

# SOLID WASTE MANAGEMENT AND DISPOSAL PRACTICE IN BAUCHI CITY, NIGERIA

*Pengurusan Sisa Pepejal dan Amalan Pelupusan di Bandar Bauchi, Nigeria*

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**ABSTRACT** *Municipal solid waste (MSW) services are critical elements of human societies and environmental infrastructure. In developing countries, household waste collection and disposal are the responsibility of local authorities, but often the volume of waste surpasses their collection capabilities. In addition, a lack of awareness and knowledge of sustainable waste practices contributes to poor waste practices. As a result, most waste ends in open dumps, roadsides, and other similar places. Massive waste disposal sites (locally termed Bingi) in every ward within the case study area, Bauchi old city are the most critical problem facing the Bauchi state environmental protection agency (BASEPA), responsible for solid waste collection and disposal. This study evaluates the disposal practices and constraints faced by residents, thus providing relevant information to BASEPA towards more effective implementation of sustainable waste management (SWM). Questionnaires were collected from 156 households, and the findings demonstrated a variety of households' waste management practices and perceptions of BASEPA's role and presence. In conclusion, the findings indicate that lack of awareness and ignorance of SWM practices still plague households, and insufficient waste facilities, finance, and lack of modernized waste equipment are probably the biggest constraints to solid waste disposal and management. These challenges bring several implications for the waste management authority's role in plan implementation and regulatory enforcement. The study proposes several strategies to address and overcome these challenges.*

**Keywords:** Waste management, Bauchi Nigeria, Waste management practices

**ABSTRAK** *Perkhidmatan sisa pepejal perbandaran adalah elemen kritikal kepada kesejahteraan masyarakat dan alam sekitar. Di negara membangun, kutipan dan pelupusan sisa isi rumah adalah tanggungjawab pihak berkuasa tempatan (PBT) tetapi seringkali, jumlah sisa melebihi keupayaan pengumpulan PBT. Selain itu, kurangnya kesedaran dan pengetahuan tentang amalan sisa lestari menyumbang kepada amalan pembuangan sisa yang salah. Akibatnya, kebanyakan sisa berakhir di tempat pembuangan terbuka, tepi jalan. Tapak pelupusan sampah besar-besaran (disebut Bingi) di setiap wad dalam kawasan kajian kes, bandar lama Bauchi adalah masalah paling kritikal yang dihadapi oleh agensi perlindungan alam sekitar (BASEPA) yang bertanggungjawab untuk pengumpulan dan pelupusan sisa pepejal.*

*Kajian ini menilai amalan pelupusan dan kekangan yang dihadapi oleh penduduk, sekaligus memberikan maklumat yang relevan kepada BASEPA ke arah pelaksanaan pengurusan sisa mampan yang lebih berkesan. Soal selidik telah dikumpul daripada 156 isi rumah, dan penemuan menunjukkan pelbagai amalan pengurusan sisa isi rumah dan persepsi terhadap peranan dan kehadiran BASEPA. Kesimpulannya, dapatan kajian menunjukkan bahawa kurangnya kesedaran dan kejahilan terhadap amalan pengurusan sisa mampan masih membelenggu isi rumah. Kemudahan sisa yang tidak mencukupi, kewangan dan kekurangan peralatan sisa yang dimodenkan mungkin merupakan kekangan terbesar kepada pelupusan dan pengurusan sisa pepejal di kawasan kajian. Cabaran ini membawa beberapa implikasi terhadap peranan pihak berkuasa pengurusan sisa (BASEPA) dalam pelaksanaan rancangan dan penguatkuasaan kawal selia. Kajian ini mencadangkan beberapa strategi untuk menangani dan mengatasi cabaran ini.*

**Kata kunci:** Pengurusan sisa, Bauchi Nigeria, Amalan pengurusan sisa

## 1. Introduction

The disposal and management of solid waste is an urban and rural issue, often discussed in sustainable development goals (SDGs) forum, Climate Change conventions and the New Urban Agenda (Abdu et al., 2019). Waste is produced by residents and various industries, while the government or administrative authorities often carry the responsibility for waste management with minimal intervention from other entities.

In the past fifty years, most cities in Nigeria have undergone rapid urbanisation with an increasing population growth rate of 2.62% (Pona et al., 2021). According to the data from the World Bank (2018), Nigerian's annual urban population almost doubled from 26% (21,421,318) to 50% (98,611,151) in 2018. Extreme population growth creates stress on urban infrastructure in many Nigerian cities. Many cities lack the infrastructure to meet the demand for sanitation and solid waste management services, which contributes to the degradation of the urban environment to air quality, soil, and water contamination, which poses threats to human health and the ecosystem. Boya and Hongtao (2017) opined on three essential aspects of sound waste management:

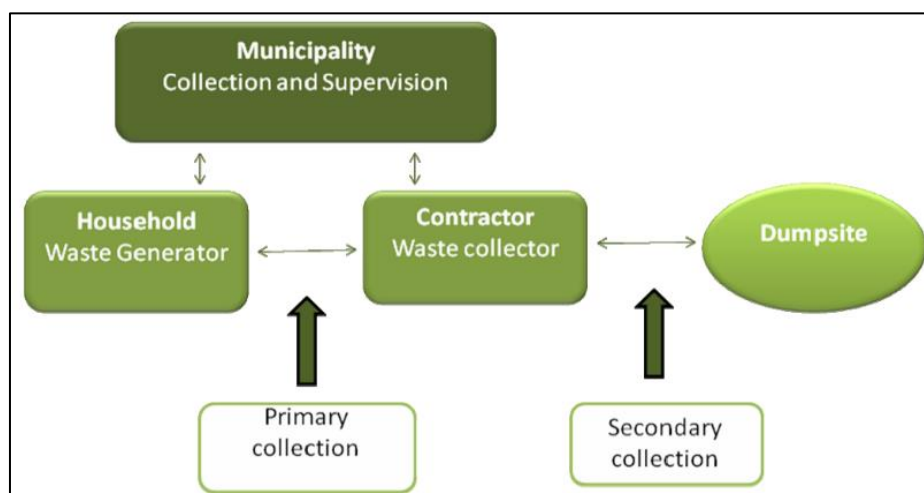
- i) Strategy monitoring
- ii) Institutional, technical, and execution
- iii) The 3Rs of waste control: reduce, reuse and recycle waste through waste generation, segregation, collection, transportation, treatments and dumping, and resource recovery require funding/financing/economics component of sustainable solid waste management.

