

ENERGY RECOVERY POTENTIAL OF SOLID WASTES IN TWO SELECTED TOWNS IN OKEOGUN AND IBARAPA AREAS, OYO STATE

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Abstract

The recent sharp increases in the prices of oil, natural gas, uranium and coal underline the importance for all countries to focus on development of alternative energy resources. There is erratic power supply in Nigeria which may be caused by pipeline vandalism, shortage of gas and others, so, there is need to look for other sources of generating power from relatively available local materials such as agricultural and other wastes. This is the focus of this study. Energy recovery potentials of waste generated in Ibarapa and Oke-Ogun, Oyo state, Nigeria were estimated. The attribute of waste as a fuel are moisture content, calorific value and volatile content. The samples were randomly selected. A total of six (6) samples were collected from the selected towns. Samples were weighed and segregated into organic and inorganic component. The organic component was thoroughly mixed, shredded, mixed and sieved for analysis at Nigeria Institute of Science Laboratory Technology (NISLT) Ibadan. The study obtained moisture content ranging between 41% to 84%. The results show the prospects of bio-chemical conversion for Ibarapa and Iseyin. The wastes obtained were of high percentage organic matter (80%) that can support conversions. The calorific value ranged between 7.983-9.859MJ/kg. The study revealed that 0.56 MW of electricity can be generated daily in Oke-ogun at 0.1 efficiency while as much as 3.75 MW of electricity can be generated daily at 70% efficiency. Ibarapa waste has physical and chemical components for generation of electricity but the quantity of the waste was relatively small.

Keywords: Energy; Inorganic, Organic; Recovery; Waste.

Introduction

In a growing world, where the conventional forms of energy are fast moving towards extinction as well as are contributing generously to global concerns like the greenhouse effect and global warming, the need to innovate and employ alternate or unconventional energy sources has become crucial for the existence of a future. It is a settled law of nature that all biological organisms must essentially generate waste it follows therefore that regardless of the social and economic status mankind must inevitably generate waste of various forms which include gas, liquid and solid on daily basis no matter the geographical location. Electricity is the set of physical phenomena associated with the presence and flow of electric charge. There is erratic power supply in Nigeria, so, there is need to look for other sources of generating power from relatively available local materials such as agricultural and other wastes. Some researchers have studied the great potentials in municipal solid waste to produce enormous amount of methane gas mixture of manure

and ashes from burning of urban solid waste have been used for soil amelioration to boost agricultural production. Solid waste disposal open dump of solid waste is a common practice (Yusuf and Oyewumi, 2008) The growing population, increased urbanization rate and economic growth are dramatically changing the landscape of domestic solid waste in terms of generation rate, waste composition and treatment technologies (Igoni *et al.*, 2007). Municipal Solid Waste is a renewable energy source that shows great promise, and all waste to energy facilities follow almost the same procedures when the waste is first received. The waste is sorted, with recyclable materials being set aside. At this point, a waste to energy facility that burns the waste will put the materials into the incinerator to burn, so the released energy can be captured in the form of steam. This steam is then used to create electricity (Jaeger and Mayer 2000). Electricity plays a very important role in the socio-economic and technological development of every nation. The electricity demand in Nigeria far

outstrips the supply and the supply is epileptic in nature. . There is a paradigm shift in the way energy resources are utilized in today's world, the shift to renewable source is not only environmental friendly but it is almost available in every country (Sambo, 2008). Nigeria's biomass resources include wood, forage grasses and shrubs, animal waste, and other wastes from forestry, agriculture, municipal and industrial activities as well as aquatic biomass., this is the focus of this research. Ottinger (2005) said the recent sharp increases in the prices of oil, natural gas, uranium and coal underline the importance for all countries to focus on development of alternative energy resources. There is a paradigm shift in the way energy resources are utilized in today's world, the shift to renewable source is not only environmental friendly but it is almost available in every country. Nigeria's biomass resources include wood, forage grasses and shrubs, animal waste, and other wastes from forestry, agriculture, municipal and industrial activities as well as aquatic biomass. Table 1 shows Nigeria's renewable resource estimate with highest energy coming from hydro. Energy can be captured in the form of steam. This steam is then used to create electricity. Weitz (2002) took comparative study of municipal wastes in urban Bangladesh to generate electricity. Solid waste which is defined under resource conservation and recovery act as any solid, semi-solid, liquid or contained gaseous materials discarded from industrial, commercial, mining or agricultural operation and from community activities solid waste also includes garbage, construction debris, commercial debris commercial refuse, sludge from water or waste treatment plants or air pollution, control facilities and other discarded materials. The composition of refuse generated in an area determines the type of disposal method suitable for a particular form of refuse. Also the effectiveness of a collection system depends on the corporation of households and individuals in various sectors of the city in providing containers for storing refuse in accordance with the regulation and regularly placing the materials for collections (Afon, 2003). Kuleape *et al.* (2014) conducted proximate analysis by looking at moisture, volatile matter, ash and carbon using Dulong's formula and determined the heating values with the data obtained from the ultimate analysis. Adewole (2009) examined the major effects of waste management on the quality of life in two perspectives such as environmental and health effect. The management of waste from the urban food system requires safe disposal (Argenti, 2000). There are evidences that show how a substantial reduction in the cost of waste management with community involvement can be

