



ADDRESSING URBAN SOLID WASTE CHALLENGES, THROUGH CIRCULAR ECONOMY MODEL IN A DEVELOPING ECONOMY (NIGERIA)

Tochukwu S. Ezeudu and Obiora B. Ezeudu

Department Of Public Administration, Federal University Gusau
Centre For Environmental Management and Control, University of Nigeria,
Nsukka.

Abstract

Urban environmental problems manifest in various forms to produce undesirable effect on the urban dwellers. In Nigeria, the most visible urban environmental problem that confronts a first-time visitor is waste accumulation and inadequate disposal methods. The circular economy (CE) is a recent and growing area of research that advocates for a regenerative approach to natural resource management, as opposed to a linear method that is hugely unsustainable as a result of the finite availability of raw resources for production and the associated environmental degradation. Hence, this study evaluates, the problems associated with urban solid waste management and opportunities of implementing the circularity principle at the state level of a typical developing economy, Nigeria and how to address such challenges through implementation of circular economy

model. Six states were selected from the six geo-political zones of the country. These states represent the major waste streams in an urban solid waste mix. This study discovered several barriers and existing pre-conditions in place that could either foster or militate against the smooth and successful application of a CE model as a simple modification of the generic model. This study also discussed future directions on the implementation of the model.

Keywords: *urbanization, urban waste, waste management, circular economy, developing economy, Nigeria.*

1. Introduction

Today, there is no doubt that the world has increasingly become urban and the 20th century witnessed rapid and unprecedented urbanization of the world's population. The global urban population increased from 13% in 1900 to 29% in 1950, 49% in 2005 and it is estimated that by 2030, 60% of the population will live in the cities. (UN, 2015). The development of urban centres in Nigeria has a historical antecedent dating back to the pre-colonial era. Urbanization in Nigeria started in the medieval times long before the advent of European colonization (Phil-Eze, 2001) socio-economic and political factors such as rapid rate of population growth, viable economic enterprises and increased size of rural-urban

migration played significant roles towards the development of urbanization in Nigeria.

The issues of environment and urban health refer to the continued exposure to the risks of infectious diseases and injuries associated with poor sanitation, unsafe drinking water, heaps of solid waste, dangerous roads, polluted air, and toxic wastes, all of which are environmental health problems of poverty. Urban poverty is the most important predictor of the environmental health risks because in its broadest sense it also includes other forms of deprivation: physical assets, political influence, access to basic services, and access to social capital. (WHO, 1995) While access to toilet facilities has been constantly higher in urban areas than rural, available data reveal improvement over the years have not been dramatic. According to the NDHS report, the proportion of households using improved, not shared toilet facilities in urban areas is 42.7% (NPC, 2014) This implies that many urbanites still exhibit their rural habits as large number of people urinate and defecate in open spaces with serious health implications in densely populated urban settlements. There is no single city in Nigeria with a modern central sewerage system. (Enweze, 2000) (A study in four major cities of Lagos, Ibadan, Kano, and Onitsha reported that the proportion of households connected with sewage systems was very low and varied from none at all in Ibadan and Onitsha to 2%–3% in Lagos and Kano while <1% of waste water in these cities were treated. (UNICEF, 2001) Hence, as urbanization proceeds and urban population continued to grow rapidly, sanitation worsened. The provision

of sanitation in Ibadan, Nigeria's largest city is grossly deficient as in most cities in SSA. (Oloruntoba, Folarin, & Ayede, 2014) There is lack of effective system of refuse collection. Unorganized, haphazard disposal of wastes takes place at the fringes of squatter and slum areas even in metropolitan Lagos. Disposal of refuse is inefficiently organized in virtually all urban areas. Mabogunje reported that uncollected solid wastes also prevent adequate water drainage and contribute to water pollution. (Mabogunje, 2002). Solid waste management has emerged as one of the greatest challenges facing states and local government Environmental Protection or Management Agencies in Nigeria. Thus, the municipal administrations have without exception failed woefully in managing the disposal of solid waste now being generated at ever-increasing rates due to lack of fund. (Don-Pedro, 2009).

Urban environmental problems manifest in various forms to produce undesirable effects on the urban dwellers. In Nigeria, the most visible urban environmental problem that confronts a first-time visitor is wastes accumulation and inadequate disposal methods. The wastes are generated from various sources such as residential areas, commercial areas, industrial areas and institutional establishments. The waste, which are either liquid or solid in nature, may also be either biodegradable or non-biodegradable. It is solid waste that creates perceptible urban environmental problems whereas the problems associated with liquid waste (e.g., Water pollution) are not readily perceived except at local level.

The circular economy (CE) is a recent and growing area of research that advocates for a regenerative approach to natural resource management, as opposed to a linear method that is hugely unsustainable as a result of the finite availability of raw resources for production and the associated environmental degradation. (Lehmann; Leeuw, Fehr, & Wong, 2014), The circularity principle is being further propelled by the overarching issue of sustainable development, which has caught global attention and adoption. Based on this perspective, this area of research has become a topic of interest for many researchers in recent times, especially in the specific areas of waste valorisation, cleaner production, life cycle thinking and green consumption. To date, managing solid waste in most world cities has traditionally followed the implementation of a linear economy system. Although this approach emphasizes integrated approaches to waste handling in order to protect the environment and public health, the central focus of this system is usually to ensure that the generated waste does not cause harm to the environment, humans and the society at large (Onipede, & Bolaji.)