In Nigerian cities, however, no substantial waste management progress has been seen in urban communities (Babalola & Busu, 2011; Batagarawa, 2011; Emmanuel et al., 2017). Poor waste attitudes, knowledge, and negative practice are still unresolved issues (Adogu et al., 2015).

Solid waste disposal and the combustion of fuel materials such as cardboard, paper, elastic, leather, textiles, wood, plastic, and leaves burn in open dumpsites, a common and unsustainable solid waste disposal practice. Harir and Kasim (2017), and Abdu et al., (2019) found that 34%, mostly high-density sub-wards residents within the old city, still dump their waste by the roadsides. Poor waste management has been a serious issue for human life and health in both urban and rural regions. (Adogu et al., 2015). In addition, poor waste practices in solid waste management, segregation, and recycling coupled with the lack of proper waste disposal infrastructure become a threat to sustainable waste management. This study, therefore, aims to explore households' waste management disposal practices, waste disposal attitudes, and waste management knowledge of households in Bauchi's old city, Nigeria as a case study and propose practical strategies to counter the issue. The findings can point towards relevant policies, actions, and opportunities towards improved management strategies and implementation for the responsible authority.

## 2. Literature Review

As people continuously assemble in cities, authorities' need for proper care and disposal of waste by authorities emerges. In addition, the inflow of migrants from neighbouring states contributes to the city's population growth, resulting in a consistent rise in household solid waste disposal. Solid waste management and disposal practices in many developing African countries involve the municipalities responsible for waste management. The system includes residential trash, waste contractors, and scavengers for collection, transportation, and disposal at landfills (Julianne et al., 2008). Figure 1 depicts the interaction between municipalities, households, and contractors regarding the waste management system, including the two steps of waste collection and disposal.



**Figure 1.** Municipal Solid Waste Management relationship

*Source:* Julianne et al., (2008)



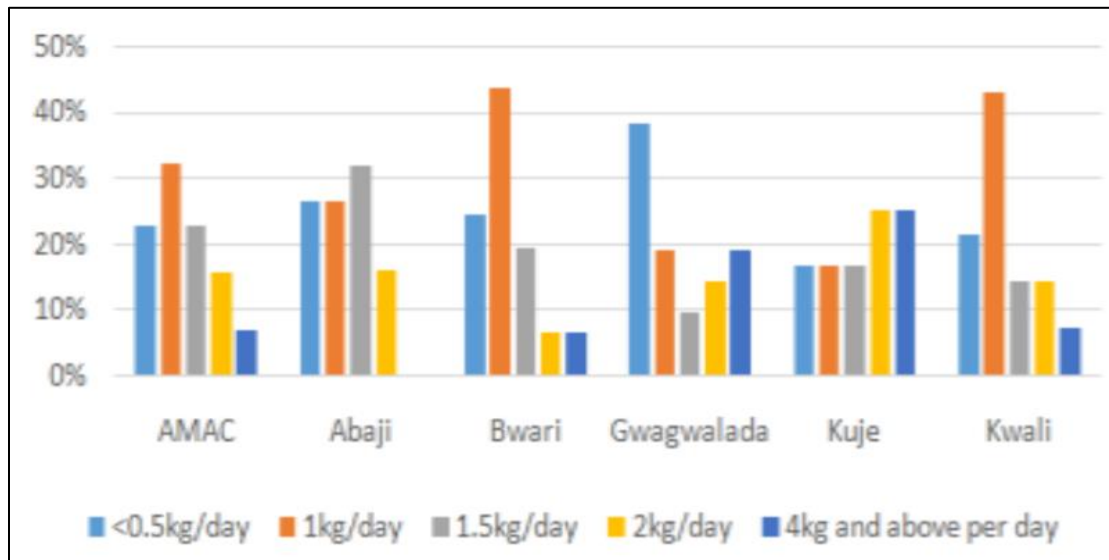
**Figure 2.** Waste collection using pushcarts and trucks

*Source:* Julianne et al., (2008)

Waste collection operates through a door-to-door collection at planned neighbourhoods and a designated open dumpsite for residents of uncontrolled districts. Waste is transferred from residences to disposal locations (primary collection) using pushcarts operated by boys to earn money. Waste goes to landfills (secondary collection) (Julianne et al., 2008). The following Figure 2 illustrates waste collection methods using pushcarts and trucks.

Waste disposal practices vary, with open dumping prevalent and households ignorant about the possibility of recycling and other advantages such as biomass-based power generation (Negm & Shareef, 2019). Africans dispose of approximately half of generated municipal solid waste at roadsides, open spaces, drainage channels, and waterways. Most MSW is discarded in landfills resulting in severe groundwater contamination, toxic pollutants and waste overflow (Cavero et al., 2017; Du et al., 2015; Nannyonga et al., 2018). Within the federal capital territory of Abuja, Nigeria, the Abuja Environmental Protection Board (AEPB), as the body under the Federal Capital Territory, is responsible for garbage management and public sanitation in the Federal Capital City (FCC) (Kadafa, 2017).

Government and private companies handle the cost of collection and transportation in the waste management process; while private companies collect waste from households three to five times per week based on the availability and efficiency of their trucks and waste transfer, including workforce and machinery, which is estimated to account for between 70% and 80% of the overall cost of solid waste management in Nigeria (Imam et al., 2008). Figure 3 shows that the Abuja Environmental Protection Board (AEPB) estimates the average waste generation rate of municipal solid waste, including clinical waste, at 14,784 tons per month and 0.5kg per capita per day in the Federal Capital City (Kadafa, 2017).

