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PLASTIC WASTE MANAGEMENT AND RECYCLING: A REVIEW

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Abstract

The annual production of plastics worldwide has thrived to about 4.05% since 1950-2021 from 1.5 million tonnes to 390.7 million tonnes. And the need for plastics has increased because of a growing population and its extensive use in our daily lives. We have reviewed in this paper pertinent literature on management of plastic waste, recycling of plastics, types of plastics and their recyclability, plastic recycling process, benefits of plastic recycling and the challenges of plastic recycling in Nigeria. Papers that reported Plastic waste generation and management in Nigeria: Issues, challenges and strategies did not directly review the recyclability of plastic waste. There are different elements that formulate plastics like the polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP), and others which result to an end product of weightless and tough substance which can be transformed for several purposes. Management of plastic waste is germane because plastic waste not disposed properly has detrimental fallout on the Environment. The recycling process involves the collection, selecting, sorting, cleaning, shredding, then melting and molding. It is important to note that all plastics cannot be recycled together as a result of different molecular makeup. For instance, melting together all types of plastics gives rise to immiscibility and then different layers which weaken the structural formation of the polymer blend. A large chunk of the plastics produced yearly are used up in a short time and returned back as garbage. This paper also presents recommendations for global waste management and recyclability.

Keywords: *Plastic Waste, Recycling of Plastics, Environment, Management of Plastic Waste, Polymer Blend.*

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1. INTRODUCTION

Plastics are elements formulated from artificial organic polymers, with an end product of weightless, tough, and affordable substance that can be transformed from one form to another for several purposes ranging from packaging materials (usually disposable), household utensils, medical facilities, construction materials, electronic appliances, etc. Hopewell et al. (2018)

The reaction is the extensive use of plastic materials in our daily lives. Consequently to our ever-increasing population, the request for plastics has led to the rise of manufacturing plastics estimated at 380 million tonnes globally in 2018, The bulk of the plastics produced yearly are used up in a short time to create disposable packaging substances which are used up and tossed out within the year of manufacturing meaning these plastics are short cycled and cannot be maintained. The implication is they return to the land as Garbage.

Management of plastic waste is germane because plastic waste not disposed of properly has a detrimental fallout on the Environment and aquatic habitat. About 10% of household waste plastics end up as debris on land. Association of Plastics Manufacturers in Europe [APME], (2002).

