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Municipal Solid Wastes (MSW) Management in High Population Density Areas of Zaria and Kaduna Metropolis in Kaduna State, Nigeria

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ABSTRACT

Anthropogenic activities on the environment have resulted in the deterioration of the environment, especially in high population density urban areas. The generation of municipal solid wastes (MSW), along with fossil fuel combustion and deforestation have been linked with ecosystem degradation. The study assessed the MSW disposal practices and its challenges in Zaria and Kaduna Metropolitan areas of Kaduna State. A total of 760 questionnaires were administered randomly to residential, institutional and industrial areas. 85% questionnaires were returned and subjected to descriptive analysis. Over 70% of the respondents generated 0 - 1kg of MSW, mainly recyclables (35%), soiled (24%) and organic waste (21%), of which a majority use refuse dumps (64.3%) and incineration (11.3%) to dispose MSW. 16.9% agreed that MSW are recyclables, while 66.4% view MSW as farm manure. Recycling MSW (37.5%) was advocated as the best control measures of MSW generation, although, inadequacy of MSW management facilities and equipment are considered to be the major challenge affecting ample MSW management, which can lead to pollution of various natural resources. Thus, it is recommended that public enlightenment on the dangers of indiscriminate MSW disposal should be intensified.

1. INTRODUCTION

Waste is any unwanted and discarded object or material, which could be in the form of plastics, rubber, metals (liquid, gaseous and solid forms), oil and other inorganic and organic matter, which is a by-product from industrial, institutional, agricultural or household activities (Benedine *et al.,* 2011, Bogoro and Babanyara, 2011). Wastes are solid or liquid, degradable or non-degradable, renewable or non-renewable organic or inorganic matter, which is thrown away due to the many anthropogenic activities of humans (THERRA, 2016). Wastes of any kind constitute a nuisance in the environment when not monitored and could lead to debilitating effects on human health, as well as pose a serious challenge to the government and the resident community (Ojo, 2008). He further states that rapid urbanization, burgeoning population density, and high standard of living are some of the factors which are responsible for the increase of Municipal Solid Wastes (MSW) in Nigerian cities. In Onitsha, Anambra State had an estimated total of 386, 593 metric tons of wastes generated in 2007, while in Osun State over 19,000 metric tons of MSW is generated every month (Oluwemimo, 2007). Similarly, Kano State in 2007 generated MSW of over 377,000 metric tons (Afolabi and Adamu, 2008). With this staggering amounts of wastes generated, one might inquire where these MSW end up.

In most Nigerian cities, roadsides, drainage systems, uncompleted buildings, empty land plots, wetlands, water-bodies, etc. have been known to be dumping sites for household wastes by residents, whose unsanitary behaviour is indulged by the ineffectiveness of waste management agencies run by the government (Ojo, 2008). Some authors attribute the indiscriminate dumping of wastes as a result of the inadequacy of infrastructural facilities for MSW management, such as roads, services for waste collection, disposal and treatment, etc. (Bogoro and Babanyara, 2011; Osibanjo, 2008). The improper management of MSW results in heaps of wastes in landfill sites, with negative consequences on the environment which threatens human health, as they become active sites for the breeding of mosquitoes, flies, rodents, etc. Such areas are bases for land, air and water (surface and ground water) pollution, as well as obstruct drainages and roads, which could lead to floods Sridhar, 2008). Biodiversity could also be lost, including revenues from tourism and aesthetics (Ojo, 2008).

In line with these negative outcomes above, MSW needs to be managed. MSW management is defined as any process which controls the generation, collection, storage, transfer, processing and disposal of MSW in line with best standard procedures (MNES, 2001). It has to be a management process which takes into consideration public health, conservation, economic, aesthetics and other environmental conditions when carrying out its functions, and routinely monitors the impact of man's anthropogenic activities on the environment. MSW generation should be sustainable states Stanley *et al.* (2012), in order not to exceed the earth's carrying capacity; this is because MSW components have varying degenerative periods as shown in table 1.

Table 1: Types and Degenerative Periods of MSW

Type of Waste	Approximate Degeneration Time
Organic wastes: Vegetative debris, Leftover Foodstuff etc.	1 – 2 weeks
Paper	10 - 30 days
Cotton Cloth	2 - 5 months
Woollen items	1 year
Wood	10 - 15 years
Tin, Aluminium, and other metals cans	100 - 500 years
Plastic and Plastic bags	1 million years
Glass bottles	Undetermined

(USEPA, 2016)

For MSW generation to be sustainable, there should be a sustainable MSW management plan, combined with an energy generation programme using biodegradable wastes need to be enforced (Stanley *et al.,* 2012). It is also advised that in order to achieve a sustainable MSW management programme, it is also necessary that MSW are segregated and characterized from the source and at recycling points (THERRA, 2016).

Appraising the sustainability management of MSW in Kaduna State, Nigeria, Batagarawa (2011) reported that strategies used in MSW management were ineffective, as Nwude *et al.* (2009) also inferred that agencies saddled with the responsibility of MSW management in Kaduna metropolis were inefficient. Using Geographic Information Systems (GIS) to determine the impact of spatial distribution of MSW in Samaru, Zaria, Benedine *et al.* (2011) noted that, MSW disposal affects public infrastructures (roads, drains etc.) which are difficult for environmental agencies to regulate and combat. Thus, this study aim to assess MSW management practices of residents in Zaria and Kaduna metropolises of Kaduna State, Nigeria. The objectives of this research include, to;

a. Determine the composition of MSW generated in Zaria and Kaduna metropolises.
b. Determine the MSW management practices implemented in Zaria and Kaduna metropolises.