achieved (Mongkolnchaiarunya, 2005). Total waste generation is the product of per-capita waste generation rate and the state population. This shows that there exists a relationship between waste generation and the state population. The management of solid waste is one of the challenges facing any urban area in the world. An aggregation of human settlement has the potential to produce a large amount of solid waste; the collection, transfer and disposal of that waste has been generally assumed by municipal government in the developed world. Electricity is the key to development. Most of the people in the studying areas are farmers who will need electricity to either process or preserve agricultural produces. They are generating enough wastes which can be processed into electricity. The population of some cities in Nigeria is increasing geometrically as a result the demand of electricity is increasing every day. Government at all levels has fewer alternatives to meet up the huge demand of electricity in Nigeria. By sorting out the municipal solid waste and through anaerobic process we can generate biogas which will lead to generate electricity. Biogas can only be produced from the compostable waste. This biogas is used in a gas generator to generate electricity. This process will assist Ibarapa and Oke-ogun dwellers to generate their own electricity for street lighting, water pump. It could be helpful to minimize the waste management cost. It will decrease the dependency on conventional electricity generation sources. The main parameters which determine the potential of recovery of energy from wastes are Quantity of waste, and Physical and chemical characteristics (quality) of the waste. Dryness of matter W_{ms} is the content of dry matter in wet matter and is computed using equation

$$W_{ms} = \frac{M_{ms}}{M_{mh}} \quad (1)$$

Where M_{ms} is the mass of dry matter and M_{mh} is the mass of wet matter. The energy from waste can be got from the following two processes, namely: i) Thermo-chemical conversion: This process entails thermal decomposition of organic matter to produce either heat energy, fuel oil or gas; and ii) Bio-chemical conversion: This process is based on enzymatic decomposition of organic matter by microbial action to produce methane gas or alcohol. The Thermo-chemical conversion processes are useful for wastes containing high percentage of organic and low moisture content (Sparks and Micheal 2012)

Materials and Methods

Materials used are: Sack, Waste, Hand Glove, air tight Container, Shovel, Nose Cover and Oral interview. Instrument and Equipment are Laboratory Oven,

Weighing balance, Crucible, Blender, Furnace and Bomb Calorimeter. Oral interview was conducted for waste management authority staff and dwellers to get average waste generated in the selected areas. The wastes were collected from different collecting centers within the towns. These collecting centers were Slaughter house, dumping sites and Markets. Waste was sorted to remove non-combustible materials; the remaining wastes were reduced to about 1kg by coning and then divided into small amount. The samples were packed and sealed in polythene bags of about 1kg and put in an air tight container which contains 3 bags from every collecting point. The total of three airtight containers was taken to Central laboratory of Oyo State College of Agriculture and Technology and NISLT (Nigeria Institute of Science Laboratory Technology) Ibadan for analysis. Standards test methods were adopted for establishing the laboratory analysis. Three experiment tests were carried out from each waste sample. The analysis was done in order to estimate the heating value of municipal solid.

