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Research Article

ENERGY GENERATION PROSPECTS FROM SOLID WASTE OF KANO METROPOLIS MARKETS

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Abstract *The health and wellbeing of every community is intricately linked to its economic growth and standard of living. Poor solid waste management has an impact on the health and consequently economy of communities. Kano Metropolis markets have vital role to play on economic growth to Nigeria and some part of West African countries at large, on the other hand they contributes on the environmental challenges. This research work assess to way of mitigating this challenges by recycling the waste generated by these markets to convert the wastes into useful such as generating of electricity. The result of the work revealed that the food and vegetable wastes were found to larger percentage from the solid wastes followed by plastics wastes. Whereas, textile materials, paper glass/ceramics, wood, electronic and metals wastes were 21%, 15%, 12%, 12%, 8% and 32% were found as the remaining solid wastes respectively and the average power generation potential in June is higher than that of July by 1014.98 kWh/day due to the higher calorific values during the period.*

Keywords: *Dumpsites; Electricity; Landfills; Incineration; Solid Waste*

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1. Introduction

Nowaday, population rate is always increasing from one city to another; therefore the quantity of waste generated every day is also increasing. Recently, researches proved that municipal solid waste generated from that cities annually is more than one billion tones which implies the cost of $205.4 billion per annum [1]. And by 2025, the quantity of solid waste is predicted to be more than two billion tonnes per year [2]; this causes solemn challenges environmentally [3].

Due to these challenges, an extensive waste management has become a more important globally. Zero solid waste management has been adopted as one of the policy in many cities of developed countries [4], [5]. They used landfills and incineration to generate heat and electricity to recycle their solid waste disposed.

Over 10 million tonnes of combustible solid waste are generated annually in Nigeria [6]. But the waste to energy (WTE) technology is not utilizing in Nigeria, hence the solid wastes disposed in a dumpsites are causing negative impact to the environment and health. Solid wastes can be used to generate electricity that will trap the problem of power electricity and help the environment to be clean. And with this electricity generation, the economy of the country would be enhanced which is one of the goals of Nigeria's Renewable Energy Master Plan (REMP), that is to achieve 400M in 2025 through biomass-based power plants [7].

Recently, it was proved that the average solid waste densities of some cities in Nigeria were 325 kg/m^3 [8], and average daily rates of 0.55 kg/capital/day, which give annual revenue generation of 25 million tons [9]. Moreover, rural-urban migration is always increasing which cause the high rate of solid wastes disposal in Nigerian cities, this makes the cities to necessitate implementing the waste to energy technology [10].

This work will focus on the potential of WTE technology potential to overcome the solid waste problem in some Kano metropolis markets. In many cities, waste-to-energy technology has been proves to be environmentally and economically beneficial to the cities as a means of recycling the solid waste disposed. Kano metropolis markets were selected because of their limited availability of space for waste disposal and lack of electricity in Kano metropolis.

2. Materials and Method

2.1. Data Collection

In this study, ten (10) markets from Kano Metropolis were randomly selected namely; Kanti Kwari textile market, Kofar Wambai plastic market, Sabon gari market, Singa market, Kurmi market, Rimi market, 'Yan Lemo fruit market, 'Yan Kaba vegetables market, Tarauni vegetables market and Farm centre computer and phone market. The waste management of each market was interviewed and gets permission to gather the solid waste from the dumpsite the markets.

Each selected market was visited bi-weekly for two months (June and July, 2021) in order to get the mass and volume of solid waste disposed in the selected markets daily. In each market, the researchers visited the waste management of the markets and get cordial understanding with them and explain the aim of the research with regard to the benefits of the market. For each market, the solid waste collected was poured inside the polyethylene containers and marked what contained with the marker.

2.2. Determination of Quantity of Waste Components

As mentioned above the solid wastes were categorized into ten namely: plastic, glass/ceramic, textiles, wood, metal, food, vegetables, paper, electronic waste, and others which represent any solid wastes other than one of the above mentioned. The weight of each category was measured using portable electronic weighing scales.

2.3. Characterization of Municipal Solid Waste

2.3.1 Bulk Density of the Solid Waste

A polyethylene container of the solid waste was used and its mass was determined as M_1 when empty. Waste collected from Dumpsite of the markets was poured into the container until it filled the container completely. The mass of the container together with the solid wastes were weighed and marked it as M_2.

The bulk density is given by the following equation [11]:

$$\rho_{bulk} = \frac{M2-M1}{V1} \quad (1)$$

Where: ρ_{bulk} is the bulk density in kg/m^3, M_2 is the mass of the container together with the solid wastes in kg and M_1 is the mass of empty container in kg.

The amount of waste disposal rate can be determined using the following equation [11]:

$$W_{disposed} = \rho_{bulk} V \quad (2)$$

$W_{disposed}$ is the mass disposed in kg, ρ_{bulk} is the average bulk density in kg/m^3 and V is the volume of the filled container in m^3.

