Characteristcs and Composition Analysis of municipal solid waste in Kano, Nigeria

Lawal Abdu Daura, Prof. Joseph Enaburekhan, Dr. A.I. Rufai

Abstract— The municipal solid wastes (MSW) in Kano, Northern Nigeria are disposed in open waste dumpsites. The existing waste disposal sites in Kano are not properly engineered or managed and characterized by odour, smoke and green house gas emissions which cause pollution problems to the environment which can lead to serious health hazard. Solid waste characteristics and composition analysis are major factors which are considered as basis for the design of efficient, cost effective and environmentally compatible waste management system. In this study the characteristics and composition of municipal solid waste in Kano were estimated and analysed. Solid waste sampling and analysis from four major dumpsites in the municipality were carried out to determine the waste composition and proximate analysis (moisture, content, volatile matter, ash content and fixed carbon) according to the random sampling method based on the American society of Testing and Materials (ASTM) standard. The result of the study shows high percentage of earth /garbage(30.97% - 21.67%), plastics (29.22% -27.88%), agricultural waste has percentage composition ranging from 21.785 to 15.54%, textile waste (11.48% -5.13%) paper(12.68% - 4.70%), food waste (7.49% - 0.67%) while the least are glass (3.63%-1.57%) and metals (0.19% -0.00%). As municipal solid waste is a potential energy source, the analysis shows heat values ranging from 10.123 MJ/kg (2419.35 kcal/kg) to 8.923MJ/kg (2132.73 kcal/kg) which indicates the feasibility of waste to energy plan such as incineration to produce electricity.

Key words— Characteristics, Composition, Municipal Solid Waste, Analysis, calorific value

1 INTRODUCTION

Municipal solid waste (MSW) is produced due to human activities and in the last two decades management of MSW has become a major concern due to considerable increase in its production in both absolute and per capita values[1]. The amount of municipal solid waste produced increases with economic growth and this demand for efficient solution [2]. It has been estimated
that in 2006 the total amount of municipal solid waste generated globally reached 2.02 billion tones, representing 7% annual increase since 2003, it is further estimated that between 2007-2011 global generation of MSW would rise by 37.3% equivalent to 8% increase per capita [3]. Nigeria with a population of 140 million (2006 census) generates about 25
million tones of municipal solid waste per annum with a generation rate ranging from 0.66kg/capita day – 0.44kg/capita day [4]. It has been estimated that Kano metropolis generates about 156,676 tonnes of solid waste per month and with a population of about 3,242,700 the per capita solid waste generation is about 0.56 kg/capita day [4], this makes Kano city second to Lagos in terms of waste generation in Nigeria.
Characteristics and composition analysis of municipal solid waste are major factors which are considered in the design of efficient, cost effective, environmentally compatible waste management system [5]. The provision of sufficient amount of energy is a global challenge faced both by developed and developing countries [6] and the limited supply of natural resources combined with ever growing demand for energy and raw materials has promoted the development of energy recovery from municipal solid waste [7]. The nature and quantity of solid waste is changing overtime with development [8], waste composition studies can therefore provide meaningful data for design and operation of resource recovery process [9]. The waste disposal sites in Kano are characterized by odour, smoke and green house gas emissions which cause pollution problems to the environment and can lead to serious health hazard. Due to increase in waste generation, the dumpsites within Kano are filling up with waste and soon there would be need to find alternative waste disposal sites. In this study the characteristics and composition of municipal solid waste in Kano metropolis were determined and analyzed.

2.0 MATERIALS AND METHODS

2.1 Preliminary data collection of waste dumps

Preliminary data of waste dumps in Kano Metropolis were collected from Kano State Refuse management and Sanitation Board (REMASAB). Average monthly waste disposals in the four waste dump sites of Maimalari (Bompai), Hajj camp, Ubagama and Court road in the Kano Metropolis are shown in table 1.

2.2 Waste characterization/ physical composition

Characterization of waste at the disposal sites were carried out according to the American Socie-

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ty for Testing and Materials (ASTM) [10]. The procedure involved random collection of waste from trucks loads in the amount of 15 to 20kg per unit. About 100 kg sample of solid waste was collected per day in each of the four dumpsites. At each dumpsite the collected sample waste was then spread on a polythene sheet and sorted into different categories of plastics, paper, textile material, glass, vegetable /Agricultural waste, metal and earth/ decayed matter. The categorized wastes were then weighted using a weighting scale and their percentage weight recorded. This procedure was conducted in the months of October, March and August (2012-2013) to cater for seasonal variations.

2.3 Proximate Analysis

Proximate analysis of the waste was carried according to ASTM 3173-3175 Standard methods. It involved the determination of moisture content, volatile matter, ash content and fixed carbon of the solid waste samples from the four dumpsites. 2 kg samples of solid wastes were collected from each dumpsite and taken to Laboratory for analysis.