2. LITERATURE REVIEW

MSW are created due to varying human activities, hence MSW composition differs significantly between cities, economies and climate. However, MSW can be broadly classified into organic and inorganic (Wolf, 2004). Organic wastes, according to the World Bank (2010), include wastes from food scraps, yard (leaves, grass, and bush) wastes, wood and process residues – majorly from farms and abattoirs, while inorganic wastes include papers of varying kinds, plastics, glass, metals and others, such as textile, leather, rubber, multi-laminates, electronic wastes (e-wastes), appliances, ash and other inert materials. The MSW compositions are largely predisposed to various factors, such as cultural norms, energy sources, climate, geographical location and level of economic development (World Bank, 2010). With population growth and rapid urbanization, cities tend to get wealthier; this triggers an increase in the consumption of inorganic materials (e.g. plastics, paper and aluminium), while organic material consumption relatively decreases (World Bank, 2010). Specifically, MSW composition in high income countries consists of over 54% inorganic wastes, while in developing countries, such as Nigeria, organic wastes accounts for over 64% (Zurbrugg, 2003; Sha'Ato *et al.,* 2006; World Bank, 2010).

Usually, domestic wastes from industrialized economies have a high content of packaging (Zurbrugg, 2003), which are basically made of paper, plastics, glass and metals, thus the MSW generated has a low density. However, in developing countries MSW contain huge amounts of inert substances, such as sand, dust, ash, stones due to process of infrastructural construction and reconstruction (Sha'Ato *et al.,* 2006), as well as high moisture levels because of the high usage of fruit and vegetables. These factors (i.e. variable MSW compositions) make wastes very dense, unsuitable for incineration and most often very difficult to recycle (Zurbrugg, 2003). This is why despite the number of MSW management approaches which have been employed to manage MSW in developing countries the open dump disposal method is still a common practice in most developing countries, Nigeria inclusive (Babayemi and Dauda, 2009).

In some notably cities like Onitsha, residents dispose of MSW into streams, while others simple dispose refuse by roadsides (Agwuwamba *et al.,* 1998). Furthermore, in some parts of Port Harcourt, refuse is generally buried around residential units and places of business, although, some are recklessly incinerated (Igoni *et al.,* 2007). It is further reported that several Nigerians consider it convenient and cheap to incinerate MSW in open places and backyards of residential units, which is detrimental to health (Babayemi and Dauda, 2009), as they reiterated that even in the supposed "designated" dumping sites provided by local authorities, mountains of MSW are irresponsibly set on fire, without recourse to the adverse effect this will have on the local populace and the environment.

Due to MSW deposits, Lagos is prone to floods, as a result of clogged drainage channels (Folorunso and Awosika, 2001). They also raised concern on the health of scavengers in designated disposal sites, who constantly inhale toxic air in these sites, as a result of the burning of obsolete electronic waste. Re-echoing this concern, (Oyelola, 2009) reported several illnesses that are consequences of inhaling the smoke emitted from burning MSW. It is believed that the noxious waste disposal habits of Nigerians are responsible for the setbacks which MSW management in Nigeria suffers from (Sangodoyin, 1993; Imam *et al.,* 2008; Babayemi and Dauda, 2009). Wrong MSW disposal practices, amongst which are inadequate service coverage and operational inefficiencies, limited utilization of recycling activities, inadequate landfill disposal and inadequate management of hazardous and healthcare wastes, employed by most residents in developing countries, makes it difficult for optimum MSW management (Zurbrugg, 2003).

3. METHODOLOGY

The study was carried out in Zaria Metropolis and Kaduna Metropolis, in Kaduna State, Nigeria during the months of May – July, 2016. Zaria Metropolis has a land mass of 563km^2 and it is located on latitude 11°08´55 " N and longitude 7°71´99 " E with a population total of 698,348 according to the 2006 census, using a 3.05% growth rate per year (NPC, 2006; NBS, 20102), the 2016 estimated population figure would be 942,645 (NBS, 2012). Kaduna Metropolis has a land mass of 3, 080km^2, and it is located on latitude 10°51´05" N and longitude 7°41´65" E, with a 2006 census population figure of 767,306, however, using a growth rate 3.05% per year (NPC, 2006; NBS, 20102), a 2016 projected population would be approximately 1,067,283. In Zaria and Kaduna metropolis areas are known to be densely packed, nucleated settlements, with lots of public and private institutions, industries and large markets; which accounts for the high population and commercial activities in the area (Stanley *et al.,* 2012). Cluster sampling was used to divide the metropolitan area into residential units, commercial centres, institutional locations and industrial layouts. In Zaria, residential districts of Kongo, Sabon-gari, Graceland, Zaria-City and G.R.A were randomly sampled, while commercial areas of Tudun-wada, PZ and Sabon-gari Market were sampled. Industrial sites of Chikaji, Muchia and Dakace which are lined with cottage industries in Zaria metropolis were also sampled, inclusive of institutional centres of Samaru, Kongo and Gaskiya.

