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PRODUCTION OF BIODEGRADABLE PLASTICS AS SUBSTITUTE FOR CONVECTIONAL PLASTICS IN NIGERIA

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ABSTRACT

The world is moving towards the 2050 net-zero emissions goal and tackling the ever-growing environmental and sustainability crisis by implementing the European Green Deal. The move towards a more sustainable society in Nigeria is success with the production, use, and disposal of plastic in Nigeria. Emissions generated by plastic production, and unlimited-growing of plastic waste has a huge negative impact on the living organisms because of the large accumulation in the landfills and aquatic environment. Adoption of bioplastics, which is under assessment, is one way to decouple Nigeria from the use of fossil resources, and to mitigate specific environmental risks related to plastic waste. In this work, we aim at reviewing the viability of bioplastics production in Nigeria, work done and yet to be done for effective production and commercialization. We also discuss some of the merits and challenges that can be currently identified with the adoption of these processes in Nigeria.

Keywords: aquatic; bioplastics; disposal; environment; fossil; landfills; sustainability

INTRODUCTION

The low cost of plastics and their varied uses have paved the way for a wide range of applications (Cho et al., 2011). By estimation the annual production of petroleum based plastic can go beyond the amount of 350 million tones (European Bioplastics Report, 2019). However, their numerous uses has led to huge environmental pollution which is due to disposal of used plastics materials in high amount, and it is about 50% of the total mass of plastics generated (Rhodes.,2019). The recycling process from 1950 to 2015 was less than 10% of the overall amount of plastic wastes generated, and about 90% were landfilled or incinerated (Geyer et al.,2017). Incineration of plastics evolves toxic environmental gases such as carbon dioxide and methane, which are major constituents of greenhouse gases (GHGs). These GHGs contribute to global warming (Philip *et al.,* 2013). In the same vein, plastics entail tightly bonded long polymer molecules, which allow them to remain in the environment for hundred years due to non-degradability (Ezgi and Havva, 2015). However the molecules of agricultural based plastics are readily attacked and broken down by microorganisms (Siracusa *et al.*, 2000). Moreover, the unlimited-growing plastic waste has a huge negative impact on the living organisms because of the large accumulation in the landfills and aquatic environment (Sarasa et al., 2009). Microplastics particles of smaller diameter upon degradation found their ways into food, drinking water, soil, and the air (Chae and An., 2018). About 13% of the plastic waste account for Microplastics mass (Eriksen et al.,2014), some living organisms consume macroplastics by mistake for which it would be lethal and cause injuries (Harrison et al., 2018) or lead to detrimental effects on human health as a consequence of being ingested (Xanthos and Walker., 2017). Base on these consequences, it is now essential to reduce over reliance on fossil fuels and to decrease the green house effect generated by the petroleum-based plastics (Javierre et al., 2015). The resistance of plastics to degradation as well as their everlasting in the environment led to the development of biodegradable bioplastics (Urbanek et al., 2017). These biodegradable bioplastics may be decomposed by some of the abiotic mechanisms such as photodegradation, oxidation, and hydrolysis (Luckachan and Pillai 2011), as well as by microbial degradation (Rhodes., 2019). Currently it is estimated that the global bioplastics generation capacity is about 2.1 million tonnes, which is equivalent to 0.6% of the global plastic generation (European Bioplastics Report, 2019).

The main aim of this paper is to carryout review on the work done and works to be done in the production of bioplastics in Nigeria

CONSUMPTION OF PLASTICS IN NIGERIA

In Nigeria, the use of plastics is far back as the second half of the 20th Century, upon the introduction of use of plastics for packaging. Hitherto, there were only about 50 registered companies engaged in the production of plastics in Nigeria (Abdul-lateef A., 2020). However, as it gains popularity, the embracement of use of plastics increases, and plastic production multiplied such that, over 3,000 registered plastic production companies had been registered in Nigeria (Abdul-lateef A., 2020). Nigeria is ranked at present, the highest importer of plastics and plastic raw materials in Africa (Abdul-lateef A., 2020). The countries that are leading the supply of these plastics into Nigeria include the United States of America (17 percent), the Republic of Korea (13 percent), and India (9 percent) among more than eighteen other countries of origin (Society of plastic Industry, 2012). Against this backdrop, current estimates by Hanafi (2018) suggest that over 100,000 tons of plastic are produced annually in Nigeria.

