International Journal of Emerging Engineering Research and Technology
Volume 7, Issue 11, 2019, PP 1-11
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

Waste-To-Wealth, Towards a Sustainable Zero-Waste in a Circular Economy: An Overview

Wali, Elekwachi[1], Wizor Collins .H[2], Nwankwoala, Hycienth .O[3*]

[1]*Department of Geography, University of Nigeria, Nsukka, Nigeria*
[2]*Department of Geography and Environmental Management, University of Port Harcourt, Choba, Nigeria*
[3]*Department of Geology, University of Port Harcourt, Choba, Nigeria*

***Corresponding Author:** Nwankwoala, Hycienth .O, Department of Geology, University of Port Harcourt, Choba, Nigeria, Email: nwankwoala_ho@yahoomail.com*

ABSTRACT

Wastes are materials that are not prime products (that is products produced for the market) for which the initial user has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose. Arising quality of life, and high rates of resource consumption patterns have had a unintended and negative impact on the urban environment - generation of wastes far beyond the handling capacities of urban governments and agencies. The major aim of this paper is to review the overall method in which wastes management system in a circular economy revolves under the scope of management, utilization and sustainable growth in an ailing economy. Waste-to-Wealth literally means moving waste from a platform of exhausted utility to valuable and desirable level. Its transformation: in engineering, requires some form of energy, and in economics requires factor of production. Zero waste means designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources and not burn or bury them. Ideally, implementing zero waste will eliminate all discharges to land, water or air that are a threat to planetary, human, animal or plant health. Circular economy can best be seen as a complex system with three basic parts: production, consumption and the surrounding support system. Globally, it is estimated that only 9% of plastic waste generated between 1950 and 2015 was recycled. India has the highest plastic recycling rate ranging from 47 to 60%. In the EU, only approximately 30% of 25 million tons of post-consumer plastic waste was recycled in 2014; China had a recycling rate of 22% in 2013; while only 9.5% of plastics entering the US municipal solid waste stream were recycled in 2014.

Keywords: *Waste, Solid Waste, Waste to Wealth-, Circular Economy, Zero Waste, Plastic Waste*

INTRODUCTION

Basel Convention in 1989 define waste as a "substances or objects, which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law". According to United Nations Statistics Division, Glossary of Environment Statistics, "Wastes are materials that are not prime products (that is products produced for the market) for which the initial user has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose" (INRES ,2019).Wastes are things we consider as unfit, unwanted and discarded due to economic reasons or ignorance of alternative technologies to re-use them (Adeyemi,2001) .Waste can occur in solid, liquid or gas. Waste could also be defined as things that could be discarded as useless but that has a potential of causing death, illness or injury to people or destruction of the environment if improperly treated, stored, transported or discarded (Tchnobauoglous *et al.*,1993, Ikechukwu ,2015).

Arising quality of life, and high rates of resource consumption patterns have had a unintended and negative impact on the urban environment - generation of wastes far beyond the handling capacities of urban governments and agencies. Cities are now grappling with the problems of high volumes of waste, the costs involved, the disposal technologies and methodologies, and the impact of wastes on the local and global environment. Waste has been a major environmental issue everywhere since the industrial revolution. Besides the waste we create at home, school and other public places, there are also those from hospitals, industries, farms and other sources. Humans rely so much on material things and they all (almost) end up as waste. Wastes are items we (individuals, offices, schools, industries, hospitals) don't need and discard. Sometimes there are things we have that the law requires us to discard because they can be harmful. Waste comes in infinite sizes-some can be as small as an old toothbrush, or as large as the body of a school bus (INRES, 2019)

Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. There are many waste types and based on their state of matter, waste can generally be classified into two groups: solid and liquid waste. Solid waste can be further classified based on composition and source of generation. Based on compositions they are ; Garbage, Rubbish, Ashes, Large (Bulky) wastes ,Dead Animals, Industrial Wastes, Mining Wastes, Agricultural Wastes, Military Wastes and Hazardous Solid Wastes . From the perspective of sources of generation, solid waste can also be classified as: Municipal (Urban) Solid Wastes, Domestic/Residential Waste, Industrial Wastes, Biomedical/Hospital Wastes, Institutional Wastes, Agricultural Wastesand Commercial Wastes (INRES, 2019).

Statement of Research Problem

Circular economy is the main driver of change in material recovering, new opportunities were created by regulatory body in charge of waste in managing recycling, reduce and reuse of recycled materials. Multinationals are tackling the rate of increase in waste management. Moreover, privatization economy has pave way for a new method in the network of waste collection in urban areas. The major aim of this paper is to review the overall method in which wastes management system in a circular economy revolves under the scope of management, utilization and sustainable growth in an ailing economy. Recycling is a complex method for protecting the environment by recovering materials or components of used products, resulting in new products .The purpose of recycling is to limit the use of new materials and decrease the amount of waste. Some benefits of recycling are resource conservation (reducing demand for new resources), reducing transport costs and energy production (energy saving by avoiding exploitation of raw materials) and saving resources that otherwise would be lost in storage sites .Recycling is preferred to incineration and disposal of non-renewable materials such as glass, metals and plastics because the total energy and global warming potential is generally low. For renewable materials (paper and cardboard) in most cases, the global warming potential is lower for recycling than for incineration. Recycling can be sustainable if it is efficient in terms of costs (Ghinea 2012). Therefore, zero waste in Europe in the context of circular economy needs more concerns in terms of waste generation improvements as well as regarding increasing the extent of waste management by recycling. The lack of ability of the agencies to improve on the financial and technical resources needed to parallel the rate of generation is an issue. The deterioration of the urban environment in terms of irresponsibly dumped and accumulated solid wastes is most apparent in our urban lives and has caused a blighted environment (Ayotamuno, *et al*., 2004).