Results and Discussion

Tsunatu *et al.* (2015) studied the municipal solid waste of Jalingo metropolis and concluded that bio-chemical and thermo-chemical conversion processes can produce 62,596.80 kW and 151,016.14 kW Net Power Generation Potential respectively. Williams *et al* (2003) said for bio-chemical conversion the moisture content should be greater than 50% and organic /volatile matter greater than 40%, this agreed with the results from table 4 which shows high moisture contents and volatile matter higher than 40%. Chart1-3 display some of table 2-4 information graphically. Table 2 shows that the waste generated per day from Ibarapa communities is lower than the waste generated from Oke-ogun because Oke-ogun community has higher population and local government areas than Ibarapa. The two communities are agrarian and waste generated from them was majorly agricultural wastes which are suitable for this research. The potential for electrical energy generation for a fuel feed rate of 51,428kg/day, calorific value of 9MJ/kg and assumed overall efficiency values ranging between 10% and 100% can be seen in table3. This shows that the output of the plants depend on its efficiency. Table4 shows that Slaughterhouses of both communities have 100 percent organic, Moisture content ranges between 64- above 80 percent. The samples were very reasonable high volatile matters. Diji (2013) wrote that in 2007, the Renewable energy Master Plan (REMP) of Nigeria envisages an aggregate electricity demand of

7000MW. The REMP projects that biomass will be expected to contribute a total of 50MW of electricity in the medium term that is 2015 and 400MW in the long term that are by 2025[16]. Average Calorific values of 9MJ/kg and a total solid waste collection rate of above 51 tones per/day from the Oke-ogun was determined, if simulation of electrical output is determined by assuming different operating overall efficiencies for the mass fired incinerator power plant. The overall efficiency of a mass-fired incinerator is given by equation below:

$$\text{Efficiency} = \frac{\text{electrical energy output}}{\text{energy input}} \dots\dots\dots (2)$$

$$\text{Energy input} = \text{mass flow rate of solid waste generated} \times \text{calorific value} \dots (3)$$

$$\text{Electrical output} = \text{efficiency} \times \text{mass flow rate fuel} \times \text{calorific value of solid waste (Edward, 2001)}$$

$$1\text{MJ/s}=1\text{MW of electricity energy.}$$

$$\begin{aligned} \text{Electrical output, } E, (\text{at } 0.1 \text{ eff}) &= \frac{51428\text{kg}}{\text{day}} \times \frac{9\text{MJ}}{\text{kg}} \times 0.1 \\ &= \frac{46285\text{MJ}}{\text{day}} \\ E &= \frac{\frac{46285\text{MJ}}{\text{day}}}{24 \times 3600} = \frac{0.56\text{MJ}}{\text{s}} = 0.56\text{MW} \end{aligned}$$

It can be seen that 0.56 MW of electricity can be generated daily in Oke-ogun at 0.1 efficiency while as much as 3.75 MW of electricity can be generated daily at 70% efficiency.

Conclusions and Recommendation

Open burning has been the most common practice of solid waste disposal. There is need for government and investors look into investing in waste to wealth so that there will be stable and regular electricity supply in Nigeria. There is need to educate people in sorting of waste so as to get waste separation right from the source. I recommend that:

- 1) Government at all levels should monitor the proper way of collecting and disposing of waste,
- 2) Funds should be made available to generate fuel from waste.
- 3) Sorting of wastes should be done before they are disposed so that organic materials can be separated from inorganic materials.
- 4) Government should diversify and formulate policies that will enable core investors into renewable energy technologies

