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Review of Economic Analysis and Management of Solid Wastes in Nigeria: Its Viewpoint and Challenges

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ABSTRACT
Solid waste management (SWM) deals with the administration of waste generation, collection, storage, transfer, transport, processing, and disposal based on environmental best practices. SWM in Nigeria faces numerous challenges due to rapid urbanization, inadequate infrastructure, and limited financial resources. This review highlights the key issues in SWM, explores the impact on public health and the environment, and proposes sustainable solutions for a more efficient waste management system. The indiscriminate dumping of waste in unauthorized places has resulted in rapid environmental degradation that leads to adverse effect on the general sustainability of the ecosystem, widespread of germs and diseases, extinction of aquatic bodies due to water pollution causing toxicity and acidification, and poor agricultural yield. The paper review was achieved through literature study, reconnaissance study and interaction with stakeholders in waste management sector. To address the challenges of SWM in Nigeria, requires a multi-faceted approach that combines sustainable practices, technological advancements, and collaborative efforts among stakeholders. By implementing these solutions, Nigeria can work towards a cleaner, healthier, and more sustainable environment.
Keywords: Solid Waste Management & System, Public Health & Environment, Disposal, Sustainability, Stakeholder, Nigeria.

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I. INTRODUCTION

Nigeria has a land area of 923,768 km^2 and is located in the western part of the African continent and a population size of over 190 million, with a growth rate of 2.6% (Ezeh, 2017). Nigeria comprised of 36 states and the Federal Capital Territory (FCT), having a total 774 of Local Government Areas. The climate is arid in the northern region of Nigeria, equatorial in the south, and tropical in North-Central. Nigeria has a GDP of $235.9 billion (Ogwueleka, 2009 and Iriruaga 2012). Nigeria is the most populated country in Africa and the ninth in the world, is one of the major producers of waste, Nigeria generates more than 30 million tonnes of Solid Waste (SW) annually with average rate of generation ranging from 0.44 kg/cap/day in rural areas to 0.66 kg/cap/day in urban areas, compared to the solid waste densities found in developed nations, In urban areas, the generation of solid waste is significantly influenced by population expansion and economic development (The World Bank, 2019).

Municipal Solid Waste (MSW), which is expanding faster than the pace of urbanization, is an issue in urban areas all over the world, according to Hoornweg and Bhada-Tata (2012). Besides this, rapid urbanization means speedy growth of shanty dwelling units that are largely unplanned for, and add to the waste, health, and hygiene problems. This will worsen the waste management problem as developing nations like Nigeria, which have inadequacies in terms of technological advancement and socio-political setting to overcome such condition. An additional significant factor that contributes to the problem of solid wastes in a developing nation is the lack of proper collection and transportation facilities, and the waste disposal workers and other employees in dumpsite facilities are at a greater risk from exposure to improperly handling of wastes and inappropriate use of Personal Protection Equipment (PPE). The improper planning coupled with rapid growth of population and urbanization serves to add congestion in streets, and as a result waste collection vehicles are inaccessible to

some places, thus allowing filth to build up over time and produce unfriendly smells. Inadequacy of financial resources, at times, results in inadequate or no transportation vehicles for waste disposal adding another dimension to the ever-rising cycle of problems (Jain 1994; Zerboc 2003).

The management of Solid Waste (SW) in Nigeria is still a major concern for the government, stakeholders, and the general populace despite a number of legislation and regulations. Solid Waste (SW) collection and disposal inefficiencies have resulted in a range of environmental problems, including the suffocation of aquatic bodies and the obstruction of sewer and drain networks (George, 2010). Despite the fact that the nation lacks a well-coordinated waste management system, established laws and regulations regarding waste management, solid waste management (SWM) is the responsibility of the Ministry of Environment at the Federal and State levels, and the Environmental Health Department at the Local Government level. The regulations include the National Environmental Standards and Regulations Enforcement Agency (NESREA) and the Harmful Waste Act (Special Criminal Provisions, etc. of 1988).