Thus, this study evaluates, the problems associated with urban solid waste management and opportunities of implementing the circularity principle at the state level of a typical developing economy, and how to address such challenges through implementation of circular economy model

2. Literature Review/ Conceptual Framework

2.1 Urbanization, conceptual clarification

Urbanization is no longer a new phenomenon in Nigeria. People have been living in settlements and there had been massive movement of people from the rural to urban areas or cities up till date. This implies that urbanization is a progressive concentration of population in towns and cities. (Abada, 2001) urbanization is perhaps the best symbol of radical. Physical, economic and social transformation that mankind is passing through as a consequence of development. This means that urbanization necessitates development by being a tool of and also a product of development. (Phil-Eze, 2001). Historically, cities have been the epicentre of economic development and centres of industry and commerce all over the world. If they are well managed, cities offer important opportunities, social and technological development, and facilitated the diffusion of information through interaction among diverse cultures. Cities have been focal points for political activities, systems of law, and good governments and employments. Cities have also been centres of scientific innovations, for instance in 19th century, urban residents in Europe were among the first people to widely practice family planning before the practice spread to countryside. (Brinckerhoff, 2000.) While, there is no universal definition of what constitutes urban settlement, the criteria for classifying an area as urban may be based on one or a combination of characteristics as human population threshold, population density, proportion employed in non-agricultural sectors, presence of infrastructures such as paved

roads, electricity, piped water or services, and presence of education and health services. (Cohen, 2006) On the other hand, urbanization denotes a process whereby a society changes from a rural to urban way of life or redistribution of populations to urban settlements associated with development and civilization. For millennia, urban areas have been centres and drivers of commercial, scientific, political and cultural life, having a major influence on the whole countries and regions. The Nigerian society is undergoing both demographic transition (people are living longer) and epidemiological transition (change in population health due to changes in lifestyle) mainly as a result of urbanization.

Urbanization is a major waste challenge of the 21st century as urban populations are rapidly increasing, but basic infrastructures are insufficient and social and economic inequities in urban areas have resulted in significant health inequalities. In this sense, therefore, urbanization in a way is similar to globalization which can be seen as a structural social determinant of health that can challenge the aspirations of equity due to tendency of accumulation of wealth and power among urban elites. (Cohen, 2006) Today, most cities in Nigeria have undergone urban decay because of lack of or breakdown in basic services; potable water supply, electricity, efficient city transport services, affordable housing, and waste disposal systems. This is largely as a result of authorities coming to terms with the “tempo” of rising urban needs. These phenomenal transitions are not without health challenges to the population in urban areas and cities. (Brinckerhoff,

2000.) These prompted this review as there is an obvious need to assess how these demographics can enhance our understanding of the current urban waste in Nigeria and its challenges.

2.2 Challenges Of Urban Solid Waste Management in Nigeria

The solid waste management (SWM) is an essential service for urban society and has attracted significant attention of experts and local and national authorities (Piippo, Saavalainen, Kaakinen, & Pongrácz, 2015). Solid waste services ought to be available to all communities, as they have public health and environmental aspects (Ahmed & Ali, 2004). Improper management of municipal solid waste (MSW) is represented by a low collection rate of waste, waste accumulation on roadsides and around containers, and the illegal dumping or burning of waste in spaces (Ahmed & Ali, 2004; Lederer, Ongatai, Odeda, 2015; Scheinberg, 2010; Wilson, Rodic, Scheinberg, Velis, & Alabaster, 2012). This situation causes severe environmental effects, risks to public health (Ağdağ, 2009; Ayomoh, Oke, Adedeji, & Charles-Owaba,; Qdais,2007; Sharholy , 2008; Turan, 2009) and other socio-economic issues such as increasing the numbers of informal waste pickers whose working conditions need improvement in addition to political and legal recognition (Ali, 2010; Wilson, Velis, & Cheeseman, 2006). In developing countries, the waste collection rate is less than 70%, and more than 15% of the generated waste is addressed through unsafe,

illegal and informal recycling, and around half of the collected waste is disposed of in open and uncontrolled dump sites (Chalmin & Gaillochet, 2009). Many factors are contributing to the vast spread of uncontrolled waste landfills across cities of developing countries, such as urban activities, population explosion, bureaucratic confusion, weakness of public power, poverty level, infrastructure and resourcing problems (Hoorweg & Bhada-Tata, 2012; Oteng-Ababio, 2013). SWM strategies aim to deal with the challenges resulting from inadequate waste collection and disposal services.

