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A Review on Solid Waste Generation and Management in Nigeria Cities

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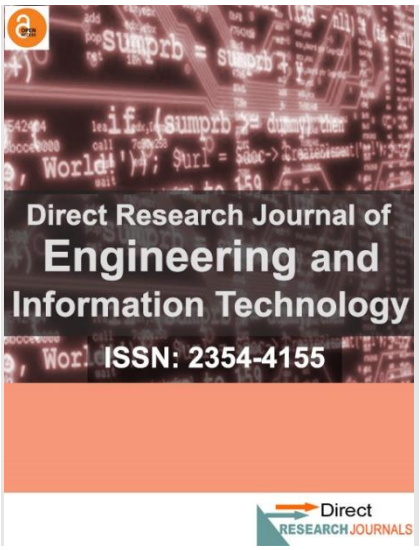
ABSTRACT

Solid waste generation is a big environmental problem in Nigerian cities, where huge amounts of rubbish are produced every day, much of it is not picked up and is disposed of incorrectly. Nigeria generates an estimated 42 million tonnes of solid garbage per year, making it a major contributor to sub-Saharan Africa. The careless disposal of this debris, especially plastic, contributes to pollution and health hazards. Large piles of the generated solid trash are indiscriminately thrown on any vacant lot, beside buildings, in drainage systems, by the sides of the road, and in public marketplaces. The people in this region of the world appear to accept living with solid trash all over the place. An extensive review of garbage creation and management in a few chosen Nigerian cities was presented in this article. The results showed that there are both major obstacles and some promising new trends in the development and management of solid waste. There are growing attempts to formalize waste management and investigate recycling and resource recovery, despite the fact that a significant amount of rubbish is generated and goes uncollected.

Keywords: *Recovery, Solid waste, waste generation, waste management, Nigeria cities*



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INTRODUCTION

The government and society in Nigeria are very concerned about the issue of solid waste generation and management. Given the growing population pressure and socioeconomic circumstances in Nigeria, this waste is concerning (Benjamin *et al.*, 2012; Igbinomwanhia *et al.*, 2012; Orhorhoro *et al.*, 2017a; Igbagbon *et al.*, 2024a; Orhorhoro, 2025). Solid wastes are goods that people in society abandon because they are unneeded and undesirable in a solid state (Akintokun *et al.*, 2011; Hoornweg and Bhada-Tata, 2012; Orhorhoro *et al.*, 2016; Orhorhoro *et al.*, 2017a). Depending on where it comes from, solid waste can be divided into three categories: industrial, municipal, and agricultural. Only 20–80% of waste is collected in Nigerian cities, which spend 20–50% of their environmental budget on solid waste management (Igbinomwanhia *et al.*, 2011; Ionescu *et al.*, 2013; Anwar

et al., 2014; Igbinomwanhia *et al.,* 2017; Orhorhoro and Oghoghorie, 2019). Due to inadequate recording of waste creation rates, ineffective storage and collection systems, and underutilization of disposal sites, Nigeria's waste management standards are at an all-time low (Ogwueleka, 2009; Igbinomwanhia *et al.,* 2017; Orhorhoro and Oghoghorie, 2019; Oloaluwa uet al., 2025; Orhorhoro, 2025). Urban areas in Nigeria are currently having difficulty removing mountains of solid garbage from their surroundings (Orhorhoro *et al.,* 2016a; Orhorhoro *et al.,* 2016b; Orhorhoro and Oghoghorie, 2019). The disorganized appearance of untended piles of solid garbage coming from the community has now displaced strategic points of interest in Nigeria (Oyelola and Babatunde, 2008; Owamah *et al.,* 2015; Orhorhoro *et al.,* 2018; Ukwaba *et al.,* 2018). Nigeria's environmental sanitation rules and regulations clearly violate the Clean Air and Health Edicts, yet city officials seem powerless to stop the illegal dumping of household and industrial garbage (Orhorhoro *et al.,* 2017a; Orhorhoro and Oghoghorie, 2019; Emifoniye *et al.,* 2025).

