Assessment and Characterization of Municipal Solid Waste Generated in Minna, Niger State (Part 1)

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Abstract
This is part one of two part elaborate work on the characterization of municipal solid waste generated in Minna metropolis in order to establish a good solid waste management plan. In this first part, the characterization of the municipal solid waste was done based on the American Society of Testing and Material (ASTM) standards. The waste generated in Minna metropolis composed mainly of plastic bottles, nylon, food waste, papers, and rubber. All the wastes used for the analysis possesses large amount of volatile matter ranging from 67.99 – 91.1%. The average moisture of the mixed sample is 16%. This proves that the waste generated in Minna metropolis possess high energy potential going by the high volatile matter. The rate of waste generation in Minna was obtained as 0.4 – 0.6 kg/capita/day and this is expected to increase with increasing population.

Keywords: Solid waste, Minna, Characterization, Generation, Management

Introduction

Municipal solid waste (MSW) is a household waste commonly known as trash, garbage, refuse or rubbish. MSW consists of domestic, commercial and industrial waste in our local or urban areas. The problem of disposal is a challenging task because improper disposal of waste has adverse effect on human health and also constitute danger to the environment, climate (Chakrabarti *et al.*, 2003, Kumar and Gaikward, 2004) etc.

The increment in human activities, due to urbanization and industrialization has led to increase in waste generation and makes the management difficult and cumbersome. Nabegu, (2010) suggested that best management policies should be put in place. Waste management involves generating, characterizing, preventing, treating, monitoring, recycling, reusing, transporting, transferring, recovery, storage, processing, separating, collecting, handling and disposal of solid waste. Solid waste management is mainly composed of four components; recycling, landfilling, composting and waste-to-energy (WTE) (Mohd *et al.*, 2010).

Waste constitute hazards and danger to life if not dispose properly. Hazardous emission can be dangerous to organic plants, fishes in the river, crawling animals, virtually everything living and even non-living things (properties) (Slack *et al.*, 2005).

The best and sustainable way of waste disposal is waste to energy, which can be ready available in every community. This system also reduces the amount of Greenhouse gases (GHG) emitted to the atmosphere (Ari *et al.*, 2013). These greenhouse gases includes; methane

(CH_4), chloroflourocarbon, carbon dioxide (CO_2) and Nitrous oxide (NO_2). Methane is emitted from sewage treatment processes or from waste water transport while nitrous oxide from human sewage. Most non-biodegradable wastes are recyclable while most biodegradables are not recyclable. While, recycling is the reduction of waste generation which is beneficial in terms of greenhouse gas emission reduction and also saving resources for manufacturing new products. Waste can be recycled to produce new products. The aim of this paper is to characterize solid waste generated from the densely populated area of Minna and the potential of exploring solid waste to energy (expected in part of this paper).

Materials and Methods

Sampling and Data Collection:

The solid waste samples were collected from the thirteen (13) waste collecting points in Minna. The samples were collected in polythene bags for the characterization. Data were collected from residents, commercial, religious centers, schools. The data were collected from the four most populated areas in Minna; Bosso, Chanchanga, Kpakungun and Tundun Fulani.

Sorting:

The samples collected were gathered and sorted. Solid waste are been characterized into different groups depending on the district and waste sources. The wastes in the dumpsite are generally classified into 15-20 several categories: food waste, film plastics, textile, metals, glasses, wood waste, batteries, fruit waste, diaper, corrugated paper, high grade papers and leathers. After sorting process, the waste samples are divided into related categories, prepared and sealed in plastic bags before taking into the laboratory.

Proximate Analysis:

This analysis was done to give an insight of the major constituent of the solid wastes. Proximate analysis separates the products into their various constituents. They are;

- Moisture contents
- Fixed carbon
- Ash content
- Volatile matter

Moisture Content (MC):

An empty crucible was weighed first before it is been weighed with the sample in it. The sample was dried at 110°C for 1 hour in the oven. After the drying process have been accomplished, the sample will be cooled in a desiccator and reweighed to get the new weight and the percentage moisture can be calculated.

$$\% \text{ moisture} = \frac{w_2 - w_3}{w_2 - w_1} \times 100 \qquad (1)$$

where

w_1= mass of empty crucible

w_2 = mass of empty crucible + sample before drying

w_3 = mass of empty crucible + dried sample

Moisture content = $w_2 - w_3$

Ash Content:

The ash is the residue and it is comprises of oxides and sulphur. It is as a result of the chemical change (combustion) the ashes are gotten. The dried sample (the remains after drying) from the first procedure was subjected to combustion

for some hours till it becomes ashes. The quantity will be measured.
The dried sample to be heated in the crucible was inserted in the muffle furnace at 750°C for 1 minute. The remains of the sample were brought out, cooled in the desiccator, reweighed and the weight percent of the sample was noted. (Wang *et al.*, 2006)

$$\% \text{ Ash} = \frac{w_3 - w_1}{w_2 - w_1} \times 100 \quad (2)$$

where
w_1 = mass of empty crucible
w_2 = mass of empty crucible + sample before heating
w_3 = mass of empty crucible + residue
Ash content = $w_3 - w_1$

Volatile Matter (VM):
The amount of the volatile matter evolved from the sample under standard conditions is known by the measured weight loss of the sample excluding the moisture percentage.
The remaining sample after combustion and crucible were weighed individually and also weighed together and were positioned together (the capacity is 10-20 mL,25-30 mm in diameter and height is 30-35 mm) with a close fitting. In the furnace, the crucible is been suspended at a specific height and the temperature of the furnace was maintain at 950°C. The evidence of the volatile matter will be noticed by the disappearance of the luminous flame, the crucible lid was properly positioned to guard against the entrance of air. The heating was carried out for 7 minutes, and then the crucible removed from the furnace and cooled in the desiccator. It will be weighed as soon as it is cold. The volatile matter equals to the percentage loss of weight minus the percentage moisture.

$$\% \text{ Volatile Matter Content} = \frac{(w_2 - w_3) \times 100}{w_2 - w_1} - M \quad (4)$$

w_2 = mass of empty crucible + sample before w_1 = mass of empty crucible heating
w_3 = mass of empty crucible + sample after heating
M = % moisture content

Fixed Carbon (FC):
To know the carbon content in the ash sample, the following equation was used to calculate it:
FC = 100 – (MC + ASH + VM)
where
ASH = % ash content
VM = % volatile matter
MC = % moisture content (kalantarifard, *et al.,)*

Results and Discussion
The result of samples collected in different part of Minna metropolis are presented in table, The samples are bottle plastics, papers, corn shafts and polyethene (nylon) and have been classified. The result of analysis of the MSW collected and sorted for the area sample are presented in Figs 1 - 8 while the composition of the MSW is presented in Fig. 9.

Table 1: Solid waste generation

Sources	Type of wastes generated	Activities
Residential	Garbage, rubbish, papers, food waste, nylon, livestock's dung, oil, car parts,	Cooking, sweeping and other household chores.

Commercial	glass, textiles, plastics, aluminum (roofing sheets, can drinks) etc.	Marketing
Agricultural	Saw dust, glasses, papers, nylon, textile, metals, hazardous wastes (soot) etc.	Farming, fumigation
Institutional	Animal dung, spoilt food, crop shafts and husks, solid, metals	Schools
	Rubbish, garbage, food waste, glass, cans, metals, papers	

