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# Comparative Assessment of Solid Waste Composition among Waste Dumpsites in Lokoja, Nigeria

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## Abstract

*Municipal waste management remains one of the significant urban environmental problems in most rapidly growing cities in Nigeria. This study assesses composition of municipal solid waste dump sites in Lokoja metropolis. Purposive sampling technique was employed in sampling the waste dump sites for the study. The waste composition at each dump site was determined through manual sorting into distinct categories, followed by precise weight measurements using a weight balance. The result indicates significant variations in the composition of municipal solid waste across the dump sites. The study's findings underscored the predominance of organic waste across all dump sites. Consequently, this research emphasizes the need for enhanced public awareness and education initiatives, focusing on sustainable waste management practices, with a particular emphasis on the effective management of organic waste.*

***Keywords:*** ***Hazardous waste, inorganic waste, organic waste, recyclable waste, solid waste management***

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## Introduction

Municipal solid waste (MSW) disposal is a pressing environmental concern globally, particularly in urban areas of developing countries. The unregulated disposal of untreated solid wastes in designated dumpsites can lead to adverse environmental consequences, including ecological disruptions and pollution of humans (Afolabi & Eludoyin, 2021). The heterogeneous composition of solid waste, encompassing materials from industrial, domestic, agricultural, and healthcare sectors, exacerbates the environmental dilemma (Moftah *et al*., 2016). The escalating generation of solid waste is mostly driven by population growth, technological advancements, and economic development. This has overwhelmed waste management infrastructure in many urban areas (Nabegu, 2010; Amos *et al*. 2024). In addition, the rapid urbanization phenomenon and migration have further exacerbated the issue, leading to increased waste generation from residential areas, private and public service facilities, and construction and demolition activities (Balogun *et al*., 2020).

The composition of municipal solid waste (MSW) exhibits significant spatial variability (Adewumi *et al*. 2017). This is influenced by factors such as socioeconomic status, consumption patterns, and cultural differences (Kuruparan *et al*., 2003). Notably, low-income areas tend to generate waste with higher organic content, whereas high-income areas produce waste with higher proportions of paper and plastic (Adewumi *et al*., 2017). These differences in waste composition can be attributed to variations in consumption patterns, with higher-income households typically using more disposable materials and packaged foods, resulting in waste with higher calorific value, lower specific density, and lower moisture content (Klundert & Scheinberg, 2001). Conversely, lower-income households tend to use more fresh vegetables and less packaged food, leading to waste with higher moisture content, higher specific weight, and lower calorific value

In Nigeria, the ineffective management of solid waste has become a pervasive problem, with many urban areas struggling to provide adequate waste collection, transportation, and disposal services (Ogwueleka, 2009; Benjamin, Emmanuel and Gideon, 2014; Moftah *et al*. 2016; Balogun et al. 2020; Opaluwa & Ibrahim, 2022). The presence of these solid waste dump sites in urban areas poses significant environmental, health, and socio-economic challenges (Perteghella *et al*., 2020). In addition, the presences of these solid waste dumpsites usually lead to the pollution of groundwater, soil of the immediate environment, contamination of surface water, habitat of disease vectors, as well as production of smelly odours (Musa, 2009; Suleiman, 2017). In spite of the efforts made by the government of Kogi State in establishing series of viable organisations such as Kogi state Ministry of Environment, Kogi State Environmental Protection Agency, Kogi State Bureau of Sanitation and Transportation, The Lokoja Waste Action Plan 2020; and Kogi State Initiative on Generated Waste 2021 for the efficient management of municipal solid waste particularly in Lokoja. There are still series of waste dumpsite spread across some major areas in Lokoja metropolis causing series of nuisance in the area.

Despite existing research on solid waste management in Lokoja, including studies on solid waste management (Adetunji & Atomode, 2015), heavy metals in solid waste dump sites (Suleiman, 2017), and the impact of improper solid waste disposal (Balogun *et al*., 2020), a significant knowledge gap still remains regarding the comparison between the composition of municipal solid waste in different parts of Lokoja metropolis. This gap in knowledge when carried out will help in understanding the composition of MSW thereby helps the urban planners and waste managers develop effective waste reduction, recycling, and disposal strategies. This study will also be helpful to policy makers through highlighting of dumpsites in the study area where sensitive waste composition need improved waste management practices. Therefore this study aims to conduct a comprehensive comparative assessment of the composition of municipal solid waste dump sites in Lokoja metropolis, with a view of providing valuable insights for optimizing waste management practices, promoting sustainable waste disposal, and mitigating the environmental and health impacts of improper waste management.