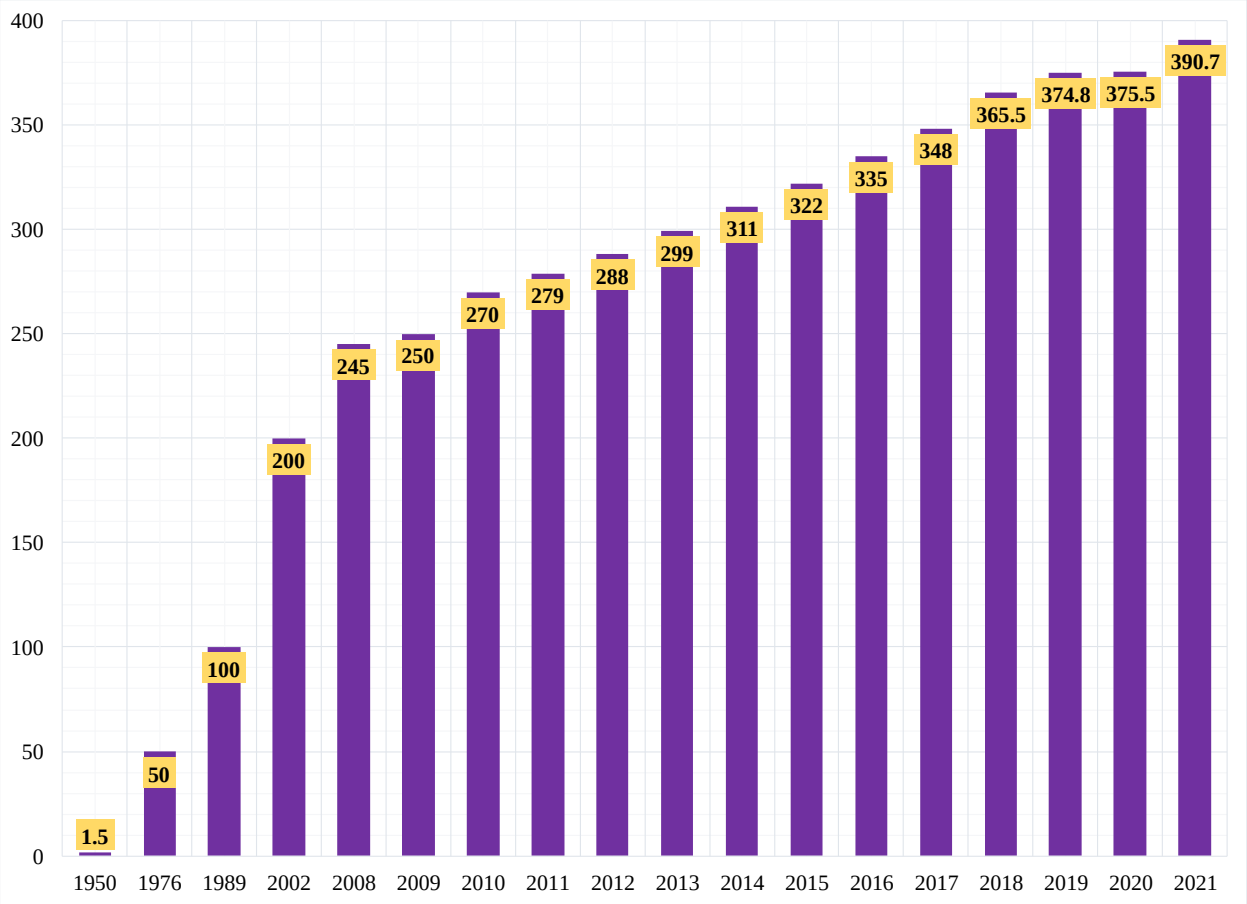
There are various methods of plastic waste management. The popular 4R seems old but still relevant. It includes Reduce, Re-use, Recycling, and Recovery. Landfilling which is very common and easy to carry out only costs the land reports from research carried out that it poses adverse effects on the environment and public health due to the toxic chemicals being emitted and absorbed by the soil (Biello, 2013).

The inability of plastics to decompose as a consequence of the make-up compound of polymer has given rise to explore recycling of the plastic waste. Recycling gives the opportunity to step down the use of oil, gas emission like $C0_2$ and the proportion of plastic waste to be disposed. It basically means refining the plastic wastes into usable products (Padanyi & Foldi, 2014). According to Hopewell, et al (2018) recycling of plastic waste can be challenging due to stages of recovery and recycling. There exist four central levels of recycling which are: primary (which involves the mechanical reprocessing of plastics into a new product with equivalent properties), secondary (which involves the mechanical reprocessing of plastics into a product with lower properties), tertiary (which involves the recovery of the chemical constituents of the plastics) and quaternary (which involves energy recovery from the plastics).

2. GLOBAL PRODUCTION RATE OF PLASTICS

Plastic produced globally in the 1950s was quite minimal. It stood at 1.5 million tones (see Figure 1). Rate of production, however rose significantly to 50 million tones in 1956 and by 1989, the total production rose by 100% to 100 million tones between 1989 and 2002.

Figure 1: Annual production of plastics worldwide from 1950 to 2021*(in million metric tons)*



Source*: https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/*

A 100% increase in global production was again recorded as the total output shifted to 300 million tonnes in 2002 from 100 million tonnes in 1989. The increase was however moderated in 2009 as the production grow only by 22.5% to 245 million tonnes. Between 2008 and 2009 the global economy recorded an increased in the manufacturing of plastic by 2.04%. the lowest in more than two decades. Global creation of plastic resumed a remarkable rise in 2010 as it

grew 250 million tonnes in 2009 to 270 million tonnes in 2010 representing an increase of 80%. These also increased at a decreasing rate in 2011 by 3.3% and further down to 3.23% in 2013.