Empirical Review

Liquid waste which can be discharged from any of various processes which may be industrial, mining, commercial, agricultural, medical and domestic in nature are also known as effluent. Examples are; sludge and chemical effluents from industries, waste oil from workshops, acid waste, waste water from fisheries, sewage, etc. (Eseigbe and Omofomnwan, 2007 ; Anthony *et al.*, 2015). Gaseous wastes are substances carried in air which move without inhibition into any available space and may or may not be coloured. They can be in the form of vehicle exhaust, cooking smoke, cigarette or cigarette smoke, asbestos dust, discharge from factory chimneys or stacks, gas flaring, etc. (Eseigbe, and Omofomnwan, 2007 ; Anthony *et al.*, 2015).

Ikechukwu (2015) carried out a study based on consistent observations on the activities of scavengers of scrap metal in Obio/Akpor local government Rivers State. The study was carried out to ascertain the profitability of scrap metal scavenging and how scrap metal waste can generate wealth to the public and the government. The study findings revealed that there was a relationship between waste and wealth in relation to scrap metal scavenging.

The concept of Waste-to-Wealth literally means moving waste from a platform of exhausted utility to valuable and desirable level. Its transformation: in engineering, requires some form of energy, and in economics requires factor of production. The latent issue here is that "waste" in itself can never be wealth otherwise generator will never discard it. Likewise, wealth is created and process of creating wealth has some cost implications that the market forces construe as the price. . This means that not all wastes are potentially of secondary benefit. In all, the slogan "waste-to-wealth connotes that waste management operations must transcend delivery of service to provision of goods or value like energy (Egun, 2012).

The ZWIA defined "Zero Waste as a goal that is ethical, economical, efficient and visionary, to guide people in changing their lifestyles and practices to emulate sustainable natural cycles, where all discarded materials are designed to become resources for others to use", similar goals than CE. "Zero waste means designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources and not burn or bury them. Ideally, implementing zero waste will eliminate all discharges to land, water or air that are a threat to planetary, human, animal or plant health" (ZWIA 2015, Cristina *et al.,* 2019).

From the Citizen's Agenda 2001 for Zero Waste, the definition of "zero waste" can be inferred, which is also considered as a complement to the community and industry positions that combine ethical practices and an economic vision, recognizing recycling and its limitations in order to reconfigure the one-way industry system into a circular economy (Connett and Sheehan, 2001). From the same perspective of Connett and Sheehan (2001), the combination of community practices such as reuse, repair and recycle and the industry practices in order to achieve ZW is promoting the need to develop both sustainable communities and companies (Cristina *et al.,* 2019; Maria *et al.,* 2019).*Zero waste* is also considered as an alternative solution for waste management problems. This concept can stimulate sustainable production and consumption, recovery and recycling and restricts incineration and land filling (Zaman, 2015).

A circular economy can best be seen as a complex system with three basic parts: production, consumption and the surrounding support system (RSA Innovate, 2016). Each of these parts has its own elements and characteristics, and the interaction of them determines the chances for Nigeria to transform into a circular economy. That first part encompasses the core concept of a circular economy. By this, we refer to the actual changes in industrial production through rethinking how linear manufacturing models can become circular closed-loop models (Yuan *et al.,* 2008; Ellen MacArthur Foundation 2013). It implies seeing material flows in an economy as being part of cycles and more in particularly of two basic cycles with distinct characteristics: bio-cycles and techno-cycles. With respect to the bio-cycle, the objective is to make biomass return into the biosphere after product use, in direct ways or in a cascade of consecutive use. With respect to the techno-cycle, which is built up of inorganic products and materials such as metals and plastics, the strategy is to keep them in closed loops to ensure the possibility of reuse and recycling and to prevent potential pollution (Jackson *et al.,* 2014; Cramer 2014; Hans*et al.,* 2019).

It also designated in Fig.1 that 'the transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized, is an essential contribution to the European Union's (EU) efforts to develop a sustainable, low carbon, resource efficient and competitive economy'. The actions support the circular economy in each step of the value chain – from production to consumption, reparation and remanufacturing, waste management, and secondary raw materials that are fed back into the economy (EC, 2018b). This circular economy concept, which foresees a production and consumption system where materials are circulated as waters are re-used, recycled and recovered, has been increasingly promoted by many governments and international organizations (Van Eygen *et al.,* 2018; Bozena, 2018).

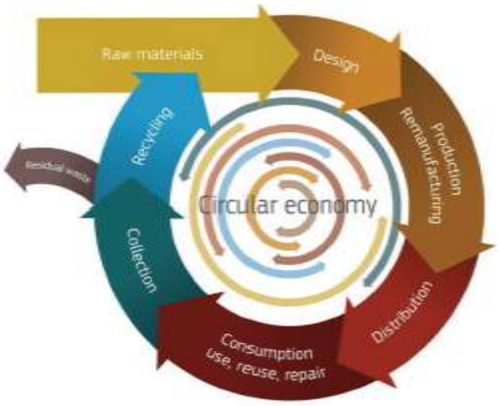

Fig1: *Diagram of Circular Economy Source. EC, 2018b*

Waste is a resource – everyone should be aware and acknowledge this, starting from those who manufacture products and continuing with the population who consumes these products. This should be the *leitmotif* of those who are responsible to recover reuse and recycle the "resources" during the manufacturing and consumption phases. Some years back, *sustainable materials management* was promoted as an approach for the exploitation of materials in a sustainable way in order to reduce environmental impacts and preserve natural capital. It is considered that *sustainable materials management* is a precursor of circular economy, which promotes recycling, reuse and remanufacturing (ISWA 2015 ; Hans *et al.*, 2019).

