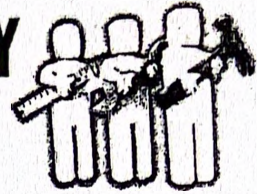




FACULTY OF TECHNOLOGY
UNIVERSITY OF IBADAN, NIGERIA



**FIRST UNIVERSITY OF IBADAN
TECHNOLOGY CONFERENCE
(UITECH2015)**

Theme: _____

**“ENERGY TECHNOLOGY
FOR SUSTAINABLE DEVELOPMENT
AND SECURITY”**

CO-SPONSORS:

Nigeria Liquefied Natural Gas Limited (NLNG)
The Postgraduate School, University of Ibadan, Ibadan, Nigeria
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Conference Proceedings

Date: Monday 6th - Wednesday 8th July, 2015.
Venue: Conference Centre, University of Ibadan, Nigeria.
Time: 9:00am Prompt



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Evaluation of Energy Generation Potential of Municipal Solid Waste in Ibadan

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Waste to energy (WTE) is a renewable and environmentally sound process that has been proven to provide reliable electricity generation in developed and developing nations. This study was carried out to evaluate the WTE potential of municipal solid waste (MSW) in Ibadan metropolis. Characterisation, and proximate analysis of representative MSW samples collected in year 2014 at two dumpsites (Ajakanga and Abu Eku) were carried out in accordance to standard procedures. Food wastes constituted 39%, the highest component of the MSW. The net calorific value was evaluated to be 22.5 MJ/kg. The energy potential per annum was evaluated as 24 GW for approximate total waste of 447 thousand tonnes generated and disposed in Ibadan in year 2012. The energy potential in MSW could be harnessed to address the energy shortfall in the city.

Keywords: Municipal solid waste, Incineration, Waste Disposal, Energy Recovery, Calorific Value

INTRODUCTION

Increased global urbanisation and economic expansion of developing countries are leading to accelerating rates of municipal solid waste production. It is reported that the global MSW generation is expected to reach 2.2 billion tonnes/year in 2025 and 4.2 billion by 2050 (Hoornweg and Bhada-Tata, 2012). Innovative waste management practices are therefore required to address the challenges of treatment of this huge amount of waste. In addition, recovery of energy from the controlled combustion of municipal solid waste (Waste to energy, WTE) should be encouraged. According to Omari *et al.* (2014), combining waste management with waste energy recovery step from municipal solid waste can address the problems of solid waste management and partly the energy crisis.

Many technological approaches are employed for exploitation of energy from organic fraction of municipal solid waste. The technologies are categorized into bio-chemical and thermo-chemical conversion processes (Curry and Pillay 2012). The anaerobic digestion is purely a bio-chemical conversion process used to produce a fuel for energy in a well-controlled enclosure called digester and involves the application of microbial actions on bio-waste in absence of oxygen for biogas production. The thermo-chemical conversion process includes gasification of municipal solid waste and incineration (Rao *et al.*, 2010).

The gasification process is used to induce production of variety of gases such as carbon dioxide, steam, methane and other byproducts like ash and tar under the conditions of high temperature and low concentration of pure oxygen or air (Mata-Alvarez, 2003). Methane is the basic product gas from gasification process and after being allowed to pass through some cleaning processes, then it can be applied directly to run an internal combustion engine for electricity generation (Arena, 2011). In the incineration process, no pre-treatment of the waste is required. The whole mass of the waste is burn in incineration, hence the name "mass burn". The incineration of MSW has the ability to drastically reduce the volume of MSW as much as 80-90% (Lee *et al.*, 2007).

Municipal solid waste disposal is a major environmental challenge confronting many developing countries. According to Babayemi and Dauda (2009), the problem of waste management has two components: collection and disposal. Disposal methods such as dumping sites, incineration, recycling, shipping and home garbage disposal units have been used in different societies (Sha'Ato *et al.*, 2006). Waste management practices in Nigeria is still evolving. Only few cities utilize functional sanitary landfill while most wastes are disposed of in open dumps or semi-landfills with poor facilities for prevention of groundwater contamination and leachate recovery or treatment (Akintayo and Olonisakin, 2014). In China, landfilling is the dominant form of waste disposal, handling over 80% of the treated MSW (Yan and Wu, 2003). With the increase in population and urbanization in Nigeria, energy potentials that are available from municipal solid waste could be harnessed to address the electricity shortfall in the country.

Incineration is a disposal method commonly practiced in Ibadan. The energy potential from this method could be harnessed to address the power challenges presently confronting the city. Hence, the objective of this paper is to evaluate the energy potential of municipal solid waste in Ibadan.