2.3.1 Moisture content

The moisture contents of the collected solid waste samples were determined using ASTM 3173 method. 1kg of the solid waste sample was placed in a pre-weighted dish and placed in an oven at 105 ^{0}C to a constant weight. The moisture content was calculated as a percentage as shown in (1):

% moisture content = [(Wet weight – Dry weight)/ Wet weight] x 100 (1)

2.3.2. Volatile matter content

Volatile matter content was determined by weighting 5g of the dried waste samples and placed in a muffle furnace for 7 minutes at 950^{0}C (ASTM 3175). After combustion, the samples were weighted to determine the ash dry weight, with the volatile matter being the difference between the dried sample and the ash as shown in (2)

% Volatile matter = [(Dry sample weight – Ash weight)/ Dry sample weight]x 100% (2)

2.3.3. Ash and fixed Carbon content Ash content of the samples waste were determined by heating the samples in an oven at 750 ^{0}C (ASTM 3174). The residue left after combustion represents the ash content. Fixed carbon was determined by the following (3):

Fixed Carbon (% weight):

= 100 – weight (% moisture content + %Ash + % volatile matter) (3)

2.4 CALORIFIC VALUE

The calorific value or lower heat value (LHV) of the municipal waste was determined using proximate analysis models. Proximate analysis models were created based on the weight percentage of volatile matter and fixed carbon. The advantage of using proximate analysis data is that it gives result based on sample sizes [11] and the models do give an accurate estimation of the calorific values (Amin et al, 2011). The model equations for predicting the calorific value of MSW based on proximate analysis are as follows [4], [12],[13]:

$$LHV = 45V - 6W \quad (4)$$

Where LHV : lower calorific value (kcal/kg)
V: combustible volatile matter (%),
W: moisture content (%)

ii. Bento's model

$$LHV = 44.75VM - 5.85W + 21.2 \quad (5)$$

Where LHV : lower heating value (kcal/kg)
VM : Volatile matter (%)

3.0 RESULTS AND DICUSSIONS

Preliminary data on solid waste disposal to the four dumpsites was collected as shown table1.

Table 1: Average monthly tonnes of waste disposals in the years 2012-2013

Dumpsite	AVERAGE WASTE DIPOSAL (TONNES)	
	Monthly	Daily
Court Road	10,674.72	355.82
Maimalari	11,849.81	394.99
Haajj camp	13,046.88	434.90
Ubagama	6,429.65	214.32

Source: Kano State Refuse management and sanitation Board.

Solid wastes from different collection centers within Kano municipality are collected by trucks to these dumpsites. The data in the table 1 shows the average monthly and daily disposals of solid wastes the four major dumpsites in Kano, with Hajj camp dumpsite having the highest disposal rate of 434.90 tonnes/ day while Ubagama dumpsite having the least with 214.32 tonnes / day.

3.1 Physical composition/ characterization

The result of the characterization of the solid waste at

the four dumpsites conducted in the months of October, March and August (2012-2013) are shown in table2

Table:2 Average % composition (weight)

Category	Court road	Maiamalari	Hajj camp	Ubagama
Plastics	27.88	28.34	29.14	29.22
Paper	7.60	4.70	12.68	8.31
Textiles	11.48	5.13	8.41	10.18
Glass	1.87	3.63	1.57	2.94
Agrcultural	21.78	15.54	18.69	17.58
Earth/ garbage	21.65	34.27	28.20	30.97
Metals	0.19	0.06	0.00	0.12
Food waste	7.49	8.33	1.32	0.67

Fig.1 shows the average percentage distribution of solid waste composition at the four dumpsites.

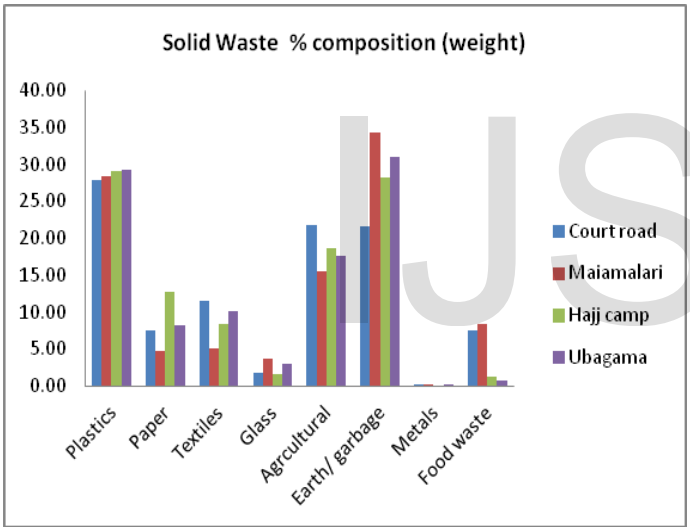

Fig. 1 Average percentage solid waste composition at Court road, Maimalari, Hajj camp and Ubagama dumpsites.