The classical model of industrial development is based on a linear model, with inputs (raw materials, energy and other resources) and outputs (wastes of products and production which are usually treated by *end-of-pipe* techniques). After ending their period of utilization, the products are discharged on landfills or incinerated as waste. Usually this model of industrial development ("take-make-dispose") is associated to resource depletion and high environmental impacts (ISWA 2015; WEF2014).

It was estimated that around 65 billion tons of raw materials were processed by the industrial system at the end of the first decade of the twenty-first century (in 2010), and this quantity is expected to reach about 82 billion tons in 2020 (WEF 2014; Hans *et al.*, 2019). The continuous growth of the raw materials price, especially from the natural reserve, the increasing pressures of the society and regulatory constraints are connected with both resources depletion and environmental impacts generated by waste discarded in the environment.

This is why in the last two decades, *circular economy* (CE) is gaining growing global consideration as new development model able to influence the existing production and consumption model. This influence is possible based on increasing resource throughput as a condition for continuous growth (Ghisellini *et al.*, 2015; Zils 2014; Hans *et al.*, 2019).Studies on the application of circular economy principles propose a refined hierarchy of resource use and adoption of the waste value-based recovery concept and related collection practices (Gharfalkar *et al.*, 2015; Ghinea et al. 2012; Singh and Ordonez 2016). Therefore, new actions should be addressed in concerted ways so as to add value to the "closing the loop" concept. Intensified recycling and reuse practices along product life cycles can bring benefits for both environment and economy, with intrinsic positive impacts to the society, as at large (Hans *et al.*, 2019; Maria *et al.*, 2019).

Ezeah & Roberts (2014) observed that the state of solid waste management in Nigeria has been a major concern to stakeholders. Ogwueleka (2009) reported that inefficient collection and unsafe disposal are some of the characteristics of waste management in the country. Ogu (2000) highlighted that about 80-90% of wastes generated in some low level income communities in Africa are not collected for safe disposal.

MATERIAL AND METHODS

Technology Options in Solid Waste Management

Waste Management Hierarchy

In the waste management hierarchy, Reuse, Recycle and Disposal are used. Disposal is the last option. Australia and New Zealand are moving towards 'Zero waste' to land fill disposal.

Controlled Landfill

A controlled landfill has daily soil cover and perimeter drainage to minimize leachate generation.

Sanitary Landfill

This involves use of an appropriate liner and keeping the waste in layers; the waste should be sprinkled with water or leachates and the methane generated should be recovered for energy.

Composting

This is an aerobic biological process where putrescible organic wastes such as animal wastes are mixed with municipal wastes, crop residues or saw dust and kept in windrows for several weeks for thermophilic degradation by microorganisms. The finished product is a good soil conditioner and is ideal for Nigerian soils for good crop yields.

Incineration

Incineration is used for burning any waste which cannot be reused or recycled. High temperature incinerators are useful for managing infectious and certain industrial wastes (Sridhar *et al*., 2014)

The Roles of Informal Sector in Circular Economy

Informal sector include waste pickers, cart pushers, itinerant waste buyers/itinerant waste collectors (IWBs/IWCs), and scrap dealers (Nzeadibe, 2019). The informal recycling sector in municipal solid waste management refers to the recycling activities of scavengers and junk buyers. In cities with a formal, municipal waste collection and disposal system, at least four main categories of informal waste recycling systems can be identified, depending on where and how material recovery takes place (Wilson *et al.*,2014). They include itinerant buyers, street waste picking, collection crew waste picking and waste picking from dumps. Informal recycling systems typically exist in developing countries and can be highly efficient. In Port Harcourt, the activities of scavengers have become very prominent. These scavengers or pickers move from one refuse dump to another, removing useable items from the dump which they sell to members of the public and to the few industries that have sprung up for industrial recycling of waste. Commonly collected materials are plastics, paper, cardboard, aluminum, steel, other metals, glass and textiles (Ogbonna and Ekere, 2006). The benefits of informal recycling are both economic and social. Apart from achieving a cleaner environment, effective recycling of waste is a feasible strategy for employment creation, income generation, agricultural production and poverty alleviation. The cost of formal waste management systems is reduced by the activities of informal waste recycling systems through reduction by the activities of informal waste recycling through reduction in collection, transportation and disposal cost (Ogbonna, 2008).

Prime Movers of Waste Economy in Nigeria

The waste economy consists of all formal and informal economic activities and all paid and unpaid activities associated with the management of waste. Informal actors include waste pickers, cart pushers, itinerant waste buyers/itinerant waste collectors (IWBs/IWCs), and scrap dealers .The primary work of waste recovery in Nigerian cities is being done by waste pickers who rummage urban refuse dumps to salvage discarded materials such as scrap metals, plastics, bottles, paper, electronic and electrical equipment, household furniture, textile material, wood, construction and demolition (C&D) wastes and sometimes food (Nzeadibe, 2019).

Itinerant waste buyers (IWBs) are people who move around cities to buy clean, source separated waste materials that they can sell for a profit (Wilson *et al.*, 2009). itinerant waste collectors (IWCs) on the other hand collect waste materials for free or sometimes they barter waste materials with people especially children who they offer such items as plastic cups, bowls, toys etc (Scheinberg, 2008). Both IWBs and IWCs are essentially small-scale operations (Ahmed and Ali, 2004) that ultimately service the middlemen or scrap dealers.