Waste management includes the handling of waste during its collection, transportation, treatment, and disposal, as well as oversight and regulation. Waste has been a problem for people as long as they have lived in settled communities, and modern society produces significantly more solid waste than did prehistoric ones (Mondal, 2014). Public health concerns have been the motivation driving improvements in waste treatment and disposal (Williams, 1998; Lane and Peto, 1995). Municipal Solid Waste (MSW) is the result of combining various kinds of household waste which includes food leftover, broken glass, human waste, organic pollutants, heavy metals, pathogenic microorganisms that can contaminate ground and surface waters. Improper waste disposal has far-reaching consequences, which leave the environment dirty and has the potential to change the environment in a way that attracts flies and other insects, serving as a breeding ground for vectors like rats, cockroaches, and mosquitoes, which can pose a threat to public health by spreading disease.

II. METHODOLOGY

This review examines the trends in waste management in Nigeria, highlighting the volume of waste generated and emphasizing the approaches used in the nation's cities as well as the overall difficulties encountered by waste management organizations in Nigeria. The paper relied on secondary data, with a focus on government publications and peer-reviewed journals and reports. This paper review adopted the desk study approach which focuses mostly on gathering data from previous research, it was determined to be more appropriate for the current paper. However, studies using both numerical and qualitative data are best served by the mix method approach, and research involving numerical data is better served by the quantitative approach. It was determined that the strategy employed in this paper review was adequate to achieve the study's objectives.

2.1 WASTE AND WASTE CLASSES

Waste is any matter or material that needs to be disposed of because it is damaged, worn out, contaminated, or has undergone other degradation, losing its value (Anifowose et al., 2011). Solid and liquid wastes are the two main categories used to describe waste. Wastewater is an example of a liquid waste since it flows freely, is neither solid nor gas, and takes the shape of a liquid. Liquid waste is the complete opposite of solid waste. Another way to describe waste is as hazardous or radioactive. Additionally, waste can be categorized under a number of topics, such as municipal waste and industrial waste. Any apparent, non-free-flowing unwanted thing or material that arises from activity by humans is potentially harmful and could exist in liquid or solid form could be often referred to as Municipal Solid Waste (MSW) since it is produced by industrial, commercial, and agricultural activities (Singh et al., 2011). Solid waste is broadly comprised of non-hazardous domestic, commercial and industrial refuse including household organic waste, hospital and institutional garbage, street sweepings, and construction wastes (Zerboc 2003). Domestic solid waste includes all solid wastes generated in the community and generally includes food scraps, containers and packaging, discarded durable and non-durable goods, yard trimmings, miscellaneous inorganic debris, including household hazardous wastes (for instance insecticides, pesticides, batteries, left over paints etc., and often, construction and demolition debris. A report prepared by World Bank (1999) lists eight major classifications of solid waste generators:

1. Residential: This includes waste generated in household units, such as chaff of food, remnants, ashes, peels etc.
2. Industrial: This has two components:

(a) Hazardous, which is toxic; flammable; corrosive, a strong sensitizer or irritant and may pose a substantial present or potential danger to human health or the environment when improperly processed, stored, transported, or disposed of or otherwise managed.

(b) Nonhazardous which includes inert and essentially insoluble industrial solid waste, usually including, but not limited to, materials such as ,dirt , rock, brick, glass, and certain plastics and rubber, etc., that are not readily decomposable.

3. Commercial: This waste is produced by wholesale, retail or service establishments, such as restaurants, stores, markets, theaters, hotels and warehouses.
4. Institutional: This waste originates in schools, hospitals, research institutions and public buildings.
5. Construction and demolition: This waste is from building material and rubble resulting from construction, remodeling, repair, and demolition operations on houses, commercial buildings, pavements and other structures .
6. Municipal services: This was is sludge from a sewage treatment plant which has been digested and dewatered and does not require liquid handling equipment etc.
7. Process: This waste is from treatment plant principally composed of residual sludge.
8. Agricultural: Spoiled food wastes, agricultural wastes, rubbish, hazardous wastes.

According to Ndubuisi-Okolo et al. (2016), the classified waste is divided into several categories, such as organic waste (agricultural and animal refuse), industrial residue (bottom ash), mining and extraction waste, construction and demolition debris, and sewage sludge. Hazardous waste has a negative impact on the ecosystem and its environment due to its physical and chemical composition. Thus, a high degree of management and control procedures are needed. Depending on the degree of risk they pose, they are further classified into several classes Nhlanhla (2014).