2.3.2 Proximate analysis

This is used to obtain the moisture content, volatile matter, ash content as well as fixed carbon content.

i. Moisture content

The moisture content can be found by measuring the amount of mass lost from the solid after removal of water content from the waste by heating it and the equation below is used to get the moisture content [12]:

$$M = \frac{S-B}{S} \times 100 \tag{3}$$

Where; M is the moisture content, S and B are the mass of solid waste before and after heating respectively.

The solid waste sample was heated in an oven at 105oC for 2 hours and then cooled in a desiccators and reweighed.

ii. Volatile matter

Volatile matter is defined as the components of solid waste which deposited when heated at high temperature and it can be found using the following expression [12].

$$VM = \frac{A-B}{A} \times 100 \tag{4}$$

Where; VM is the volatile matter, A is the mass of the solid wastes after moisture content analysis, B is the mass after heating.

The remaining sample used for moisture determination was covered in a crucible and heated at 75^{o}C in a furnace for 2 hours. The crucible was later taken out of the furnace and cooled in a desiccators and reweighed.

iii. Ash content

After the solid wastes undergo combustion, there are some residues that are non-combustible. These non-combustible residues are called ash content and it is expressed in percent which is determined using the formula given below [12].

$$AC = \frac{A-B}{C} \times 100 \tag{5}$$

A is the mass of the non-combustible residue + mass of the container in kg, B is the mass of the container when empty and C is the initial mass of solid waste with moisture.

Fixed carbon content

Fixed carbon can be found by using the expression given below [13].

$$FC = 100 - M - VM - AC \tag{6}$$

Where; FC is the fixed carbon content, M is the moisture content, VM is the volatile matter and AC is the ash content.

2.3.3 Ultimate analysis

To get the percentage composition of Oxygen, the sum of the percentage composition of the elements (hydrogen, carbon, Nitrogen and Sulphur) and ash content was subtracted from 100. This analysis is called ultimate analysis.

$$O = 100 - (C + H + N + S + AC) \tag{7}$$

Where; O, C, H, N and S are the percentage of Oxygen, Carbon, Hydrogen, Nitrogen, Sulphur respectively, AC is the ash content.

Each element is determined through chemical analysis and expressed as a percentage of the total mass of the original waste sample.

2.3.4 Energy potential

The electrical energy potential is determined using the following equation [14]:

$$E_o = \frac{E_i \eta}{3600} \tag{8}$$

Where: E_o is the electrical energy output, E_i is the energy input and η is the conversion efficiency.

$$E_i = \dot{m} \times CV \tag{9}$$

Where; E_i is the energy input, $\dot{m}$ is the mass flow rate of MSW in kg/day and CV is the calorific value in kJ/kg.

The maximum gross efficiency for electricity production was given as 22% [19]. The energy potential was determined using equation 8 and 9

For the month of June,

Using equation (9);

$$E_i = \dot{m} \times CV$$
$$E_i = 59900 \times 18454.08 = 1105399392 \text{ kJ/day}$$

At η = 0.22 (minimum efficiency)

Using equation (8);

$$E_o = \frac{E_i \eta}{3600}$$
$$E_o = \frac{1105399392 \times 0.22}{3600} = 67552.19\ kWh/day$$

For the month of July,

Using equation (9);

$$E_i = \dot{m} \times CV$$
$$E_i = 59000 \times 18454.08 = 1088790720 \text{ kJ/day}$$

At η = 0.22 (minimum efficiency)

Using equation (8);

$$E_o = \frac{E_i \eta}{3600}$$
$$E_o = \frac{1088790720 \times 0.22}{3600} = 66537.21\ kWh/day$$

3. Results and Discussion

3.1. Results

The results obtained for Kano Metropolis Market solid waste in June and July are presented in Figure 1-4.

