



**Solid Waste Challenges and Management in a Traditional Sahelian
City: A Case Study of Sokoto, Nigeria**

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ABSTRACT

This study assessed the solid waste generation, management, and consequences in the traditional city of Sokoto. The utmost challenges facing this Sahel region include scarcity of modernized and control measures of waste resulting from daily hectic impacts on the community. In this city, solid waste is characterized by inefficient control, insufficient coverage of collection system and improper disposal methods. The increasing population of residents has accelerated more pollution of all categories, and the consequence is a dearth of hygienic standards. This work further sampled different materials from heaps of waste such as; the level of sub-soils at 0-30 cm (at random) from each of the dump sites to determine the extent of heavy metal concentrations and for fertility supplement in comparison with the National Environmental Standards and Regulations Enforcement Agency (NESREA). Fifty structural questionnaires were administered randomly to selected residents around dumping sites and the staff of Sokoto Waste Management & Planning Board to solicit relevant information that can assist the governments, stakeholders, and waste control agencies. Also, Landsat data was utilized to map out the waste sites for spatio-temporal analysis. Results indicated that 89% of respondents agreed that Sokoto metropolis is characterized by untidiness with masquerades of biodegradable wastes, while major streets especially in the congested areas which displayed a lot of drains and channels remain blocked.

1. Introduction

The generation and transportation of waste is an essential part of any society like Nigeria and other developing cities in the world. Essential basic clearance is needed where household members leave refuse and discarded matter in an open space, outside the residence or market, which thereby becomes an accumulation of waste. The percentage of Nigeria's population living in cities and urban areas has more than doubled in the last 15 years (Jimoh, 2005). Thus, many cities in Nigeria experience a constant growth of solid waste that contributes to a mammoth mess of unhealthy living standards. The management of solid waste is supposed to be the concern of all stakeholders, individuals, corporate bodies, and governments among others. Apart from the large volume and amount of solid waste not only that not only constitute category problems, but the ineptness and incapability of governments play a significant role in the management of waste/disposal that continuing frailly in our city environment common more prominent in the Northern parts of Nigeria (Ahmed, et al 2017). There is no doubt that an unclean environment affects the standard of living, aesthetic sensibilities, health being of the people and thus the quality of their lives (Mowoe, 1990). Waste often generated by human beings since time immemorial has continued to be a threatening problem and a growing one that is of major concern to every nation of the world. The objective of this paper is to show the fusion between the glaring challenges associated with waste control and management in a traditional city of Sokoto in the Sahelian region of Nigeria, with efforts to ameliorate poor attitudes towards waste management. It also aims to propose a better standard of management approach for tackling solid waste problems in the study area and the country as a whole. For an in-depth understanding of these issues and solutions, the article covers the existing management of city solid waste and suggests more controlling measures in addition to the existing waste policies and regulations. For

example, problems affecting waste management, information on management challenges relating to old city solid waste, proposed knowledge management solutions, and so forth. Waste is an unavoidable by-product of most anthropogenic actions of humans that influence natural World (Rodgers, 2011). The United Nations (UN, 2020) submits that waste management is a systematic control of the generation, storage, collection, transportation, separation, processing, recovery, and disposal of waste. For the best understanding of the subject matter of waste the World Health Organization opines that solid waste is any type of garbage, trash, refuse or discarded materials that had reached the end parts of their uses or beginning their re-use through new life(recycling)(Ahmed,2008; WHO, 2021). Waste products can be categorized according to where the waste is generated, for example, municipal solid waste, health care waste, and e-waste among others. Waste, therefore, is something that falls out of the normal commercial circle or utility. The European Commission (EC) Circular 2020 suggests four broad categories that may be considered in deciding the question of whether an object is a waste:

- I. Worn but functioning substances or objects which are still usable (though, after repair) for the purpose for which they were made are not to be considered as waste.
- II. Objects that can be put to immediate use otherwise than by a specialized waste recovery operation or undertaking are likewise not to be considered as waste.
- III. Degenerated substances or objects that can be used only by establishments or undertaking specializing.
- IV. Substances that the possessor does not want and which he must pay to be taken away are waste, where the holder intends that the objects are to be discarded.