Table 1: Types of General Waste and Their Source

Types of General Waste	Waste Generator	Source
Food wastes, paper, plastics, textiles, leather, curtilage wastes, wood, glass, metals, ashes etc.	Household	Residential
Paper, cardboard, plastics, wood, food, special waste, etc	Stores, hotels, restaurants, markets etc.	Commercial
Housekeeping wastes, packaging, food waste, construction and demolition waste, special and hazardous waste.	Construction sites, industries and manufacturing companies.	Industrial
Same as commercial	Schools, hospitals, prisons, government centers	Institutional

Source: Nhlanhla (2014)

Table 2: Hazardous Waste Sub Classes

Class Number	Class Type
Class 1	Explosives
Class 2	Gases
Class 3	Flammable liquids
Class 4	Flammable solids
Class 5	Oxidising substances and organic products
Class 6	Toxic and infectious substances
Class 7	Radioactive substances
Class 8	Corrosives
Class 9	Other miscellaneous substances

Source: Nhlanhla (2014)

2.2 SOLID WASTE GENERATION IN NIGERIA

2.2.1 Waste Generation

Waste generation is the act and process of producing waste from human activities which is directly related with the people's consumption pattern and thus, of their socio-economic characteristics. Waste generation is conditioned to an important degree by people's attitudes towards waste, their patterns of material use and waste handling, their interest in waste reduction and minimization, the degree to which they separate waste, and the extent to which they refrain from indiscriminate dumping and littering (Schübeler et al., 1996). Nigeria's solid waste density is quite high, ranging from 250 to 370 kg/m^3 (Ogwueleka, 2009), out of which only 20-30% are collected (Bakare, 2016). According to Ibrahim et al. (2014), the weekly average generation of household Solid Waste (SW) in the city's high residential density area is 30.39 kg/ week, and 22.75 kg/week in the medium residential density area. According to Amasuomo and Baird (2016), it is concerning that these wastes generated in developing countries like Nigeria are not being properly managed, since the nation currently lacks sufficient budgetary provisions for the implementation of integrated waste management programs across the States, inappropriate waste collection and disposal is causing an environmental disaster (Wale, 2016).

According to Ogwueleka (2009); Beatrice and Jussi (2013), sorted the waste characteristic of the cities in the six Geopolitical Zones of Nigeria as shown in Table 1 in descending order with Lagos been the most populous and Nsukka been the least populous. Lagos recorded the greatest of all the cities in waste generator with a density of 294 kg/m^3 with a 0.63kg/capital/day. It was concluded that the volume and composition of

waste generated varies considerably from city to city and directly proportional to each city's population, socioeconomic standing, and degree of urbanization. One of the main factors influencing the amount of waste generated in a given location is its population (Ezerie et al., 2007).

Table 3: Characteristic of Waste In Some Cities In Nigeria

City	Population	Gg/month	Density (kg/m³)	kg/capita/day
Lagos	8,029,200	255.56	294	0.63
Ka no	3,248,700	156.8	290	0.54
Kaduna	1,4558,900	114.43	320	0.58
Port Harcourt	1,053,900	117.83	300	0.60
Maiduguri	971,700	850,000	-	-
Aba	784,500	236,703	-	0.46
Ilorin	7560,400	-	-	0.43
Abeokuta	529,700	-	-	0.66
Onisha	509,500	84.14	310	0.53
Warri	500,900	66,721	-	-
Akure	369,700	-	-	0.54
Ibadan	307,840	135.39	330	0.51
Makurdi	249,000	24.24	340	0.48
Ado-Ekiti	241,200	9,518	-	0.71
Abuja	159,900	1479	280	0.66
Uyo	102,400	20,923	-	-
Nsukka	100,700	12.00	370	0.44

Source: Ogwueleka (2009), Beatrice and Jussi (2013)

According to Abila and Kantola (2013) and Tobore (2013), sorted the municipal solid waste generation for some cities in the six Geopolitical Zones of Nigeria as shown in Table 2 in order of their Geopolitical region with Lagos been the most populous in all the Geopolitical Zones with a population of 8,029,200 and also recorded the highest values in terms of waste generator with a density of 294 kg/m³, 0.63kg/capital/day and 255,556 tonnage/ month . It was observed that the population is proportional to tonnage/ month in the respective city in the various geopolitical zones. The main reasons for the growing quantity of solid waste generation in the cities in the Geopolitical Zones in Nigeria are increasing opportunities and activities leading to urbanization, growth in the non-agricultural sector, and shifting patterns of consumption; packaged foods, electronics, plastics, and other modern home appliances are reasons in the shifting patterns of consumption.