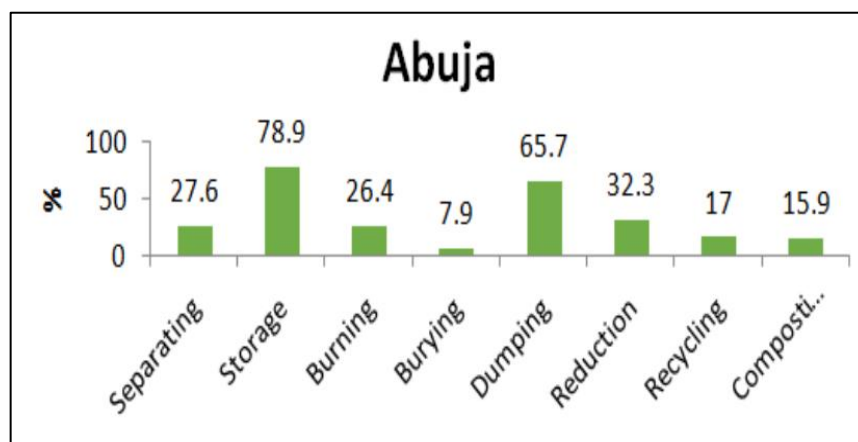


**Figure** Error! No text of specified style in document. Estimated Daily Waste Generation per Household

Source: Kadafa (2017)

## 2.1 Solid Waste Management Practices in Nigerian cities

The form of waste disposal in Abuja, Nigeria is diverse; there is no effort to separate biodegradable and non-biodegradable wastes during removal (Sadiq et al., 2019). Employers in the private sector frequently sort recyclable goods and discard undesirable degradable rubbish across the neighbourhood (Ayuba et al., 2013). Waste management agencies blame the public's attitude and ignorance for this. However, individuals criticise the authorities for non-collection services (Kadafa, 2017). Figure 4 shows the proportions of a method of waste disposal practice by households. Kadafa (2017) also reports that 27.6% of households separate their garbage at the point of generation, 26.4% burn their substantial trash, 7.9% bury their solid waste, and 65.7% dump their solid waste in an open area (see Figure 4).



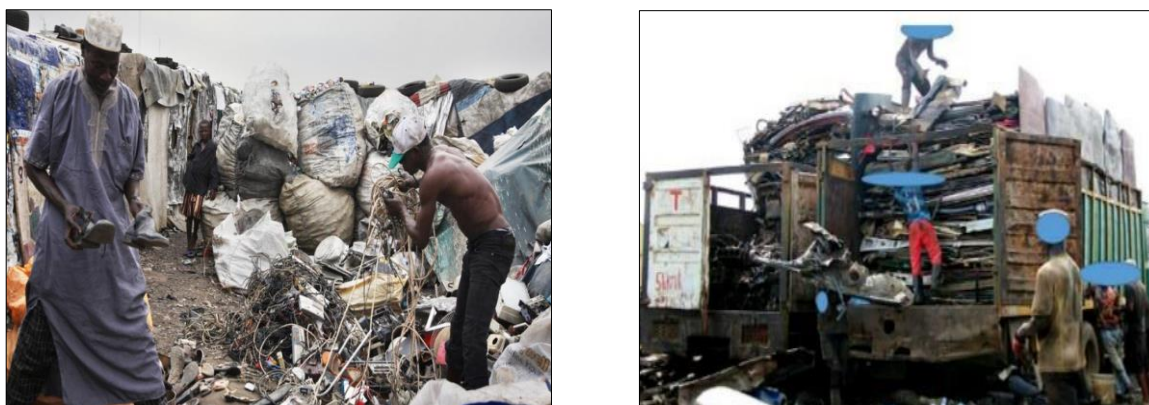
**Figure 4.** Frequency Based on Solid Waste Management Practices Among Residents

Source: Kadafa (2017)



## 2.2 Controlled Solid Waste Disposal Practices

Recycling of waste occurs, but waste management authorities do not officially approve recycling practices (Otitoju, 2014). The informal sector implements it rather than government agencies (Kamaruddin et al., 2013). The locals, especially in central and northern Nigeria, call them "Yan Bola" (Custodians of the trash), "Yan Makera" (Metal fabricators), "Yan Tinka" (Tin boys), "Yan Gwangwani" and (Metal scrap collectors). Casual workers recover valuable items from construction sites (see Figure 5), household garbage bins, factories and markets (Umaru, 2010). Many people in Nigeria make a living by scavenging open dumpsites for products to sell (Ogwueleka, 2009) and segregating the items at warehouses or dumpsite places. Scavengers then sell the materials obtained to large companies, of which numerous develop income by selling the discarded materials in the market. Nigeria's first Material Recovery Facility (MRF) was in Lagos (Adegboye, 2015).



**Figure 5.** Olusosun dump site, Lagos State Nigeria and truck collecting metal scraps

Source: Lawal (2019)

## 2.4 Uncontrolled Solid Waste Disposal Practices

Ojo (2014) suggests that open dumpsites are low-cost to manage, and vacant pieces of land, ditch erosion places or areas can be reclaimed for future development. On the other hand, the neighbourhood discards waste inefficiently (Nnaji, 2015) (Figure 6). Another traditional practice in Nigeria for eliminating garbage is open burning (see Figure 7). Some families burn garbage in their courtyards since it is easy for them to dispose of their trash. Araba (2010) narrates that the family unit in low-income districts without waste collection facilities uses this approach.



**Figure 6.** Showing wastes dumped alongside road  
*Source: Uchendu (2016)*



**Figure 7.** *Open burning of waste*  
*Source: Bakare (2016)*

Less practised waste disposal but equally polluting includes waste disposal by filling holes such as neglected wells or pit latrines around dwellings (Efe, 2013). Residents sometimes fill the holes with waste and dig another, continuing the unsustainable cycle.