Most human activities generate waste (Brunner and Rechberger, 2014). The

production of waste remains a major source of concern as it has always been since the primeval period (Chandler et al, 1997). However, the rate by which wastes are generated in volume and quantity no doubt, has been on the increase more in the developing world and Nigeria is no exception. As the volume of waste increases, so does the variety of waste (Vergara and Tchobanoglous, 2012). Unlike in the historic time wastes were merely a source of nuisance that needed to be disposed of completely. Proper management was not a major issue as the population was small and a vast amount of land was available to the population to discard their waste. Also in primitive times, the environment easily absorbed the volume of waste produced without any form of degradation (Tchobanoglous et al, 1993). A sizeable increase in the volume of wastes generation started in the sixteenth century when people began to migrate from rural areas to urban areas/cities as a result of the Industrial Revolution (Wilson, 2007). This migration of people to cities has led to a population explosion that in turn resulted in a surge in the volume and variety in composition of waste generated in cities. As people engaged in farming activities as well as industrial work, more foods, new items, and materials developed with new civilization. While, the old materials turned waste as population of new migrants surged in the towns, urban areas, and cities. It was then that materials such as metals and glass began to emerge in large quantities in municipal waste streams (Williams, 2005). The indiscriminate dumps in turn formed breeding grounds for rats and other vermin, posing considerable hazard to public health (Tchobanoglous et al, 1993). Consequently, in the twentieth century, public officials began to dispose of waste in a controlled manner in order to safeguard public health. The impacts of this new knowledge and progress paved the ways for the government to make it compulsory that all states and local government authorities in Nigeria must establish waste control and management

institutions in their domains. It was because of this synergy that many states established two or more waste control and management modules in their areas. Some states based their units on global and modern categories videlicet: non-hazardous solid waste; and hazardous waste. Such a classification is also used in the distinct legislation and policy instruments usually in place in different countries which are the 'Basel Convention'. According to Tchobanoglous et al, (1993), hazardous waste is usually regulated at the national level, while non-hazardous is regulated at the regional or local level. In Nigeria, the Federal Environmental Protection Agency (FEPA) Act of 1988 did not define waste but gave some states statutes attempt to do so, making them have different edicts to control waste. For example, section 32 of the Lagos State Environmental Sanitation Edict 11 has a definition similar to the UK and Estonia Environmental Protection Act 1990/2020. Estonia had a waste prevention planning programme which is the first country in the world with a fully digital real-time monitoring system for waste management which also helps assess people's garbage sorting behavior (EEA, 2013a) Estonia Programme refers to waste as follows:

- a) Waste of all 'descriptions' which include food items, household waste, or domestic waste.
- b) Any substance which constitutes a scrap material, an effluent, or other unwanted surplus substance arising from the application of any process.

The challenges faced in the traditional city of Sokoto are ongoing due to weak institutions and policies including environmental laws, a chronic under-funding, rapid urbanization and, paucity of industrialization. The situation is similar to all traditional cities in Nigeria. These challenges include the lack of understanding by different factors that contribute to the poor control of waste management that in turn affect the treatment

of waste. It is imperative, therefore, to examine the situation and bring it under control. This study is therefore, designed to identify methods of solid waste disposal within the metropolis; and methods of disposal adopted by the inhabitants; and to evaluate the level of efficiency in the control and management of urban waste in the traditional city.

2. Materials and Methods

The strategies employed for this study are highlighted as follows. In the first instance, reconnaissance visits were carried out by the researchers on different occasions at different locations within the traditional city of Sokoto. This was done to obtain information at an 'On-the-spot' assessment and to set up Focus Group Discussion' (FGD). This sampling method was facilitated by choosing both males and females randomly among the selected households (participants) in the study area. This was done in as to discover the salient but hidden and unidentified locations of dumpsites as well as to update information collected from secondary data sources such as information from SEPA and WMBS. The study also investigated the common solid waste dumped around the metropolis. It distributed fifty (50) questionnaires to male and female households in other to know how the wastes are being generated and transported from the dumping sites to where they are disposed of. The other techniques used for the study included; descriptive statistics, cross-tabulation, means generation, and focus group discussion among the selected households and managers of wastes like SEPA and WMBS in the metropolis. Furthermore, Landsat images 1985, 1995, and 2005, the simplest form of remote sensing that helps land managers and policymakers make decisions about land cover and land use inventory were also used to map out the waste sites for spatio-temporal analysis. Sokoto Traditional City is the capital of Sokoto State with a population

of 603,000 in 2019. Its annual growth rate is 2.90 % and its population density is 179.63 people per sq. km (Knoema 2010: NPC 2006). The research gathered data from two main sources, primary and secondary. The primary data were collected using structured questionnaires administered to selected households in the dumping sites (legal or illegal sites) and information from the SEPA and WMBS. This was done so as to discover the locations of dumpsites and to update information collected from the data sources. Figures 2 and 3 displayed maps of Nigeria's states and capitals, also showing the list of solid waste management/stakeholders in the Federal and States with their respective locations. Sites were also indicated which showed the category of waste composition and waste characteristics based on soil sampled from the waste sites respectively (see Table 1). The results of the outcome were discussed in detail later in the work.