Table 4: Municipal Solid Waste Generation for Some Cities in Geopolitical Zones in Nigeria

City	Population	Tonnage/ month	Density (kg/m³)	Kg /Capita/ Day
South West				
Lagos	8,029,200	255,556	294	0.63
Ibadan	307,840	135,391	330	0.51
Ado-Ekiti	241,200	9,518	-	0.71
Akure	369,700	-	-	0.54
Abeokuta	529,700	-	-	0.66
South East				
Nsukka	100,700	12,000	370	0.44
Onisha	509,500	84,137	310	0.53
Aba	784,500	236,703	-	0.46
South South				
Port Harcourt	1,053,900	117,825	300	0.60
Warri	500,900	66,721	-	0.60
Uyo	102,400	20,923	-	0.60
North Central				
Abuja	159,900	14,785	280	0.66
Makurdi	249,000	24,242	340	0.48
Ilorin	756,400	-	-	0.43
North West				
Kano	3,248,700	156,676	290	0.56
Kaduna	1,458,000	114,433	320	0.58
North East				
Maiduguri	971,700	850,000	-	0.58

Source: Abila and Kantola (2013) and Tobore (2013)

According to a forecast by Yusuf et al. (2019) as shown in Table 5, waste generation has been trending upward since 1959 as the nation's population grows. By 2030, the estimated amount of waste generated will be 36,251 Gg.

Table 5: Annual Waste Generation in Nigeria

Year	Waste Generation (Gg)	Year	Waste Generation (Gg)
1959	6,471	2000	17,940
1960	6,601	2005	20,383
1965	7,335	2010	23,243
1970	8,195	2015	26,601
1975	9,281	2020	29,849
1980	10,760	2025	33,050
1985	12,249	2029	35, 611
1990	13,961	2030	36,251
1995	15,829		

Source: Yusuf et al. (2019)

2.3 SOLID WASTE DISPOSAL METHOD IN NIGERIA

There are numerous ways to dispose of solid waste. Nonetheless, anaerobic digestion, composting, incineration, land filling, and recycling are the techniques employed (Abila & Kantola, 2017). According to Adeyemi et al. (2001), landfilling, open burning, open dumps, reuse/recycling, and waste conversion are the main practices used in Nigeria to handle municipal solid waste. The following categories could be used to group the many approaches of managing solid waste:

2.3.1 Landfills/ Dumpsites

Municipal Solid Waste (MSW), which is often disposed of in sanitary landfills, is produced by human settlements, small businesses, and commercial operations. The location where solid trash is disposed of is a dumpsite.

Merits of Landfills/ Dumpsites

1. Landfills are excellent energy sources, such carbon dioxide, methane gas, which can be taken out filtered and used to produced energy or as cooking gas.
2. Landfills are easily accessible open –air dumps for our solid waste.
3. Landfills provide a place to dump recyclable and non-recyclable waste separately.
4. Landfills are less expensive as waste travels relatively short distance.
5. Landfills create secondary market for waste pickers and scavengers.

Demerits of Landfills/ Dumpsites

1. Landfills can be a very dangerous site, in an enclosed space with poor ventilation, landfills can go up in flames, if the methane concentration is 5 to 15% of the total air volume.
2. Landfills contaminate groundwater and soil, as leachate and toxins seep from landfills and get mixed with groundwater and soils, causing water and pollution.
3. Landfills locations affect plants and animals negatively. Animals and birds take their food from landfills, thereby ingesting plastic, aluminum, lead and other dangerous materials.
4. Landfills Affect Human Health, people living close to or having extended contact with landfills has been related to cancer, respiratory conditions, and developmental abnormalities in children.

3.2.2 Incineration

The least expensive method of disposing of urban waste is incineration, which is occasionally employed in Nigerian clinics to burn medical waste on a small scale (Ogwueleka, 2009).

Merits of Incineration

1. Incinerators have the capacity to reduce the amount of waste generated overall by up to 95%.
2. Incineration plants produce energy from waste that can be utilized as electricity.
3. Incineration are less prone to cause environmental pollution than solid waste landfills
4. Incinerators produce less odorous waste because the byproducts of the burning process are controlled inside the facility, preventing waste from decomposing outside and contributing to air pollution as compared to landfills.