Furthermore, Nigerian society is concerned about the country's inadequate solid waste management (Orhorhoro *et al.,* 2017a). These wastes threaten urban management, harm the nation's cities' aesthetics with their growing piles of solid trash, and endanger public health by clogging drainage systems, which leads to erosion and flooding (World Bank, 1999; Sabejeje *et al.,* 2014; Orhorhoro and Oghoghorie, 2019; Igbagbon *et al.,* 2024b; Emifoniye et al., 2025b). Because it serves as a mosquito breeding ground, the people of Nigeria are at great danger for health problems. Because collected solid wastes are currently dumped at open dump sites, the amount of solid trash generated has increased consistently over time due to urbanization, industry, and population growth (Ogawa, 1996; Ogwueleka, 2009; Kolekara *et al.,* 2016; Osunde *et al.,* 2017). According to the most recent United Nations World Population Estimate, as of Tuesday, September 18, 2016, the populations of Nigeria, West Africa, Africa, and the world are 187,896,647, 362,807,216, 1,221,837,143, and 7,432,663,275, respectively. This suggests that Nigeria's population, which currently makes up 2.48% of the global population, is expected to double by 2050 (UNWPE, 2016). Nigeria is home to more than 15% of Africa's overall population and nearly half of West Africa's entire population. After China, India, the United States, Indonesia, Brazil, and Pakistan, she is rated seventh in terms of population (UNWPE, 2016). Nigeria has a total land area of 910,802 km² and a population density of 205 per km². With farming as their primary occupation, the remaining population is concentrated in rural areas, with an estimated 48.1% of them living in urban areas (91,668,667) (UNWPE, 2016). There are many different ways that garbage is produced, and the type and amount of waste produced are influenced by the industrial and economic systems that are in place as well as the patterns of consumption (Hoornweg *et al.,* 2012b; Hoornweg *et al.,* 2014; Orhorhoro *et al.,* 2017c; Orhorhoro and Oghoghorie, 2024). Rapidly growing waste management is a major problem for nations with high rates of economic expansion (Orhorhoro and Oyejide, 2020). For instance, during a time of high economic growth, from 1979 to 1995, China's trash generation climbed by 9% yearly; by 2030, this is predicted to double as a result of increases in China as well (Njiribeako, 2003; Lim *et al.,* 2012). Due to their detrimental impacts on the environment, waste generation and management are difficult global challenges that both developed and developing nations must deal with (Hoornweg *et al.,* 2013).

Solid Waste Generation in Nigeria Cities

There are several different ways that solid waste is produced. However, the amount of solid waste produced in Nigerian cities is mostly determined by the industrial and economic institutions that are in place as well as the patterns of consumption (Orhorhoro *et al.,* 2017a). Hoornweg *et al.* (2013) claim that nations with rapidly expanding economies typically deal with large amounts of solid waste production. For instance, during a period of high economic growth, from 1979 to 1995, China's trash generation climbed by 9% yearly; by 2030, this is predicted to treble (Forbes Economy ranking in Africa, 2018). With an estimated $172 billion, Nigeria has the largest economy in Africa. South Africa comes in second with $166.735 billion. Therefore, it is concerning that more solid waste will be produced in Nigeria if the report of Hoornweg *et al.* (2013) is any indication. Furthermore, many studies conducted in Nigeria to ascertain and assess the amount of solid waste produced daily have revealed that the country generates 0.43 to 0.66 kg of solid garbage per inhabitant per day (Table 1).

Plastics, paper, textiles, metal, glass, and food scraps make up the majority of Nigeria's solid waste, which is produced at a rate of 25 million tons per year and 0.44–0.66 kg per capita per day (Igbinomwanhia *et al.,* 2011; Orhorhoro and Oghoghorie, 2019; Orhorhoro, 2025). In Lagos, the largest commercial city in Nigeria and West Africa, the per capita rate of garbage generation varies from approximately 0.21 kg/day/person to approximately 0.35 kg/day/person (Orhorhoro and Oghoghorie, 2019; Orhorhoro, 2025). Table 2 lists the many sources of solid waste produced in Nigerian cities.

A study conducted by Ebunilo *et al.,* (2015); Orhorhoro and Oghoghorie, (2019); Orhorhoro, (2025) using Mushin LGA and Oredo LGA, both in the Nigerian cities of Lagos and Benin, revealed that the average weekly amount of household solid trash in the Lagos metropolis was 2263.2 kg. They calculated a daily generation rate of 0.57 kg per person per day (ppd.) based on that value. The capitals of Nigeria's Edo State and Lagos State are Benin City and Lagos, respectively. The largest city in Africa, West Africa, and Nigeria is Lagos. In addition to being one of the world's fastest-growing urban areas, it is also one of the world's most densely populated urban agglomerations.