## Materials and Methods

### Study Area

Lokoja, the capital city of Kogi State, Nigeria, is situated between latitudes 7°45'27.56'' - 7°51'04.34'' N and longitudes 6°41'55.64'' - 6°45'36.58'' E (Figure I) and lies at an altitude of 45 to 125 metres above sea level. It is situated on the western bank of the River Niger close to its confluence with River Benue and sandwiched between the River and the Mount Patti (Suleiman, 2017). As a result of the strategic location of area, it is a gateway to five geopolitical zones out of the six such zones in the country. The town is characterized by tropical climate that comprises of wet and dry seasons and falls within the Guinea Savannah vegetation belt. The annual rainfall is about 1150 mm, with mean annual temperature of about 27.7°C. The terrain of the region comprises of dissected undulating plains on the one hand, and lofty hill masses on the other. Mount Patti is the dominant physical feature of the town coupled with a number of intermittent valleys and streams criss-crossing the breadth of the town.

It covers all parcels of land within 16 km radius of a circle around the Lokoja. This 16km radius encompasses portions of five Local Government Areas (LGA(s)) which include Lokoja LGA (Lokoja township, Kogi LGA (North East) Adavi LGA (South West) Ajaokuta LGA (South) and Bassa LGA (East) (Ukoje, 2016).

Historically, Lokoja served as the capital territory of the British Northern Protectorate under Lord Lugard's administration (Olawepo, 2009). Following Nigeria's state creation in 1991, Lokoja became the capital of Kogi State, having served as the headquarters of Kogi Local Government Area since 1976.

Lokoja has experienced rapid population growth, which is a characteristic of many urban centers in Nigeria. This demographic shift coupled with the town being an epicentre that connects five political zones across the country has led to increased demand for goods and services, thereby resulting in a substantial rise in waste generation.

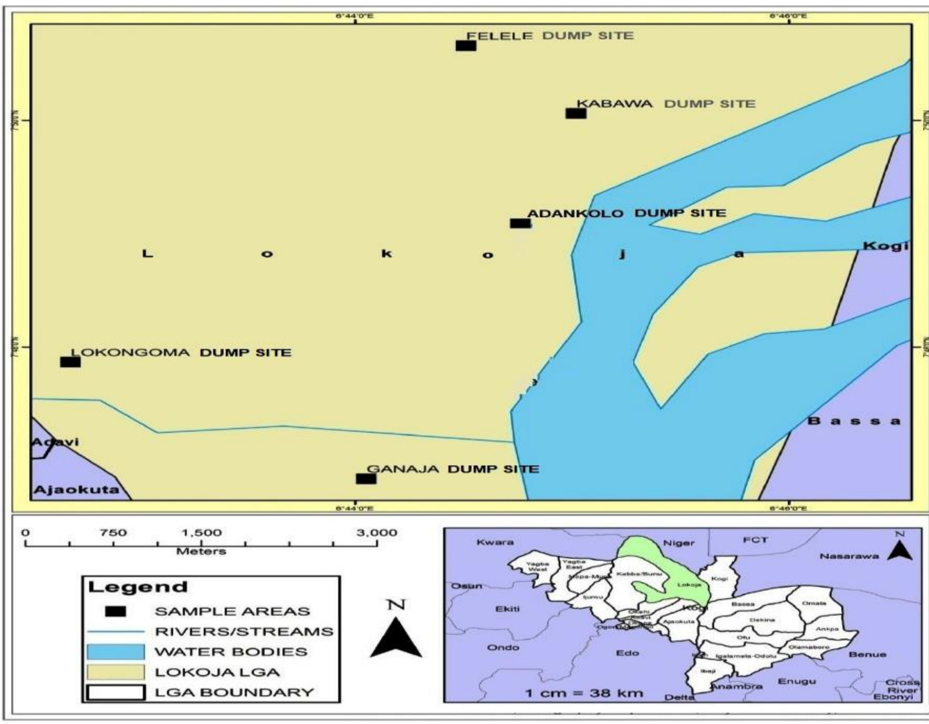


*Fig. 1:* ***Urban Lokoja showing the study sites. Source: Modified from Google Earth, Department of Environmental Management, Bayero University Kano.***