Demerits of Incineration:

1.Modern incinerators are expensive to install due to the expensive infrastructure and equipment needed to build an incineration plant.
2. Incinerators produce a significant pollution level of particles, heavy metals, nitrogen oxide, and acid gasses, such as the carcinogen dioxin, which can be found in the smoke produced while burning. The environment is poisoned by these gasses.

3. Incinerators are known to pose a significant risk to human health and the environment. Communities near waste incineration plants are particularly vulnerable to long-term adverse health effects, including cancer, birth defects, reproductive dysfunction, neurological issues, and other health problems that can arise even from very low exposure to many of the metals and pollutants released by these facilities According to CAP (2013).

3.2.3 Composting

Composting is the process of recycling organic matter naturally, such as food, leaves and scraps, into a useful fertilizer that can enrich soil and plants. Plant and animals decompose eventually; composting simply speeds up the process by providing an ideal environment for bacteria, fungi, and other decomposing organisms e.g. sowbugs, worms, and nematodes. According to (Anon, (2016), organic waste is transformed into humus, which has the ability to fertilize since it contains a lot of nitrogen, phosphates, and other minerals that are necessary for healthy plant growth.

Merits of Composting

1. A good quality nutrient rich and environmental friendly manure is formed which improves the soil conditions and fertility.
2. Composting ensures nutrients are recycled and returned to the soil.
3. It increases the soil's ability to retain water, nutrients and makes the soil easier to cultivate (Mondal, 2016).

Demerits of Composting

The problems that arise when making compost are few and the solutions are many, (such as odour, lack of water,). Non-consumables have to be disposed separately; the technology has not caught-up with the farmers and hence does not have an assured market (Gour, 2013).

3.2.4 Gasification

Gasification is a process that involves the conversion of organic materials, such as coal, waste or biomass into a synthesis gas (syngas) consisting mainly of hydrogen and carbon monoxide. This conversion is achieved through a series of reactions at high temperatures (usually between 700°C and 1200°C) in the presence of a catalyst or under oxygen-limited conditions. The process can be divided into three main stages: drying, partial oxidation, and methanation. In the drying stage, water is removed from the feedstock. In the partial oxidation stage, the feedstock reacts with a controlled amount of oxygen or steam, producing syngas. Finally, in the methanation stage, carbon monoxide and hydrogen in the syngas are converted into methane, which can be used as a cleaner fuel. Previous research has demonstrated that the aforementioned disposal techniques are widely employed in industrialized nations (Alhassan and Mohammed, 2013; Kumar and Nandini, 2013 and Nwachukwu et al., 2010).

Merits of Gasification

1. Gasification can be used to generate electricity.
2. Gasification can be used to produce chemicals.
3. Gasification can be used to create cleaner fuels like hydrogen.
4. Gasification offers advantages over other methods of waste disposal, as it reduces the volume of waste, recovers energy from it, and minimizes the environmental impact.
5. Gasification is an environmentally friendly and efficient method for converting organic materials into valuable energy sources and chemicals.
6. Gasification is preferable since it recovers energy from burning without polluting the air (Rick, 2016).

Demerits of Gasification

1. Gasification requires precise control of temperature, pressure, and gas flow rates to ensure optimal use. Maintaining these conditions can be technically challenging and may require advanced process control systems and skilled personnel.
2. Gasification reduces the volume of waste and produces fewer emissions compared to traditional waste disposal methods but, it can still generate pollutants such as particulate matter, nitrogen oxides, and sulfur dioxide. Proper emission control technologies must be implemented to minimize these emissions.
3. The value of gasification largely depends on the successful utilization of the produced syngas. If there is no suitable market for the syngas or the produced fuels or chemicals, the gasification process may not be economically viable.
4. Public acceptance and support are crucial for the successful implementation of gasification projects. Public concerns about potential environmental and health impacts, as well as the visual impact of gasification facilities, may pose challenges in gaining approval for new projects.

3.2.5 Open Burning

Open burning refers to the practice of burning waste in an uncontrolled manner, typically by igniting waste in a pile or on the ground. In Nigeria, open burning of waste is a regular practice (Wale, 2016).