Cart pushers are involved in house-to-house waste collection at a fee using specially built hand-pulled cart. They may also be involved in the recovery of recyclable materials as added value to waste collection. Scrap dealers (or middlemen), on the other hand, buy materials directly from waste pickers for sale to industry or end users. Through sorting and cleaning of the materials, the dealers add value to them. By aggregating large volumes, they ensure that delivery of materials to industry is timely and to specifications (Nzeadibe and Iwuoha, 2008). Dealers therefore serve as a vital link between the waste pickers and the recycling industry in the waste value chain. There may however be different scales of dealers depending on their economic power and the materials they deal in. some trade in a range of large high value materials while others are small buyers. Small and medium scale industries finally recycle these materials. They deal directly with the middlemen and they motivate and finance the recovery and recycling of these recyclable materials (Nzeadibe, 2019).

Circular Economy and the Waste Sector

There are several reasons for business to start focusing towards industrial production that tends to decouple its development from natural resources exploitation. Numerous studies and research are demonstrating that this new model of industrial development is able to foster sustainable economic growth and create new jobs. This model is based on closed loops or circular setups associated with the concept of circular economy and is materialized by new practices such as (a) reengineering/ remanufacturing and (b) exploiting the whole technical and economic value of materials all along the life cycle with favorable consequences on waste minimization by reusing, refurbishing, maintaining, recycling and recovering operations (Zils, 2014).Circular economy (CE) is a relatively simple but a sustainable strategy, which strives to reduce the inputs of virgin raw materials as well as the generation of waste by closing the economic and environmental loops of resource flows (Haas *et al.*, 2015; MacArthur Foundation 2012). The circular economy, considered as a regenerative and restorative system, determines the shift from the *cradle-to-grave* approach to new ones such as *cradle-to-cradle* and *cradle-to-gate*, which means “closing the loop” of the life cycle of a process, product or service by recycling and reuse (Zils 2014).

Maximizing recycling and minimizing waste, reducing natural resources consumption and reusing resources and waste are the key actions connected to “zero waste” philosophy. This is based on management principles which compete to achieve the “age of zero waste”. There are members’ states which already apply principles of “zero waste” philosophy. The EU action plan for the circular economy stimulates the preservation of “the value of products, materials and resources in the economy for as long as possible” and waste minimization or elimination (COM2015). This policy can be made feasible by going through several steps, starting with tracking waste data and continuing by defining zero waste, prioritizing waste-reduction tasks, strengthening supplier partnerships, resolving regulatory challenges, achieving landfill-free waste management and sharing the best practices (changing rules, creating jobs for the environment, promoting producer responsibility, recovering resources, empowering consumers, producing by cleaner technologies, designing for the environment, shifting subsidies, etc.).The goal of recycling is not purely achieved by high recycling rates, also needs the transformation of the whole production system and adaptation of consumption via technological and social innovation (Jávor 2015).

Plastic Waste and Circular Economy

Plastics consist of lightweight, durable, moldable, versatile materials which have changed man’s life in many ways. They are present to a certain degree in virtually every object around us today from packaging materials, disposable goods, fishing nets, food wrappers to containers of all sorts. Because plastics are non-biodegradable and durable they can remain around for nearly 1000 years and more. Common forms of plastics are Polyethylene terephthalate (PET), High density and low density Poly ethylene (HDPE and LDPE), Polyvinyl chloride (PVC), Poly propylene, Polystyrene, and Polycarbonates (Lale, 2018).

Besides, plastics have enabled innovation in many sectors allowing the development of products and solutions that could not exist today without these materials. Production and distribution of plastics continue to increase both in developed and developing countries. World and EU plastics production were respectively 322 and 58 million tons in 2015 and 335 and 60 million tons in 2016 (Plastics the facts, 2017). Future plastics production is projected to double by 2035 (EC, 2018a) and almost quadruple by 2050 (Barra and Leonard, 2018). It is assessed that about 4900 million tons of the estimated 6300 million tons total of plastics ever produced have been discarded either in landfills or elsewhere in the environment. This is expected to increase to 12,000 million tons by 2050 unless action is taken (Barra and Leonard, 2018). Pollution of the seas from plastics and micro plastics (in principle items smaller than 5 mm) is one of the most important problems. Micro plastics are a threat to ecosystem health as small organisms and those in early life-stage can more easily uptake these materials. Therefore, micro plastics may become entrained in benthic and pelagic food webs (Conkle *et al.*, 2018). It has been estimated that between 4.8 to 12.7 million tons of marine litter enter the seas from land and coastal sources around the globe each year (Brink*et al.*, 2018, Conkle *et al.*, 2018). The oceans contain over 150 million tons of plastics or more than 5 trillion micro and macro plastic particles. The amount of plastic in the oceans could triple by 2025 without further intervention (Barra and Leonard, 2018). Great accumulation zones occurring in oceanic gyres are sometimes also referred to as a ‘plastic soup’ of waste. More recent research reveals that most of the plastic litter there is actually micro plastics and not large piles of material forming ‘islands’, whereas, itis assumed, most of the plastic released in the ocean finds its way to the sea floor. Concentration of litter is also high on the beaches (EC, DG Environment).

Globally, it is estimated that only 9% of plastic waste generated between 1950 and 2015 was recycled. India has the highest plastic recycling rate ranging from 47 to 60%.In the EU, only approximately 30% of 25 million tons of post-consumer plastic waste was recycled in 2014; China had a recycling rate of 22% in 2013; while only 9.5% of plastics entering the US municipal solid waste stream were recycled in 2014 (Barra and Leonard, 2018). Nevertheless, slowly but steadily, the recycling of plastic waste has been increasing. The data for 2016 on the management of plastic waste in Europe indicate that the first time recycling has exceeded land filling. In 2016, 27 million tons of plastic waste was collected, of which 41.6% was used for energy recovery, 31.1% was recovered in recycling processes, and 27.3% of waste was land filled. The levels of recycling, energy recovery and land filling of plastic waste vary between the EU countries. In 10 countries, the recycling and energy recovery as a sum exceeds 90%, in some the value is below 30%. This means that more than 9 million tonnes of plastic waste are still land filled in Europe (Plastics the facts, 2017).

