic and incineration process accounts for emissions of CO2 253 and −673 g kg−1 to 4605 g kg−1, respectively (Eriksson and Finnveden 2009). The most damaging impact of PW is on aquatic ecosystems affecting entanglement, ingestion, and blockage of the intestine, and microplastic is even worse causing intrinsic toxicity due to leaching, absorbing contaminants, and pathogens, disturbing chemical interaction in aquatic animals (Amobonye et al, 2021). The plastics with a big carbon footprint metrics should be monitored timely for reducing their impacts on the environment (Pandey et al, 2016 b) Therefore a need for better research on plastic wastes, large-scale clean-up drives, public awareness, and information sharing among decision-makers for fulfilling knowledge gaps should be preferred (Syberg et al 2020).

II. PLASTIC WASTE GENERATION IN INDIA

In the post-independent era, India has witnessed a progressive increase in the production and consumption of plastic. However, the country lacks proper waste collection and segregation technology, therefore the management of discarded plastics waste has become a challenging task (Banerjee et al 2014). In India nearly 9.4 Million tonnes of plastic waste is generated per annum (which amounts to 26,000 tonnes of waste per day), and nearly 5.6 million tonnes of plastic waste is recycled (i.e. 15,600 tonnes of waste per day) whereas 3.8 Million tonnes is left uncollected or littered (9,400 tonnes of waste per day) (UNIDO, 2018). About 60% PW is recycled, which is higher than the global average of 20% (Geyer et al, 2017) but still, over 9,400 tonnes of plastic waste is either landfilled or ends up polluting streams or groundwater resources. Around 25,950 tonnes of plastic waste produced per day, 40% is thrown unattended causing soil and water pollution, affecting drainage and river systems, ingestion by stray animals, and littering of the marine ecosystem (Yadav, 2019). The present clean-up strategies of plastic pollution are not sufficient enough to compete with the increasing volume of plastic entering our ecosystem and require a global multifaceted approach (Prata et al 2019).

III. IMPACT OF PLASTIC WASTE

Plastic waste pollution shows a wider impact on environment diversity, perseverance, raises global issues, and threats to human health and organism. The plastic cycle operating in the atmosphere, aquatic and terrestrial systems is also a matter of serious concern (Li et al 2020). The single-use plastics (SUPs) waste are even more harmful as they are causing a threat to floral growth, soil invertebrates, land animals, birds, and marine lives (Chen et al 2021). The impact of plastic pollution on the soil ecosystem using the earthworm model comes with an outcome that microorganisms, invertebrates, insects, and plants should be experimentally tested to understand the deleterious effect on the whole soil ecosystem (Chae and An 2018). The disposal mechanism of plastic waste creates social and environmental impacts. The used polyethylene terephthalate (PET) plastic bottles should be cent-per-cent disposed and a study reports that 75 % flake production and 25 % landfilling shows the least social impact (Foolmaun and Ramjeeawon 2013). Household and industrial plastic waste mainly contain phthalate contamination in form of DBP (Dibutyl phthalate), DBP (Di-iso-butyl phthalate), and DEHP (Diethylhexyl phthalate). Among these DEHP shows highest frequency hence recycling plastics requires phthalates-sensitive execution (Pivnenko et al 2016).

IV. REDUCING AND RECYCLING PLASTIC WASTE

In order to reduce plastic waste pollution the modulation of production and uses, eco-designing, practice of using recycled plastics, the habit of reduction of the use of plastics, using renewable energy technique for recycling, production house responsibility to manage waste, proper waste collection mechanism, recycling, using biodegradable and bio-based plastics, and advancement in the recycling of e-waste, are some best practices (Prata et al 2019). Recycling by a reduction in material use through product reuse or downgauging, using alternative biodegradable materials, and energy retrieval in form of fuel are some best techniques to get rid of plastic waste (Hopewell et al 2009). The carrying of reusable bottles and bags can help to minimize the plastic footprint. The recycling of polyethylene terephthalate, into useful polyester fabric and automotive parts, is also a good practice (NRDC, 2020). Civil Engineering processes also show the reuse of plastic bottles. The use of fly ash as an infill material in composite cells with optimum height increases the load-carrying potentiality of the cells and can be used as a compression object (Dutta et al 2016). The scientific sterilization and the use of eco-friendly sealed bags like bio-plastics help in the safe disposal of contaminated plastic wastes and also reduce the risk of disease transmission (Vanapalli et al 2021). The degradation of synthetic plastics using bacteria, fungi, certain actinomycetes, algae, and insects should be attempted as they have shown the potential to ingest polymers and convert them into eco-friendly carbon compounds. In order to facilitate and enhance the microbial mechanism scientific techniques like changes in metabolic pathway design, enzymatic characteristics and molecular cloning should be given more priority (Amobonye et al, 2021). The present regulatory instruments like regulations, norms, laws, and recommendations for the reduction of the eco-toxicological impact of plastics in the environment should be properly monitored (da Costa et al 2020).