Merits of Open Burning

1. Traditional Methods: In some cultures and communities, open burning has been a traditional method of waste disposal for centuries. It may be seen as a familiar and culturally acceptable way of managing waste.
2. Cost-Effectiveness: Open burning can be a relatively low-cost method of waste disposal, particularly in areas where there is limited access to modern waste management facilities or resources.
3. Quick Disposal: Open burning can provide a rapid means of disposing of waste materials, especially when dealing with large quantities of waste or in emergency situations.
4. Land Management: In some cases, open burning has been used for land management purposes, such as clearing vegetation for agricultural or development projects. This can help create new land for cultivation or construction.
5. Pest Control: Open burning can help control pests and invasive species by eliminating their habitats or reducing their populations.

However, it is crucial to recognize that these merits are often short-term and come at the expense of long-term environmental and health concerns. It is essential to transition towards more sustainable and environmentally friendly waste management practices to minimize negative impacts on the environment and public health.

Demerits of Open Burning

1. Air Pollution: Open burning releases a variety of pollutants into the atmosphere, such as particulate matter, carbon monoxide, volatile organic compounds, and greenhouse gases. These emissions can contribute to poor air quality, which can have adverse health effects on humans and the environment.
2. Health Risks: Exposure to the pollutants released during open burning can cause respiratory problems, eye irritation, and other health issues, particularly for vulnerable populations such as children, the elderly, and those with pre-existing medical conditions.
3. Climate Change: The burning of organic materials releases carbon dioxide, a potent greenhouse gas, contributing to climate change. Additionally, open burning may also release methane, another potent greenhouse gas, particularly when burning materials like rice straw or other agricultural residues.
4. Visibility Impairment: Open burning can lead to reduced visibility, especially in areas with high smoke production. This can affect transportation safety, recreational activities, and general quality of life.
5. Soil and Water Contamination: Open burning can release ash and other residues containing heavy metals, toxic compounds, and other contaminants into the soil and nearby water bodies. This can lead to soil degradation and water pollution, affecting ecosystems and the quality of drinking water.
6. Wildlife and Ecosystem Impact: Open burning can have negative effects on local wildlife and ecosystems. Smoke and ash can harm plants and animals directly, while changes in habitat and food sources can lead to long-term ecological imbalances.
7. Property Damage: Open burning can cause damage to nearby properties, such as homes, vehicles, and infrastructure, through smoke infiltration, ash deposition, or potential fires spreading from the burn site.

3.2.6 Dumping into the River:

Dumping waste into rivers in Nigeria, as in many other countries, has a significant environmental issue with various negative consequences. It is crucial to address that dumping waste in rivers, regardless of the country's development and poverty level, is detrimental to the environment, public health, and overall well-being. However, since this paper is a review on solid waste and the peoples opinion for dumping of waste into rivers is reviewed and these are some of their perspectives.

Merits of Dumping into River

1. Temporary storage: In developing countries where waste management infrastructure may be limited, rivers can serve as a temporary storage solution for waste disposal. This could be seen as a way to cope with the immediate issue of waste accumulation.
2. Cost-effective: Dumping waste in rivers might seem cheaper than investing in proper waste management systems. However, this short-term cost reduction often leads to long-term environmental and health issues, which can be more expensive to address.
3. Employment opportunities: Managing the waste disposal process could create jobs for people living in the area. However, this advantage should be weighed against the potential harm to the environment and public health.

Remember that these points highlight the potential short-term benefits from an economic or employment perspective. In the long run, it is essential to invest in sustainable waste management solutions to protect the environment, public health, and the overall development of a country.