The common practice for waste management in Nigeria is landfilling (open dumping). (Agwu, 2012) Substantial quantity of solid waste generated in Nigeria Urban centres are indiscriminately deposited on roads or roadsides, unapproved dumpsites, in water ways (drainage system) or in open sites which negatively impact the environment and de-beautify its landscape). (Odoemen & Ofodu, 2016) Some of the open dumps are indiscriminately located at streams, valleys, water lands, open fields and abandoned borrow-pits. (Ukpong, Udo, & Umoh, 2015). This system of waste disposal accumulates huge quantity of waste annually and is associated with several problems such as contamination of groundwater and outbreak of various human diseases (Akor; Ayotamuno; Aman & Enokela, 2013). In Aba, experimental studies have shown that about 47.39% of the total solid waste is organic and compostable whereas recyclable waste accounts for about 4.69–9.90% (Ajero & Chigbo, 2012.) improper disposal of

these untreated wastes can be deleterious. Air pollution, underground water contamination, land degradation, soil contamination and habitat deterioration can be caused by improper waste disposal. (Odoemen & Ofodu, 2016). Environments close to dumpsites are constantly exposed to risk of infection, reduced agricultural yield, groundwater contamination, decline in benthic communities due to toxicity and exposure to hazardous compounds (Ayuba; Manaf; Sabrina, 2013). Additionally, global warming, photochemical oxidant creation, acidification, ecotoxicity of water, eutrophication and abiotic resource depletion can be caused by indiscriminate dumping of waste (Nkwachukwu, Chidi & Charles, 2010). According to the World Health Organization (WHO) and the United Nations International Children Education Fund (UNICEF), bad sanitation, decaying or non-existent sewage system and toilets fuels the spread of various diseases (cholera, diarrhoea and basic illness) which kill a child in every 21 seconds. (Momodu, Dimuna &, Dimun, 2011)

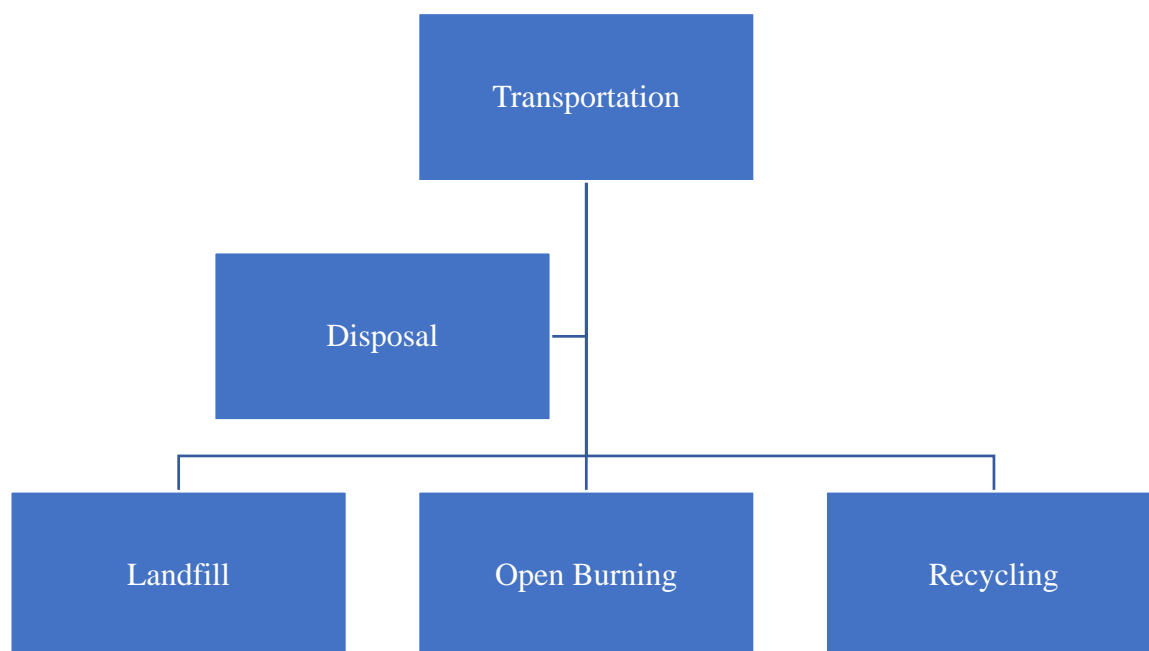


Fig 1. Existing Urban Solid Waste Management Flowchart in Nigeria

2.3 Waste Management Methods in Developed and Developing Countries

There are several techniques for waste management in both developed and developing countries, Significant among them are incineration, landfilling, source reduction, recycling and composting. These techniques have been widely employed in waste management in both developed and developing countries. However, these techniques have their merits and demerits.

Incineration

Incineration is a widely used waste management technology. The mechanism of incineration depends on the combustion of waste at high temperatures.

(Narayana, 2009). Incineration has the capability to:

- i. Reduce total organic matter content
- ii. Destroy organic pathogens or contaminants
- iii. Significantly reduce waste volume
- iv. Preserve raw materials and resources

However, Incineration does not eliminate waste but reduce and transform it into new forms which also require disposal in landfills (Sabbas, Poletini, & Pomib, 2003). There are great concerns about incinerators due to aesthetic issues such as foul odors, noxious gases and gritty smoke. Additionally, air quality deterioration, toxicity, disposal of produced ash and potential leaching of heavy metals from fly ash are critical concerns about incineration. (Nkwachukwu, Chidi & Charles, 2010) In developing nations where waste composition is mainly organic, incinerators require the supply of excess fuel for waste combustion due to high moisture content of solid waste (Ogwueleka, 2009; Zhang, Herbal, & Gaye-Haake, 2004). According to Seik (1999) waste management by incineration is estimated to cost about 7 times more than landfilling. Recycling of MSW is widely practiced in developed nations. Thus, it is widely acceptable that incineration may not be suitable for developing nations.