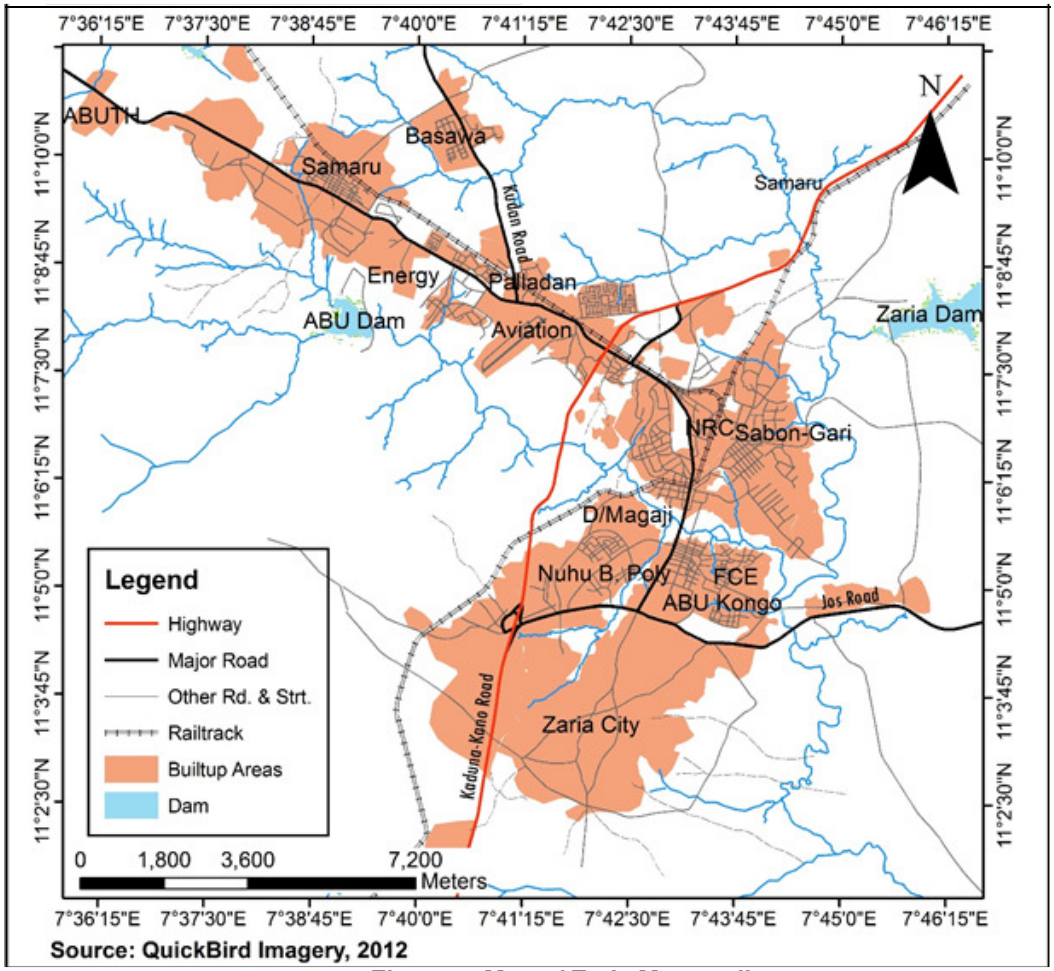


Figure 1: Map of Zaria Metropolis

In Kaduna, residential areas randomly sampled were Unguwar Rimi, Kawo New Extension, Unguwar Dosa, Sabon-Tasha, Narayi and Barnawa, while businesses in commercial areas of Kasuwa, Ahmadu Bello Way, Kawo, By-Pass, Tudun-Wada were also sampled. Institutional areas of Malali, Tudun-Wada and Unguwar Rimi, and Industrial layouts of Kakuri were randomly sampled.