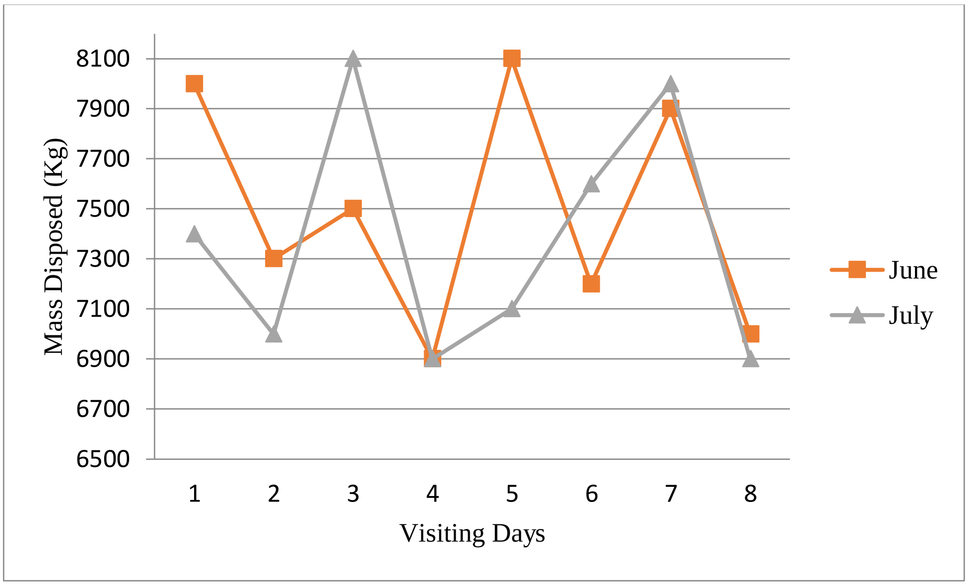

Figure 1. Daily disposal of combustible waste

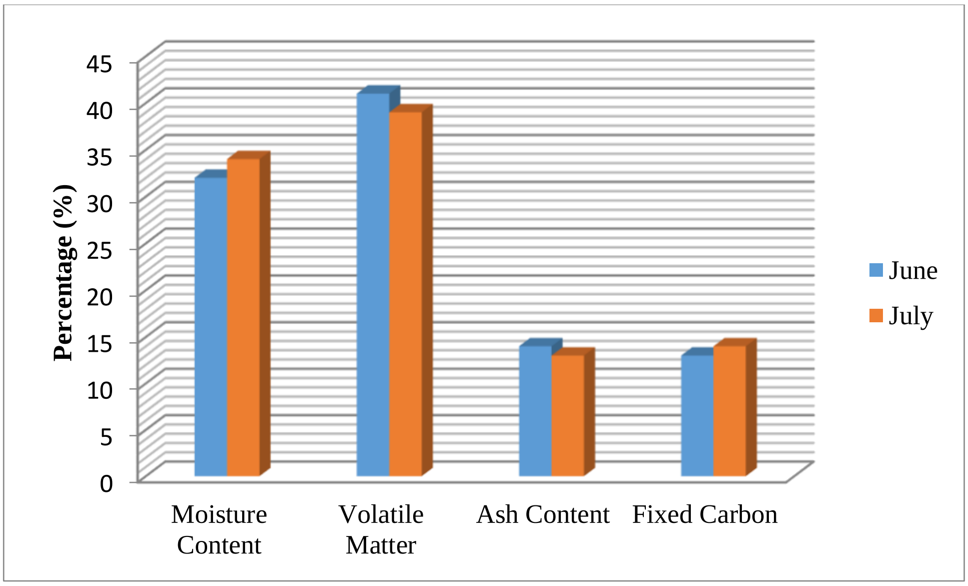

Figure 2. Proximate Analysis of Kano Metropolis Markets Solid Waste

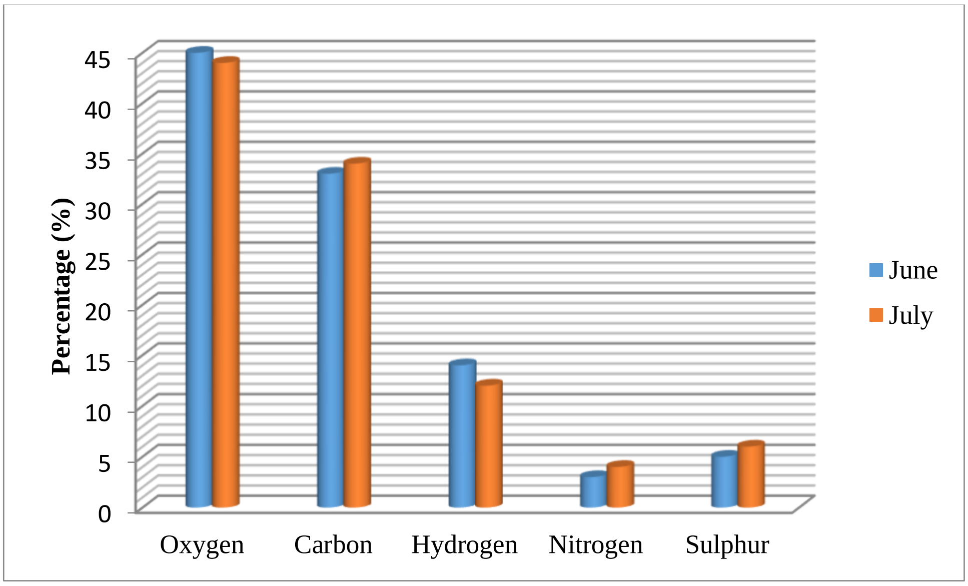

Figure 3. Ultimate Analysis of Kano Metropolis Markets Solid Waste

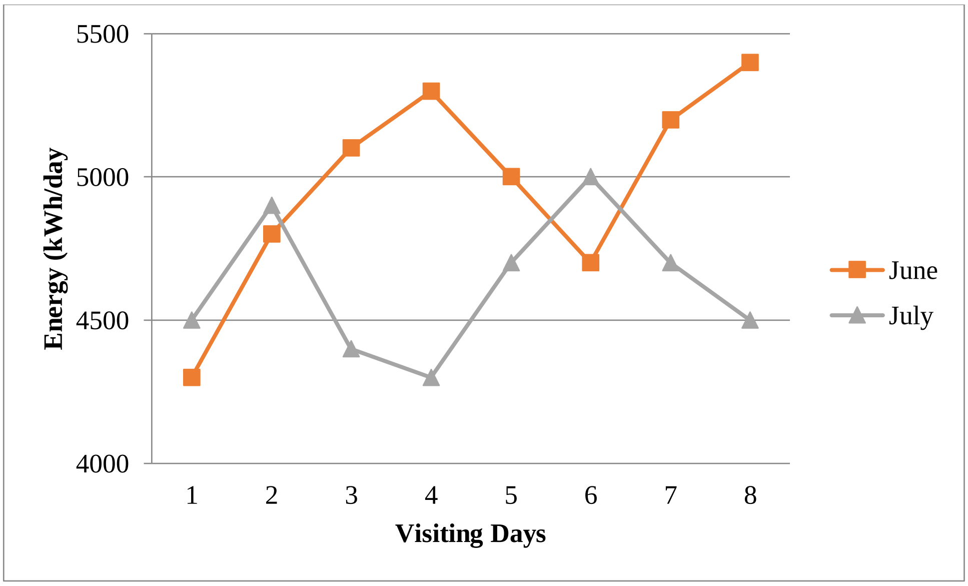

Figure 4. Energy output with recycling

3.2. Discussion of Results

The Analysis of solid waste composition indicates that 58% of the solid waste was from food and vegetable wastes. This is almost equal to the values of the result of a similar study done by Nabegu [15]. Plastic materials are much as 42% of the solid waste being generated in Kano metropolis markets. Textile, paper, glass/ceramics, wood, electronic and metals wastes were 21%, 15%, 12%, 12%, 8% and 32% were found as the remaining solid wastes respectively. This result concurred with the studies conducted at some states in Northern parts of Nigeria [16-18]. Recycling of these solid wastes was essential method since the electronic wastes were negligible quantitatively small but it has negative impact environmentally.

Kofar wambai, Sabon gari, Farm centre, 'Yan Lemo and 'Yan Kaba markets have more plastics, paper, electronics, fruit and food waste respectively. On the other hand the high percentage of textile wastes in Kantin Kwari. In June, 59900 kg/day of waste were disposed in the selected markets while 59000 kg/day were disposed in July. It can be seen from figure 1 that the waste disposed is in periodical form but the waste disposed in June is higher than that of July due to large congestion in the markets in May since it's the month that edil-fitr occurred.