Fig 2. Waste incinerator in a developed country (Germany)

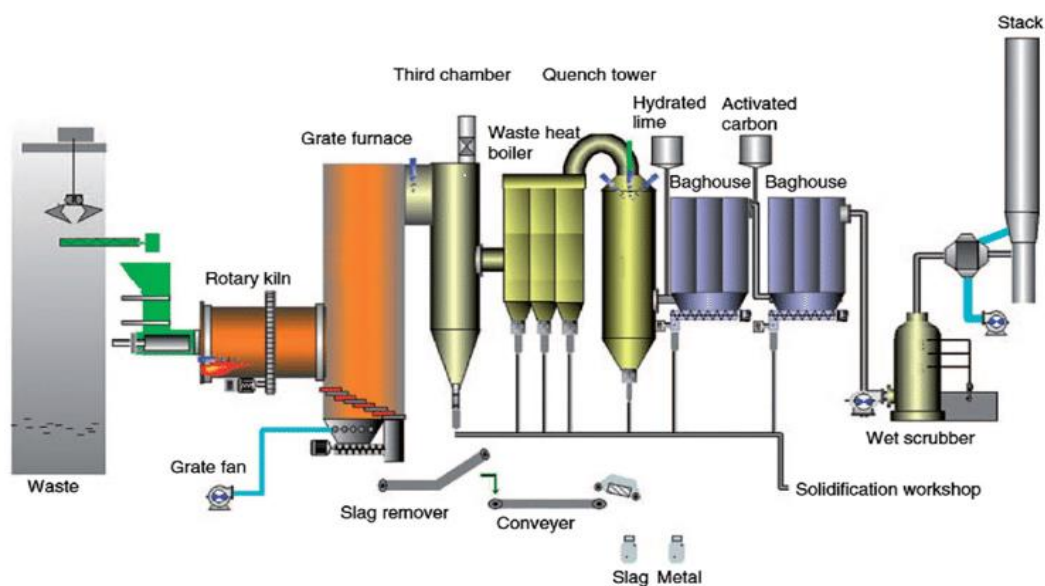


Fig 3. Waste incineration system.

Landfilling

A landfill relates to an area designated for waste disposal in such a manner that it does not pollute the surrounding environment especially, groundwater. Landfills are used for a specific period of time. However, the use of landfill for waste management has become less sustainable due to the rising cost of

construction, operation and environmental consequences (Ezechi, Isa, Kutty & Sapari, 2011). For instance, methane emissions from landfills in Germany have previously accounted for about 25% of total methane emissions. Thus, disposal of highly organic waste into landfills were prohibited in 2001. (Zhang, Keat & Gersberg, 2010) Landfills produce leachate and gases which are harmful to both humans and natural systems. These landfill gases (LFGs) which are product of anaerobic decomposition of complex molecules contribute to urban ozone problems and global warming. (Sharma, 2003) Some of the challenges of landfilling include:

- i. Shortage of dumping sites
- ii. Strict environmental legislation
- iii. Contamination of groundwater through leaching of leachate

Landfills could be classified into three categories namely open landfills, semi-controlled landfills and sanitary landfills. The challenges, health and environmental implications of open landfills are enormous and may not be suitable for developing countries. Although it is the common practice (open dumping) in developing countries, it's environmental and health implications are enormous. Therefore, municipalities must put into consideration, the health and environmental concerns of their citizens and adopt approaches that will mutually serve the citizens and their government.



Fig 4. Waste landfill in a developed country (Germany)

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Composting

Composting is a microbial technology occasionally used to stabilize various type of waste. Composting can capably reduce waste volume by 40–50%, metabolically destroy pathogens in the thermophilic phase and produce an end product suitable for soil amendment (Singh, Ibrahim, Esa & Iliyana, 2010). As a natural aerobic biochemical process in which thermophilic microorganisms decompose organic materials into a stable soil like product, composting eliminates payment of tipping fees at landfills and pathogens present in the waste do not survive the thermophilic temperature (40–70°C) during composting (Schaub, & Leonard, 1996). Composting can be conducted using

several approaches such as open aerated systems and contained systems. (Couth, & Trois, 2012) The benefits of composting biogenic waste include:

- i. Replacement of synthetic fertilizers
- ii. Reduction in greenhouse gas emissions

The most significant challenge to composting of USW is sorting/separation of waste. Municipalities must develop a strategy to separate the organic waste in order to produce good compost. Application of unstable and immature compost to agricultural soil can cause N starvation to plants (Kato, Miura, Tabuchi & Nioh, 2005), phytotoxic effects due to the emission of ammonia and other substances like phenolic compounds and low molecular weight organic acids. (Bernal, Albuquerque & Moral, 2009) and the presence of pathogens (Fang, Wong, Ma & Wong, 1999). To ensure the safety of compost in agricultural application, the maturity and stability have been used to define compost quality (Moral, Paredes, Bustamante, Marhuenda-Egea & Bernal, 2009). Therefore, composting of MSW may be viable for developing nations.