Table 1. Solid wastes generation in some major urban cities and towns in Nigeria.

City	Population	Agency	Tonnage per Month	Density (kg/m^3)	Kg per capita per day
Abuja	159,900	Abuja state environmental protection agency	14,785	280	0.66
Benin	2,085,676	-	-	-	0.45
Nsukka	500,700	Enugu state environmental protection agency	12,000	370	0.44
Lagos	22,029,200	Lagos state management authority	255,556	13,000	0.63
Onitsha	2,509,500	Anambra state environmental protection agency	84,137	310	0.53
Kano	7,348,700	Kano state environmental protection agency	156,676	290	0.56
Makurdi	549,000	Urban development board	24,242	340	0.48
Ibadan	2,307,840	Oyo state environmental protection commission	135,391	330	0.51
Port Harcourt	2,053,900	River's state environmental protection agency	117,825	300	0.60
Kaduna	1,958,900	Kaduna state environmental protection agency	114,443	320	0.58

Source: (Igbinomwanhia *et al.,* 2011; Hoornweg *et al.,* 2014; Owamah *et al.,* 2015; Igbinomwanhia *et al.,* 2017).

Table 2: Type of waste across Nigeria cities

Source	Typical Waste Generators	Types of Solid Wastes
Residential	Single and multifamily dwellings	Food wastes, cardboard, paper, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, home hazardous wastes (such as paints, aerosols, gas tanks, waste containing mercury, motor oil, cleaning agents), and special wastes (such as bulky items, consumer electronics, white goods, batteries, oil, tires) as well as e-waste (such as computers, phones, and televisions).
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants.	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes.
Commercial	Stores, hotels, restaurants, markets, office buildings.	Paper, cardboard, Plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes, e-wastes.
Institutional	Schools, hospitals (non-medical waste), prisons, government buildings, airports.	As reported in commercial
Construction and Demolition	New construction sites, road repair, renovation sites, demolition of buildings.	Wood, steel, concrete, dirt, bricks, tiles.
Municipal Services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants.	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas, sludge.
Process	Refineries, chemical and power plants, heavy and light industries, and the mining and processing of minerals.	Industrial process wastes, scrap materials, off-specification products, slag, tailings.
Medical waste	Hospitals, nursing homes, clinics.	Hazardous wastes (sharps, tools, chemicals), infectious wastes (bandages, gloves, cultures, swabs, blood, and bodily fluids), radioactive waste from cancer treatments, and pharmaceutical wastes.
Agricultural	Crops, orchards, vineyards, dairies, feedlots, farms.	Spoiled food wastes, hazardous wastes (like pesticides), and agricultural wastes (such rice husks, cotton stalks, coconut shells, and coffee debris).

Source: (Babayemi and Dauda, 2009; Adewumi and Ajibade, 2015; Adewumi *et al.,* 2017; Ebunilo *et al.,* 2015; Mokuolu *et al.,* 2021; Orhorhoro *et al.,* 2022; Oghoghorie *et al.,* 2024)

With an estimated population of nearly 22 million, the metropolis has a population density of 13,000 people per square kilometer (Ebunilo *et al.,* 2015). According to data on the quantity of solid waste produced in Lagos, 4.92% of the garbage was ash, 46.47% was trash, and 47.86% was food waste [46]. Rubber and plastic materials accounted for 12.63% of the 46.47% of the trash, followed by other combustible materials (paper, fabric, foam, etc.) at 18.16% and non-combustible materials (metal, glass, ceramics, etc.) at 15.685%. Babayemi and Dauda (2009), Hoornweg *et al.* (2014), and Olukanni and Mnenga (2015) conducted a study titled "Characterization Study of the Municipal Solid Waste Generated in Nigeria." The composition, average mass, and relative percentages of municipal solid waste were used to establish seasonal variation in the study area. The findings revealed that the waste generation rate ranged from 0.59 to 0.79 kg/capita/day during the wet and dry seasons, respectively. Food waste and putrescibles constituted the largest fraction of the solid waste stream, followed by rubber, paper, glass/ceramics, plastics, metals, and miscellaneous materials such as dust particles, ash, and stones (Table 3).