### Methods of Data Collection

Five dumpsites were purposively selected for the study. At each of the dumpsites, 80m by 80m sizes of the dumpsite were measured, thus each of the sites were apportioned or divided into four representative units with the same measurements of 40m by 40m using the measuring tape. Therefore ten

(10) grids were sampled to represent the five dump sites selected for the study. At each grid selected, after sorting of the waste composition using manual means, it was categorized into the following; organic waste, inorganic waste, recyclable waste, textile waste, and hazardous waste. The waste compositions identified were then weighed based on the categorization by putting them into a plastic container and weighed to determine its fraction in the total solid waste sample for each of the categorization in each of the waste dump sites. The weight of the container was subtracted to obtain the net component weight. The percentage of weight for each category was calculated using the formula described by Adewumi *et al*. (2017). In each of the dump sites, a sample of solid waste was collected four times in a week.

$$\text{Mean Sample of Solid Waste} = \frac{TWS1+TWS2+TWS3\ TWS4}{4} \quad \text{.........................1}$$

$$\text{PSW} = \frac{NWS}{TWS} \times 100 \quad \text{.........................................................................2}$$

Where; PSW is the percentage of the sub-category of waste (%); NWS is the net weight of the sub-category of waste in (g); TWS is the total sample weight of the sample in (g)

## Method of Data Analysis

The data were analyzed using descriptive statistics, including mean, range, and percentages. Additionally, rank analysis, a non-parametric method, was employed in the study. The findings are presented in tabular form.

## Results and Discussion

### Composition of Categorization of Waste

#### Organic Waste Component

The composition of organic waste in the study was found to be the highest among all waste components, as presented in Table I. The results show that the organic waste composition varies across the different dump sites, with

Felele dump site having the highest composition (34.9%), followed by Ganaja (32.8%), Kabawa (32.1%), Adankolo (32%), and Lokongoma having the lowest composition (30.5%). The high concentration of organic waste in the study may be attributed to several factors, including high population density, food consumption patterns, inadequate food waste management, and insufficient public waste bins. These findings are consistent with previous studies (Adedibu, 1993; Musa, 2009), which identified similar components of organic waste, including food leftovers, bread and grains, eggshells, and garden waste. However, it is worth noting that other factors, such as low income levels, education and awareness, climate and weather, and soil type and fertility, may also contribute to the high composition of organic waste in an area (Afuno & Rabiu, 2017; Ana Carolina *et al*., 2021). According to Nabegu (2008), a high concentration of organic waste in a dumpsite presents an opportunity for diversion, thereby reducing the volume of municipal solid waste requiring disposal and the associated spatial requirements. This, in turn, can lead to a decrease in municipal waste management expenses. Furthermore, Nabegu (2008) suggests that the diverted organic waste can be harnessed through the adoption of suitable technologies, enabling its conversion into bio-fertilizers or sources of renewable energy. This approach contributes to the promotion of sustainability and mitigates the degradation of the urban environment. The results of this study highlight the importance of effective organic waste management strategies in reducing the environmental impacts of waste disposal in the study area.

**Table I: Composition of categorization of waste in the area**

| Wastes Composition | Adankolo Dumpsite (%) | Kabawa Dumpsite (%) | Lokongoma Dumpsite (%) | Felele Dumpsite (%) | Ganaja Dumpsite (%) | Rank |
|---|---|---|---|---|---|---|
| **Organic Waste** | 32 | 32.1 | 30.5 | 34.9 | 32.8 | 1st |
| **Inorganic Waste** | 19 | 17.3 | 24.8 | 18.1 | 19.3 | 3rd |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Recyclable Waste** | 11.4 | 16.1 | 14.4 | 15.6 | 14 | 4th |
| **Textile Waste** | 27 | 19.7 | 20.8 | 18.6 | 20.7 | 2nd |
| **Hazardous Waste** | 10.6 | 14.8 | 9.5 | 12.8 | 13.2 | 5th |
| **Total** | 100 | 100 | 100 | 100 | 100 | |