Fig 5. Waste compost method

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2.4 Circular Economy in Urban Solid Waste Management

The CE as a concept that is currently trending in the global research arena and it has garnered considerable attention among scholars as well as being adopted by institutions, policymakers, and other key economic sectors. This can be attributed to its uniqueness in articulating a restorative and regenerative approach to resource administration as opposed to the traditional linear model (Ezeudu, &

Ezeudu, 2019). The concept focuses on the product and is commonly applied at the design, production, consumption and waste management stages (Zhijun, Nailing, & Putting, 2007). In the area of waste resource management, the existing solutions tend to view waste products as a nuisance that constitute negativities to the environment, natural resources and public health therefore, solutions have been proffered bearing this in mind. Furthermore, in the linear economy model, solid waste handling modality's view waste products as a problematic commodity that often entails the deployment of scarce resources to manage them. In most developing countries, waste management is seen as an essential service to the citizenry and therefore, municipalities carve out a substantial part of their annual budget for solid waste management without projecting any significant return on the investment (Scarlet, Motola, & Dallemand, 2015). Even when a public-private partnership is deployed, the aim is often to maximize revenue collection from the public to ensure effective waste management services such as collection, transportation, and disposal. However (Agunwamba, 2013), the CE model promotes the concept that a product that has been perceived to have reached its end-of-life in a particular system might be used as a raw material in another or the same system. The circularity principle further reframes the traditional viewpoint by considering waste products as resources that could have an endless or multiple lifespans, with economic, social and environmental gains. (Plastinina, Teslyuk, Dukmasova, & Pikalova, 2019). Even when a public-private partnership is deployed, the aim is often to maximize revenue collection from the public to

ensure effective waste management services such as collection, transportation, and disposal (Agunwamba, 2013). However, the CE model promotes the concept that a product that has been perceived to have reached its end-of-life in a particular system might be used as a raw material in another or the same system, as shown in Figure 6. The circularity principle further reframes the traditional viewpoint by considering waste products as resources that could have an endless or multiple lifespans, with economic, social and environmental gains (Plastinina, Teslyuk, Dukmasova, & Pikalova, 2019).



(a) The circular economy (CE) Model



(b) Linear economy model

Fig 6. Circular economy (CE) model versus Linear economy model (a) is labelled CE model and (b) linear economy model.

According to some explanations, the linear economy model leads to the inefficient use of scarce resources, increases harmful emissions and yields increasing amounts of waste from the entire value chain including the extraction of resources, manufacturing, transportation, and consumption. (Kjørboe, Sramkova, & Krarup, 2015) Therefore, expert consensus in favour of CE is based on the fact that the intrinsic mechanics of the linear economy operates on the wasteful take-make-disposal flow, which is not only detrimental to the environment but cannot supply the growing populace of our planet with essential services and it naturally leads to strained profitability (Sariatli, 2017). However, it is crucial to mention that because CE is still an evolving concept that lacks an extant body of theory, some have challenged its effectiveness, for instance, in optimizing the organizational cost when it is holistically evaluated with regard to the transaction cost of contracts, the reconfiguration cost for resource portfolio and influences on the business network. (Lahti, Wincent, & Parida, 2018) other areas of possible weakness in the CE have been highlighted, including its thermodynamic limitations, the unclear definition of CE system boundaries and the challenges pertaining to the governance and management of CE-type inter-organizational and inter-sectorial material and energy flow .(Korhonen,

Honkasalo, & Seppala, 2018) However, the growing popularity of the CE concept is essentially due to its influence on the sustainable development concept in two key areas of economic prosperity and environmental quality . (Kirchherr, Reike, & Hekkert, 2018) even the opposing views rightly agree that CE as a concept has significant merit based on its ability to draw the business community, policymakers, and governments to sustainable development work .(Korhonen, Honkasalo, & Seppala, 2018) Meanwhile, for the efficient and comprehensive implementation of CE, efforts are required at three levels which include the micro-level (enterprises, factories, and production outfits), meso-level (eco-industrial park and inter-firm level) and macro-level (provinces, regions, states, and cities) (Su, Heshmati, Geng, & Yu, 2013) . This is in rhythm with the sustainable development objective that emphasizes cooperation of multi-levels—local, national and regional—in a formal partnership towards combating the world’s problems together. (Ngan, How, Teng, Promentilla, M.A.B. Yatim, Er, & Lam, 2019) Nevertheless, recent studies have suggested that theoretical CE models could be proposed prior to the evaluation and subsequent adoption by the socio-economically disadvantaged nations in the frugality context. This is a confirmation that CE models can be flexibly applied considering the fact that cities and societies could differ in the socio-economic, political and even cultural context (Ferronato, Rada, Portillo, Cioca, Ragazzi, & Torrenta, 2019) In this vein, a theoretical CE model was proposed by Ferronato et al. The work studied municipal solid waste management systems in two developing countries of

Romania and Bolivia and proposed a trimmed down (from the standard) CE model to the suitability of the studied countries. Like most developing countries, waste management policies, practices, and regulations in Nigeria have not been adequately developed and the existing ones are poorly implemented (Abila, & Kantola, 2013). Most policies that involve solid waste management in industries were mainly articulated and implemented as an integral part of the general urban solid waste management system. The aftermath is rightly reflected in the poor state of solid waste management in the country.