If it remains "business as usual" (i.e. no anticipated change in policy, use and waste attitude), and the volume continues to increase, it is determined that plastics importation and

consumption is expected to reach a total of over 40 million tonnes by 2030 (Society of plastic Industry, 2012).

WASTE GENERATED FROM PLASTIC IN NIGERIA

The end of life of plastics is a non-biodegradable wastes, improper management of these wastes; tend to pose huge threats to environmental security. This is prevalent in societies where solid wastes are neither recycled nor incinerated, that is, those with inefficient waste management regimes. In the light of this, African countries rank high in terms of the inability to recycle solid waste despite high waste generation (Abdul-lateef A., 2020).

The most conservative estimates suggest that over 30,000 tons of plastic wastes are generated annually across Nigeria (Okafor, 2020). Relaying on available data for plastic production to estimate Nigeria‟s plastic waste is problematic. This is especially because, despite the growing business of plastic production in Nigeria, a very significant proportion of plastics used in Nigeria are from direct importation of finished goods (Obiezu, 2019).

For two main reasons, it is difficult to ascertain the actual amount of plastic wastes generated annually in Nigeria. First is the absence of official statistical data in relation to waste generation, disposal, and management in Nigeria. Next, is the culture of illicit disposal of solid waste in Nigeria which makes data collection a very challenging process (Okafor, 2020). On this note, Obiezu (2019) suggests that the total amount of plastic waste generated annually in Nigeria could be as high as 2.5 million tonnes.

Nevertheless, there is no doubt that Nigeria generates some of the highest amounts of plastic wastes in Africa, most of which often end up in marine environments, landfills, or indiscriminate waste burning (Dumbili& Henderson, 2020; Ikpe et al, 2020). Sadly, in all three methods of plastic waste disposal, there are adverse consequences for the environment.

DIFFERENT REPORT ON THE DISPOSAL

The plastics waste generated in Nigeria are disposed indiscriminately, that is, dumping at undesignated areas and is identified as a major challenge facing Nigeria's waste management regime (Alumona & Onwuanabile, 2019). According to Adeleke (2018), the spate of indiscriminate waste disposal in south-Western Nigeria is so alarming that it already constitutes adverse public health consequences. Similarly, Abubakar et al (2019) stress that in North Central Nigeria, domestic and industrial waste is indiscriminately disposed. While indiscriminate dumping of wastes poses a series of adverse environmental and health consequences, it also makes it difficult to be recycled. The plastics that are not recycled or incinerated for electricity generation end up accumulating and sitting in landfills for hundreds even thousands of years without decomposing (Stock et al., 2020). These plastics in landfills and the environment; discharge toxic pollutants which contaminate groundwater and the soil; cause changes in the carbon dioxide (CO_2) cycle; some plastics like Styrofoam (foamed polystyrene) bring about a release of neurotoxins at high doses when temperatures hike (Adeleke, 2018). Plastics bags, bottles, films, and other items also clog drainage systems causing flooding. Terrestrial wildlife might also ingest this plastic matter leading to intestinal blockage and inherently death (Dumbili& Henderson, 2020; Ikpe et al, 2020). In excess of 80 percent of ocean plastic is leaked from land-based sources; plastic garbage generated by in-landers irrespective of proximity to the sea still finds its way to the sea (D'Alessandro, 2014).

