

Implementation of Circular Economy Principles in Industrial Solid Waste Management: Case Studies from a Developing Economy (Nigeria)

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Abstract

The existing solid waste management principles are increasingly being replaced with discussions on circular economy (CE) principles in contemporary deliberations on solid waste handling. This shift is supported by the global adoption of the concept of sustainable development. The CE offers better prospects to solid waste management and has been implemented successfully in its full theory, practice, and policies in some developed locations of the world. The socio-economic disadvantages, insufficient expert knowledge and a lack of information have hindered its appropriateness and implementation in low and middle-income countries. Hence, the current research study examines the challenges and opportunities of implementing the circularity principle at the industrial sector level of a typical developing economy, Nigeria. Four different industries were selected for this case study telecommunications, water packaging, pulp and paper and the food industry. These industries represent the major waste streams in an urban solid waste mix (waste electrical and electronic equipment (WEEE), plastic, paper and organic). 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: Circular Economy; Developing Economy; Waste Management; Environmental Policy; Sustainability; Nigeria.

Introduction

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 [1].

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 valorization, 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 [2].

Hence, it proposes the handling of waste according to hierarchies, which means seeking the best waste disposal method and resorting to the second-best alternative when the first is not feasible and so forth. Although it encourages waste minimization, recycling and re-use at all costs, the overall motive and intent are to manage waste resources with the focus on environmental protection. However, it is not often linked to business and economic possibilities [3].

Several nations of the world have moved from the implementation of traditional waste management practices and policies and have fully adopted CE principles [4, 5]. The majority of these countries share commonalities in terms of viable economic status, advanced technologies, strong political will, credible public governance and state-of-the-art public infrastructure. This has raised the issue of the capability and eligibility of low and middle-income countries in adopting the same CE in its full theory, practice and policies.

The additional factors that result in the non-adoption of CE in Africa are the lack of knowledge on the implementation processes and the absence of information [6, 7]. The practical benefits of CE adoption have been widely reported at national, sub-national and local government levels and even in the economic sectors in the countries where they are currently in practice, whereas CE is still a relatively new concept in developing countries with the exception of G20 countries, such as China [8–10].

As the lack of knowledge on how it can be implemented has partly hindered most African countries from adopting the concept, this suggests that research efforts should offer direction in this regard [9]. Thus, the reason for this research. The current work looks at the possibilities of CE application in solid waste management at an industrial level in Nigeria—a typical developing country. The majority of the waste management policies in the country are qualitative in nature and are often devoid of scientific, business and economic merit, which is partly the reason for their failure. Therefore, it has become necessary to integrate the CE principle into the formulation and implementation of these policies and practices in order to ensure positive outcomes. To the best of the authors' knowledge, no work has analyzed the industrial solid waste management system in Nigeria with the aim of proposing a CE solution

Hence, the aim of this work is to analyze the policies and practices of industrial solid waste management in Nigeria and to also evaluate the prospects, challenges, barriers, and opportunities for implementing the CE in the country's industrial solid waste management. This current work does not consider the hazardous waste generated by these industries.

The current work adopts a case study methodology. Four industries were selected as a case study: the telecommunication industry, food industry, pulp-paper industry and water packaging industry. This was done to represent the major waste stream characteristics of a typical municipal solid waste constituent WEEE, plastic, paper, and organic waste. In the first section of this work, the general background of the study is presented; including the socio-economic status of Nigeria, the industrial development background of a developing economy and an overview of the country's solid waste management practices is discussed.

CE in 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.