3. The Study Area: Nigeria

3.1 Brief History

Nigeria is a federal republic consisting of 36 states and a Federal Capital Territory. The states are subdivided into 774 administrative units of unequal size called Local Government Areas (LGAs). In some states, especially in the far north, these LGAs are grouped into emirates, districts, or traditional council areas. The 36 states are also grouped into six geopolitical zones that reflect ethnic identity in most cases. (Ezeudu, Agunwamba, Ezeasor, & Madu, 2019) Nigeria is one of Africa's most endowed economies, with an abundance of both natural and human resources. Its citizens are noted for their high degree of resourcefulness and entrepreneurial skills. Ironically, the country's per capita

income of U.S.\$350 in 1999 is one of the lowest in the world. The economy is largely agricultural. Sectoral contributions to the gross domestic product may give a distorted picture of reality since more than 50 percent of the population is engaged in agriculture. (Udeala, 2010) The structure and growth of the economy is therefore not easy to categorise. The main feature of the economy has always been that a high proportion of the national income is derived from the export of a wide range of mineral and agricultural products, with crude oil currently taking the lead. Since 1980, crude oil production has accounted for more than two-thirds of the gross domestic product and more than 80 percent of total government revenue. There exist vast industrial and commercial concerns that are largely dominated by state enterprises. There are also large, multinational companies, as well as poorly organised small-scale enterprises.

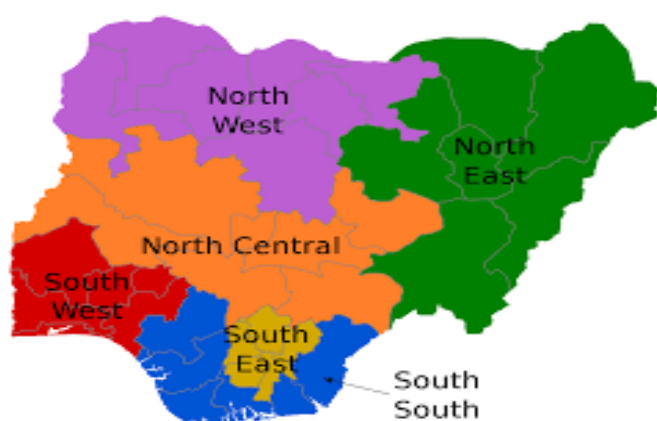


Fig.7. map of Nigeria showing the six geo-political zones.

The Six Geo-Political Zones in Nigeria

- **Central: Consisting** of Benue, Kogi, Kwara, Nasarawa, Niger, and Plateau States, as well as the Federal Capital Territory.
- **East: Consisting** of Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe States.
- **West: Consisting** of Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara States.
- **East: Consisting** of Abia, Anambra, Ebonyi, Enugu, and Imo States.
- **South South** (also known as **Niger Delta region** Consisting of Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers States.
- **West: Consisting** of Ekiti, Lagos, Ogun, Ondo, Osun, and Oyo States.



4. Material and Methods

4.1 Case Selection

The study adopted multistage sampling techniques, the study area was first divided into six geo-political zones, where the six states from each geo-political zones were stratified into low, medium and high residential density, a state with population of more than 4 million population was regarded as high residential density. The six states from each geo-political zones were Plateau State (North

Central), Bauchi State (North East), Kano State (North West), Anambra State (South East), Rivers State (South South), Lagos State (South West). The purposive selection was done in conformity to information-rich cases (Patton, 2001). The selected states are information-rich in the following context: economic viability, versatility, geographical coverage, and robustness with the study area (Nigeria)

4.2. Data Collection

The standard and documented data on solid waste management in most sub-Saharan African countries (including Nigeria) are not available (Scarlet, Motola, Dallemand, Monforti-Ferrario, & Mofor, 2015) The current study adopted a qualitative research method for data collection. Further reasons for adopting the current methodology include: (i) Quantitative measurements or survey-based methodologies are either inappropriate or less preferred for assessing organizational processes, such as industrial waste management processes (Strauss, & Corbin, 2007; Kuo, 2017) (ii) Specifically, when the aim of the study is to gain an understanding of the richness and complexity of the phenomenon, quantitative methods, such as experimental and survey methods, are less capable of capturing the details and providing insights, which makes a qualitative method more appropriate (Kuo, 2017; Lincoln, & Guba, 1985) (iii) Exploratory fieldwork is important in a new area of research (circular economy) that lacks an established body of theories and data (Kuo, 2017; Lincoln, & Guba, 1985; Noda,

& Bower, 1996) . (iv) The use of case research allows concepts to be developed for further study (Glaser, 1967; Noda, & Bower, 1996) (v) The case study research approach helps in developing a thorough understanding of how things work rather than testing hypotheses that are derived based on existing theory (Yin, 1983). The data required for the study were collected through three main sources: (i) Documented evidence through, academic peer-reviewed journals, company websites, policy briefs, government publications, magazines, newspapers, and other relevant grey publications; (ii) semi-structured interviews were also conducted on the selected respondents from the six states waste management agencies in order to capture information that might not be available in the reviewed materials; (iii) observation through exploratory fieldwork. The multiple sources of data collection are to meet the basic criteria for construct validity in case study research. The current study, therefore, applies a descriptive case study method to examine the current urban solid waste challenges in the selected Nigerian states. The data obtained from the different sources were triangulated, revealing a high level of consistency (Strauss, & Corbin, 2007; Denzin, & Lincoln, 2005; Miles, & Huberman, 1984)