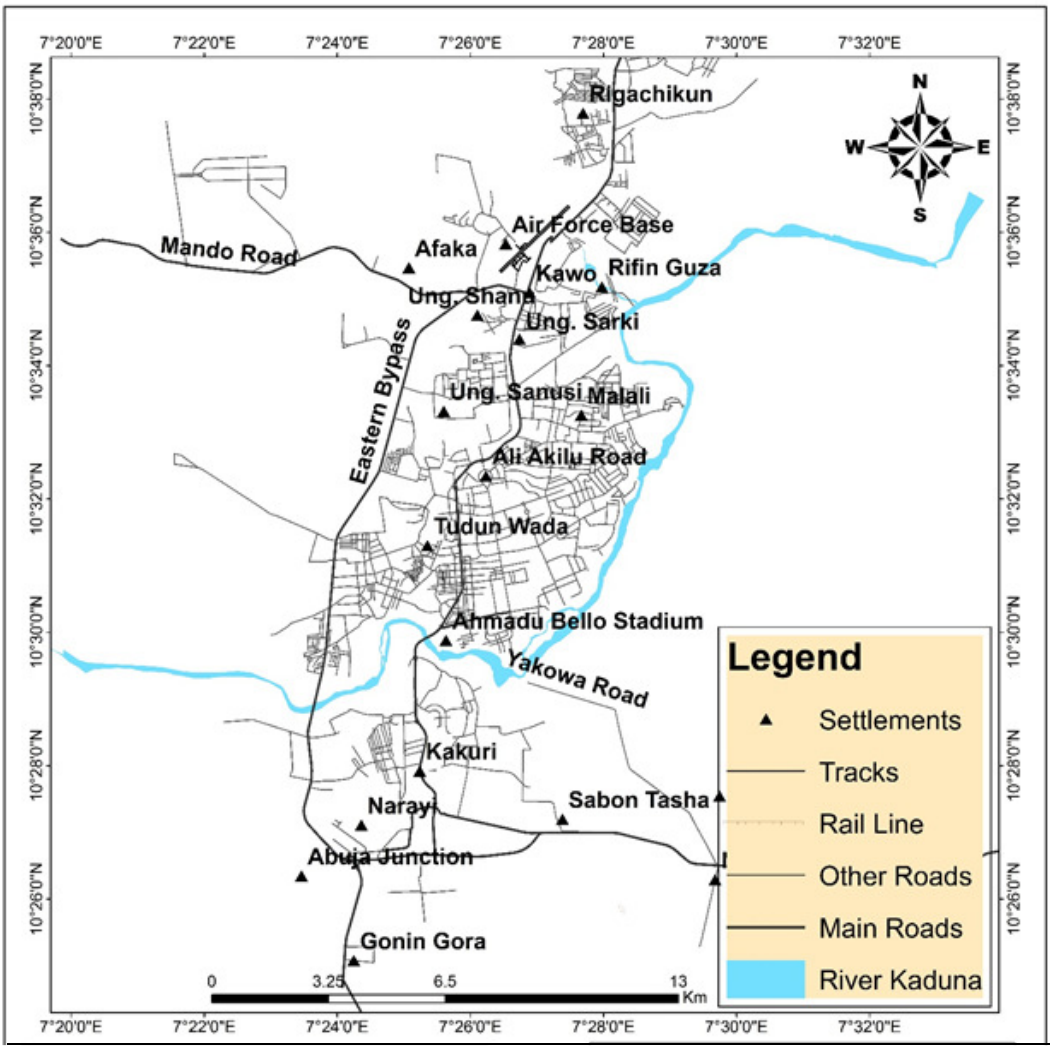


Figure 2: Map of Kaduna Metropolis

Sample Size Determination

Sample determination was patterned after (Naing *et al.,* 2006) and was considered adequate for the research. The sample size for this study was obtained using the formula:

$$n = \frac{Z^2pq}{d^2}$$ (Naing *et al.,* 2006)

Where: n = the desired sample size

Z = the standard normal deviation, usually set at 1.96

p = the proportion in the target population having the particular trait (when no estimate 50% is used; i.e. 0.5)

q = 1 – p

d = degree of accuracy desired, usually set at 0.05

Therefore, $n = (1.96)^2(0.5)\ (0.5)/\ (0.05)^2 = 384$

Qualitative and quantitative approaches were used in this study, where the administration of questionnaires constituted the data collection tool for this study, as well as face-to-face interviews with eleven (11) staff members of the Kaduna Environmental Protection Agency (KEPA). A total of 760 questionnaires were administered (380 in Zaria Metropolis and another 380 in Kaduna Metropolis) to selected households, commercial, institutional and industrial firms within the study area.

Table 2: Questionnaire Distribution

Units	Zaria				Kaduna					
	ND	%	NR	% R	ND	%	NR	% R	Total	Total %
Households	275	72.4	245	72.9	275	72.4	228	73.8	473	73.3
Commercial Centres	55	14.5	49	14.6	55	14.5	51	16.5	100	15.5
Institutions	35	9.2	28	8.3	35	9.2	21	6.8	49	7.6
Industries	15	3.9	14	4.2	15	3.9	9	2.9	23	3.6
	380	100	336	88	380	100	309	81	645	85

ND – Number Distributed, NR – Number Returned, % R – Percentage Returned

A total of 336 (88%) questionnaires were returned, while 44 (12%) were invalid in Zaria, while 309 (81%) was returned in Kaduna metropolis, as 71(19%) were invalid. A total of 645 (85%) questionnaires were returned and the data obtained were subjected to descriptive statistics, using Microsoft Excel (Windows 8 – 2011) and presented in form of tables and charts.