Demerits of Dumping into the River

1. Water Pollution: Directly disposing waste into rivers leads to the contamination of water bodies, affecting both surface and groundwater sources. This pollution can have severe consequences on the quality of water used for drinking, irrigation, and other purposes, posing health risks to humans and animals. A study by the Federal Ministry of Environment, Nigeria, found that "the quality of surface water in Nigeria is generally poor due to anthropogenic activities such as industrial and domestic waste disposal, agricultural runoff, and mining activities." (Source: Federal Ministry of Environment, 2019)
2. Soil Contamination: Waste materials often contain heavy metals, toxic compounds, and other contaminants. When these materials are dumped into rivers, they can leach into the surrounding soil, contaminating it and affecting the growth of plants and crops.
3. Aquatic Life Impact: The contamination of rivers due to waste dumping can have detrimental effects on aquatic ecosystems, including fish kills, reduced water quality, and the decline of aquatic species. This can lead to imbalances in the food chain and negatively impact the overall health of the ecosystem. A research paper published in the Journal of Environmental Science and Natural Resource Management states that "the continuous discharge of untreated wastewater into rivers has led to the degradation of aquatic life in Nigeria." (Source: Okafor, 2015)
4. Aesthetic Impacts: The presence of waste materials in rivers can lead to unsightly scenes, affecting the beauty and appeal of natural water bodies. This can negatively impact tourism and recreational activities, such as fishing and boating.
5. Economic Consequences: Contaminated rivers can lead to economic losses in various sectors, including fishing, agriculture, and tourism. This can result in job losses and reduced income for local communities that rely on these resources. A report by the United Nations Development Programme (UNDP) in Nigeria notes that "poor waste management and pollution of rivers can lead to reduced agricultural productivity, loss of tourism potential, and increased healthcare costs." (Source: UNDP, 2021)
4. Potential Spread of Diseases: Contaminated water can lead to the spread of waterborne diseases, affecting human and animal health. This can put additional pressure on healthcare systems and lead to increased morbidity and mortality rates. A study by the Nigerian Medical Association highlights that "the quality of water from rivers in Nigeria is compromised due to industrial and domestic waste disposal, which poses significant health risks to the population." (Source: Nigerian Medical Association, 2018)
5. Climate Change Contribution: Waste materials, particularly organic matter, can decompose in rivers, releasing methane, a potent greenhouse gas. This contributes to climate change, exacerbating its impacts on global temperatures and weather patterns.

To address this issue, it is crucial to implement proper waste management systems, promote recycling and composting, and raise awareness about the importance of protecting water resources. This will help to reduce the practice of dumping waste in rivers and safeguard the health of both humans and the environment.

3.3 MUNICIPAL SOLID WASTE MANAGEMENT (MSWM) FUNCTIONAL ELEMENTS AND ITS SHORTCOMINGS IN NIGERIA

Municipal Solid Waste Management (MSWM) is the control of generation, segregation, storage, collection, transfer and transportation, resource recovery and processing, treatment and disposal of the solid waste by using the most efficient technique in an environmentally friendly, socially acceptable and economical means without compromising the health hazards of the people. The development of an environmentally friendly waste disposal system is the current global community's problem (Olanrewaju and Ilemobade, 2009; Amadi, et al., 2012a). Inadequate collection and transportation system, improper treatment and dumping of the solid waste leads to serious health hazards and environmental pollution. Every process of the Municipal Solid Waste Management (MSWM) plays a vital role in effective implementation of policies related with solid waste management (SWM). Solid waste management is a crucial aspect of maintaining a clean and healthy environment in Nigeria. It involves the collection, transport, processing, recycling, or disposal of waste materials. The functional elements of solid waste management in Nigeria can be categorized into the following:

3.3.1 Waste Generation

This is the initial stage where waste is produced by households, industries, and other establishments. Proper waste segregation at the source is vital to ensure that recyclable materials are separated from non-recyclable ones. According to Ogu (2000), 80–90% of the waste generated in some low-income African communities is not collected for proper and safe disposal.

3.3.2 Waste Collection

Waste collection is the process of gathering waste materials from various sources such as households, markets, and industries. This can be done through door-to-door collection, communal bins, or designated waste collection points. According to Ogwueleka (2009), reported that Nigeria's waste management practices include unsafe disposal and ineffective collection. Adegoke (1989) and Singh (1998) confirmed that Waste is only regularly collected in major cities and open landfils are eyesore in several cities with uncontrolled recycling of contaminated materials, and water source pollution that pose health risks to the public

3.3.3 Waste Transportation

Waste is transported from collection points to treatment facilities using various modes of transportation such as trucks, barges, or trains. Efficient transportation is essential to minimize the environmental impact of waste movement.

3.3.4 Waste Processing and Treatment

This stage involves the conversion of waste materials into reusable materials or energy. Processing techniques include composting, recycling, and waste-to-energy technologies. Proper waste treatment helps in reducing the volume of waste and conserving natural resources. Afon (2008) reported that currently, no treatment exists for collected wastes, which are transported to dumpsites and burnt in order to reduce their volume.