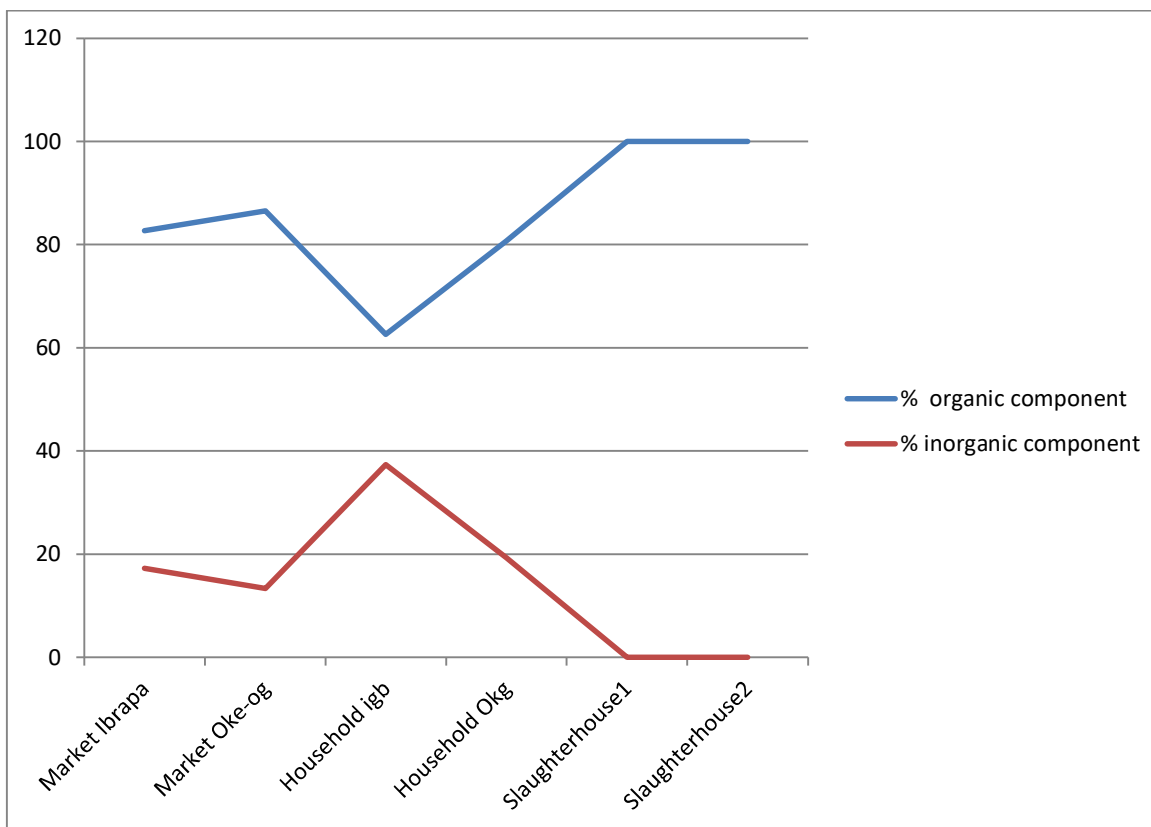


Chart 1: Graph of Organic versus Inorganic

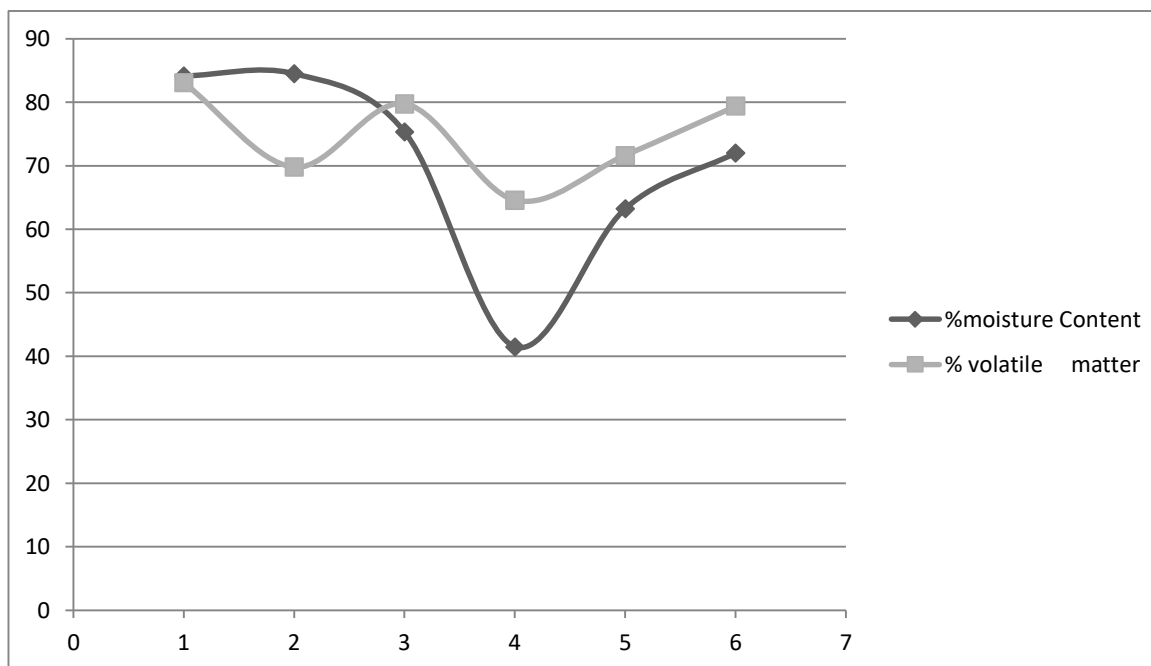


Chart2: Graph of Moisture content and volatile matter

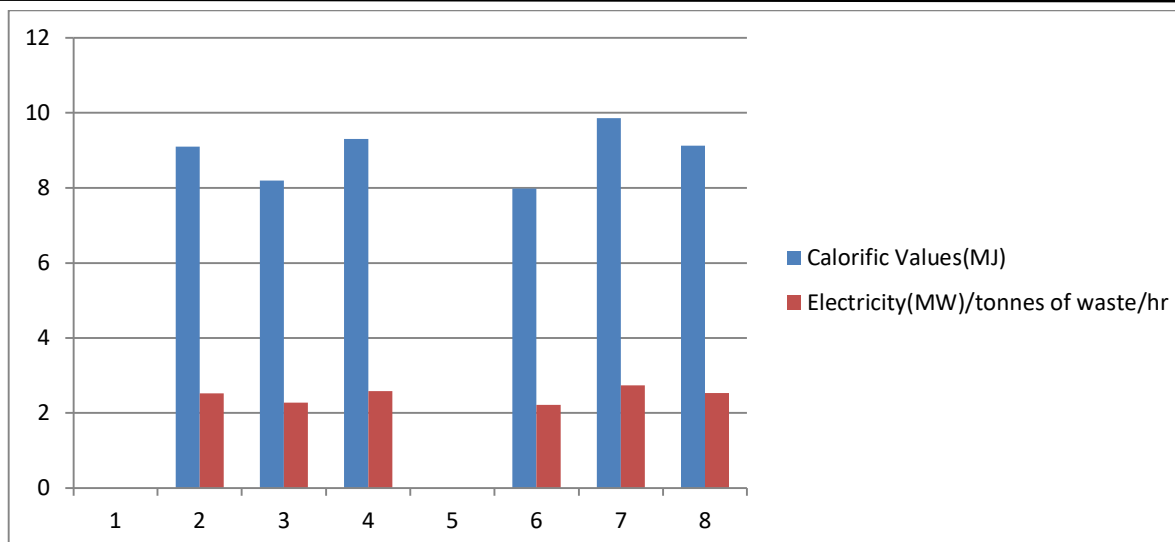


Chart 3: Chart showing the calorific values and expected electricity potential of the waste

and Behavior Association of Nigeria held in Akure, 23th – 25th Oct.

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Efficiency (%)	Energy Output (MW)	Average Calorific Value (MJ/Kg)	Calorific Values
10.00	0.56		9.102
			8.196
20.00	1.07		9.304
40.00	2.14		7.983
50.00	2.68	9.00	9.859
60.00	3.21		9.120
70.00	3.75		
100.00	5.36		

Table 1: Nigeria's renewable resource estimate

ENERGY SOURCE	CAPACITY
Large Hydropower	11,250MW
Small Hydropower	735MW
Solar Radiation	3.5 – 7.0 kWh/m ² -day
Wind	2 – 4 m/s (annual average) at 10m height

Source: Energy Commission of Nigeria; National Energy Masterplan

Table 2: Estimated quantity of wastes generated at the selected towns

TOWNS	QUANTITY/DAY (kg)	QUANTITY/WEEK (kg)	YEAR (kg)
IBARAPA	12857	90,000	4,680,000
OKE-OGUN	51428	360,000	18,720,000

Table 3: Electricity potential at different efficiencies

**Table 4: Percentage of the various component of solid waste**

Site	Sample Source	% organic component	% inorganic component	%moisture Content	% volatile matter	% Ash
Ibarapa	Market	82.7	17.3	84.14	83.1	16.813
Oke-ogun	Market	86.6	13.4	84.49	69.8	30.170
Ibarapa	Household	62.6	37.4	75.34	79.746	20.254
Oke-ogun	Household	80.7	19.3	41.49	64.565	35.435
Ibarapa	Slaughterhouse	100	-	63.24	71.63	28.370
Oke-ogun	Slaughterhouse	100	-	71.98	79.38	20.620