## 2.5 Challenges to Solid Waste Disposal in Nigerian Cities

In Table 1, Abila & Kantola (2013) categorised six challenges in managing solid waste in Nigeria.

**Table 1.**

*Identified challenges to solid waste disposal in Nigeria*

S/N	Category	Examples
1	Societal	Unplanned municipalities increased waste production because of urbanisation and population development.
2	Institutional or regulatory	Lack of good practice and policies, absence of environmental amendments and a weak monitoring system. There are no distinct plans, tactics, or actions in place. Public interest in SWM decisions is non-existent.
3	Political	Political appointment and interventions
4	Operational	Unqualified workers in administrative roles, there are little to no prospects for instruction. Inadequate staffing and low pay activities restricted to waste collection and disposal, poor or outdated facilities
5	Economic	Insufficient financing, high risk and low return on investing from SWM
6	Cultural	Bad social behaviour against solid waste in the informal sector, lack of public awareness

*Source:* Aliyu (2013); Awodele et al., (2016)

## 2.6 The Role of BASEPA

Bauchi State Environmental protection Agency (BASEPA) is responsible for waste management regulations and enforcement. It is one of the agency's powers, in section 10(10), to conduct an inspection and a program of continued surveillance to ascertain a possible violation of this mandate or the regulations made in the future.