The EC has classified plastics amongst the five priority areas, where progress needs to be made towards a circular reality, recently launching a relative strategy (EC, 2018b). To monitor the progress towards a circular economy, many different indicators have been proposed to quantify the calculation of this performance. Huysman *et al.*, (2017) have suggested the circular economy performance indicator (CPI). The CPI was defined as the ratio of actual environmental benefit over the ideal environmental benefit according to quality. These benefits are expressed in terms of resource footprints, calculated through Life Cycle Assessment (LCA). Van Eygen *et al.*, (2018), in their analyses, used three indicators. First – Recycling Rate (RR), which is frequently used in policy documents to quantify the amount of waste materials that is fed back into the economy. RR is defined as the amount of re-granulate produced at the mechanical recycling plant divided by total waste amount. Second indicator – the Collection Rate (CR) is the amount collected divided by the total waste amount. And third indicator – the Sorting Rate (SR) is the amount sorted and sent to the mechanical recycling processes divided by the total waste amount.

However, as the authors have emphasized the general consensus for the EU targets is to calculate the recycling rate at the gate of the recycling plant, that is, the input to the recycling process, although this has not been clearly defined. This causes confusion, especially with regard to comparing the performance of different regions or countries. However, monitoring and assessing the waste management system is indispensable. Therefore, the best or most favorable mass-based indicators should be used. These considerations are a subject of now and further researches. Composition and application of appropriate tools – optimal indicators are necessary to assess the principal goal of circular economy, which is to protect the natural environment whilst at the same time lay foundations to a new plastic economy, where the design and production fully respect reuse and recycling needs and more sustainable materials are developed (Bozena, 2018). Given the global scale of plastic pollution, the cost of removing plastics from the environment would be prohibitive. Most solutions to the problem of plastic pollution, therefore, focus on preventing improper disposal or even on limiting the use of certain plastic items in the first place. Awareness of the serious consequences of plastic pollution is increasing, and new solutions, including the increasing use of biodegradable plastics and a “zero waste” philosophy, are being embraced by governments and the public (Lale, 2018).

Table .1 below show how biodegradable waste items will disintegrate with the passage of time even when left on their own but, apart from creating health hazards, the rate of disintegration may be too slow for the rate of generation thereby making the environment aesthetically unappealing. Owing to the multidimensional nature of waste and its attendant negative effects on humans, wildlife and the environment, its management is highly crucial and requires concerted effort (GDRC, 2013; Mbina *et al* ., 2015).

Table1. *Rate of Degeneration of Waste Item*

Types of Waste	**Time Needed to Degenerate, if left Untreated**
Organic wastes (vegetable, fruit, food, etc)	7 – 15 days
Paper	10 – 30 days
Cotton cloth	2 – 5 months
Woolen cloth	12 months
Tin, aluminium and other metal cans	200 -500 years
Plastics	100 – 1000 + years
Glass	Not determined

Source: *Global Development Research Centre, 2013*

In addition to global trends, What a Waste 2.0, of World Bank, 2018 (Fig.2) maps out the state of solid waste management in each region. For example, the East Asia and Pacific region is the region that currently generates most of the world’s waste at 23%. And although they only account for 16% of the world’s population, high-income countries combined are generating over one-third (34%) of the world’s waste. Because waste generation is expected to rise with economic development and population growth, lower middle-income countries are likely to experience the greatest growth in waste production.

The fastest growing regions are Sub-Saharan Africa and South Asia, where total waste generation is expected to triple than double by 2050, respectively, making up 35% of the world’s waste. The Middle East and North

Africa region is also expected to double waste generation by 2050.Upper-middle and high-income countries provide nearly universal waste collection, and more than one-third of waste in high-income countries is recovered through recycling and composting. Low-income countries collect about 48% of waste in cities, but only 26% in rural areas, and only 4% is recycled. Overall, 13.5% of global waste is recycled and 5.5% is composted (World Bank Group, 2018).