Soil Sampling and Composition of Waste Materials in Sites

The textile composition of wastes in the traditional city of Sokoto was determined through soil samples that were collected from the sites using Soil Auger from 0-15cm depth. Samples were collected from each site in four replicates which were bulked, out of which a portion was taken in a clean polythene bag for laboratory test (see Table 1). Samples were provided as thus:

(a) Sample Digestion for Heavy Metals

The soil samples were air-dried for 72 hours, grounded, and sieved with 2mm mesh from which the representative sample was obtained. One gram of the air-dried soil was taken from each sample and placed in a 100cm Kjeldahl digestion flasks and treated with 2cm of 60% chloric acid (HClO_4), 10cm of concentrated nitric acid (HNO_3) and 10cm concentrated sulphuric acids (H_2SO_4). The mixtures were swirled gently and slowly at a moderate heat on the digester for 15 minutes

and allowed to cool down, and later diluted with 50 ml of distilled water. The mixture was filtered through a filter paper into a 100 ml volumetric flask and used for testing using the Atomic Absorption Spectrophotometer (AAS) (Tijani et al., 2007). From this indication, the results of the tests remitted the following: It was discovered that soils of the waste dump sites were enriched with heavy metals (Zn, Cu and Cd) than the adjacent soils (control) but were still within critical levels.

(b) Heavy Metal Analysis

The mean concentration for each heavy metal for all the sites was also tested with a one-sample T-test against the National Environmental Standard and Regulation Enforcement Agency (NESREA) standard to know whether it is safe for agricultural use or not.



Figure 2. Nigeria States & Capital Cities.

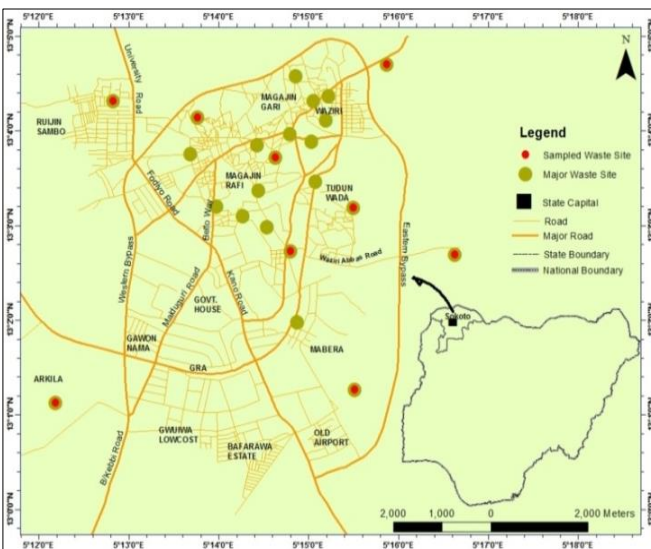


Figure 3. Few Waste sites in Sokoto metropolis

The other heavy metals tested include manganese and chromium. The concentrations of the metals are presented in the tables below (see Table 1). Also, table 2 presents the critical values of the heavy metals by the National Environmental Standards and Regulations Enforcement Agency (NESREA, 2009). This indicates that there are more metallic objects around the study environment (area).

Major Waste Sites commonly found in Sokoto metropolis

Waste sites are usually found in the streets of the residential areas, behind walls of school buildings and places officially designated as dump sites provided with incinerators.

Material Composition of Waste Sites

Materials found are essentially household wastes such as polythene bags, paper, remnants of food, human and animal feces, metals and bottles, wood and plant remains.

Table 1: Soil Heavy Metal Concentrations at Selected Waste Sites in a Traditional City of Sokoto.

S/No.	Waste Sites in Traditional City of Sokoto	Concentration of the metals			
		Zn	Pb	Cr	Cd
1	Ruijin Sambo	0.594	0.397	0.076	0.016
2	Magaji Gari	0.174	0.513	0.112	0.007
3	Waziri area	0.101	0.533	0.235	0.007
4	Magaji Rafi area	0.242	0.383	0.183	0.010
5	Tudun Wada	0.493	0.344	0.131	0.017
6	Waziri Abbas area	0.691	0.221	0.221	0.023
7	Eastern bye-pass	0.348	0.524	0.168	0.026
8		0.890	0.442	0.217	0.008
9	Arkila	0.131	0.338	0.141	0.011
Mean Total		0.407 ± 0.28	0.411 ± 0.10	0.165 ± 0.05	0.014 ± 0.001