4. RESULTS AND DISCUSSION

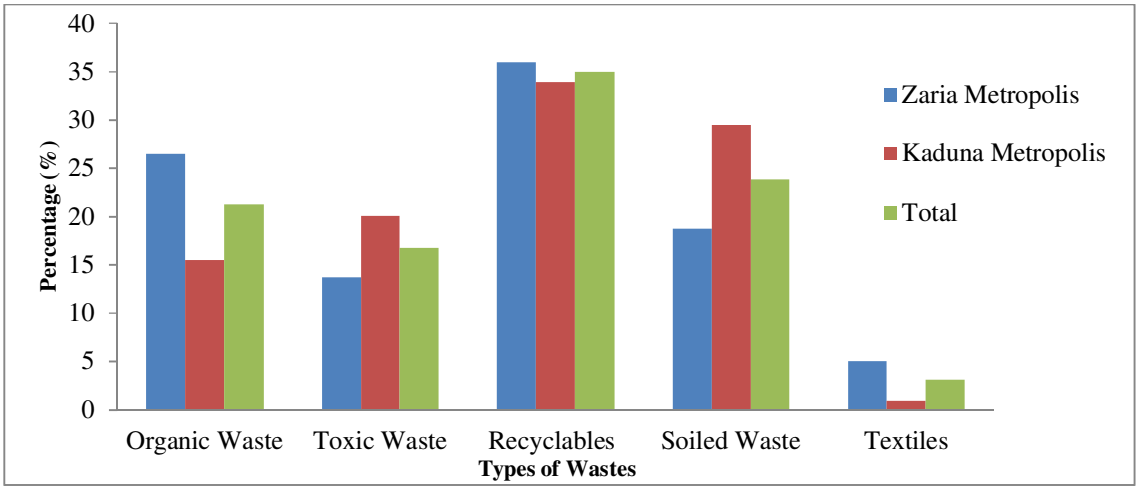


Figure 3: Composition of MSW Generation

The constituents of waste generated by residents, shows that Recyclables (35%) such as plastics, plastic bags, metals, paper and glass were the most generated in both Zaria Metropolis (36%) and Kaduna Metropolis (34%) as shown in Figure 3. Total soiled wastes generated (24%) is made up of hospital wastes and anatomical wastes from abattoirs and human faeces, was highest in Kaduna Metropolis (29%), while that of Zaria Metropolis was (19%). Kitchen wastes, wood and vegetative debris which make up this class of organic wastes (USEPA, 2016), had a total percentage of 21%, with Zaria Metropolis having 26%, while Kaduna Metropolis was 16%.

Toxic wastes (e.g. discarded chemicals and medicines, batteries and containers of sprays, paints and pesticides) in MSW are a growing phenomenon, as there is little information about its production, use and disposal, especially in low income countries (USEPA, 2016), this is evident in Figure 3, as toxic wastes make up approximately 17% of the MSW generated in both towns, with the highest in Kaduna Metropolis (20%), while Zaria Metropolis was 14%. The total textile wastes generated in both towns was 3%. Textile materials which are majorly composed of woollen materials and other fabrics make up 5% of the wastes generated in Zaria Metropolis, while that of Kaduna Metropolis was 1%. This difference is of note, as Kaduna metropolis houses two of the most prominent textile industries in northern Nigeria (Arewa and Kaduna Textile Ltd), although they have since been shut down, while the rest six in the State are also in comatose conditions (Leadership Newspaper, 2015), while Zaria have only a single ginnery factory located in Sabon-Gari. Generally, the pattern of wastes generated agrees with (Wolf, 2004; UNEP, 1997; ESCAP, 1999) as they all reported that recyclables and biodegradables are the wastes that are mostly generated in developing countries.

The study also observed that 70.5% of the total number of respondents generated 0 – 1kg of MSW, as shown in Table 3, while the over 83% of the respondents temporarily store their generated wastes

within their house, businesses, institutional or industrial units, with 65.1% disposing such waste weekly. Only 11% of respondents segregate wastes before disposal, with Zaria Metropolis having 13.4% respondents in this category. This result agrees with (Babayemi and Dauda, 2009) who opined that MSW generated daily could be as high 0.71 – 1kg in high density urban areas, such as Kaduna, Ibadan, Abuja and Makurdi (Babayemi and Dauda, 2009; Sha'Ato *et al.,* 2006; Imam *et al.,* 2008).

Table 3 further shows that, 64.3% of the respondents revealed that they dispose their refuse in communal dump sites, this makes such areas susceptible to land, air and water (surface and ground water) pollution, and impede drainages and roads leading to floods (Sridhar, 2008). Incineration (11.3%) and compost pit (3.1%) are the least used MSW disposal methods, while (Wolf, 2004) discourages incineration, due to air pollution, he recommends that urban residents should segregate MSW and use compost pits to degenerate organic wastes. In line with this, only 4.2% of Zaria Metropolis residents keep to this recommendation.

Table 3: MSW Management Practices in Zaria and Kaduna Metropolises

Variable	ZMP*	%	KMP*	%	Total	%
Quantity of Daily Generated MSW						
0 - 1 kg	243	72.3	212	68.6	455	70.5
2 - 3 kg	78	23.2	55	17.8	133	20.6
Above 3kg	15	4.5	42	13.6	57	8.8
Total	**336**	**100**	**309**	**100**	**645**	**100**
Storage of MSW						
Temporarily	284	84.5	254	82.2	538	83.4
Permanently (Compost)	14	4.2	6	1.9	20	3.1
Immediate Disposal	38	11.3	49	15.9	87	13.5
Total	**336**	**100**	**309**	**100**	**645**	**100**
Frequency of MSW Disposal						
Daily	98	29.2	108	35.0	206	31.9
Weekly	232	69.0	188	60.8	420	65.1
Monthly	6	1.8	13	4.2	19	2.9
Total	**336**	**100**	**309**	**100**	**645**	**100**
Segregation of MSW						
Always	45	13.4	26	8.4	71	11.0
Sometimes	18	5.4	37	12.0	55	8.5
Never	273	81.3	246	79.6	519	80.5
Total	**336**	**100**	**309**	**100**	**645**	**100**
Method of Disposal of MSW						
Refuse Dumps	217	64.6	198	64.1	415	64.3
Incineration	40	11.9	33	10.7	73	11.3
Garbage Company	65	19.3	72	23.3	137	21.2
Others (Compost Pit)	14	4.2	6	1.9	20	3.1
Total	**336**	**100**	**309**	**100**	**645**	**100**
Monthly Cost of Disposing MSW						
₦0	271	80.7	237	76.7	508	78.8
₦500 - ₦1,500	43	12.8	55	17.8	98	15.2
₦1,500 - ₦2,500	15	4.5	6	1.9	21	3.3
Above ₦2,500	7	2.1	11	3.6	18	2.8
Total	**336**	**100**	**309**	**100**	**645**	**100**