CONCEPT OF BIOPLASTIC

The manufacturing of bioplastics was back in the 1950s and re-surfaced in the 1980s (Soroudi and Jakubowicz., 2013), but only recently received the necessary attention , in particular, their industrial-scale production began in 2000s (Song et al., 2009).
Bioplastics is a generic term that describes bio-based plastics, which includes the ones that are made of biogenic materials, and those plastics that are biodegradable that may include petrochemical ones in fact, not all bio-based plastics are biodegradable. On the other hand, some biodegradable plastics may be of petrochemical origin (Penkhrue et al., 2015). Therefore, a bioplastic is the plastic that is either bio-based, biodegradable or both.
The annual bioplastics production is relatively low, and is less than one percent of the total annual projected production which is almost 360 million tonnes (European Bioplastics Report, 2019).
In 2019, bioplastic production was 2.11 million tonnes (of which 44.5% were bio-based/non-biodegradable bioplastics and 55.5% biodegradable bioplastics). Moreover, in 2024, the bioplastics' production is expected to reach about 2.43 million tones (European Bioplastics Report, 2019). Because of similar applications, bioplastics seem to be the ideal replacement for conventional plastics (Karamanlioglu et al., 2017). Because they are produced from biogenic raw materials and their biodegradability make them viable solution for environmental sustainability and also contribute to the goals of circular economy (Ryan.,2017). For instance, the production of conventional plastics uses irreversible processes as they are fossil fuel based (Tsang et al., 2019). But bioplastics can be synthesized from chemicals produced by micro-organisms utilizing various waste products (Sharma et al.,2020). The agricultural land used requirement for the production raw materials of bioplastics is about 0.02% of the total available Earth's arable, this makes bioplastics an important replacement for conventional plastics (European Bioplastics Report, 2019). Agricultural crop-based feedtocks is still the source for vast majority of bioplastics production, that is, from carbohydrates and plant materials (Karan et al.,2019), that both lead to increased water usage and to the reduction of food production (Bastos et al.,2018). This point of view will necessitate the adoption of new technologies to manufacture bioplastics for efficient transition from a fossil-fuel-based society, and an inefficient waste management, to one based on renewable resources, reduced fossil fuel consumption, and reuse-oriented waste management (Marone et al.,2016). The latter situation agrees with the concept of circular economy

CHARACTERISTICS OF BIOPLASTICS

Reduction of carbon dioxide emissions

Bioplastics can reduce carbon dioxide emissions by 30–70% compared with conventional plastics (European Bioplastics, 2016). it productions can significantly reduces greenhouse gas emissions and decreases non-renewable energy consumption (Gironi et al., 2011). Firms worldwide would also be able to increase the environmental sustainability of their products by using bioplastics (Brockhaus, et al., 2016**).**

Sustainability

Bioplastics are potential solution for environmental sustainability, since they are biodegradable and manufacture from biogenic materials (Ryan et al., 2020). For instance, while bioplastics can be synthesized from chemicals produced by micro-organisms utilizing various waste products (Sharma et al., 2017), the production of conventional plastics uses irreversible processes as they are fossil fuel based (Tsang et al., 2019).

Advantages of Bioplastics

A bioplastic material represents, in most cases, a suitable replacement for conventional plastics (Song et al., 2009). Therefore, the bioplastics have started to enter slowly into the market in a variety of sectors such as Packaging (Bilo et al., 2018), Sponge cloths (Vaverkova & Adamcova,., 2015), Electronics applications (Bilo et al., 2018), Starch-based Films (Hottle & Bilec., 2013), Rigid materials (such as plates and cutlery and foams) Films (Hottle & Bilec., 2013), Medical products (Rincones et al., 2013) etc. Bioplastics are used in a wide range of applications. This is attributed to the fact that several desired characteristics can be obtained (such as, flexibility, strength, shape memory capability, or resistance to liquids) by easily changing the processing conditions during their production (Rincones et al., 2013). In general, packaging for both food and non-food materials is the most common use of bioplastics, independent of the type of their polymer-based source (Bilo et al., 2018).

However, a variety of bioplastics is being nowadays industrially manufactured competing in price and performance with the oil-based polymers (Song et al., 2009). The energy requirement is lower for bioplastics (57 MJ kg^{-1}) compared to conventional plastics (77 MJ kg^{-1}), which impacts global warming less (Sharma et al.,2020).

Disadvantages of Bioplastics

Bioplastics still have higher production costs than conventional plastics. It is estimated that biopolymers' price is 2 to 5 times higher compared to the conventional plastics (Prosperi et al.,2018). On the other hand, most bioplastics are not yet cost-effective, due to the high cost of the manufacturing processes (Prosperi et al.,2018).

Another issue limiting the bioplastic market may be the matching of the specific properties of a petroleum-derived plastic with those of the replacing 'biological' alternative (Rhodes et al., 2018).

However, the often low mechanical strength of bioplastics is the property that mostly limits their application and requires the use of synthetic fibers, such as glass or carbon, to increase this property (Yang et al.,2018).This leads to environmental problems due to reduction of their biodegradability (Yang et al.,2018).

Potential of Bioplastic production in Nigeria

Ogbu et al. (2009), worked on the evaluation of starch biodegradable plastics derived from cassava and their rates of degradation in soil, they discovered that the rate of degradability of the bioplastics produced from cassava does not depend on the level of amylose and amylopectin in the starch but rather on the amount of the starch itself that is used in the formulation. They concluded that the bioplastics produced from starch having a higher amylopectin level would have a higher tensile strength; however, they do not necessarily have a faster and greater rate of degradation when composted.