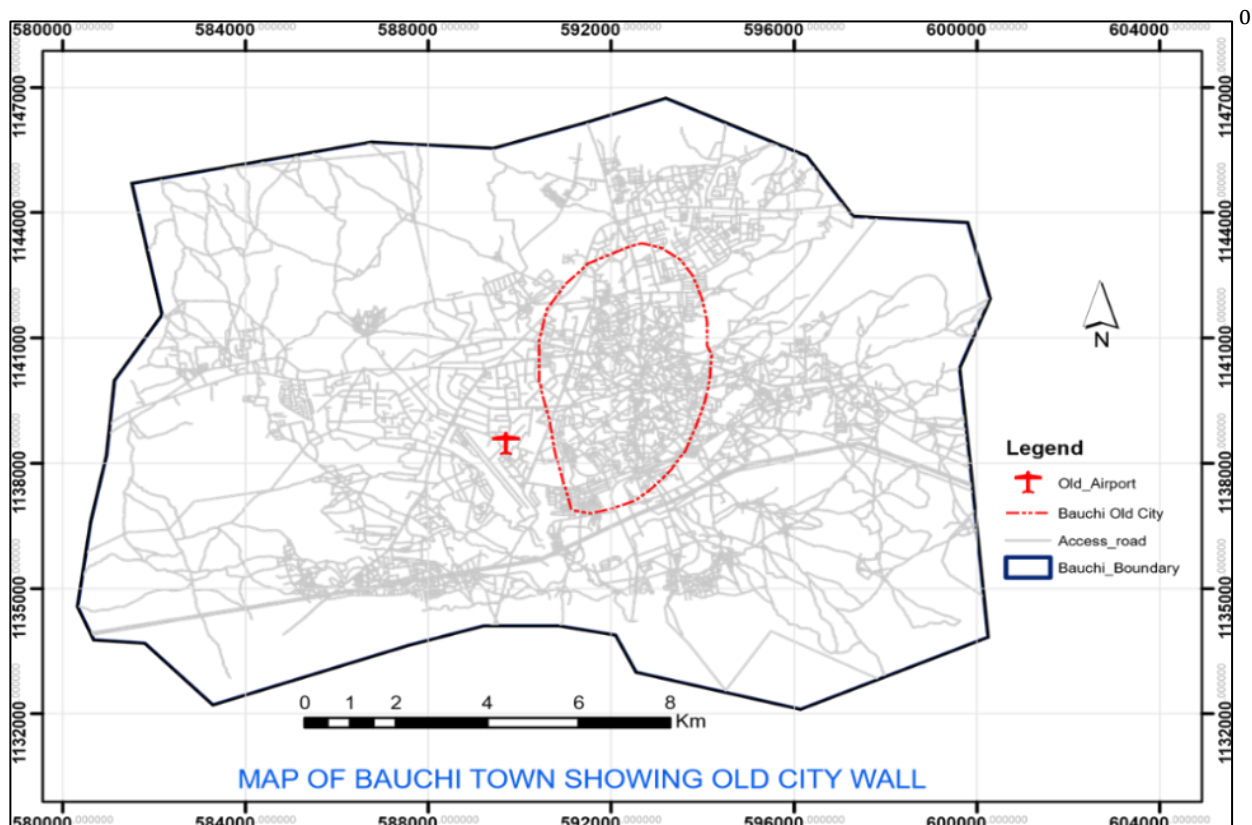


### 3. Methodology

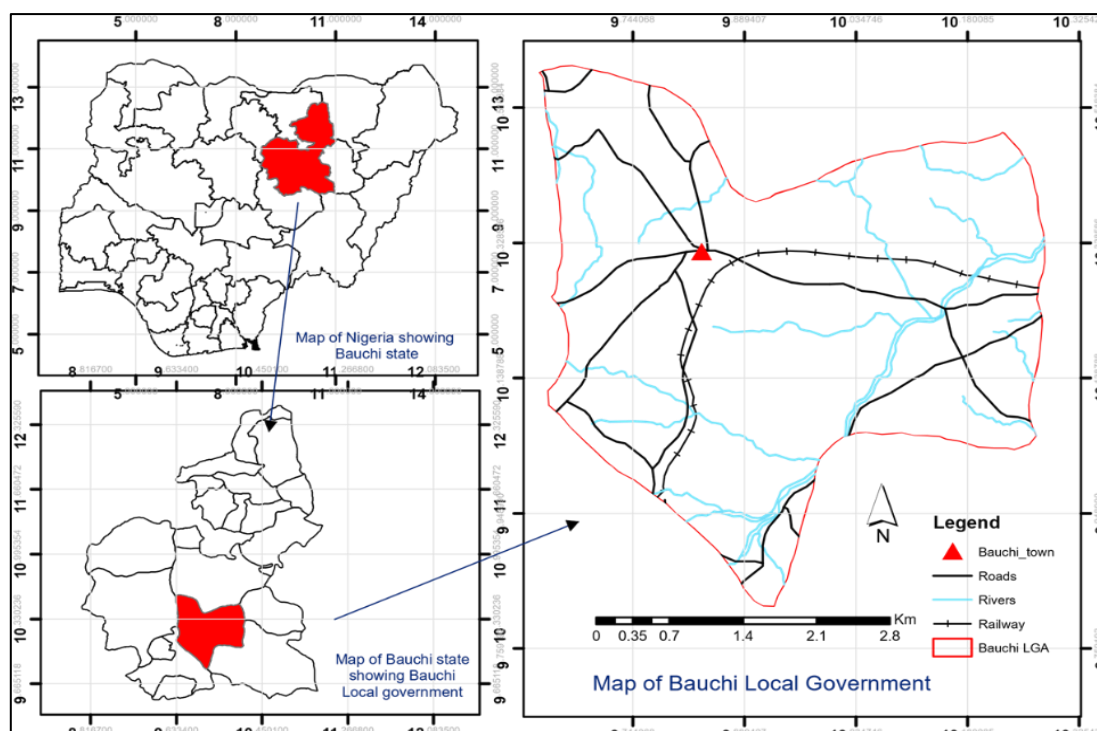
#### 3.1 Case Study Area

Bauchi's old city area, encircled by the Ganuwa fortification, is the most densely crowded area of the capital city (Figure 8). Bauchi's old city is located between  $9^{\circ} 00' - 9^{\circ} 30'$  north of the equator and longitude  $10^{\circ} 25'$  and east of the greenish meridian and dominates an overall land area of 3,604 hectares.

There is an emir's palace, the central mosque, the jail yard, and a prominent market within the ancient city. As predicted by the 2006 census, the population of the Bauchi metropolis rose to 318,038 in June 2010 by the National growth rate for urban centres, which is 4.5%. The census record shows that females dominate 50.6% (160,972) of the population and are customarily accountable for sweeping, cooking and general housework (Bogoro, 2018). Bauchi state derives a settler's name, "Baushe", as the first person the Emir met when he founded the town. The Emir ordered the building of "Ganuwa" to fortify the city against intruders. Bauchi old city is located between  $9^{\circ} 00' - 9^{\circ} 30'$  north of the equator and longitude  $10^{\circ} 25'$  and east of the greenish meridian, and dominates an overall land area of 3,604 hectares (Figure 9).



**Figure 8.** Study Area Plan  
*Source: Atuman et al., (2019)*



**Figure 9.** Location Map  
Source: Atuman et al., (2019)

The informal sector and traditional cottage businesses dominate the development of Bauchi's old city. However, as in most cities in northern Nigeria, the public sector salaries and other public spending are the primary sources of funds that support trading. In the 1960s and 1970s, the government significantly increased industry, agriculture, infrastructure, and social services investments. Industries include the Styr truck and tractor assembly plant, the meat factory, the fertilizer blending company, the tiles-making factory, and recently the Waste Recycling Plant, Fariah Bottle and sachet water and several Bakeries and sachet water factories. Most Nigerian banks have representation in the town. Educational institutions in the city are the Abubakar Tafawa Balewa University of Technology, which was established in 1988, the Faculty of Management Sciences of the Bauchi State University, Federal Polytechnic, The Army School of Amour, The state Polytechnic, the College of Nursing and Mid-Wives, the College of Agriculture and the Institute of Arabic and higher Islamic studies. The town's significant transport linkages include the Abubakar Tafawa Balewa International Airport, the Northeast Railway Line, the Bauchi to Maiduguri, Bauchi, and Jos/Abuja; Bauchi to Gombe/Yola, and Bauchi to Jigawa/Kano Roads. In fact, except for Jalingo (Taraba state), the trunk A roads passing through Bauchi town to are the shortest routes linking the state capitals in north-eastern Nigeria with the Federal Capital City, Abuja.

### **3.2 Solid Waste Management Issue in City of Bauchi, Nigeria**

The city of Bauchi (in the State of Bauchi) in northeast Nigeria has seen a range of challenges for solid waste management through the years (Ogwuche 2013). However, Bauchi's recent population explosion and unbalanced development patterns intensified the challenges. Monthly environmental sanitation programmes and street cleaning exercises are some of the solid waste management options implemented in the past without success in solving waste disposal in the Bauchi metropolis. Due to the increase in population growth and consumption rate, solid waste generation and disposal rates are high. The method adopted in the disposal of solid waste in the Bauchi metropolis is open dumping which has a potential impact on the environment (water, air and soil). Some wastes are biodegradable or non-biodegradable, toxic or non-toxic (Ezemokwe & Istifanus 2021). The solid waste dumpsites within Bauchi's old city serve as dumping points, usually through open dumping. The garbage files seen in the Figure 10 were in practically every ward and sub-ward within the housing in the old city.



**Figure 10.** Open burning of waste and dumpsite

*Source:* Ezemokwe & Istifanus (2021)

### **3.3 Data Required**

The study focused on the baseline situation of the disposal practice and operations in Bauchi old city. Table 2 shows the sets of data required for the study.

**Table 2.***Sets of data required for the Study*

S/N	Parameters	Variables
1	Sample Population	Size of households, age and education levels of respondents
2	Solid waste generation/households	Daily Waste volume per household, 3R practices, physical waste infrastructure available, waste disposal related behaviour
3	Waste disposal data	Frequency of collection, location of dumpsite, location of main bins
4	Waste Collection data	Approaches, spatial location of collection clusters.