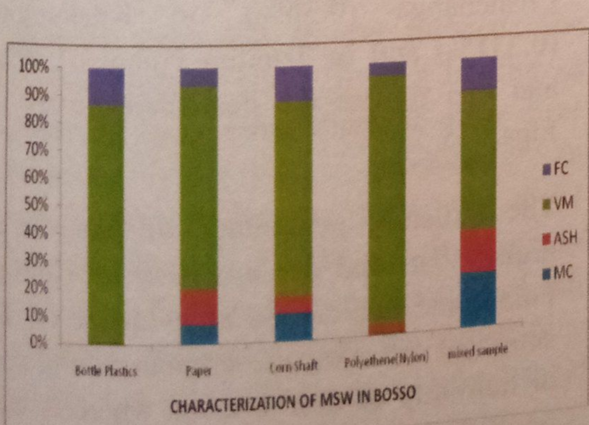

Fig. 1: characterization of MSW in Bosso

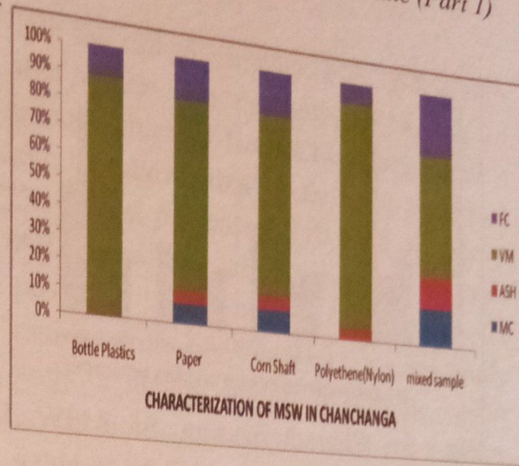

Fig. 2: characterization of MSW in Chanchanga

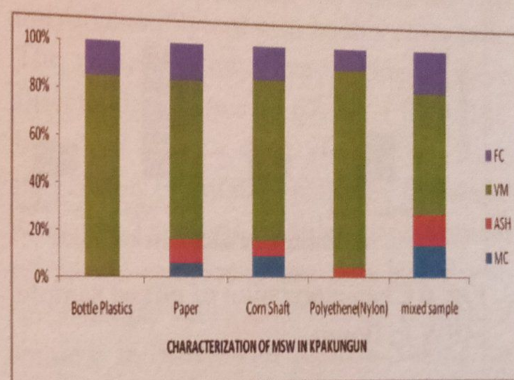

Fig. 3: Characterization of MSW in Kpakungun

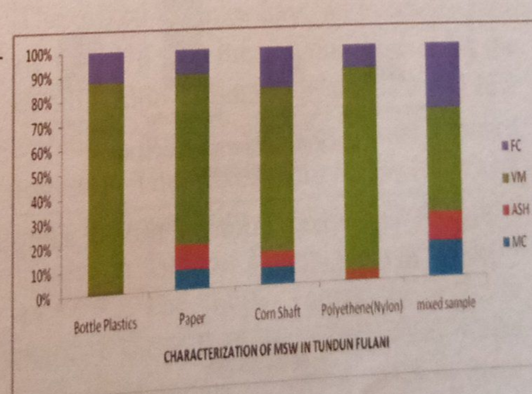

Fig. 4: Characterization of MSW in Tundun Fulani

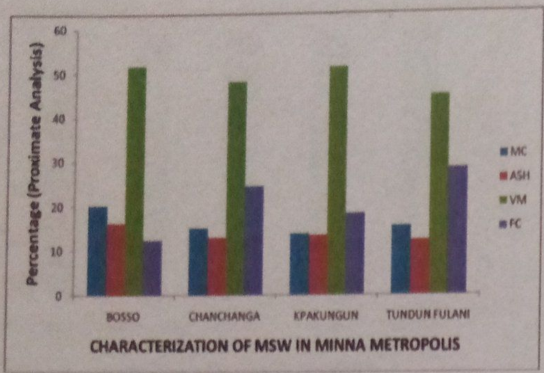

Fig. 5: Characterization of MSW in Minna

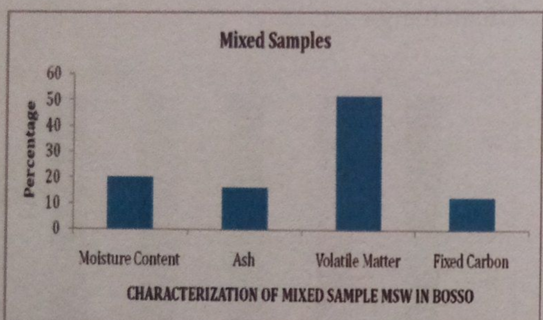

Fig. 6 Characterization of mixed sample MSW in Bosso

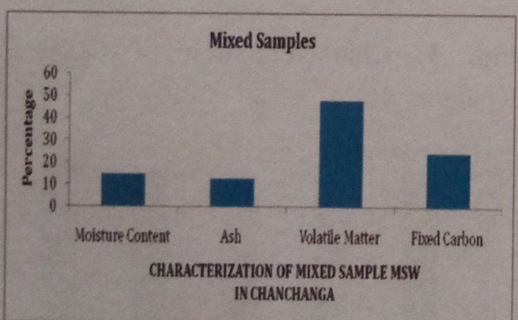

Fig. 7: characterization of mixed sample MSW in Chanchanga

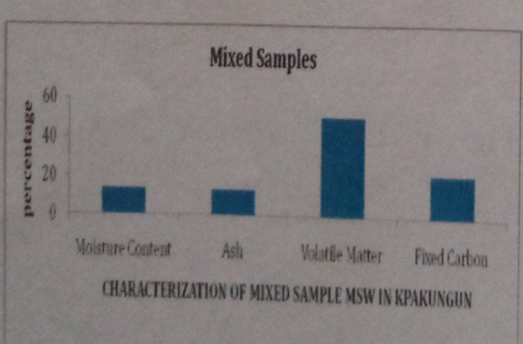

Fig. 8: characterization of mixed sample MSW in kpakungun

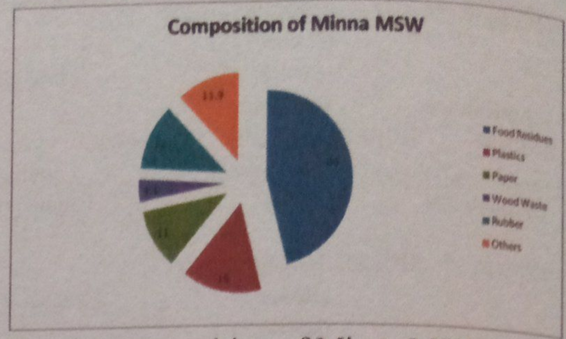

Fig. 9: Composition of Minna MSW

Based on the proximate analysis which is the basis of the main characterization performed, it can be said that that corn husk have the most moisture of all the samples and its highest composition of corn husks sample is that taken from Bosso with a 10.1% moisture content while the lowest moisture content of corn husks sample is that taken from Tundun Fulani with a 7.024% moisture content. The average percentage moisture content of corn husks from the form locations in Minna metropolis is 8.76%.