3.3.5 Waste Disposal

The final stage of solid waste management is disposal, which includes landfilling, incineration, or open dumping. However, due to environmental concerns, landfilling is now considered the least preferred method of disposal. Mull (2005) and Adewole (2009), observed in their study that in many developing nations, such as Nigeria, the practice of disposing of trash at open dump sites deviates greatly from accepted standards of practice Improper waste disposal practices and a disregard for topography, geology, and hydrogeology are the main contributors to pollution (Amadi et al., 2010; Amadi et al., 2012a).

According to Ezerie et al. (2007), residents should leave their waste at designated collection points, which are typically found next to busy roadways and open marketplaces. The local contractors, in collaboration with government organizations, then pick up these garbage. Ayotamuno & Gobo (2004) counteracted that indiscriminate dumping continues to occur in the city notwithstanding this arrangement.

3.3.6 Waste Monitoring and Regulation

The government and relevant authorities are responsible for setting standards and monitoring the implementation of solid waste management practices. This includes issuing permits, enforcing waste management laws, and conducting regular inspections. Agunwamba (1998) observed that the government often takes an ineffective approach regarding waste management. According to Omuta (1987), the absence of an appropriate waste management policy is a significant weakness in the administration of waste management in developing nations. An efficient waste management system requires the integration of several government functions, including engineering, urban planning, geography, economics, public health, and law, under a suitable policy. Amasuomo & Ojukonsin (2015) submitted that an appropriate policy is a crucial component of efficient Urban Solid Waste Management (USWM) since it serves as an institutional tool for the waste management method, regardless of the person in charge.

3.3.7 Public Awareness and Education

Raising public awareness about the importance of solid waste management and promoting environmentally friendly practices among citizens is crucial. This can be achieved through educational campaigns, community engagement programs, and public-private partnerships. Waste issues are generally not widely known or accounted for by the public, and at the moment, wastes are only transported to one inadequately designed land disposal facility. According to Imam (2007), the current system is beset by institutional, legal, technical, and operational limitations in addition to unfavorable economic conditions.

IV. CONCLUSION

Waste generation and collection are inevitable, but they can be reduced by taking a number of actions, such as the "4Rs" reduce, reuse, recycle and recover of solid waste materials and minimizes pollution and contributes to cost, energy, and raw material savings. Thus, there is a chance to gain a number of advantages from sensible and consistent waste management techniques. The following recommendations are put forward;

V. RECOMMENDATION

In Nigeria, addressing the issue of solid waste management requires a joint effort of households, institutions, manufacturing companies and government in combination with an effective policies, public awareness, and innovative technologies. Here are some recommendations for solid waste management in Nigeria:

1. Policy and Legislation: Develop and enforce comprehensive waste management policies and legislation at the federal and state levels. This includes setting targets for waste reduction, recycling, and proper disposal, as well as establishing penalties for non-compliance.
2. Public Awareness and Education: Launch campaigns to educate the public on the importance of waste segregation, recycling, and proper disposal methods. This can be done through schools, community programs, and mass media.
3. Waste Segregation and Collection: Implement a household waste segregation system where wet waste (food scraps, garden waste) and dry waste (plastics, metals, paper) are separated at the source. This will make recycling and composting more efficient.
4. Waste-to-Energy Projects: Encourage the development of waste-to-energy projects, which convert waste into electricity or heat. This will not only reduce the volume of waste but also generate clean energy.
5. Recycling Infrastructure: Develop and support recycling infrastructure, including recycling facilities, collection centers, and markets for recycled materials. This will create jobs and reduce the amount of waste sent to landfills.
6. Landfill Management: Improve the management of existing landfills by implementing modern waste containment technologies, such as landfill liners and leachate collection systems. This will help prevent environmental contamination and reduce the risk of health issues.
7. Public-Private Partnerships (PPP): Encourage public-private partnerships to invest in waste management infrastructure and services. This can lead to more efficient waste collection and disposal, as well as increased investment in waste reduction and recycling technologies.
8. Community Involvement: Engage local communities in waste management efforts by involving them in decision-making processes and providing training on waste management practices. This will help create a sense of ownership and responsibility for waste management among citizens.
9. Waste-to-Compost Systems: Promote the development of composting facilities to convert organic waste into nutrient-rich compost for agricultural use. This will not only reduce the volume of waste sent to landfills but also contribute to food production.
10. Monitoring and Evaluation: Regularly monitor and evaluate the effectiveness of waste management initiatives to identify areas for improvement and ensure continuous progress towards a cleaner and healthier environment in Nigeria.

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