Table 3: Municipal Solid Waste Composition by Season.

Waste Component	Wet Season (%)	Dry Season (%)
Food and putrescibles	56.20	52.00
Rubber	10.20	3.56
Paper	10.00	12.46
Glass/Ceramics	7.60	1.42
Plastics	7.40	2.85
Metals	2.60	0.71
Other (dust, ash, stones)	5.60	25.62

Solid Waste Management

In Nigeria, the conventional approach to solid waste management was to simply pick up the rubbish and dispose of it in an open dumpsite. It seems obvious that burying waste in the earth is an ineffective way to handle

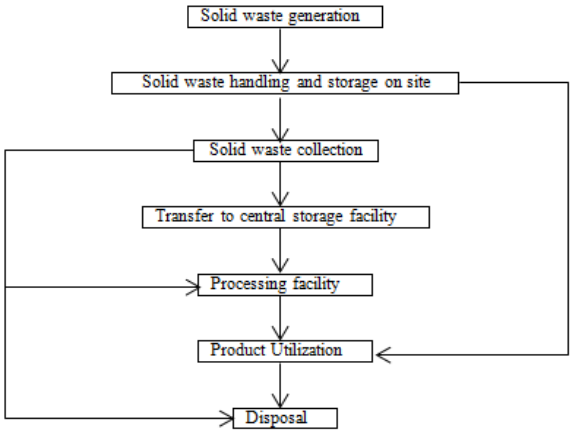

Figure 1: The solid waste Chain

materials (Omran and Read, 2007). From the moment of generation through "collection" and "disposal," all actions involving solid waste are referred to as "solid waste management" (Ebunilo *et al.,* 2016a). Solid waste management's overarching goal is to reduce the negative economic and environmental effects of careless solid waste disposal, particularly hazardous trash (Ebunilo *et al.,* 2016b). An essential component of environmental preservation is waste management. Its goal is to offer solid waste storage, collection, transportation, and treatment or disposal that is hygienic, economical, and efficient without contaminating the air, land, or water system. The solid waste chain is the route that solid waste follows during management, from the point of generation to the point of sanitary disposal and management. As seen in (Figure 1), solid waste management is a multi-step process (solid waste chain) (Orhorhoro and Oghoghorie, 2019).

The creation of solid waste is the initial stage in the solid waste cycle, as shown in (Figures 1 and 2). A material is deemed to be a waste whenever its owner no longer values it and refuses to accept responsibility for it (Ebunilo *et al.,* 2016a; Orhorhoro and Oghoghorie, 2019). Solid waste needs to be appropriately managed and processed at the source as soon as it is produced. To guarantee that some of the waste is recycled, the processing and handling may involve sorting or segregation, washing, and storage. Collection, transportation to a central storage facility, final processing facility, product use, and disposal are additional phases in the solid waste chain (Ebunilo *et al.,* 2016b; Orhorhoro and Oghoghorie, 2019). But according to Igbinomwanhia *et al.* (2017), an initial investigation into solid waste management in the Nigerian metropolis of Benin found a significant departure from the route depicted in Fig. 2. Large piles of generated solid trash were observed in drainage systems, the open marketplace, the vicinity of residences, and illegal solid waste dump sites. Additionally, this has led to major environmental catastrophes in the city, including disease outbreaks and water flooding (Orhorhoro and Oghoghorie, 2019).

Therefore, gathering mixed waste items and then burning, burying, and disposing of them in approved dumpsites is the most widely used waste generation management method in Nigeria (Igbinomwanhia *et al.,* 2011; Orhorhoro and Oghoghorie, 2019; Orhorhoro, 2025). Approved alleged landfills, where solid garbage is disposed of and overseen by waste management organizations. Only two of the city's eight authorized dumpsites were operational at the time of this investigation because the responsible authorities had neglected them. As a result, disposal agents dumped solid trash carelessly, even at authorized disposal sites.

Solid Waste Management Hierarchy

Figure 3 depicts the hierarchy of solid waste management. The environment will be more hospitable and healthier if Nigeria can implement an integrated solid waste management program and use the vast amount of solid waste produced for energy production and other purposes.