5. Findings and Discussion

The research data was analysed using the content analysis and iterative process of case comparison and the results are discussed below. In the six cases described, there was an absence of specialized state-level policies, regulations or even

campaign exercises on the ways of managing the solid waste generated by these states. However, in all the six states there is an independent regulatory body or agency that oversees the affairs of waste management. For example, Plateau Environmental Protection and sanitation agency (PEPSA), for Plateau State (North Central), Bauchi State Environmental Protection agency (BASEPA) for Bauchi state (North East), Cape-gate Investment Company for Kano State (North West), Anambra State waste management Authority (ASWAMA) for (South East), Rivers State waste management agency (RIWAMA) for Rivers State (South South), Lagos State waste management Authority for Lagos State (South West). The current opportunity is that the existing institutional framework has created a subtle platform for the introduction of CE policies for the regulation of solid waste generated in each geo-political zone. These waste management regulators may have existing databases of the residents and their addresses which makes it convenient for the introduction of the policy, implementation, and monitoring of compliance. NESREA is responsible for the general environmental standard regulation of the entire Nigerian environmental and sanitation sector, but it has been constantly argued that the agency lacks human resources and the capacity to efficiently perform these multiple functions (Ezeudu, Agunwamba, Ezeasor, & Madu, 2019) Recognizing the importance of distinctive state policy measures, the NCC has already drafted a guideline in this respect in 2018. (NCC, 2018) While this is a good starting point, the drafted guideline by the NCC is replete with qualitative edits upon which its enforcement depends. It is lacking in some

basic principle, practice and theory of the CE that recognizes waste as a means of wealth creation. For instance, there were no incentives for e-waste collection and recycling and the informal collection was not recognized or promoted as an important party to e-waste management as it is obtainable in most developing economies. (Ferronato, Rada, Portillo, Cioca, Ragazzi, & Torrenta, 2019) Furthermore, NAFDAC has a strong guideline and regulatory framework for food and water administration in the country in terms of standard operating guidelines, but with no known CE programme as regards to the solid waste produced by the states.

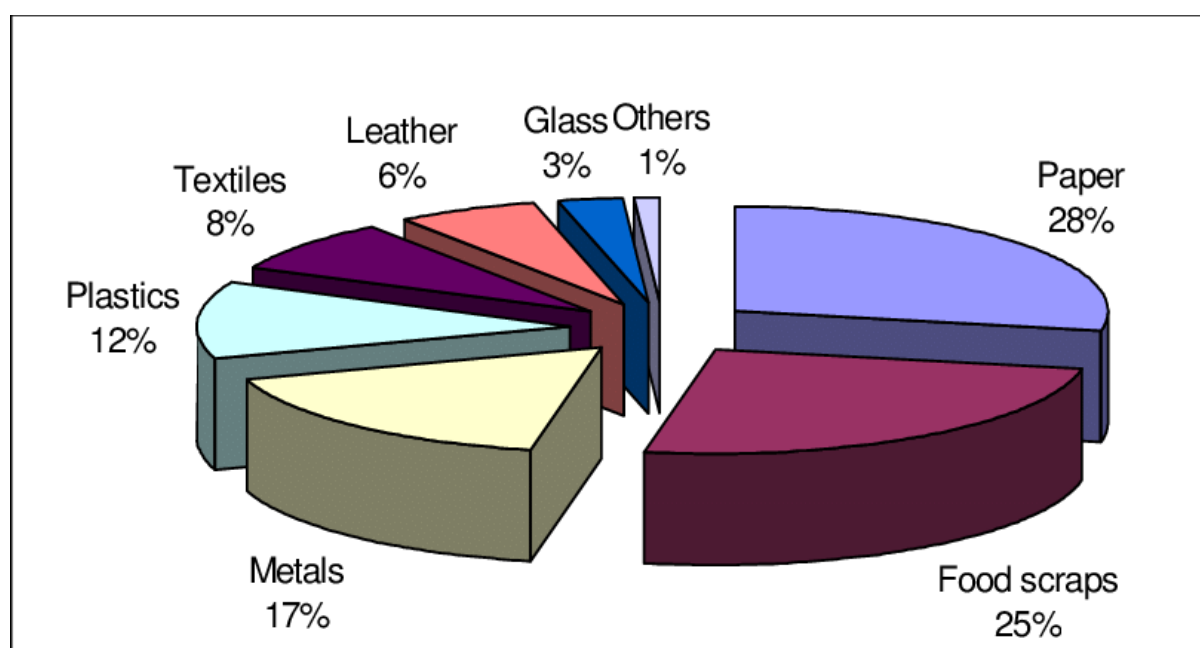


Fig. 8 characterization of solid waste in kano.

The study findings also revealed a considerable amount of informal waste picking activities present across the states. Previous studies have noted that a large

number of scavengers migrate from rural areas to urban areas for this purpose, especially during the dry season (non-farming season) (Nzeadibe, 2009) They pick metal scrap, plastic waste material and WEEE for onward sale to the middlemen or whole seller who bulk-sells them to the small and medium scale industries that make use of them. Their operation is motivated by profits and harsh economic conditions. However, the activity is haphazardly practiced with little or no government recognition or regulation (Agunwamba, 2003). the food waste and leftovers being a new development among the recyclable material may not have caught the attention of many scavengers and hence, have not been widely collected. According to one of the food vendors interviewed, she noted that, “We sometimes give them out to our customers at no fees, so far it has relieved us of the stress of evacuating the waste. The clearly identified and committed stakeholders’ participation is a key performance indicator of a CE system (Ferronato, Rada, Portillo, Cioca, Ragazzi, & Torrenta, 2019). Both existing institutional and policy arrangements in the six states do not factor in the complete parties in the product production, use, consumption, and disposal. For instance, an interviewed respondent from Anambra state waste management authority (ASWAMA) noted that “the nylon and the PET bottles used in restaurants and other food vendors are picked by scavengers for sales to water packing industries for recycling. They are rather outsourced to separate plastic companies.” This means that the final user of the waste bottles (for reproduction) in the reverse logistics supply chain system is basically the plastic industry. Therefore, this has