*Source: Authors' fieldwork, 2024.*

**Inorganic Waste Component**

As shown in Table I, the inorganic waste comprised the third largest component of the waste composition in the study, but the inorganic waste composition varies across the different dump sites, with Lokongoma dump site having the highest composition (24.8%), followed by Ganaja (19.3%), Adankolo (19%), Felele (18.1%), and Kabawa having the lowest composition of inorganic waste composition (17.3%). The presence of inorganic waste in the study may be due to inadequate waste management practices such as lack of recycling programs or improper segregation of waste which can lead to inorganic waste ending up in the dump sites. However, Balogun *et al.* (2020) were of the view that the presence of inorganic waste composition in a municipal solid waste dumps sites are caused by factors such as inadequate waste management infrastructure, and inadequate regulations and enforcement mechanisms that can contribute to improper waste disposal practices and the presence of inorganic waste in dump sites. The component of inorganic waste seen in the study area include metals, ceramic, nylon, polythene bags, glass bottles, tiles, bricks, copper wires, battery cells, asphalt, shingles, and bitumen. The finding of the component of the inorganic waste is in line with earlier study such as Adewumi *et al*. (2017). The prevalence of inorganic waste in this study can be attributed to the urban setting characterized by a high density of income-generating activities. This finding is consistent with the observations of Afuno and Rabiu (2017), who noted that areas with higher income levels tend to produce a greater proportion of inorganic waste materials. The presence of inorganic waste composition in municipal solid waste dump sites can have several negative implications on the environment. This can lead to generation of leachate, a toxic liquid that can contaminate groundwater (Musa, 2009), and heavy metal contamination of the soil (Suleiman, 2017), alteration of ecosystems and disruptions of habitat thereby affecting local wildlife (Babayemi & Dauda, 2014), as well as the decomposition of inorganic waste lead to the production of greenhouse gases thereby contributing to climate change (Hammed *et al.*, 2018).

**Recyclable Waste Component**

The result in Table I shows that recycle waste comprised the fourth largest component of the waste composition in the study and varies across the different dump sites, with Kabawa dump site having the highest composition (16.1%), followed by Felele (15.6%), Lokongoma (14.4%), Ganaja (14%), and Adankolo having the lowest composition (11.4%). The low concentration of recycle waste in the study area can be attributed to high patronage of scavengers who usually search for valuable or reusable items from the waste dump sites. However, previous study like Agunwanba (2013) is of the view that unclear or missing label and signage could make it difficult for residents to identify recyclable materials. These findings are consistent with previous studies (Adedibu, 1993), which identified similar components of recycle waste, including plastics, tin, bottles, glass, papers, junk mails, aluminium cans, copper wires, spoiled televisions, spoiled printers, and spoiled computer.

**Textile Waste Component**

As seen in Table I, it shows that textile waste composed the second largest component of the waste composition in the study and reveal varying textile waste compositions across the dump sites with Adankolo (27%) having the highest composition, followed by Lokongoma dump site with composition

(20.8%), Ganaja (20.7%), Kabawa (19.7%), and Felele (18%) is having the lowest composition of textile waste. The composition of textile wastes in the study area include worn out clothes, discarded shoes, hats, scarves, belts, socks, under wears, used towel, old tablecloths, napkins, curtains, drapes, rugs, carpets, yarn and thread waste. The reason for the high composition of textile waste in the study especially in Adankolo dump could be attributed to more commercial and tourist centres like retail stores, hotels, and restaurants thereby generating textile waste from packaging, and other sources in the study area. Also– this could be traced to inadequate waste management infrastructure leading to improper disposal of textile waste. Deborah *et al*. (2020) is of the view that the absence of awareness of the residents of an area on the environmental impacts of textile waste or may not know how to properly dispose of textile waste, high population density, and transient population contribute to the composition of the waste dump sites with textile waste. The impacts of the textile waste on the environment cannot be overemphasised. This could lead to chemical contamination of the soil, burning of textile lead to the release of particulate matter thereby exacerbating respiratory issues and air quality problems, lead to habitat destruction and fragmentation, as well as exposing of humans to toxic chemicals that likely to health issues (Alabi *et al*., 2019).