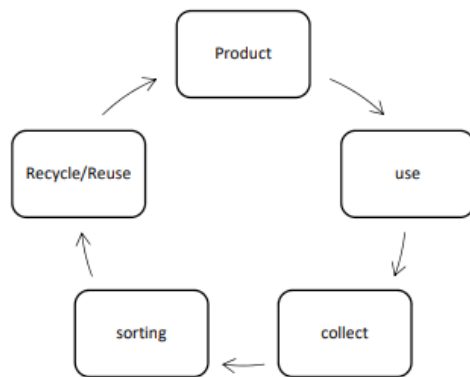
This can be attributed to its uniqueness in articulating a restorative and regenerative approach to resource administration as opposed to the traditional linear model [1]. The concept focuses on the product and is commonly applied at the design, production, consumption and waste management stages [11].

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 modalities 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 [12].

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 [13].

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 1. 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 [14].



(a) The circular economy (CE) Model



(b) Linear economy model

Figure 1: Circular economy (CE) model versus linear economy model. (a) is labeled CE model and (b) linear economy mode

Socially, adapting the CE model can generate employment and foster greater social inclusiveness of the general public in environmental management. Economically, it can generate wealth and minimize the cost of production, while environmentally it ensures the optimal use of natural resources while abating pollution.

Industrial Development: Developed vs. Developing World

Historically, industries in developed countries have evolved over time as a result of breakthroughs in science and technology. For instance, the nineteenth-century industrial revolution in Europe was as a result of the discovery of coal as a primary energy source which replaced firewood and created an avenue for the invention of coal-fired power plants and train systems that facilitated mass transportation and other industrial activities [23].

To some extent, industrial development and revolution in developed societies could be tied to successes in scientific research and development which created a platform for orderliness and the systematic transition from one industrial age to another. In line with this, industry 4.0 (the 4th industrial revolution), which is the latest production paradigm, has already been proposed and is currently being discussed for possible adoption [24].

However, the industrial development approach in developing nations, especially in sub-Saharan Africa, has been different, unconventional and most times erratic. Industries appear unconventionally and blossom as a result of the huge low-income population, large and vibrant informal sector and the criticality of the societal problem that the emerging industries solve. A typical example is the telecommunications industry in Nigeria.

This industry has thrived and contributed immensely to the socio-economic development of the people, despite the poor status of energy supply infrastructure in the country. A further example is the water packaging industry in Nigeria which has grown greatly as a result of the criticality of their products and services to the general masses sanctioned by the failure of the government in providing the standard traditional water supply services to the citizens [25, 26].

On the other hand, opinion has been conveyed that firms and industries, both in developing and developed societies, are ever willing to embrace circular and sustainable business models in order to attain commercial differentiation, a competitive advantage and potential growth with economic benefits and hence, require expert support towards this objective [14,27].

It therefore becomes necessary that the CE waste management model that should be adopted by the industries operating in the developing economies be designed to reflect the unconventional business models under which they originate, operate and thrive. This point is considered in the current study.

The Study Area: Nigeria

Socio-Economic Status

Nigeria is a developing West African country with enormous prospects specifically in the areas of natural resources and human capital potential. It has a great endowment in crude oil and natural gas, solid minerals, vast and suitable land for agriculture and water and forest resources

[28]. The population of Nigeria has been approximated at 198 million people as of 2018, calculated with 3.2% annual population growth index and also based on the 2006 population census figure of 140,431,790 [29].

However, the country's rich endowment in natural resources somehow has facilitated enormous economic prosperity, such that it has been consistently rated among the largest economies in sub-Saharan Africa since 2004. Further speaking of potential, Nigeria and China share many similarities when measured against ethnic diversity, mineral and human resources [30].

For instance, China is the largest single market in the world, while Nigeria is the largest single market in Africa. However, the difference is that China has been able to exploit its vast demographic, human and natural resources to build a strong and virile domestic economy which has positively affected its citizenry [31].

In the exact term, China has lifted approximately 662 million people from poverty since 1981 through various economic reforms [32]. Nigeria in its own case is currently contending with enormous social-economic challenges, such as a high unemployment index, technological backwardness, an underdeveloped agricultural sector and per capita poverty index. Hence, Nigeria was recently rated the poverty capital of the world.