Source Reduction, and Reuse

Reuse and source reduction are solid waste management strategies that include all planned actions aimed at lowering the amount of solid waste produced or the toxicity of items over the course of their life cycles. It entails the creation, production, use, and disposal of goods having a longer useful life, less harmful content, and/or a smaller material bulk. It can take many different forms, including rethinking and cutting back on products, buying in bulk, decreasing packaging, and reusing or donating objects (Oziegbe, 2015). McKendry (2002) lists the following as particular instances of source reduction:

i. The redesigning of products to use fewer materials (material substitution),
ii. Reusing products and materials that have served the main purpose it was meant for (e.g., a refillable water bottle),
iii. Extending the useful lifespan of products. The following benefits can be obtained from source reduction and reuse (McKendry, 2002):

i. It helps in savings natural resource,
ii. It brings about conservation of energy,
iii. It helps in the reduction of pollution,
iv. It brings about reduction in the toxicity of wastes.

Recycling/Composting

One waste management technique that turns solid waste into useable items is solid waste recycling/composting. It includes things like gathering abandoned, repurposed, or unwanted objects and turning them into products that can

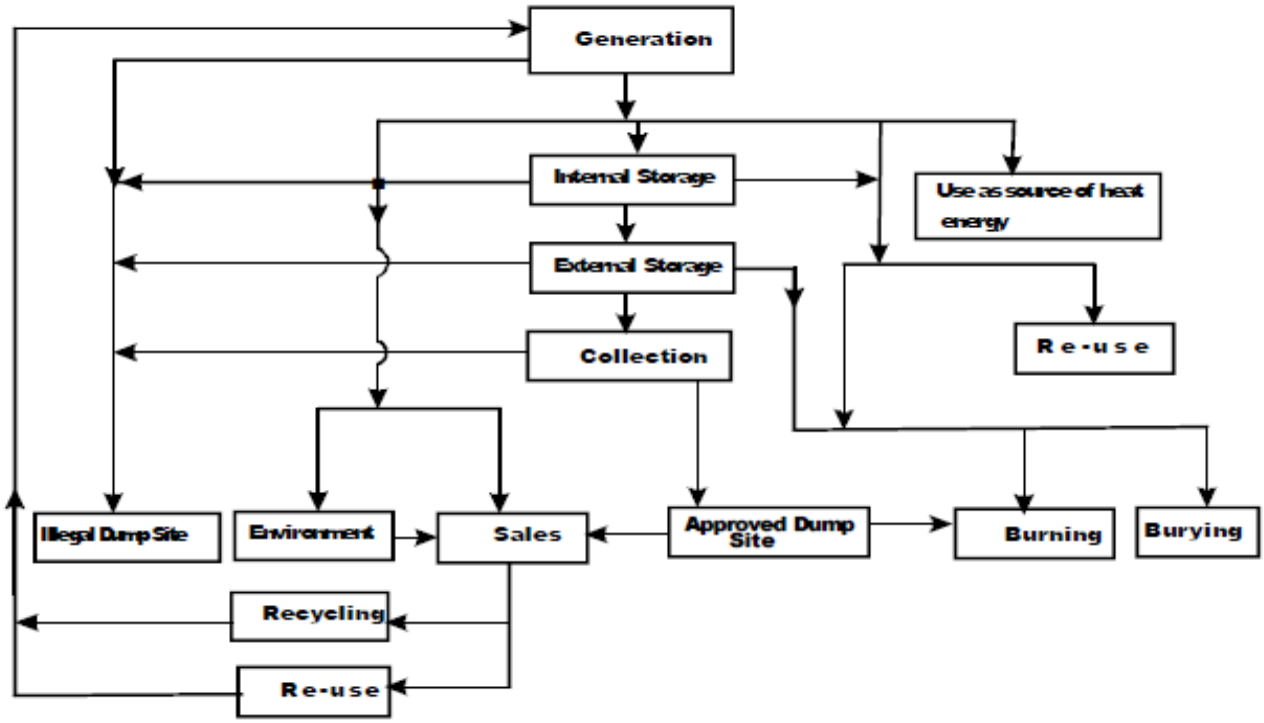

Figure 2: Solid Waste Chain in Benin metropolis, Nigeria (Igbinomwanhia *et al.,* 2011).