Based on the physical characterization of the solid waste at the four dumpsites, the result shows that earth/garbage have the highest percentage composition (30.97% -21.67%) followed by plastics (29.22% - 27.88%). Agricultural waste has percentage composition ranging from 21.785 to 15.54%, textile waste (11.48% -5.13%)., paper(12.68% - 4.70%), food waste (7.49% - 0.67%) while the least are glass (3.63%-1.57%) and metals (0.19% -0.00%).

3.2 Proximate analysis

Proximate analysis was conducted to determine the volatile matter, ash content, fixed carbon content and moisture content of the solid waste from the four dumpsites. The analysis was conducted for the solid waste collected in the months of October (2012), March and August (2013) from the dumpsites. The average result of the proximate analysis is shown in table 3.

Table 3: Average moisture, volatile matter, ash and carbon contents of solid waste from the dumpsites

	Proximate Analysis			
ITEMS (% weight)	Court road	Maimalari	Hajj camp	Ubagama
Moisture	43.29	28.77	27.64	26.75
Volatile matter	54.34	51.23	55.29	57.33
Ash	40.82	45.93	39.99	36.44
Fixed Carbon	4.84	2.84	4.72	6.19

The result shows that the solid waste at Court road dumpsite has the highest moisture content of 43.29%, while the waste at Ubagama dumpsite has the lowest moisture content (26.75%) but highest volatile matter content at 57.33%. The ash content ranges from 45.93% -36.44% with solid waste at Maimalari dumpsite having the highest and Ubagama dumpsite the lowest. Also solid waste at Ubagama dumpsite has the highest fixed carbon content while Maimalari dumpsite has the lowest content. Figure 2 shows the presentation of the proximate analysis.

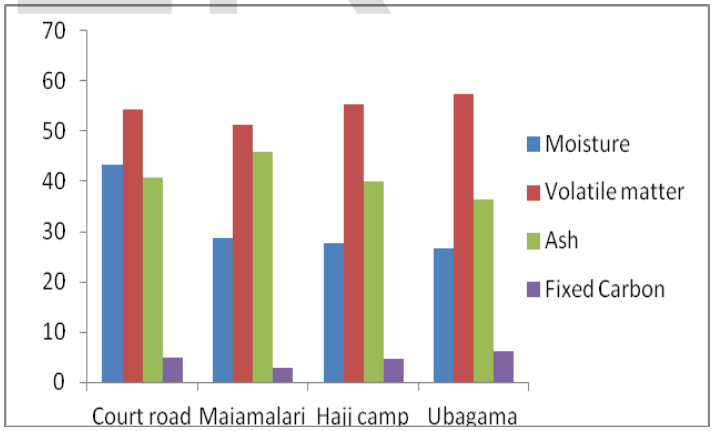

Fig.2 : Average moisture, volatile matter, ash and fixed carbon contents of solid waste at Court road, Maiamalari, Hajj camp and Ubagama dumpsites

3.3 CALORIFIC VALUE

The lower caloric value or lower heat value (LHV) of the municipal solid waste was determined using mathematical model based on the proximate analysis (equation 4). Table 4 shows the calorific values of MSW at the four dumpsites.

Table 4: Lower heat values (LHV) of MSW at the four dumpsites

Dumpsite	Lower heat values (LHV)	
	kcal/kg	MJ/kg
Court road	2185.56	9.144
Maimalari	2132.73	8.923
Hajj camp	2322.21	9.716
Ubagama	2419.35	10.123

The lower heat values of the MSW in the four dumpsites ranges from 10.123 MJ/kg – 8.923 MJ/kg with MSW from ubagama dumpsite having the highest LHV(10.123 MJ/kg) while MSW at Maiamalari dumpsite have the lowest (8.923 MJ/kg).

4.0 CONCLUSION

Solid waste composition and characterization analysis are critical in resource recovery in management of municipal solid waste. Characterization and composition analysis of municipal solid waste from major dumpsites in Kano municipal was conducted and the result shows high percentage of earth /garbage(30.97% -21.67%), plastics (29.22% -27.88%), agricultural waste has percentage composition ranging from 21.785 to 15.54%, textile waste (11.48% -5.13%) paper(12.68% - 4.70%), food waste (7.49% - 0.67%) while the least are glass (3.63%-1.57%) and metals (0.19% -0.00%). As municipal solid waste is a potential energy source, the analysis shows heat values ranging from 10.123 MJ/kg (2419.35 kcal/kg) to 8.923MJ/kg (2132.73 kcal/kg) which indicates the feasibility of waste to energy plan such as incineration to produce electricity.

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