Current Waste Management Framework in Nigeria: Brief Overview

A major milestone in solid waste management in Nigeria came with the establishment of the Federal Environmental Protection Agency (FEPA) in 1988 [22]. The FEPA was later merged with other key government agencies to form the Federal Ministry of Environment in 1999. The responsibility of this ministry is to issue guidelines on how key environmental issues, including solid waste management, should be tackled. However, the task of making laws, implementations and enforcement mostly lie on the state governments through various state ministries of the environment and municipal councils. The guideline on solid waste management in the country was released in 2005 by the Federal Ministry of Environment.

The policy document recognized the fact that strategies for waste management at the grassroots level should interface with the local culture, land use type, economic base, climatic condition, existing urbanization level and institutional arrangements [33]. The guideline, however, was not detailed on each aspect of solid waste management, such as waste reuse, recycling, and final disposal techniques.

Furthermore, it did not create room for updating based on issues that might arise in the future, such as the issue of informal recycling activities [28]. Another major setback is that the ministry's guideline recommends land filling as a method of final waste disposal but was silent on the modalities for landfill construction and operation, whether at the present or in the future. However, a recent study has demonstrated that many landfills in developing countries (Nigeria inclusive) are non-engineered, which makes it quite difficult to harness the waste resources into valuable products for commercialization [34].

Due to these inconsistencies, studies further reported that approximately 68% of the solid waste generated by communities in Nigeria are indiscriminately dumped, barely 21% is disposed of through landfill sites and 11% are burnt [35, 36].

Materials and Methods

Case Selection

Three industries were selected for the study using purposive sampling methodology—telecommunication industry, food industry, and water packaging industry. The pulp and paper industry was included based on recent comprehensive work on paper waste management and practices in Nigeria [28]. The solid waste from the selected industries represents a major stream in the country's urban solid waste mix which includes organic, plastic, paper and WEEE.

The purposive selection was done in conformity to information-rich cases [39]. The selected industries are information-rich in the following context: economic viability, versatility, geographical coverage, and robustness within the study area (Nigeria).

Data Collection

The standard and documented data on solid waste management in most sub-Sahara African countries (including Nigeria) are not available [12]. 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 [40–43].
- (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 [43,44].
- (iii) Exploratory fieldwork is important in a new area of research (circular economy) that lacks an established body of theories and data [43, 45, 46].
- (iv) The use of case research allows concepts to be developed for further study [45, 46].
- (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 [42].

The data required for the study were collected through three main sources:

- (i) Documented evidence through, academic peer-reviewed journals, company websites, financial reports, policy briefs, government publications, magazines, newspapers, and other relevant grey publications;
- (ii) Semi-structured interviews were also conducted on the selected respondents from the four industries 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 solid waste practices in the selected Nigerian industries. The data obtained from the different sources were triangulated, revealing a high level of consistency [40, 47, 48].

Findings and Discussion

The research data was analyzed using the iterative process of case comparison and the results are discussed below. In the four cases described (with the exception of telecommunications), there was an absence of specialized industrial-level policies, regulations or even campaign exercises on the ways of managing the solid waste generated by these industries. However, in all the industrial cases, with the exception of the pulp and paper industry, there is an independent regulatory body or agency that oversees the affairs of the industry.

For example, NAFDAC and Standard Organization of Nigeria (SON) for food and water packaging; NCC for telecommunications. 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 the industries. These industrial regulators may have existing databases of the registered firms 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 industrial sector, but it has been constantly argued that the agency lacks human resources and the capacity to efficiently perform these multiple functions [28]. Recognizing the importance of distinctive industrial policy measures, the NCC has already drafted a guideline in this respect in 2018 [59]. 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 [21]. 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 industry.

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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 industry of each respective industry could add to the gross net worth of the industries. It is recommended that the existing industrial 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 industrial sector is duly regulated by an independent body, while strengthening their job functions and objectives to also cover the industrial solid waste management. Hence, the policies should be executed in line with CE principles.

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