The recovery in growth rate of global production of plastic in 2014, as the total rose to 311 million tonnes in 2014 as against 299 million tonnes in 2013. The 2015 witnessed a 3.54% increase in production whereas in 2016 production grew to 355 million tonnes representing a 4.04% annual increase. In 2018 total global output of plastic rose by 5.03% to 365.5 million tonnes. The transition was however moderated in 2019 to 374.8% million tonnes translating 2.54% annual increase. The lowest was recorded in 2020, perhaps due to covid-19 pandemic. The total production in 2929 stood at 375.5 million tonnes representing a meagre 0.19% growth rate. Available data on global plastic production stopped at 2021, a period which saw the peak of globally plastic production which stood at 390.7 million tonnes translating 4.05% annual increase.

Management of Plastic Wastes

Plastics are made up of a good number of our household items which usually finishes on the soil surface (Hopewell et al., 2009). An example of the methods in waste management is Land Filling. It is believed to be common and conventional in many countries. However, it causes nuisance as there are no more space to accommodate them on the land. In the United Kingdom for example, land filling was seamless to practice until in recent times, the option has been disregarded.

The burning of plastic garbage offers an alternative to land filling, which provided the option of incineration. But the challenge is that there are rising worries about the possible atmospheric emission of dangerous chemicals during the process. For instance, the burning of plastics releases furans, dioxins, and polychlorinated biphenyls (PCBs) into the environment along with halogenated compounds and polyvinyl chloride (Gilpin Wagel & Solch, 2003). The drawback of burning plastics are the toxic gases emitted into the environment cause air pollution. When plastics are destroyed through fire, they irreversibly destroy the combustion heater of the flue systems, and the by-products of this combustion are harmful to both people and the environment. There by, pollute the air by vaporizing into it directly. In the case of some element, certain weighted substances may also produce flammable mixtures, while others may oxidize into solid form.

3. RECYCLING OF PLASTIC

Plastic is an extremely pervasive material that sees an annual production of over 350 million tons globally (Plastic Europe, 2021). The persistent issue of single-use plastic has resulted to damages in the environment. Discarded plastic waste poses significant harm to the environment and ecosystems, and its accumulation in the oceans is contributing to a growing problem of plastic pollution. Recycling a good method to reduce plastic waste, involves a process of collection, sorting, cleaning, and reusing plastic materials. However, in the United Nations, merely 9% of the world's plastic waste is recycled, while the majority is either incinerated, landfilled or ends up in the environment (United Nations, 2018). This figure is alarming, given the projected growth in plastic production and usage in the future. Despite this, there are global endeavors aimed at increasing plastic recycling rates and reduce plastic waste. These initiatives include implementing laws to prohibit single-use plastics usage, increasing funding for recycling programs, and developing innovative recycling technologies. This study will strive to look at the current state of plastic recycling, its benefits, challenges and future prospects.

3.1. Types of Plastics and their Recyclability

Plastic is a widely used material in various industries because of its durability, versatility, and low cost. The broadly commonly used plastics include polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP), polystyrene (PS), and others. PET is commonly used to put together water bottles, food containers, and packaging materials. HDPE is used in making milk jugs, detergent bottles, and toys. PVC produces plumbing materials, electrical cable insulation, and vinyl siding. LDPE is used in the creation of grocery bags, trash bags, and squeeze bottles. Furthermore, PP is used in the making of yogurt containers, margarine tubs, and bottle caps. PS gives rise to disposable plates, cups, and cutlery. However, all the categories of plastic can not be recycled equally. PET and HDPE are mostly recycled together because they are durable and have a high demand. The US Environmental Protection Agency (EPA), in 2018, reported that 29.1 million tons of plastic waste was generated and only 3.14 million tons (10.8%) of that was recycled (EPA, 2021). The recycling rate for PET and HDPE in the US (United States) in 2018 was 29.2% and 28.9%, respectively (EPA, 2021). In contrast, the recycling rate for PS was only 0.5% (EPA, 2021).