### **3.4 Sample Frame and Technique**

The population of the study is Bauchi state households, and the sample frame is the entire household of Bauchi old city in Bauchi Local Government Area of Bauchi State, Nigeria. According to the 2006 census, the total population of the Bauchi Local Government Area is 493,730. According to Dataphyte.com, Nigeria was due for another census in 2016. However, due to a lack of funds, no census was conducted in that year, leaving the country to use the 2006 census figure and the National Bureau of Statistics (NBS) annual growth rate of 3.2% for its population projection. This study adopts a simple random sampling method because every household has an equal chance of being selected (Taherdoost, 2018).

### **3.5 Data Sources and collection**

The researchers obtained primary information through an online questionnaire distributed to households and waste management agency staff. The online questionnaire was administered through various email groups by one of the researchers who resides in Bauchi, Nigeria. Due to the COVID-19 pandemic situation in February 2021, an online survey was the most practical method of obtaining data. The questionnaire was designed taking into consideration the aim of the study which was to describe the households' perspective on waste management and their disposal practices and waste disposal related behaviour. Based on the review of previous studies on household's waste management and practices (Adzawla et.al., 2019; Kadafa, 2017) questions were designed to obtain information deemed relevant to the study. Questions include respondents' demographic profile, household size, waste disposal practice and frequency, knowledge about the type of waste generated and location of waste collection points, knowledge about the role of the waste management agency. The researchers distributed more than 250 questionnaires randomly to the households in Bauchi's old city of Nigeria through email for a few months, and 197 questionnaires were received.

A total of 41 questionnaires were invalid and excluded from the analysis due to incomplete data. One hundred fifty-six questionnaires were considered reliable for this study. Secondary data obtained through library materials and published journals also clarified the research issue's definitions, concepts, techniques, and perspectives.

In ensuring internal consistency and accuracy of the instrument of measurement, the Cronbach alpha test of reliability was tested on the two construct variables. For this study, we wanted to obtain responses about "solid waste" (with 13 items or queries) and "environmental impact (with five items or queries). The Cronbach alpha was between 0.746 to 0.80. Ghazali (2016) and Mugizi et al., (2016) stated that any tool with a Cronbach alpha of .600 to .900 is considered reliable. Upon analysis of the responses, a validity estimation was also conducted and based on Pearson's correlation coefficient, both constructs are content related and estimated to be valid.

## 4. Analysis and Findings

This study used descriptive statistics to explain the results of the sample data.

### 4.1 Socio-demographic Profile of the Respondents -Gender and age and educational level of respondents

Table 3, Table 4 and Table 5 indicates the sociodemographic information of the respondents. Most of the respondents, are male (84.6%), while the remaining 15.4% are females. The head of households in this study are mostly males, concurrent with the household culture in Nigeria.

**Table 3.**

*Gender of the Respondents*

Gender	Frequency	Percent (%)
Male	132	84.6
Female	24	15.4
Total	156	100

**Table 4.**

*Age of the Respondents*

Age	Frequency	Percent (%)
18-25 years	34	21.8
26-40 years	120	76.9
41-60 years	2	1.3
Total	156	100



**Table 5.**  
*Educational Qualification of the Respondents*

Education Level	Frequency	Percent (%)
Secondary	4	2.56
Tertiary (NCE and above)	132	84.6
Degree	15	9.64
Masters	5	3.2
Total	156	100

*Source:* Survey (2021)

Most respondents (76.9%) are between 26-40 years old. Culturally, females (household heads) will be more likely to use proper solid waste disposal (SWD) methods. In African culture, it is a norm that most women will be responsible for keeping the house clean and properly disposing of the refuse regardless of income level. At the same time, a male household head will practice improper SWD. These expectations are consistent with the findings of Adzawla et al., (2019) and Addai & Danso-Abeam (2014). The educational qualifications of the respondents vary, with the majority 84.6% having tertiary (NCE and above) while the illiteracy rate is very low. According to Ojewale (2014), the more educated a person is, the more conscious he is of improved sanitation and more likely to use proper solid waste management and disposal practices.

#### **4.2 Household Size and Occupation**

Household size is the number of individuals residing in a house. In the different districts of Bauchi state, the observed average household size is shown in Table 6. A study by Anaman & Niyadzi (2015) and Njenga (2012) confirm that household size has a significant relationship with waste generation; the larger the household size, the more the waste generation.

**Table 6.**  
*Per Capita Waste Generation and Average Household Size*

District	Ward	Sub-Ward	Waste Generation Rate (kg/capita/day)	Average Household Size
Bakaro	Bakaro	Bakaro	0.45	11.7
Kobi	Shekal	Shekal	0.24	13
	Wunti	Wunti	0.44	10.9
Jahun	Jaja	Fadan Bayak	0.33	12
	Gwallaga	Gwallaga	0.36	10.8
	Gwabba	Unguwar Gwabba	0.41	11.2
Warinje	Tura	Tura	0.39	12.2
	Kofar Wambai	Kofar Wambai	0.48	11.1

*Source:* Survey (2021)

Table 7 shows the occupations of the respondents. 11% of the respondents are farmers, 19.1% are businessmen, 30.5% are students, and 37% are civil servants, while 2.4% are in another business sector. The high percentage of the civil servant in the study population collaborates with the findings of Bogoro & Babanyara (2011).