The moisture content gradually increases from about 32% in June to about 34% in July. While the volatile matter decreases from 41% to 39% in June and July respectively and there is a slight increase and decrease in the ash content and the fixed carbon content from June to July as shown in Figure 2. Moisture content was higher in July, this is because the fully rainy season and high humidity. Whereas, the ash content was relatively low due to low inert materials in the waste.

Figure 3 shows the ultimate analysis of the solid waste and it was found that high amount of Carbon and Oxygen, however the Nitrogen and Sulphur content were relatively small. There is an increase in Hydrogen content from June to July.

From figure 4, the energy output was lower in July compared to that of June due to the lower calorific values during the period, it is also imperative to note that the kWh/ton was higher due to the higher calorific values of Kano metropolis markets solid waste. This result is in agreement with Diso [20] who found that 13MW of electricity could be produced from wastes in 1995 covering at least the entire Kano metropolitan area. All the waste samples considered have heat values greater than some well-known biomass-fuels and fall within the limit for the production of steam in electricity generation [21].

4. Conclusions

An assessment of solid wastes of Kano metropolis markets was conducted to obtain the suitability for energy production and the following are remarkable conclusions obtained:

i. The solid wastes of Kano metropolis markets disposal rate recorded were 59900 kg/day in June and that of July was 59000 kg/day.
ii. Food and vegetable wastes were found to larger percentage from the solid wastes followed by plastics wastes. Whereas, textile materials, paper glass/ceramics, wood, electronic and metals wastes were 21%, 15%, 12%, 12%, 8% and 32% were found as the remaining solid wastes respectively.
iii. The average power generation potential is 67552.17 kWh/day in June and that of July was 66537.21 kWh/day.

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