Identifying the different categories of plastic is crucial for effective recycling. The conventional way to identify plastic is by confirming the resin identification code (RIC), a number placed on the bottom of plastic products that range from 1 to 7, indicating the type of plastic. PET has a RIC of 1, HDPE has an RIC of 2, PVC has a RIC of 3, LDPE has a RIC of 4, PP has a RIC of 5, and PS has a RIC of 6. Thus, plastic is a versatile and widely used material in different industries. However, not all types of plastic can be recycled equally. Identifying the different types of plastic is crucial for effective recycling.

3.2. Plastic Recycling Process

In Nigeria, plastic waste is a substantial environmental challenge, as it contributes to pollution, flooding, and health hazards. The plastic recycling process is a potential solution to this challenge. The process involves numerous steps with careful execution and attention to detail to achieve successful recycling. The first step in the plastic recycling process is collection. In Nigeria, the collection of plastic waste is often a significant challenge due to inadequate waste management systems and low awareness of recycling practices. According to a study by Adelopo et al. (2019), less than 10% of plastic waste generated in Nigeria is collected for recycling. The next step involves sorting plastics. Sorting involves separating the different types of plastic, as not all plastics can be recycled equally. In Nigeria, sorting is usually done manually, which can be time-consuming and labor-intensive. Moreover, inadequate infrastructure and equipment for sorting further complicate the process.

Cleaning is the next step, which involves removing contaminants such as dirt, food, or other debris from the plastic waste. Cleaning is crucial to ensure that the recycled plastic meets quality standards. In Nigeria, cleaning is another significant challenge, as many plastic waste collectors do not properly wash or rinse the waste, which can lead to low-quality recycled plastic. Shredding is the process of breaking down the plastic waste into smaller pieces. Shredding is crucial for the efficient melting and moulding of the plastic into new products. In Nigeria, shredding is also a significant challenge due to inadequate shredding machines and equipment. Finally, melting and moulding are the last steps in the plastic recycling process. The melted plastic are formulated into new products like the plastic bottles, containers or even building materials. However, the quality of the recycled plastic is highly dependent on the previous steps in the process. In Nigeria, the lack of adequate infrastructure and equipment for melting and moulding further complicates the process. Therefore, plastic recycling involves several steps which has its unique challenges that require careful execution and attention to

detail to achieve successful recycling. Addressing these challenges requires a collective effort from stakeholders, including the government, private sector and individuals to ensure efficient and sustainable plastic waste management in Nigeria.

3.3. Benefits of plastic Recycling

Recycling plastic in Nigeria has numerous benefits that contribute to a healthier environment. A substantial benefit is the reduction in the percentage of waste found in landfills. According to a research by the Federal Ministry of Environment, about 2.5 million tonnes of plastic waste is generated in Nigeria annually, with only 10% of that amount being recycled (Olofinjana et al., 2020). The rest ends up in landfills, leading to environmental degradation, air pollution and a significant health risk to communities living around those areas. Recycling plastic also conserves natural resources. The making of new plastic requires the use of inputs that are non-renewable such as oil and gas. By recycling plastic, these resources can be conserved and used for other purposes. According to a report by the African Development Bank, recycling 50% of plastic waste in Nigeria could save up to 2.4 million barrels of crude oil and reduce greenhouse gas emissions by 1.5 million tonnes (AfDB, 2019).

In addition, recycling plastic beings down greenhouse gas emissions, that contributes to global warming. The making of new plastic requires a significant amount of energy, which often comes from the burning of fossil fuels, leading to the emission of greenhouse gases. A report by the United Nations Environment Programme, recycling one tonne of plastic can save up to 1.5 tonnes of carbon dioxide equivalent emissions (UNEP, 2018). In addition to these benefits, recycling plastic creates employment opportunities and helps to promote a circular economy. By recycling plastic, waste can be spuned to serve as valuable raw materials which can make new products and create opportunities in the recycling industry. Recycling also reduces the dependence on imports of raw materials, which contribute to the expansion of the local economy. Therefore, recycling plastic has numerous benefits that provides a healthier environment, including reducing the percentage of waste that goes back to the landfills, conserving natural resources and reducing greenhouse gas emissions. It is pivotal that awareness is increased and promoted to encourage individuals and industries to recycle plastic, thereby promoting sustainable development in Nigeria.