*ZMP – Zaria Metropolis, KMP - Kaduna Metropolis

23.3% of residents pay sanitary companies to dispose their wastes in Kaduna Metropolis while 19.3% do same in Zaria Metropolis. Only 2.8% of the residents pay over N2,500 to garbage companies to dispose their wastes, while 3.3% pay between N1,500 to N2,500 and 15.2% pay between N500 to N1,500. Majority of the residents (78.8%) do not pay for refuse disposal, which suggests a high degree of wastes not being handled properly, with Zaria Metropolis (80.7%) having the highest frequency in this group.

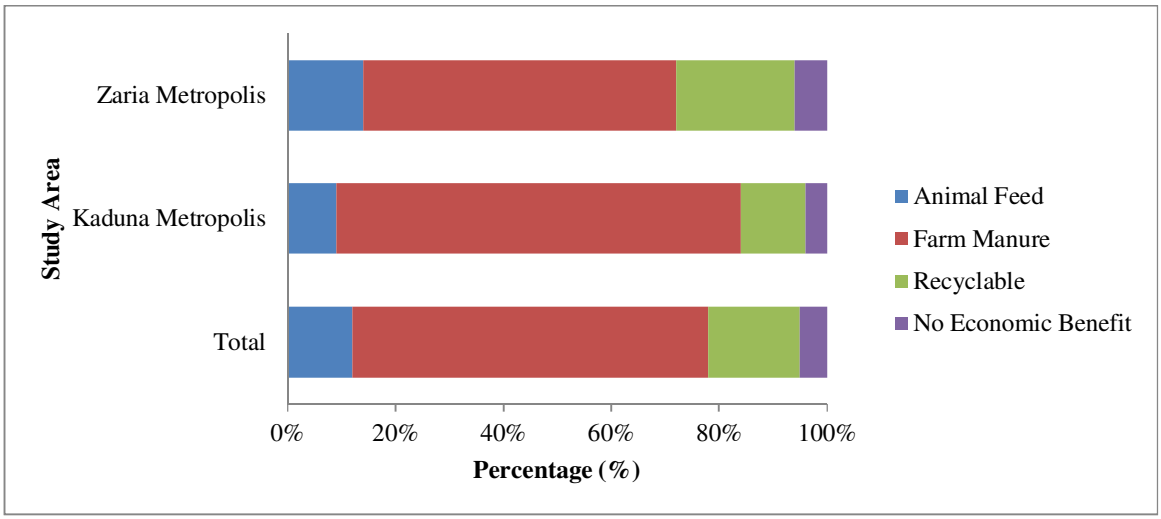


Figure 4: Economic Perception of MSW to Respondents

Figure 4 shows that 75.1% and 58.3% of residents in Kaduna Metropolis and Zaria Metropolis, respectively, identified that the economic value of MSW is to produce farm manure. This agrees with Pasquini and Alexander, 2004), as they noted that MSW is used for soil enrichment to boost agriculture in Jos. Furthermore, 21.7% and 11.7% for Zaria Metropolis and Kaduna Metropolis, respectively remarked that majority of MSW are being recycled. Approximately 11.9% responded that MSW serve as animal feed while only 4.8% reports that MSW have no economic benefits.

When asked the best strategy to manage the rate which MSW is produced, 37.4% of the respondents favoured the reduction of items that generate wastes, with Zaria Metropolis (29.2%) and Kaduna Metropolis (46.3%), responding affirmatively, as shown in Figure 5.