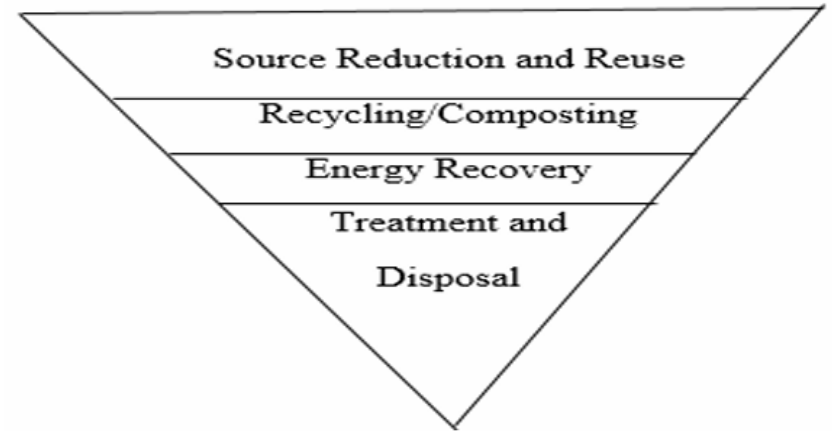

Figure 3: Waste management hierarchy

be used (Kreiger *et al.,* 2014).

Energy Recovery

The process of turning non-recyclable waste materials into useful heat, power, or fuel using a range of techniques (such as combustion, gasification, pyrolysis, etc.) is known as energy recovery from solid wastes. Waste-to-energy (WTE) is a common term for this process. Waste management and energy production are the two main functions of energy recovery (Thomson, 2010).

Treatment and Disposal

The most popular way to dispose of waste is in landfills. However, open dumpsites are encouraged as a waste management method in Nigeria due to the absence of an engineering landfill infrastructure. An integrated waste management system must include a landfill. State and local governments are largely in charge of regulating landfills that take in municipal solid waste. Landfills nowadays have to adhere to strict design, operation, and

closing guidelines. The landfill system's biomethane can be gathered and converted into fuel. The land may be developed into parks, golf courses, and other recreational areas once a landfill has been covered.

Current Practice of Waste Management in Nigeria Cities

Approved Dump Sites: Approved dump sites are management agents around houses, business premises and at the dumpsites in the metropolis.

***Burying*:** Covering garbage in holes dug in the earth is known as "burying." The practice of burying solid refuse is widespread in the city of Benin. According to this study, during construction, people excavate trenches behind their homes to obtain sand for filling the foundation to damp proof course (DPC) levels. When they move in, they bury their solid waste in the holes that were dug behind their homes when they were being built.

Use as Source of Heat Energy: Residents of Benin City burn solid trash to provide heat energy for cooking, according to this study. For instance, some city dwellers visit wood processing stores to gather wood shavings and sawdust, which they then burn to generate heat for cooking. Additionally, in order to generate heat for preparing corn for sale, the boiled-corn vendor burns the corn curb during corn season.

Burning: This involves lighting the trash on fire and letting it burn till it hurts. This analysis found that trash sellers and generators were burning solid waste in an uncontrolled manner.

***Sales*:** According to this study, some of the solid waste generated by the generators is sold to consumers, such as used bottles that are used for storing vegetable oil and other culinary supplies. They also sold pharmaceutical packaging bottles.

Conclusion

High generation rates, ineffective collection, and insufficient disposal techniques make solid waste management in Nigerian cities a serious environmental concern. Waste generation in Nigerian cities has increased due to fast urbanization and population growth, surpassing the capacity of current systems and infrastructure. Widespread problems like inadequate sanitation, environmental contamination, and possible health risks are the outcome of this. The treatment, collection, and disposal of solid waste are the primary issues. The city has rules pertaining to solid waste management, but they are hardly enforced, therefore most of them are broken. In recent years, it seems that residents in the city have come to accept living with solid trash all over the place. According to the analysis, solid waste management in Nigerian cities is a major problem that is typified by a lack of funds, poor public awareness, and inadequate infrastructure. A multifaceted strategy including all stakeholders, including trash generators, the commercial sector, and governmental organizations, is necessary for effective waste management. To safeguard the environment and public health, a move toward integrated waste management systems that combine recycling, trash reduction, and contemporary disposal techniques is essential.

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