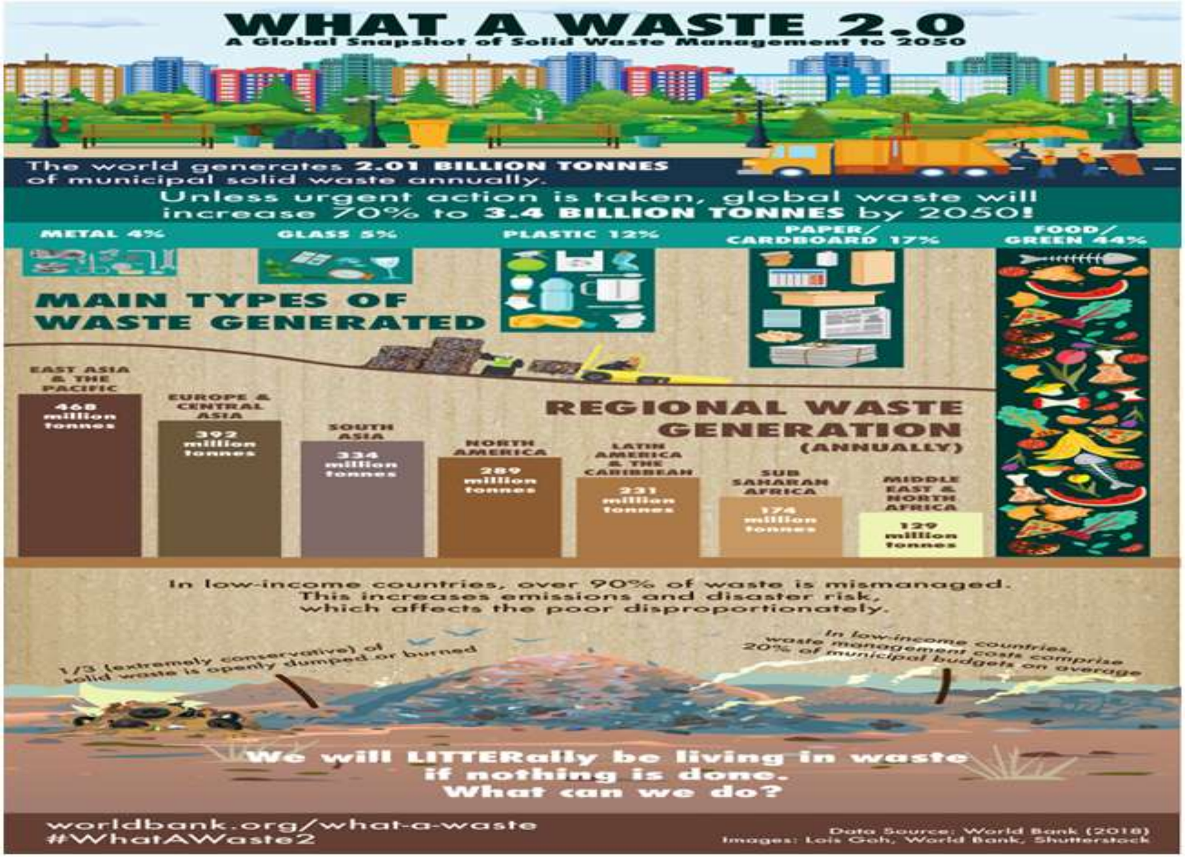

Fig2: *Global Trend of Solid Waste Generation by Region in Billion Tonnes By 2050*

Data Source: *World Bank, 2019*

Materials Recovery and Recycling

Material recovery is a massive challenge with the aim to minimize the amount of waste sent to landfills by recycling and remanufacturing (Ghinea *et al*. 2013). The materials which can be recovered from municipal solid waste mainly include paper (basis for new paper production), glass (basis for new glass production or direct reuse of bottles), plastic (basis for new plastic production), electronic scrap and metals (recovering of gold, molybdenum, copper, etc.) and energy (from residual waste: incineration with combined heat and power – CHP) (Ghinea *et al*. 2013; Hall, 2010).

As part of the material recovery, recycling has evident environmental benefits at every stage in the life cycle of a product from the raw material extraction to its final disposal. Recycling reduces air and water pollution associated with making new products from raw materials (such as greenhouse gases emissions, which contribute to global warming) (Ghinea and Gavrilescu 2010b; US EPA 2007). For example, according to Maguin (2015), aluminum recycling saves up to 92% of CO_2 emissions, while steel recycling saves up to 58% of CO_2 emissions.

Conclusion

Finally, recycling is an intricate technique for protecting the environment by recovering materials or components of used products, resulting in new products. The drive for recycling is to limit the use of new materials and decrease the amount of waste. About the profits of recycling are resource conservation (reducing demand for new resources), reducing transport costs and energy production (energy saving by avoiding exploitation of raw materials) and saving resources that otherwise would be lost in storage sites .Recycling is ideal to incineration and disposal of non-renewable materials such as glass, metals and plastics because the total energy and global warming potential is generally low. For renewable materials (paper and cardboard) in most cases, the global warming potential is lower for recycling than for incineration. Recycling can be sustainable if it is well-organized in terms of costs. Consequently, zero waste in the World view in the framework of circular economy requirements more concerns in terms of waste generation progresses as well as vis-à-vis increasing the amount of waste management by recycling.

REFERENCES

[1] Adeyemi, A. S., Olorunfemi, J. F., & Adewoye, T. O. (2001): Waste scavenging in Third World cities: A case study in Ilorin, Nigeria. *Environmentalist*, *21*(2), 93-96. https://doi.org/ 10.1023/A:1010655623324

[2] Ahmed S.A. and Ali M. (2004): Partnerships for solid waste management in developing Countries: Linking theories to realities, *Habitat International* 28 (3) 467 –479.

[3] Anthony A.M, Edem E.E (2015): Challenges of Urban Waste Management in Uyo Metropolis, Nigeria. Civil and Environmental Research Vol. 7. No.2 IISTE, 2015.

[4] Barra R., Leonard S.A. (2018): Plastics and the circular economy. 54-th Global Environment Facility Council Meeting, June 24 – 26, 2018 Da Nang, Viet Nam.

[5] Bozena M, (2018): Plastics in the circular economy (CE).Journal of Environmental Protection and Natural Resources. Vol. 29 No 4(78): 16-19 DOI 10.2478/oszn-2018-0017, Sciendo

[6] Brink P., Schweitzer J.P., Watkins E., Janssens C., De Smet M., Leslie H., Galgani F. (2018): Circular economy measures to keep plastics and their value in the economy, avoid waste and reduce marine litter. Economics: 3: 1-14.

[7] COM (2015): Closing the loop – an EU action plan for the Circular Economy. Communication from the Commission to the European Parliament. The Council, the European Economic and Social Committee and the Committee of the Regions, European Commission. Brussels *Communications in Waste & Resource Management*, 9(1), 24-30.