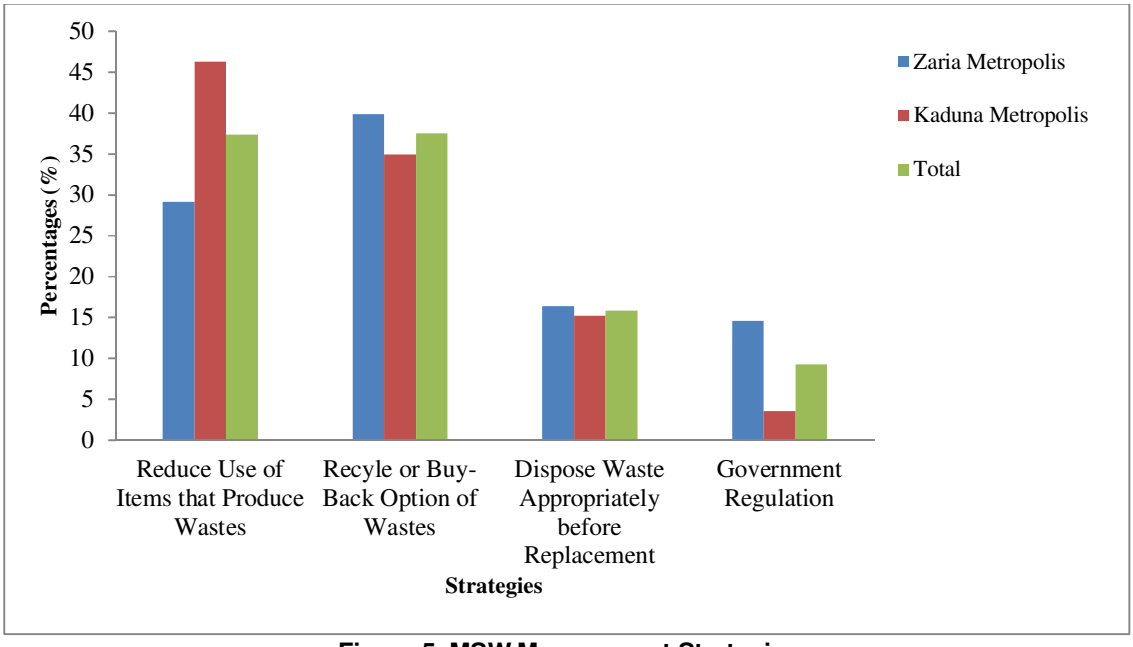


Figure 5. MSW Management Strategies

37.5% of the total respondents (39.9% and 35% for Zaria Metropolis and Kaduna Metropolis, respectively) revealed that recycling used products or a buy-back option by the product's manufacturers is the best strategy to manage MSW generated by residents, while 15.8% stated that wastes should be disposed properly before replacing them with another. A further 9.3% (14.6% and 36% for Zaria Metropolis and Kaduna Metropolis, respectively) reported that government regulation to manage waste generation is the best strategy to minimise MSW generation, as shown in Figure 5. This result is in disparity with that of Ojo (2008) and Stanley *et al.* (2012), who stated that the government should be responsible for the

regulating the rate at which MSW is generated by the public.

As earlier stated, KEPA is saddled with the duty of handling waste in Zaria and Kaduna towns. It was noted that such agencies are responsible for identifying, constructing and maintaining MSW facilities, as well as sanctioning defaulters of environmental laws as enshrined in the Federal Environmental Protection Act (FEPA, 1991; Stanley *et al.,* 2012). However, Figure 6 shows results of interviews with staff of the agency, where only 72.7% agreed that the agency is responsible for the identification of dumpsites, of which 27.3% inferred that it is not the agency's duty to identify all dumpsites within towns.

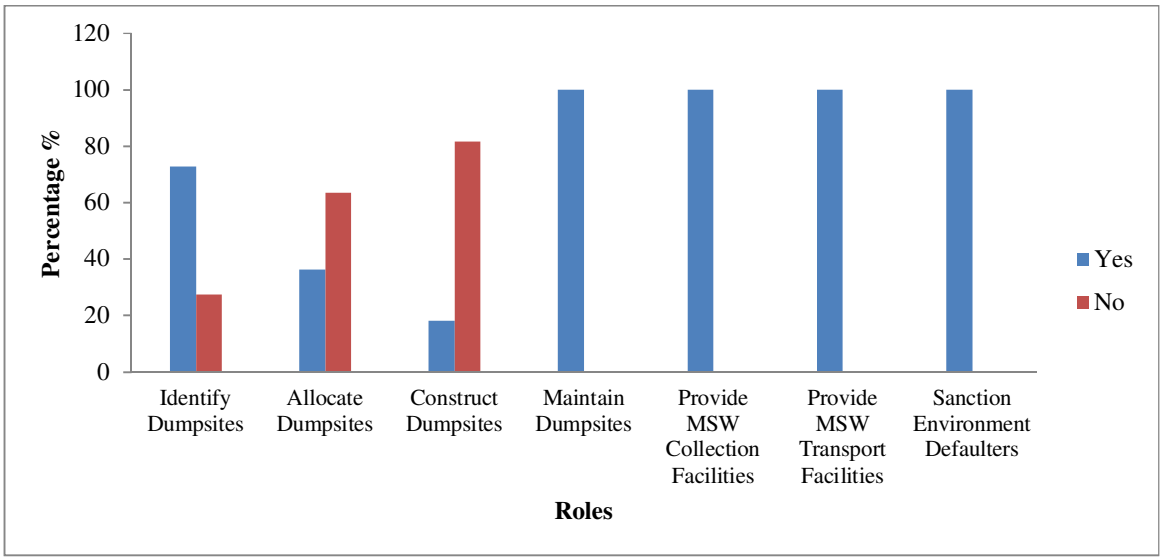
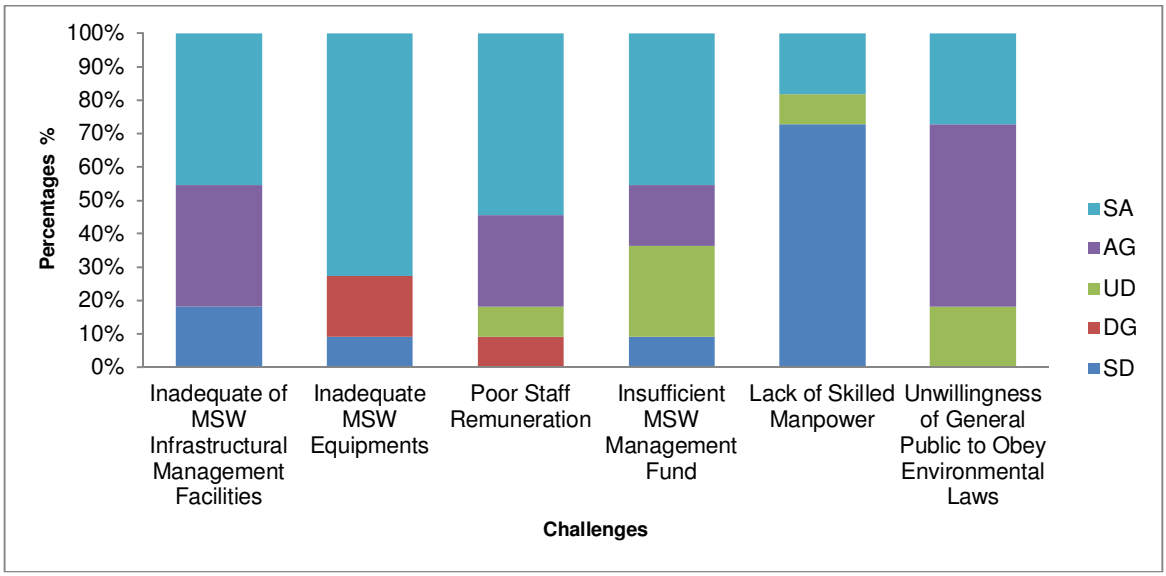