created another key opportunity for the meso-level (inter-industry) CE solid waste management planning in the country. The final part of the non-recyclables and non-reusable waste from the studied industries are disposed along with the general municipal solid waste in landfills or dumpsites which is statutorily managed by the state government waste management authorities under which they fall (Nzeadibe, 2009) This has made the state authorities also a stakeholder in the country's industrial solid waste management. In states across the country, the independent waste management authorities supported by their respective state governments make laws and collect levies in order to perform this function. The regular practice is to collect this waste and transport them to dumpsites or landfills with little or no due diligence. The unsatisfactory performance of this duty has also been reported across the country caused by the huge quantity of waste to handle and poor financial resources available to the agencies (Agunwamba, 2003; Abila, & Kantola, 2013)



Fig. 9 urban solid waste indiscriminately dumped on the street in Nigeria.

6. Future Directions and Conclusions

The CE as a concept offers huge promise in urban solid waste management but needs to be well articulated prior to implementation. The key elements of this principle which include the policy and institutional framework, stakeholders' involvement, good waste disposal techniques and the recognition of informal activities need to be well organized in order to yield an optimal result. Having highlighted and discussed issues, the challenges and barriers to the implementation of CE in industrial solid waste management in Nigeria, a number of recommendations are suggested in this paper. The first is that many streams of waste material generated in the Nigerian have a proven marketable and reusable ability that could provide profit for the waste producer and the user. Even though the CE framework is non-existent, this practice has been continuing across the country. The implication is that the basic CE criteria, that proposes multiple lifespans for products while ensuring business profitability, has been met. E-waste, for example, that has been largely regarded as constituting a greater threat to environmental sustainability, also has vast business and economic opportunities. There is one hundred times more gold in a ton of e-waste

than in a ton of gold ore, alongside other scarce and valuable materials such as platinum, cobalt and rare earth elements (UNEP, 2019) Therefore, a safe, organized and efficient e-waste recycling has the potential to be a big business venture. The general success and economic and business worth of Nigerian have always been underquoted without factoring the additional value that the waste recycling sub-sector of each respective states could add to the gross net worth of the states. It is recommended that the existing urban solid waste management system should be overhauled towards achieving this objective. This could start with a reorganization of the regulatory bodies by ensuring that the states are duly regulated by an independent body, while strengthening their job functions and objectives to also cover the urban solid waste management. Hence, the policies should be executed in line with CE principles. Secondly, the role of informal waste recycling activities has been regarded as a key component of the CE waste valorisation system in developing countries (Ferronato, Rada, Portillo, Cioca, Ragazzi, & Torrenta, 2019; Nzeadibe, 2009). Informal waste recycling makes a great contribution to waste resource recovering, job provisioning and by extension, the sustainable urban development. Formalizing the activities is one of the foremost steps in CE implementation in any developing economy. There is evidence of informal waste recycling operations in the vast number of Nigerian states. It is the authors' opinion that the state regulatory agencies

could create a place for informal workers in their policy guidelines through incentives, such as providing them with supportive health and safety education and legal backing to operate. The safety issues can also come in the form of ensuring that informal workers have healthy working conditions, safety kits and pension benefits (Ferronato, Rada, Portillo, Cioca, Ragazzi, & Torrenta, 2019; Nzeadibe, 2009). Considering the level of poverty and unemployment in the country, there are great prospects for attracting more informal workers when the CE is formally proclaimed through appropriate policies and incentives. These measures have been repeatedly emphasized in previous research efforts (Scarlet, Motola, & Dallemand, 2015; Ferronato, Rada, Portillo, Cioca, Ragazzi, & Torrenta, 2019; Nzeadibe, 2009). Again, what differentiates CE initiatives from regular waste management practices are the introduction of business and economy realities to waste product handling (Romero-Harnandez, & Romero-Harnandez, 2018) This study highlighted that most Nigerian residents do not participate actively in the final disposal of their solid waste. Although they pay levies to the government authorities that solely perform this function. However, the so-called levies are not often apportioned according to the quantity, character or nature of the generated waste. If measures are introduced where the levies are distributed according to aforementioned criteria, it would hasten effort by the waste generating states to minimize their disposable waste. Further, this could

create consciousness among waste management agencies so they make an effort to sell their recyclables/reusables in order to generate funds to finance the ones they are disposing. There is equally a need for the stakeholders to embark on aggressive mass education as the general Nigerian public is yet to contemplate waste as a means of wealth generation but rather it is still regarded as all rubbish that needs to be discarded (Ezeudu, Agunwamba, Ezeasor, & Madu, 2019). This has affected the public attitude to waste collection and the scavengers. Nevertheless, for CE at any level to work optimally, there should be modalities for identifying the whole stakeholders with clearly defined functions and roles (Geissdoerfer, Savaget, Bocken, & Hultink, 2016). One way to do this is to clearly articulate the forward and reverse logistics in the product supply chain management at the states level in the policies.

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