Table 2: Critical Limits for Heavy Metals in Soils

Metals	Zn	Pb	Cr	Cd
Critical Limit	421	164	100	3

2. Results and Discussion

On the general feeling of some respondents on the hygienic standard in Sokoto metropolis, about 89% of the respondents agreed that Sokoto metropolis is dirty. They argued that the metropolis is characterized by heaps of household solid wastes which are left stranded for long periods of times before being evacuated. As some of the generated wastes are biodegradable, most streets, especially in congested areas remain air polluted, mosquito infested, and littered with nylons of different types.

On the mechanism used by households to control solid waste in the metropolis, most respondents (male and female households), about 90%, claimed SEPA-provided refuse bunkers and metal skips that are distributed at strategic locations within the metropolis but are grossly inadequate and located at far distances from most residents. This, however, has made the residents of the metropolis adopt the method of designating an open space as a household solid waste dump site. Other residents have equally cultivated the habit of dumping their waste in nearby bushes and uncompleted buildings or open plots of land, and in front of drainage along major streets. Some residents indiscriminately dump waste in front of their houses while some rich individuals among them organize for the services of private firms or local scavengers who go about with wheelbarrows to collect household solid wastes from homes on payment services. These groups of refuse collectors are mostly found every morning in densely populated areas of the metropolis and commercial areas of Emir Yahaya Road, Rijiya area, Old Airport area, Ahmadu Bello Way, Zoo Lane area, Jallen area, and Fodio Road area respectively to render their services. This practice of indiscriminate refuse dumping has led to the situation in which improperly sited open dumps deface several parts of the major roads, streets, street corners, and highways in the metropolis with exposed and fermenting

refuse with repugnant, offensive, and nuisance odors is almost everywhere in the metropolis.

From the frequency of waste evacuation by Sokoto Environmental Protection Agency (SEPA), 74% of the respondents argued that wastes in their area is removed about once a month, while 26% could not be specific but maintained that the frequency is low. In terms of the mechanism of waste management, 56% of the respondents (male and female households) that were given questionnaires/interviewed argued that best and standard practices have not been adopted by SEPA as a large proportion of areas in the city are filled with filth and piles of garbage. According to them, the use of heavy-duty trucks and earth-moving machinery that is driven and operated for many hours in densely populated environment causes noise and air pollution which is detrimental to human health. This is besides the traffic impendence that comes with the operation of this heavy-duty machinery. About 90% of the respondents (males and females) also argued that SEPA transports waste materials in open trucks within the township without covering the loaded trucks with tarpaulin, thereby making the materials in transit fly and drop on the roads.

Thus, such materials find their way into the drainage channels leading to a further pile-up that causes other problems. Other salient reasons why the mechanism adopted for household solid waste collection and disposal is inadequate are unplanned houses, narrow and non-paved winding roads, streets, and degraded environment which prevent timely evacuation of piles of rubbish littering the roads and street corners. Respondents further argued that lack of adherence to city planning is a fundamental reason for inaccessibility. It could also hamper the free movement of appropriate refuse collection and disposal equipment such as compactor trucks.

In the case of waste control and management in Sokoto through heavy metal concentration studies, this was found to be below the critical limits set by the NESREA. The waste materials that generate them are essentially domestic. This gives room to perhaps assume that domestic wastes are fewer sources of heavy metals than industrial wastes which is partly why low values were observed in this study. It is also safe to infer that sandy soil which largely characterizes the study area is partly responsible for the observed concentrations as leaching that occurs mostly in sandy soils around the metropolis. Further discussions resulting from information gathered from the fieldwork also reviewed that, despite all the government efforts to alleviate poor waste management and control in the Sokoto metropolis, several challenges persist, and these include:

- a) Decrease of moral ethics towards healthy environmental practices due to indifferent attitudes towards environmental management and control.
- b) Increase of migrant traders into the city from neighboring states and countries that continue to increase the quantity of waste generated, thus making it more difficult to make adequate provisions commensurate with wastes generated.
- c) Inadequate manpower to manage waste as there are just a few sanitation and environment engineers in the state. Whereas most private sector operators in waste management are mainly political stalwarts who have little knowledge about waste control and management.
- d) Weak enforcement which results in people becoming careless towards waste management policies
- e) Lack of modern technology, inadequacy of equipment, paucity of funds to purchase equipment like row-row, waste bins, towing vehicles, and waste pulverization machines among

other modern gadgets for daily use by waste managers. Also, the inaccessibility of some streets especially the congested and unplanned areas, and non-compliance of the residents to sanitary rules and regulations as the main problems of the agencies that manage waste in Sokoto city at the time of this study.