Figure 6: Role of Government Agency in MSW Management

100% revealed that the agency is responsible for maintaining dumpsites, providing MSW collection and transport facilities and fining defaulters of environmental laws. Furthermore, 63.6% revealed that it is not the agency but the State Ministry of Land and Urban Planning that is responsible for earmarking dumpsites or areas for landfills within the State, although, with consultation with the agency. In constructing dumpsites, only 18.2% affirmed that this is a function of the agency, with 81.8% in dissent, further stating that the agency only serve as consultants, while the State Ministry of Environment awards the contract for MSW facilities construction. This view is contrary to Stanley *et al.* (2012) and Dauda and Osita (2003) who both stated that environmental agencies are responsible for constructing MSW facilities.

On the challenges faced by the agency, 45.5% and 36.4% strongly agreed and agreed, respectively, that the inadequacy of MSW management facilities inhibits the ample management of MSW in the towns, the study supports the findings of (Bogoro and Babanyara, 2011), while 18.2% rated it the least inhibiting factor. 72.7% strongly agreed that inadequate MSW equipment hinders the agency from performing its functions, while 18.2% and 9.1% disagreed and strongly disagreed, respectively.



SA – Strongly Agree, AG – Agree, UD – Undecided, DG – Disagree, SD – Strongly Disagree
Figure 7. Challenges Faced by Gov't Agencies in MSW Management

Figure 7 further shows that, 54.6% and 27.3% strongly agreed and agreed, respectively, that poor staff remuneration was responsible for the dip in MSW management functions in the towns. The results contrast positively with the (UNEP, 1997) report, which observed that inadequate MSW infrastructural management facilities and equipment, is responsible for dearth of MSW management capability in low income countries. Poor staff welfare was responsible for dysfunctional state of MSW management as corroborated by (Stanley *et al.,* 2012). Inefficient MSW control in the towns was also attributed to insufficient MSW management funding, where 45.5% strongly agreed that it was a major factor, however, 27.3% remained undecided in this category. A majority (72.7%) strongly disagreed that lack of skilled manpower is a challenge to MSW management in the towns, which is supported by the (USEPA, 2016) report that states that, with the increase of education and training, developing economies have been able to bridge manpower capabilities in managing MSW. However, Babayemi and Dauda (2009) stated that Nigeria and her citizens still has a long way to go in terms of environmental education/awareness, indiscriminate waste disposal and waste management, as 18.2% strongly agreed that lack of manpower was liable for poor MSW managing mechanism.

Wolf (2004), Ojo (2008), Osibanjo (2008) and Babayemi and Dauda (2009) all agreed with this study (where 54.5% and 27.7% agreed and strongly agreed, respectively) that the unwillingness of community residents to obey environmental laws was a major challenge for the agency in carrying out its functions.

5. CONCLUSION

The study shows that the two towns generate substantial MSW, which are mostly recyclables, soiled and organic wastes. These MSW are not properly segregated and disposed-off, as refuse dumps and incineration are the two prominent ways by which residents manage their wastes, which is unhealthy for the environment as they cause pollution of air, land and water (surface and groundwater), as well as the clogging of drainage systems, reduce the aesthetic quality of the environment and obstruct vehicular traffic. It is recommended therefore that there's a need for more public enlightenment on the dangers of indiscriminate waste disposal, and encourage residents to obey environmental laws, and advising them to use disposal and collection facilities and services provided by government agencies to minimize MSW, for it is relatively cheap as result indicates. However, adequate MSW facilities and equipment, and appropriate MSW funds both for management and staff welfare of environmental agencies need to be provided, for apt management of MSW.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding this paper publication.

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