**Hazardous Waste Component**

From Table I, the composition of hazardous waste differs significantly across the various dump sites and it shows that Kabawa dump site recorded the highest hazardous waste composition at 14.5%. Ganaja followed with 13.2%, Felele had composition of 12.8%, Adankolo with 10.6% of hazardous waste. Lokongoma had the lowest hazardous waste composition with 9.5%. The high composition of hazardous waste at the Kabawa dump site could be attributed to series of mechanic workshop around the area which may likely make it very easy for the workshops owners in the area to dump the waste from their shops to the dump site. Adewumi *et al* (2017) is of the view that the high composition of hazardous waste in dump sites is as a results of inadequate waste categorization, insufficient waste treatment capacity, absences of awareness about hazardous waste, lack of effective regulation, and economic constraints. The high level of hazardous waste composition especially at the Kabawa dump site signifies the handling of hazardous waste in the study area shows that there is no commitment to environmental responsibility and public safety; also it shows there is no serious compliance with regulations and laws about waste management in the study area. The composition of hazardous waste in the study area include batteries, electronic, needles and syringe, chemicals containers, oil based paints, varnishes, thermostats, fluorescent lamps, solvents, insecticides containers, herbicides containers, fungicides containers, disinfectants, sterilants, brake pads, and used oil filters from motor cycles, cars, and trucks. These ranges of hazardous waste in the study area needs special handling to prevents exposure to toxic substances that cause serious health problems like cancer, neurological damage, and reproductive issues.

**Variation of Solid Waste Composition among the Study Dump Sites**

**Adankolo Dump Site**

Table II shows the variation of waste components among the dump sites selected in this study. The mean composition of solid wastes at the Adankolo dump site indicates that organic waste constitutes the largest proportion, with a mean composition of 4,500g. Textile waste follows closely, with a mean composition of 3,787g. In contrast, hazardous waste has the lowest mean composition, at 1,500g. The mean compositions of inorganic waste and recyclable waste are 2,680g and 1,600g, respectively. The dominance of organic waste at the Adankolo dump site is evident, accounting for the highest mean composition. This finding can be attributed to the high density of households, restaurants, and food establishments in the area, which generate substantial amounts of food waste. The large quantity of organic waste disposed of at the dump site underscores the need for effective organic waste management strategies, such as composting or anaerobic digestion, to mitigate environmental impacts.

**Kabawa Dump Site**

As indicated in Table II at the Kabawa dump site, the range of organic waste was found to be between 2450g and 4555g, while inorganic waste ranged from 2045g to 2785g. Recyclable waste and textile waste ranged from 1850g to 2750g and 1673g to 2436g, respectively. Hazardous waste was present in the range of 1465g to 2580g. The study revealed that organic waste was the dominant waste type at the Kabawa dump site, accounting for the largest proportion of waste. This finding is corroborated by existing literature, including Moftah *et al*. (2016), who observed that organic waste predominantly constitutes the majority of municipal solid waste in urban areas. The prevalence of organic waste at the dump site suggests that inadequate waste management practices in Lokoja metropolis may be a contributing factor, despite initiatives by the Kogi state government aimed at maintaining environmental cleanliness. This highlights the need for effective waste management strategies to mitigate environmental impacts and promote sustainable waste disposal practices.

**Table 2: Variation of composition of solid waste among the area**

| Dump Sites | Descriptive Statistics | Organic Wastes (g) | Inorganic Wastes (g) | Recyclable Wastes (g) | Textile Wastes (g) | Hazardous Wastes (g) |
|---|---|---|---|---|---|---|
| **Adankolo Dump site** | Mean | 4,500 | 2680 | 1600 | 3787 | 1500 |
| | Range | 3600-5600 | 1900-3500 | 1250-2455 | 2345-3892 | 1350-1800 |
| **Kabawa Dump site** | Mean | 3800 | 2050 | 1910 | 2340 | 1750 |

| Dump Sites | Descriptive Statistics | Organic Wastes (g) | Inorganic Wastes (g) | Recyclable Wastes (g) | Textile Wastes (g) | Hazardous Wastes (g) |
|---|---|---|---|---|---|---|
| | Range | 2450-4555 | 2045-2785 | 1850-2750 | 1673-2436 | 1465-2580 |
| **Lokongoma Dump site** | Mean | 4350 | 3545 | 2058 | 2967 | 1350 |
| | Range | 3500-4890 | 3680-4700 | 2406-3425 | 2756-3753 | 1360-1965 |
| **Felele Dump site** | Mean | 5600 | 2900 | 2500 | 2980 | 2050 |
| | Range | 4300-6525 | 2865-3230 | 2540-2850 | 2750-3860 | 2350-3150 |
| **Ganaja Dump site** | Mean | 4895 | 2890 | 2085 | 3090 | 1980 |
| | Range | 4800-5020 | 2650-3750 | 1950-2550 | 3000-3710 | 1995-2900 |