- f) Poor funding by Waste Management Agency i.e. in places where people pay to dispose of waste makes it a challenge for the financially less privileged to comply with such policies

This study assessed urban solid waste management in Sokoto state with its attention focused on the city of Sokoto. It specifically, sought to find out why indiscriminate solid waste dumps/disposal have persisted in the city. We investigated the measures put in to curtail the tide and ascertain the extent to which indiscriminate waste disposal affects people's health environment and other ways of life. Evacuated wastes are dumped at the designated treatment points only in the outlying parts of the metropolis. Dumping distance is not enough to prevent pollution in the city. Some dumping of refuse is done in the open spaces while others are at any available pits. Because Sokoto metropolis experiences high and frequent winds and since the capacity to industrially recycle waste is lacking, the wastes are incinerated to prevent them from getting transported back to their origins by winds. Incineration is also carried out to prevent mosquito breeding at the treatment sites. On the challenges faced by the SEPA, many residents of the city cited paucity of funds, inadequacy of equipment, inaccessibility of some streets especially the congested and unplanned areas and non-compliance of the residents to sanitary rules and regulations as the main problems of the Agency's operations. According to them, funds are grossly inadequate to purchase the necessary equipment like row-row, waste bins, towing vehicles, and waste

pulverization machines among other modern gadgets for daily use by waste managers.

The findings of this study reveal the devastating effects of urban solid waste in Sokoto metropolis as a result of inapt and dwindling waste management. We therefore put forward that both the individuals and the government through SEPA have some decisive role to play in creating healthy living standards by all stakeholders. The resultant negative consequences will have multiple effects on the present and future inhabitants of the metropolis. The government is therefore advised to re-orientate the masses through enlightenment campaigns about the best ways to dispose of solid wastes with the seriousness they deserve if they must keep faith in protecting the environment and lives of people in Sokoto states in general. The study avers that SEPA's waste control efforts are grossly inadequate; their collecting bins spot locations are too far from one another, and/or partly the residents manage their waste products by indiscriminate dumping on different illegal avenues. All these measures must be discouraged. SEPA must overcome all measures that hamper their progress such as poor funding, inadequate machinery, and the unplanned nature of most parts of the metropolis which imposes considerable limitations on waste evacuation, deposition, and outright total disposal.

4. Conclusion and Recommendation

This present work emphasizes the need for proper monitoring of waste generation, management, and the consequence of solid waste in the traditional city of Sokoto. The city has been brought to the limelight when compared with other regions/areas in the country, where dumping of wastes is done indiscriminately in the open. The consequential effects often caused eye-sore and breeding grounds for rats and other vermin. This often poses a considerable hazard to public health and the potential hygienic environment in the city. The focus

attention of any urban/city in the present dispensation are that solid waste control and management should not only be technology-centered but also people's point of orientation. Presently, waste management is a big issue in a sustainable environment. Hence, it should be everyone's concern across class; the government and its agents, community heads and stakeholders should be more proactive.

In line with the findings from this study and its implications, the following predictable mitigation features are put forward to serve as futuristic solutions to the waste management challenges in the Sokoto metropolis.

- I. Sokoto State in general, should as a matter of urgency strengthen the already established SEPA to manage and preserve the environment, and protect its inhabitants from hazardous waste problems by making it incumbent on all Local Government Areas in the state, to join hands in the crusade for better hygienic standards.
- II. The government should establish partnerships with firms under a public-private-partnership (PPP) arrangement to commence operation in the state as co-specialists in waste management operation that would include: waste generation, sorting/separation, recycling and conversion as it is being done in some modern cities of the world.
- III. State government should, as a matter of urgency, provide permanent waste dumpsites that must be far away from health service centers, markets, schools, churches, and commercial and residential areas. This will curtail the risk of infectious diseases catching and spreading within the city environment.
- IV. Landlords/heads of households and other residents within the metropolis should be appropriately represented and well-informed when planning for any new waste control management strategy.

- V. The various media organizations including radio, television, magazines, newspapers and so on should complement the government's efforts to sensitize the residents to the dangers of a dirty environment and the need to maintain good personal and environmental hygiene.
- VI. All the above suggestions could work if followed with regular public enlightenments, symposia, workshops, and seminars to sensitize residents on the modalities for waste control from point of generation to collection and disposal centers which must be increased beyond the current limited SEPA equipment.

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