Among all the samples taken, Polyethene (Nylon) shows the lowest in moisture content in the four locations. In Bosso, it has the lowest moisture (0.63%), in Chanchanga (0.36%), in Kpakungun (0.331%) and in Tundun Fulani (0.36%) and this figures are described clearly in Figs. 1-5

The moisture percentage of paper was higher than that of corn husk in Tundun Fulani and this can be an evidence of the action of the moisture content of the soil or humidity of that location where it was taken from. Polyethene (Nylon) and bottle plastics contain little or no moisture. Bottle plastics has it highest moisture in Tundun Fulani with a moisture of 0.88% and lowest in Chanchanga (0.715%). The range of moisture content of bottle plastics is 0.723 – 0.88%. The low moisture content is due to the fact that plastics and nylons are already processed material fully dried off moisture and with no pore space for moisture to intrude in even before it reaches the hand of the consumers (Khatib, 2011).

Papers and corn husks are organic products and moisture loving, they can easily absorb moisture to themselves and that constitute their great moisture percentages that other samples. The average moisture content of papers from the four locations is 7.22% with a range from 6.11 – 8.11%.

The samples taken from each location were mixed together to get the average moisture contents for each locations. From the bar charts above (Figs. 6-8), it can be seen that on the aggregate the mixed samples have it highest value in Bosso (20.1%) and it lowest moisture value in Kpakungun (13.68%). The average value of moisture content of the mixed samples from the four locations is 16% with a range from 13.68 – 20.1%. Papers gave the highest percentage of ash; they produce more ash in the furnace. The sample (paper) taken from Chanchanga produced more ashes than the other three locations. 14.95% produced in Chanchanga while the least was a tie between Tundun Fulani and Kpakungun with 10.22%. The high percentage of ash exhibited by paper than the other four samples is due to their dryness and their affinity for combustion.

Based on the results, bottle plastics produce least ash with a range of 0.51 – 0.671% and the highest been in Chanchanga (0.671%) and the least been in Tundun Fulani (0.51%).

For the mixed samples, Figs. 6-8 shows the highest ash percentage (14.95% of paper) which is from Chanchanga and it can be shown that Kpakungun possesses the lowest percentage (10.22% of paper). All the wastes used for these analysis possesses large amount of volatile matter ranging from 67.99 – 91.1%. The sample with the highest amount of volatile matter is the bottle plastics having an average value of 85.55%, the highest is 87.051 in Chanchanga and 84.221 for the lowest value of bottle plastics (Kpakungun). But polyethene (Nylon) also have a close to it. The values for other waste samples were flunctuating between 67.99 – 71.551%. Figs. 1-5 gives a clear view of the large possession of volatile matter by the waste samples. The least volatile matter content of all the samples is the corn husks with an average value of 69.49%. It highest value is in Bosso with 70.66%. Taking for the mixed samples, they have a relatively fair amount of volatile matter compared to the samples been analyzed individually. The mixed samples have an average value of 48.79% and these value is due to the combination of both high volatile and low volatile giving samples been mixed together. The mixed sample has it highest peak in Bosso with a value of 51.61% and lowest in Tundun Fulani with a value of 44.56%. The high values of volatile matters show that municipal solid waste have great among of useful gases in them and can be driven out when subjected to heat. The volatile matter are the gases present in the material. The samples have average value of volatile matter as 21.69% for the mixed samples. The highest peak at 28.17% in Tundun Fulani and the lowest is 12.2% in Bosso.

Conclusions

Municipal solid wastes have great potential due to the large possession of volatile matter which can be used to generate energy rather than polluting the environment. Improper disposal of waste makes the environment not conducive for people and can be becomes a threat to the ecosystem. It can be concluded that increase in earnings and population leads to greater release of waste to the environment. This is true comparing the population of Minna with other cities in Asia like Kerala in India which generates 0.21 – 3.5kg/capita/day which can be compared to Minna city which generates 0.4 – 0.6kg/capita/day of municipal solid wastes. From the outcome of these experiments, it is clear that biological or organic waste produces more moisture and also that municipal solid waste have a large amount of volatile matter (gases) in them.

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