[8] Conkle J. L. Barez Del Valle C.D., Turner J.W. (2018): Are we underestimating micro-plastic contamination in aquatic environment? Environmental Management: 61:1-8.

[9] Connett P, Sheehan B (2001):A citizen's Agenda for zero waste. http://archive.grrn.org /zerowaste/community/activist/citizens_agenda _2_read.pdf Countries: Linking theories to realities, *Habitat International* 28 (3) 467 –479.

[10] Cramer J (2014): Moving towards a circular economy in the Netherlands: challenges and directions. Utrecht Sustainability Institute, Utrecht University and Economic Board Amsterdam, the Netherlands. http://usi-urban.wp.hum.uu.nl/files/ 2015/04/Paper-HongKong-JC-april-2014. pdf. Accessed 5 Apr 2001

[11] Cristina G, Maria G (2019): Solid Waste Management for Circular Economy: Challenges and Opportunities in Romania –The Case Study of Iasi County. In M.L Franco-Garcia et al., (eds). Towards Zero Waste, Circular Economy Boost, Waste to Resources. Greening of the Industry, Networks Studies. Vol.6, Springer Nature Switzerland AG, 2019.

[12] Egun N.K (2012): The Waste to Wealth Concept: Waste Market Operation in Delta State, Nigeria. Greener Journal of Social Sciences. Vol. 2 (6), pp 206- 2012.

[13] Ellen MacArthur Foundation (2013):Towards the circular economy volume 2: opportunities for the consumer goods sector. https://www .ellenmacarthurfoundation.org/publications/tow ards-thecircular-economy-vol-2-opportunities for -the-consumer-goods-sector. Accessed 2May 2017

[14] Eseigbe, J. O. Omofomnwan, S. I. and Kadiri, M. A. (2007): Solid Waste Generation and Managementin Benin Metropolis Confluence Journal of Environmental Studies Vol. Number 2. pp 34 – 43.

[15] European Commission (2018b): Commission staff working document, Report on Critical Raw Materials and the Circular Economy, Brussels, 16 January 2018 SWD (2018) 36 final part. (180116 CRM and Circular Economy Report.pdf.) (b)

[16] Ezeah, C., & Roberts, C. L. (2014): Waste governance agenda in Nigerian cities: A comparative analysis. *Habitat International*, *41*(1), 121-128. https://doi.org/10.1016/j.habitatint .2013.07.007

[17] GDRC (2013): Global Development Research Centre, 2013

[18] Gharfalkar M, Court R, Campbell C, Ali Z, Hillier G (2015): Analysis of waste hierarchy in the European WASTE DIRECTIVE 2008/98/ EC. Waste Manag 39:305–313. https://doi. org/10.1016/j.wasman.2015.02.007

[19] Ghinea C (2012): Waste management models and their application to sustainable management of recyclable waste. PhD Thesis, Gheorghe Asachi Technical University of Iasi, Romania

[20] Ghinea C, Gavrilescu M (2010b): Models for sustainable waste management. Bulletin of the Polytechnic Institute of Iasi, Chemistry and Chemical Engineering Section, LVI (LX) (2): 21–36

[21] Ghinea C, Petraru M, Bressers HTA, Gavrilescu M (2012): Environmental evaluation of waste management scenarios – significance of the boundaries. J Environ Eng Landsc Manag 20: 76–85. https://doi.org/10.3846/16486897.2011 .644665

[22] Ghinea C, Simion IM, Gavrilescu M (2013): Solid waste recycling for remanufacturing and bio remediation. Bulletin of the Polytechnic Institute of Iasi, Chemistry and Chemical Engineering section, LIX (2), 35–48

[23] Ghisellini P, Cialani C, Ulgiati S (2015):A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. J Clean Prod 114:11–32. https:// doi.org/10.1016/j.jclepro.2015.09.007

[24] Haas W, Krausmann F, Wiedenhofer D, Heinz M (2015): How circular is the global economy? An assessment of material flows, waste production, and recycling in the European Union and the World in 2005. J Ind Ecol 15: 765–777. https://doi.org/10.1111/jiec.12244

[25] Hall D (2010): Waste Management in Europe: framework, trends and issues. PSIRU, business school. University of Greenwich, Park Row

[26] Hans D, Maria CMR, (2019): Potential and Challenges for a Circular Economy in Mexico. In M.L Franco-Garcia et al., (eds). Towards Zero Waste, Circular Economy Boost, Waste to Resources. Greening of the Industry, Networks Studies. Vol.6, Springer Nature Switzerland AG, 2019.

[27] Huysman S., De Schaepmeester J., Ragaert K., Dewulf J., De Meester S. (2017) : Performance indicators for a circular economy: A case study on post-industrial plastic waste. Resources, Conservation and Recycling 120: 46-54.

[28] Ikechukwu E.E, (2015): Assessment of the Activities of Scavengers in Obio/Akpor Local Government, River State, Nigeria. Journal of Environmental Protection, 64, 272-280, 2015

[29] Informal sector. Paper delivered at Solid Waste Planning in the Real World CWG-Green Partners Workshop, Cluj, Romania, 22-23 February.

[30] Institute of Natural Resources University of Port Harcourt (2019): Lecture Module / Handbook, INRES, 2019.

[31] ISWA (2015): Circular economy: trends and emerging ideas. International Solid Waste Association, Vienna

[32] Jackson M, Lederwasch A, Giurco D (2014): Transitions in theory and practice: managing metals in the circular economy. Resources 3:516–543

[33] Jávor B (2015): Circular economy – what we can achieve with ambitious recycling targets and what is crucially needed beyond. In: Circular economy in Europe towards a new economic model, The European Files, September 2015

[34] Lale N.E.S. (2018): The theme for 2018 World Environment Day "Beat Plastic Pollution" to be hosted by India. An Address by Professor Ndowa E. S. Lale Vice-Chancellor, University of Port Harcourt at the World Environment Day Celebration Under the Auspices of the Institute of Natural Resources, Environment and Sustainable Development (Inres), University of Port Harcourt at The International Students' Centre on Wednesday, 6th June, 2018.