4. CHALLENGES AND LIMITATIONS OF PLASTIC RECYCLING IN NIGERIA

In Nigeria, the plastic recycling industry faces several challenges and limitations that hinder its growth and development, despite the numerous benefits of plastic recyclingg. One of the Limitations facing plastic recycling in Nigeria is an inadequate waste management system. The Federal Ministry of Environment, Nigeria generates an estimated 32 million metric tonnes of solid waste annually, out of which only 20-30% is collected (Federal Ministry of Environment, 2018). This means that a chunk of plastic waste return to the landfills, causing environmental pollution and health hazards. Another challenge facing plastic recycling in Nigeria is the inadequate infrastructure for the collection and sorting of plastic waste. There is a lack of effective collection mechanisms, and waste segregation is not widely practiced, leading to the mixing of different types of waste making the sorting process more challenging, and the durability of the recycled plastic is compromised.

Furthermore, the recycling process can be expensive and time-consuming in Nigeria because of the high cost of energy, machinery, and labour. This makes it difficult for small-scale recyclers to compete with larger companies, and many recyclers struggle to stay in business. In addition to these challenges, some types of plastic are difficult to recycle, which limits the volume of plastic to be recycled. For example, PVC and PS are not easily recyclable and are often excluded from recycling programs. This further reduces the potential for plastic recycling in Nigeria. Inspite these shortcomings, efforts are being made to improve plastic recycling in Nigeria. The Federal government has launched various policies and programs aimed at improving waste management, and private organizations are investing in recycling infrastructure.

5. RECOMMENDATION

The Importance for plastic waste management and recycling gives the opportunity to curtail oil usage, gas emission like CO_2 and the percentage of plastic waste to be disposed. The following recommendations might be helpful:

1. Policy Makers

The end product of recycled plastics is usually in low quality compared to metals and glass. This could be as a result of melting together all types of plastics which gives rise to immiscibility and then different layers which weaken the structural formation of polymer blend. Block copolymer is a recent research on plastic recycling which can help to overcome the challenge of phase separation in recycling of plastic waste Creton (2017). Government and policy makers can adopt this technique to ensure efficiency.

The Government and policy makers can invest in automated machines to select different types of plastic which can also solve the challenge of production of weak structural polymer blend.

Globally, the demand for recycled plastic is projected to boost up in the coming years, driven by growing perception about the impact of plastic waste, on the environment. Government initiatives will reduce plastic waste, and corporate commitments to sustainability (Grand View Research, 2021). In 2020, the global recycled plastic market size was estimated to be USD 37.5 billion, and it is expected to grow at a compound annual growth rate (CAGR) of 6.8% from 2021 to 2028 (Grand View Research, 2021). The Asia Pacific region is expected to lead the global recycled plastic market, with China being the largest producer of recycled plastic (Grand View Research, 2021). In Nigeria, plastic recycling is still in its infancy, and there is a significant opportunity for growth in the industry. According to a study by Adelopo et al. (2019), the plastic recycling industry in Nigeria has the potential to generate up to USD 68 million annually, create employment opportunities, and boost economic growth. However, the industry faces several limitations, including impaired infrastructure, lack of government support, and limited access to financing (Adelopo et al., 2019).

2. Researchers

To improve the future prospects of plastic recycling in Nigeria, the Federal government has enforced policies and initiatives aimed at reducing plastic waste and promoting recycling. For example, in 2019, the Nigerian government launched the Extended Producer Responsibility (EPR) policy, which requires manufacturers and importers of certain products, including plastics, to take charge of their products throughout their expected life span, from production to disposal (AfDB, 2019). The Federal government has also procured funding and support for the development of recycling infrastructure and the establishment of recycling plants (Federal Ministry of Environment, 2018). Hence, with the growing public awareness and government

support, the plastic recycling industry has substantial potential for growth and development in the future. This can serve as an opportunity for researchers to explore.