**Table 7.**

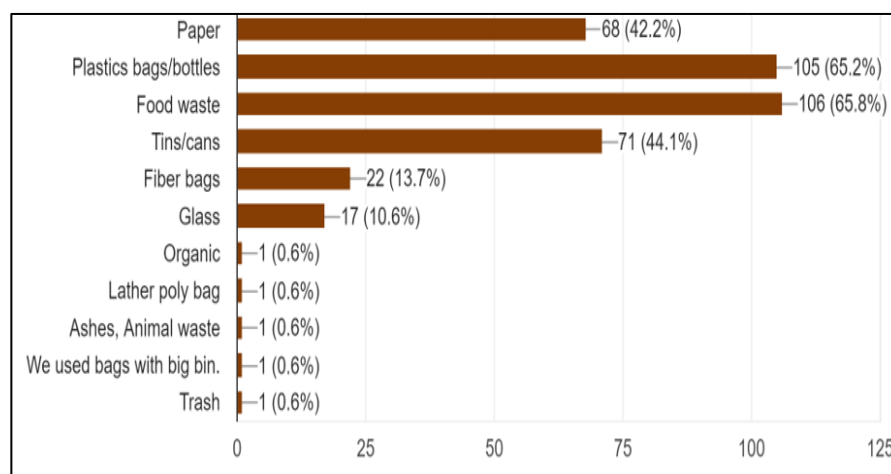
*Occupation of the Respondents*

Type of Occupation	Frequency	Percent (%)
Farming	15	11
Business	32	19.1
Student	50	30.5
Civil servants	55	37
Others	4	2.4
Total	156	100

Source: Survey (2021)

#### **4.3 Households Solid Waste Generation and Storages System, Collection Process, Routes and Disposal**

Figure 11 shows the eight significant components of household waste in Bauchi's old city. The respondents were given questions with multiple-choice answers. The figure below shows that food waste, polymers, paper, tins/cans, and fibre bags constitute the bulk of municipal solid waste generation. The respondents dispose of food waste and plastic bags/bottles the most (<65%), while 3% of the respondents generate other solid waste.

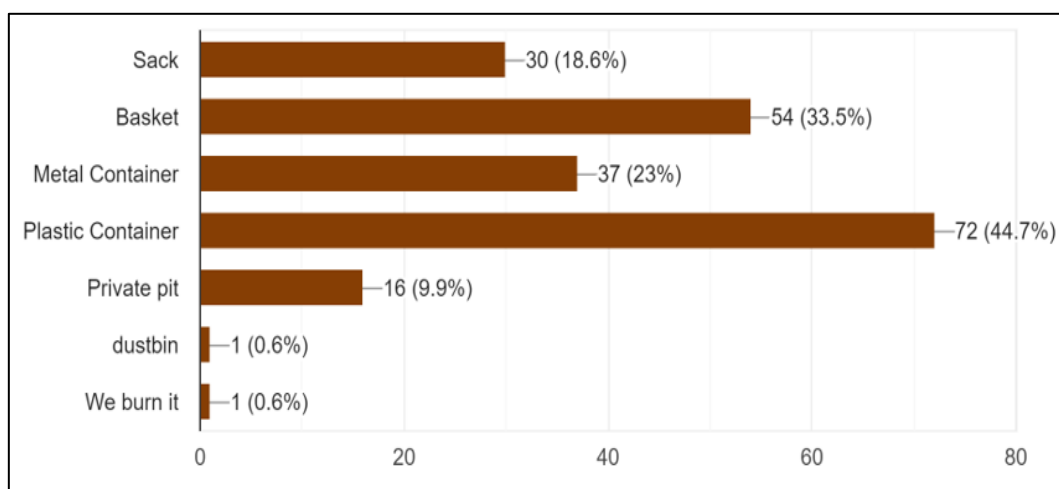


**Figure 11.** Type of Waste Generated in the Study Area

Source: Survey (2021)

According to BASEPA (2021), the average kg/capita/day of old Bauchi city is 0.30 kg/capita/day. Therefore, the implication is that about 136.5 metric tonnes of solid waste are generated in the Bauchi metropolis daily, which needs to be disposed of safely in a controlled manner that may not be harmful to the environment.

Figure 12 shows where respondents store the solid waste generated within their premises. 19.2% of respondents stored in a sack, 34.6% of respondents in a basket, 22.4% in a metal container, 43.6% in a plastic container, 10.3% in a private pit, and 1.2% of respondents on other storage. However, the municipal agency (BASEPA) required that each household use a non-rust, plastics, alloy, or galvanized container. Unfortunately, the households are unaware or not ready to adhere to these recommendations and instead use containers that suit their choices and environment. Solomon (2011) states a good waste management by law may exist. Still, if not appropriate to the circumstances, it becomes obsolete and does not ensure that households follow correct waste management methods.



**Figure 12.** *Respondents Domestic Solid Waste Storage Facilities*  
Source: Survey (2021)

#### 4.3.1 Solid Waste Collection process: Routes and Disposal in the Study Area

Table 8 shows the mode of waste collection. 56.4% of the respondents said that they have solid waste collection points within their area by the municipality, but 44.2%, said they do not have access to door-to-door solid waste collection service. 34.6 % of respondents have a door-to-door waste collection, followed by 29.9% of the respondents who rely on roadside collection. The third highest collection method is through communal container collection (18.2%) and 17.3% through curb side collection.

**Table 8.***Respondent Mode of Collection System*

Mode of Solid Waste Collection in the Study Area		
	Frequency	Percent (%)
Roadside collection	48	29.9
Door to door collection	54	34.6
Communal container collection	29	18.2
Curb side collection by garbage contractors	20	14.3
Others	5	3.0
Total	156	100
Do you have solid waste collection points within your area?		
	Frequency	Percent (%)
Yes	88	56.4
No	68	43.6
Total	156	100
If your answer for question 10 is "Yes", do you have access to door-to-door solid waste collection service delivered by the Municipality solid waste collection vehicle		
	Frequency	Percent (%)
Yes	69	44.2
No	87	55.8
Total	156	100

Source: Survey (2021)

Apaydin et al., (2008) stated that optimal routes are essential to save costs in the long-term management of garbage disposal and enhance the quality of city life. There are three categories of waste vehicle collector routes: truck1 (red) and up to five stops, truck 2 (green) and up to five stops, and truck 3 has a yellow colour and up to five stops. The journey begins in the Wunti wards, stops in all the sub-wards and ends in the low-cost service region.