[35] Maguin D (2015): Why Europe needs a market-driven circular economy? In Circular economy in Europe towards a new economic model, The European Files, September 2015 *Management and Research* 32(9) 797–799.

[36] Maria LFG, Jorge CCA and Hans B (2019): Towards Zero Waste, Circular Economy Boost, Waste to Resources. Greening of the Industry, Networks Studies. Vol.6, Springer Nature Switzerland AG, 2019.

[37] Mbina A.A., Edem .E.E (2015): Challenges of urban waste management in Uyo Metropolis, Nigeria Civil and Environmental Research www.iiste.orgISSN 2224-5790 (Paper) ISSN 2225-0514 (Online)Vol.7, No.2, 2015

[38] Nzeadibe T.C and Iwuoha, H.C. (2008): Informal waste recycling in Lagos, Nigeria *Communications in Waste & Resource Management*, 9(1), 24-30.

[39] Nzeadibe T.C. (2019): Value Reclamation by Municipal Solid Waste Pickers and Scrap Dealers in Nigerian Cities. Guest Lecture presented At School of Public Health, Room 1G, University of Western Cape, South Africaon Thursday 9 May 2019.

[40] Ogbonna, D. N and Ekere, T. O (2006): Land use, Urbanization and Economic Development on solid waste generation: A case study of Port Harcourt, Rivers state, Nigeria. *Niger Delta Biologia* 5(2):132-143

[41] Ogbonna, D. N., (2008): Assessment of the Activities and Contributions of the Waste Pickers /Scavengers to Solid Waste Management in Port Harcourt, Nigeria. Niger Delta Biologia Vol. 8 No [1] 2008, 53-64 ISSN 1118-8731

[42] Ogu, V. I. (2000): Private sector participation and municipal waste management in Benin City, Nigeria. *Environment and Urbanization, 16*(2), 103-117. https://doi.org/10.1177/095624780001200209

[43] Ogwueleka T.C (2009): Municipal solid waste characteristics and management in Nigeria. *Iran J Environ Health Sci and Eng*, 6(3): 173-180

[44] Plastics the facts, (2017): org/application /files/5715/1717/4180/Plastics the_facts_2017) (https://www.plasticseurope Rates through the informal sector. Waste Management, 29 (2), 629-635.

[45] RSA Innovate UK (2016): Designing for a circular economy: lessons from the great recovery 2012–2016. The great recovery. Redesigning the future. ISBN: 978-0-901469-85-4

[46] Scheinberg, A. (2008): A bird in the hand: solid waste modernization, recycling and the Informal sector. Paper delivered at Solid Waste Planning in

the Real World CWG-Green Partners Workshop, Cluj, Romania, 22-23 February.

[47] Singh J, Ordonez I (2016): Resource recovery from post-consumer waste: important lessons for the upcoming circular economy. J Clean Prod 134:342–353. https://doi.org/10.1016/j.jclepro.2015.12.020

[48] Sridhar M.K.C and Hammed T.B (2014): Turning Waste to Wealth in Nigeria: An Overview Journal of Human Ecology, 46 (2): 195 -203 (2014)'

[49] Tchnobauoglous, G., Theisen, H. and Vigil, S. (1993): Evolution of Solid Waste Management in Integrated Solid Waste Management in Perugia. A Research Work on Perugia Italy.

[50] US EPA (2007): Municipal solid waste generation, recycling, and disposal in the United States: facts and figures for 2007. http://www.epa.gov/waste/nonhaz/municipal/pubs/msw07-fs.pdf. Accessed 12 Apr 2011

[51] Van Eygen E., Laner D., Fellner J. (2018): Circular economy of plastic packing: Current practice and perspectives in Austria. Waste Management 72: 55-64.

[52] WEF (2014): Towards the circular economy: accelerating the scale-up across global supply chains World Economic Forum, Geneva

[53] Wilson, D.C. and Velis, C.A. (2014): Cities and waste: Current and emerging issues. *Waste Management and Research* 32(9) 797–799.

[54] Wilson, D.C., Araba, A.O., Chinwah, K. & Cheeseman, C.R. (2009): Building recycling Rates through the informal sector. Waste Management, 29 (2), 629-635.

[55] World Bank Group (2018): What a Waste 2.0. A Global Snapshot of Solid Waste Management to 2050

[56] Yuan Z, Bi J, Moriguichi Y (2008): The circular economy: a new development strategy in China. J Ind Ecol 10:4. https://doi.org/10.1162/108819806775545321

[57] Zaman AU (2015):A comprehensive review of the development of zero waste management: lessons learned and guidelines. J Clean Prod 91(15 March):12–25

[58] Zils M (2014): Moving toward a circular economy. http://www.mckinsey.com/business-functions/sustainability-and-resourceproductivity/our-insights/moving-toward-a-circular-economy. Accessed 31 Mar 2016

[59] ZWIA (2015): Zero waste international alliance. http://zwia.org/aboutus/. Accessed 1 Sept 2017

Citation: *Wali, Elekwachi, Wizor Collins .H, Nwankwoala, Hycienth .O, "Waste-To-Wealth, Towards a Sustainable Zero-Waste in a Circular Economy: An Overview", International Journal of Emerging Engineering Research and Technology, 7(11), 2019, pp. 1-11*