6. CONCLUSION

There is an ever increasing population which signifies more demand for plastics in our daily use. There are also challenges and limitations of plastic recycling in Nigeria that limit the potential for plastic recycling and hinder the growth of the industry. However, more is to be done to address these issues. This is an opportunity for the Federal government and other stakeholders to take advantage of such as, proper policies, investment and awareness, and adopting new technologies. So that these challenges can be overcome, heading us to a healthier and more sustainable environment.

REFERENCES

Adelopo, A. O., Afolayan, A. O., & Oyewunmi, O. A. (2019). Plastic waste generation and management in Nigeria: Issues, challenges and strategies. International Journal of Environmental Science and Technology, 16(12), 7871-7882. https://doi.org/10.1007/s13762-019-02439-w.

AfDB. (2019). Nigeria: A waste-driven economy. African Development Bank Group. https://www.afdb.org/en/blogs/afdb-championing-inclusive-growth-across-africa/post/nigeria-waste-driven-economy

Association of Plastics Manufacturers in Europe (APME) (2002) Plastics consumption data by sector. Brussels, Belgium.

Biello & David (2011). Are Biodegradable Plastics Doing More Harm Than Good? *Scientific American.* Retrieved 1 August 2013.

Creton C. Molecular stitches for enhanced recycling of packaging. Science. 2017 Feb 24;355(6327):797-798. doi: 10.1126/science.aam5803. PMID: 28232538.

Federal Ministry of Environment. (2018). Solid waste management in Nigeria. Retrieved from https://www.environment.gov.ng/2020/01/10/solid-waste-management-in-nigeria/.

Fisher, J. P. (2015). Recycling of mixed plastic waste - Is separation worth it? Waste Management, 45, 458-467. doi: 10.1016/j.wasman.2015.07.006.

Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. Science Advances, 3(7), e1700782. doi: 10.1126/sciadv.1700782.

Gilpin R., Wagel D., & Solch J. (2003). Production, distribution, and fate of polychlorinated dibenzo-p-dioxins, dibenzofurans, and related organo halogens in the environment. In Dioxins and health (eds Schecter A., Gasiewicz T.), 2nd edn Hoboken, NJ: John Wiley & Sons Inc

Grand View Research. (2021). Recycled Plastic Market Size, Share & Trends Analysis Report By Product (PET, HDPE, PP, LDPE), By Application (Packaging, Construction), By Region (APAC, North America), And Segment Forecasts, 2021 - 2028. https://www.grandviewresearch.com/industry-analysis/recycled-plastic-market

Hopewell J, Dvorak R, Kosior E. Plastics recycling: challenges and opportunities. Philos Trans R Soc Lond B Biol Sci. 2009 Jul 27;364(1526):2115-26. doi: 10.1098/rstb.2008.0311. PMID: 19528059; PMCID: PMC2873020.

https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/

Olanipekun, O., & Olukanni, D. (2021). Assessment of the challenges of plastic waste management in Nigeria. International Journal of Energy Economics and Policy, 11(2), 109-114. https://doi.org/10.32479/ijeep.10754.

Olofinjana, A., Adefulu, A. S., & Adeniyi, O. F. (2020). Analysis of plastic waste management in Nigeria: Case study of Lagos State. Journal of Cleaner Production, 254, 120141.

Padanyi J, Foldi L (2014) Environmental responsibilities of the military soldiers have to be "Greener Berets". Ecology Manage 2: 48-55.

PlasticEurope. (2021). Plastics - the Facts 2021. Retrieved from https://www.plasticseurope.org/application/files/6316/4510/9658/Plastics_the_facts_2021_AF_web.pdf.

Plastics Industry Association. (n.d.). Resin Identification Codes. Retrieved from https://www.plasticsindustry.org/advocacy/resin-identification-codes.

UNEP. (2018). Single-use plastics: A roadmap for sustainability. United Nations Environment Programme. https://wedocs.unep.org/bitstream/handle/20.500.11822/25496/singleUsePlastic_sustainability.pdf?sequence=1&isAllowed=y

United Nations. (2018). Single-use plastics: A roadmap for sustainability. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/25496/singleUsePlastic_sustainability.pdf?sequence=1&isAllowed=y.

United States Environmental Protection Agency. (2021). Plastics: Material-Specific Data. Retrieved from https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/plastics-material-specific-data.