V. BIODEGRADABLE PLASTICS

The use of biodegradable plastics has emerged as an alternative to synthetic plastics to reduce plastic pollution. Natural plastics are generally made from microorganisms or plant and animal sources. In this process, under favorable fermentation conditions, bacterial strains utilize carbon sources and produce and store bio-plastics. These materials are referred polyhydroxyalkanoates (PHA) and are safe, are without toxic by-products, and are easily degraded by microorganisms (Alshehrei, 2017). The use of biodegradable plastics helps to reduce the problems of microplastics, climate change, and littering. The bio-plastics minimizes the socio-economic and environmental impact of plastics, thus their use, production, and commercialization should be preferred (Filiciotto, & Rothenberg, 2021). Various standardization bodies have introduced scientific and technical standardized techniques and criteria to assess Environmentally degradable polymers and plastics (EDPs), based on some basic characteristics like biodegradability, providing certification to the material (Krzan et al, 2006).

VI. MICROORGANISM INVOLVED IN BIODEGRADATION OF PLASTIC

Plastic degradation is always a serious threat to the environment. The use of microorganisms for plastic degradation is the cheapest and eco-friendly method as it helps to convert the waste into low molecular weight compounds without harming the ecosystem (Fazakat and Hashmi, 2020). Biodegradable plastics are easily assimilated by microorganisms and disappear from our environment. The bioremediation process using microbial enzymatic degradation is safer without waste accumulation. The environmental factors such as thermo-stability, pH, substrate molecular weight and complexity, and the surface erosion of polymer film are some of the important criteria for hydrolytic biopolymer degradation producing monomer of low molecular weight, and also generates methane, carbon dioxide, and water (Roohi et al, 2017). The biodegradation of plastics depends on the physicochemical structure of the used materials, environmental conditions, and the microbial community involved in biodegradation. Some common misconceptions like the gaps among biodegradation levels, between the biodegradation conditions, and between public perception and the actual environmental fate of biodegradable products should be properly addressed and sorted (Choe et al, 2021). The biodegradation kinetics of certain bioplastics like PHBV, PHB, and PCL reveals that poly(3-hydroxybutyrate-co-valerate) (PHBV) and poly(3-hydroxybutyrate) (PHB) degrades anaerobically and aerobically in 77 and 117 days respectively, while Polycaprolactone (PCL) biodegraded aerobically in 177 days. The total biomass growth reported to be 10 to 30.5% of the total initial carbon and the lowest size of the particle that can be used for testing were in the range of 100–250 µm, indicating the significance of bioplastic degradation suitable for standardization in bio-economy in context of plastic waste biodegradation (Garcia-Depraect et al, 2022).

According to research, certain species of bacteria like *Ideonella sakaiensis* that exist during plastic bottle-recycling have the potential to degrade and metabolize plastic and hydrolyze polyethylene terephthalate (PET) (Yoshida et al, 2016). A study reports that caterpillar wax moth larvae *Galleria mellonella* was reported to biodegrade polyethylene (PE), which are largely used in packaging with significant environmental impact, producing ethylene glycol (Bombelli et al, 2017). The soil microbiota plays a significant role in the degradation of bioplastics in soil. The soil bacteria *Pseudomonas chlororaphis* and *Cupriavidus necator* has potentiality in biodegradation and decomposition of bioplastics formulated from Polylactide acid (PLA) in 250 days (Blinkova and Boturova, 2017).

VII. CONCLUSION

In conclusion, plastics have become an integral part of our lives. The use of plastic products that are biodegradable should be preferred over synthetic plastics. The use of landfills, bio-plastic, and degradation of plastics using microorganisms are some better alternatives without any harmful impacts on the environment and human health. The recycling and reuse of bio-plastic are safer from a human health point of view. Moreover, they do not show any harmful impact on air, water, and the land ecosystem.

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