The process involved householders bringing and dumping their wastes at designated dumpsites. There are three service regions each within a 200 metre, 350 metres, and 500 metres distance. The distances increase as you move away from each large dumpsite and closer to the homes.

Still, the issue arises when households dump on unauthorised space despite the cities' service regions' views that the dumpsites' placement was ideal for garbage collection. According to Emmanuel et al., (2017), bins need to be in strategic places, near service places. Abdu et al., (2020) observe the followings:

- i) Roadside Collection of waste - Sub-Wards of Collection and Service Area within the Old City: Wunti, Kofar Wambai, Shekal, Gwallaga, and Unguwar Gwabba along the dual- carriageways, dumped their waste at any available spaces for collection by the Municipality.

- ii) Communal container collection - Sub-Wards of Federal Low-Cost Service Area: Tambari, Yelwan Tudu, old GRA, and Tudun Salmanu bring their waste to a designated transfer station or unauthorized public spaces.

In terms of collection frequency, the results from this Study's survey indicated that 5% of respondents said the waste collectors collect the waste once a day, 21.2% of the respondents said once in two days, 19.9% stated once in three days, while 29.5% of the respondents said once a week. Most of the respondents emptied their solid waste containers once a day. Solomon (2011) stated that Communal bins or transfer stations made the difference between the primary and the secondary level of the solid waste management sequence. It links the primary and secondary stages of the waste chain and its key actors.

One challenging issue that this study found was the placement or location of a communal bin or transfer station in areas such as open/vacant plots, uncompleted building sites, public buildings like schools, public drains, and road junctions. In addition, almost half of the respondents (42.3%) said there are no public bins near their dwellings provided by the municipal solid waste management agency in the study area, either by BASEPA or the waste contractors. Almost half of the respondents also described the state of public bins near their house as rusting/rotting and not in good condition (46.1%). The study also found that apart from the role of a solid waste management agency in collecting and disposing of municipal waste, respondents frequently use other means to dispose of their household solid waste. 33.5% of the respondents dump on the roadsides and open fields, 9.9% bury inside their compound, 23.6% dispose in their backyard, 8.7% dumping in riversides and gullies, and 22.4% in open burning in their compound. However, 33.5% also reported taking their waste to the designated collection centre (public dump), as required by law. Generally, the bins overflow, creating a nuisance to the public and jeopardising evacuation efforts.

The study also found that a majority of the respondents (71%) were aware that indiscriminate dumping also could cause health problems like malaria, cholera, diarrhoea and fever. For example, 20.6% of the respondents notice dark flowing water, 19.2% notice the bad odour, 15.3% of the respondents see mosquitos and cockroaches, and 18.1% of the respondents notice scavengers within the dumping areas such as the roadsides and public areas. Almost half of the respondents (48.71%) reported that they knew most areas in the Bauchi metropolis were assigned, sanitary inspectors.

However, more than half (51.29%) of the respondents were unsure of the presence of sanitary inspectors in their regions, which implies that BASEPA's authority in waste management enforcement is not visible enough despite the laws and regulations in place.



## 5. Conclusion

Households in high-density sub-wards resolve to indiscriminate disposal or open dumping when confronted with inadequate waste collection services, a lack of law enforcement and regulations from the side of municipal agency (BASEPA) and poor infrastructure, e.g. proper bins. The lack of disposal facilities in the wards prompts the persistence of indiscriminate disposal in the Bauchi metropolis. This reasoning is similar to a study published by Solomon (2011), who stated that when primary waste management services are unreliable, the first step is to look into other alternatives. For example, waste is dumped on roadsides, open drainages, public areas or areas with dilapidated structures. The study also revealed that it is easy for households to burn waste because of the availability of spaces in their yards and lawns in their compounds. On the other hand, alternatives to discard their waste when not collected by the municipal agency or private contractors include collection by informal waste collectors with compactor vehicles. Therefore, waste management awareness campaign, monitoring and feedback as part of waste management policies must be given serious attention by the government and authorities. In addition, enforcement of sustainable waste practices e.g. 3R with public campaigns in schools to counter negative public practice of dumping rubbish along the roadside should be implemented (Kamaruddin et al., 2013). Some recommendations towards more SWM are as follows:

1. Negative practice of dumping rubbish along the roadside should be penalized.
2. Erecting modern landfills can accommodate the growing amount of waste generated and examined the adverse effect of open dumping.
3. The agency, local authority, and state level should enforce a law to divert at least 50% of the municipal solid waste rate at the home level. These will necessitate each ward in the old city diverting at least 40% of its solid wastes from waste disposal sites towards resource treating activities such as reuse, reduce and recycling.
4. Government should urge the public to pay for solid waste evacuation services to ensure environmental sanitation and long-term sustainable development.
5. To improve its legal responsibility of solid waste collection and disposal, the Bauchi government could seek funding from other sources to purchase refuse processing equipment. In addition, the local government should limit its services to the old city while the agency could handle outside the old city.
6. An environmental regulation on Solid Waste Management should be adopted in reaction to the expanding piles of solid waste on urban land and the lack of disposal in Bauchi old city.

A policy that every building must have a rubbish container for occupants to dispose of their trash could improve public's indiscriminate disposal behaviour. BASEPA could enlist reliable private waste contractor to collect and manage the waste in addition to allowing informal waste collectors to collect recyclables from households. Although the municipal waste agency BASEPA encourages services of private waste disposal companies and community organizations, the level of patronage of the private waste vendors can still be improved to increase the number of subscribers. We suggest that BASEPA clears their public collection centres at two-week intervals while the private waste vendors evacuate waste weekly. In conclusion, the waste municipal agency BASEPA, as the sole government institution responsible for solid waste management in the study area, must review the system and process in managing solid waste in the study area, raise public awareness in SWM at all levels of the community and strengthen law enforcement.

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**Data Availability Statement:** The authors confirm that the data supporting the findings of this study are available within the article.

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