*Source: Authors' fieldwork, 2024.*

**Lokongoma Dump Site**

Table II shows that the mean composition of various waste types at the Lokongoma dump site indicate that organic waste exhibited the highest mean composition, with a value of 4350g, followed by inorganic waste (3545g), textile waste (2967g), recyclable waste (2058g), and hazardous waste (1350g). As shown in Table II, the waste composition at the Lokongoma dump site varied significantly, with the following order of dominance: organic waste > inorganic waste > textile waste > recyclable waste > hazardous waste. Notably, this study's findings diverge from those reported by Adewumi *et al.* (2017), who observed a higher concentration of recyclable waste in their characterization of solid waste. The discrepancy between these findings may be attributed to differences in waste management practices, demographic characteristics, or socioeconomic factors between the two study areas.

**Felele Dump Site**

As presented in Table II, the range of organic waste was found to be between 4300g to 6525g, while inorganic waste ranged from 2865g to 3230g. Recyclable waste composition ranged between 2540g to 2850g, textile waste ranged between 2750g to 3860g, and hazardous waste ranges between 2350g to 3150g. The study revealed that organic waste was the dominant component at the Felele dump site, exceeding other waste compositions. The preponderance of organic waste may be attributed to consumption patterns and inadequate waste reduction and reuse practices, leading to increased organic waste generation. This finding is consistent with the notion that socio-economic factors, such as high population density and growth, as well as limited awareness and education about proper waste management practices, can contribute to the dominance of organic waste in urban dump sites (Adetunji & Atomode, 2015). As shown in Table II, the range of variation in solid waste composition at the Felele dump site followed the order: organic waste > textile waste > inorganic waste > recyclable waste > hazardous waste.

**Ganaja Dump Site**

The results in Table II show that organic waste has the highest mean composition (4895g), followed by textile waste (3090g), inorganic waste (2890g), recyclable waste (2085g), and hazardous waste (1980g). The mean composition reveals that organic waste dominates the waste stream at the Ganaja dump site, accounting for the largest proportion. This finding is consistent with the trend observed at other dump sites, such as Felele and Lokongoma, where organic waste was also found to be the predominant component. However, the mean composition of organic waste at Ganaja (4895g) is higher than that reported at Felele (4300-6525g) and Lokongoma (4350g). In contrast, the mean composition of hazardous waste at Ganaja (1980g) is lower than that reported at Felele (2350-3150g). As indicated in Table II, the grading of waste compositions at Ganaja follows a similar pattern to that observed at Felele, with organic waste > textile waste > inorganic waste > recyclable waste > hazardous waste.

## Conclusion

The generation of waste is an inherent aspect of urbanization, presenting a significant challenge to sustainable development. In Nigeria, the proliferation of waste from domestic and commercial sources has escalated dramatically over the past decade, driven by rapid industrialization and population growth in urban centers. Consequently, waste generation rates have surpassed the capacity for collection, transportation, and disposal, exacerbating environmental and health concerns. The results from the study show that organic waste is the dominant component at all five dump sites, accounting for the largest proportion of waste. The dominance of organic waste can be attributed to high food waste generation, inadequate waste management practices, and socio-economic factors such as high population density and growth. In the light of the findings from this study, the study recommended that the government should provide modern municipal waste management infrastructure such as composting plants, crusher plants, and anaerobic digesters, to manage organic waste effectively, public private partnership (PPP) should be established in the area of municipal waste management to ensure effective management at all level, environmental education should be introduced at all level of education this will help to change people attitude and develop positive behaviour towards the environment, government and non-governmental organisations should create awareness on sustainable waste management practices, which prioritizes zero waste, via waste reduction and segregation at household’s level to separate organic waste from other waste types, there be sound and effective environmental policies should be enacted, through the application of polluter pay principles (PPP) to improve the current waste management for effective policy regulations to govern waste disposal practices in Lokoja, Nigeria.

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