Adigun et al.,(2018) investigated on the exploration of agricultural waste in the production of biogel fuel and bioplastic in their study, starch gotten from waste cassava peel was mixed with plasticizer at ratio of 20:1:1 and also repeated for ratio 20:1:2 These were cooked in a non-sticky pot over a gas burner until a bio-resin which was subjected to chemical, mechanical and biodegradable tests was formed. Their results suggested that, there is feasibility of producing bioplastics from cassava peels. And the produced bioplastic has appropriate strength properties and higher degradable rate as also confirmed in the FTIR Acknowledgements.

Ezeonu ea al., (2018). Studied on the Trends on Bio-Synthesis of Plastics, they discovered the viability of bioplastic production from agricultural products. The study also emphasized on the future commercialization despite the current costly production. It was concluded that the Bio-Synthesis of Plastics is the way to go in future since it will eliminate all the environmental challenges imposed by the conventional petroleum hydrocarbon derived plastics.

Abioye et al.,(2018) Worked on the Review of Biodegradable Plastics in Nigeria. It was established from the review that, despite, the possibility of bioplastic replacing petroleum-based plastics, the cost of producing biodegradable plastics is very high compared to the conventional plastic because the process of modifying most plants used for production of bioplastics are very costly.

The review also emphasized on the setback associated to the achievement of optimal mechanical properties of bioplastics products. To attain these optimal mechanical properties, the producing materials must be blended with plasticizers and other materials. These make the cost of producing bioplastics much more than the petroleum-based plastics.

Ezeoha and Ezenwanne, (2013), investigated on the Production of Biodegradable Plastic Packaging Film from Cassava Starch. The study was carried out based on blending of cassava starch and a synthetic biodegradable polymer (PVA). The film produced was found to have a biodegradability of 41.27% compared to 10.33% and 85.99% for polythene and paper respectively. The film also has a tensile strength of 24.87N/mm^2compared to 10.86N/mm^2 and 8.29N/mm^2 for polythene and paper. The results indicated that, bioplastic is not only better in terms of biogradability but can also withstand the mechanical strength as compared to convectional plastics.

Potential area Research on Bioplastics in Nigeria

It is fascinating that biodegradable plastics can completely substitute petroleum-based plastics in Nigeria (Ezeonu ea al., 2018). Based on the review on potential of bioplastic production in Nigeria**,** there is need for further research in some of the fundamentals areas like modification process, blending ratio, process optimization and economic analysis. Emphasis must also be on the design and fabrication of process plant, for commercial production in Nigeria, as well as environmental

impact assessment, waste and disposal managements of produced bioplastics.

Benefit of Bioplastic to Nigeria

The Nigeria Petroleum oil stock will end in the near future. It is important for the country to have an alternative for products derived from petroleum oil such as bioplastics. Progress in the areas of biological engineering and materials science in Nigeria has created a surge in the development of feasible bioplastics as industrial products. The produced bioplastics are biodegradable, which makes them potentially useful for green technologies in Nigeria. It satisfies the exponentially increasing demand for materials caused by the quickly increasing population in Nigeria. To avoid devastating environmental issues, this demand must be met with sustainability. It avoids the cost of disposal incurred by synthetic plastics in Nigeria, because they are biodegradable in the presence of certain enzymes or when left decomposed after a specified amount of time.

It avoids emission of CO_2 during the production process thereby limiting the green house effect. It can also be used to fill almost any niche currently filled by harmful, industrial plastics in Nigeria, because, they have a wide range of mechanical, thermal, and chemical properties and can be processed using a wide range of methods including molding, drying, and extrusion to give them properties specific to their desired use.

All sorts of biodegradable packaging materials, including composting bags, food packaging, sanitary articles like diapers, fishing nets, bottles, cosmetic containers, golf tees, pens and scaffold for tissue engineering can be produced from them (Javed and Gruys, 2002). They all find their applications in Nigeria.

CONCLUSION

From the review it was understood that, replacing petroleum based plastics with bioplastics is a necessity in Nigeria. In this regards, many attempts were made in the area of producing bioplastic from cassava starch, its biodegradability, mechanical strength and blending ratios were studied with promising successes. But more research focused on the production of bioplastics from other agricultural products, modification process, mixing & blending ratios, Design & fabrication of process plant, Economic analysis and environmental impact assessment must be well established for efficient production and commercialization in Nigeria.

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