METHODOLOGY

Study Area

The two locations selected for this study are Ajakanga and Aba Eku dumpsites with approximate landmass of 10.34 and 9.42 hectares respectively. Ajakanga dumpsite is located along old Ijebu road in Oluyole Local Government Area; Aba Eku is along Akanran-Olunloyo road in Ona Ara Local Government Area. The two dumpsites were opened in 1996 and owned by the government of Oyo State.

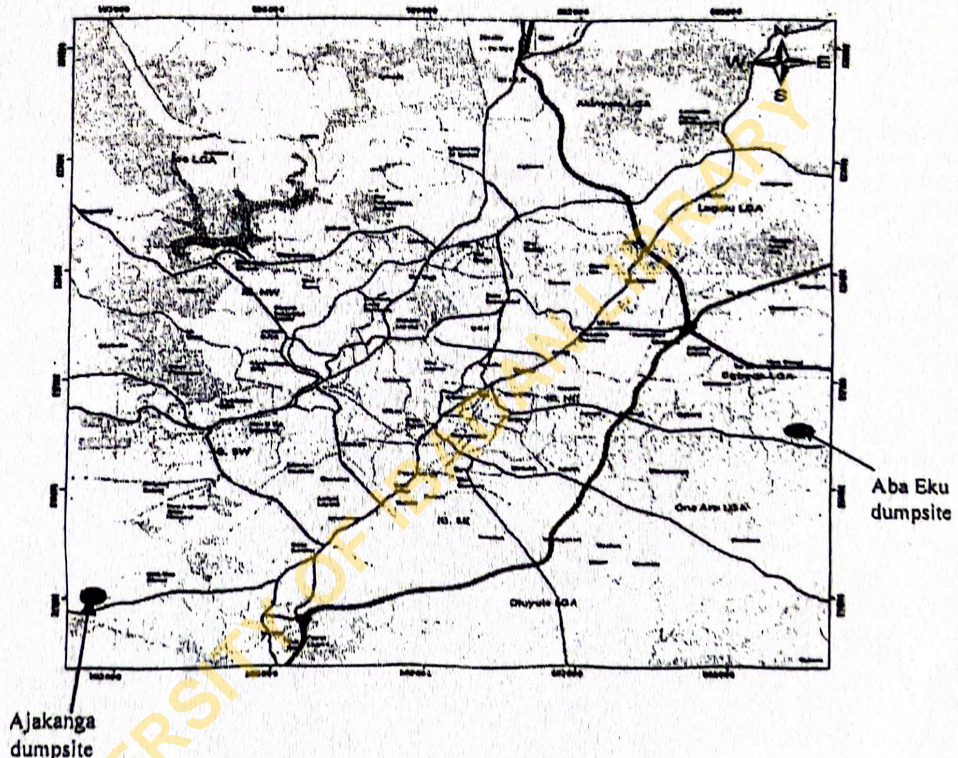


Figure 1: Map of Ibadan showing the study areas

Sample collection and analysis

The quantity of waste generated monthly in Ibadan was obtained from the Oyo State Waste Management Authority (OYOWMA). Preliminary field study was carried out at the two dumpsites in June 2014. Sample data were collected and characterized based on standard test method for the determination of the composition of solid waste (ASTM D5321). Proximate analysis to determine moisture, volatile matter, ash and fixed carbon; and ultimate analysis to determine the percent of carbon, hydrogen, oxygen, sulphur and ash of the waste were analysed using experimental methods. The calorific value of MSW was determined in accordance to ASTM E 711-87.

Determination of energy content

Incineration method (thermo-chemical process) of waste disposal is generally practised in Ibadan. In thermo-chemical process, all of the waste components (organic matter, biodegradable and non-biodegradable) contribute to the energy output (Tsunatu *et al.*, 2015). The energy potential of the waste was computed using



equations 1 to 3 (Amber *et al.*, 2012).

$$\text{Energy Recovery Potential (kWh)} = \text{NCV} \times W \times 1000/860 = 1.16 \times \text{NCV} \times W \quad (1)$$

$$\text{Power Generation Potential (kW)} = 1.16 \times \text{NCV} \times W/24 = 0.048 \times \text{NCV} \times W \quad (2)$$

$$\text{Net power generation potential (kW)} = ? \times 0.048 \times \text{NCV} \times W \quad (3)$$

Where,

NCV = Net Calorific Value (kcal/kg)

W = Total waste quantity (tonnes)

? = conversion efficiency (25% is assumed, typical values ranged between 20% to 40% for open dumpsites, Amber *et al.*, 2012)

RESULTS AND DISCUSSION

Waste Flow Analysis

The waste flow (generated and collected) data for year 2012 in Ibadan obtained from OYOWMA MSW is shown in Table 1. The total MSW recorded for the year is 447,436 tonnes. This is a fraction of the total MSW generated in the city because other wastes find their way into drains and water channels across the city, burn illegally or dump directly on roads and various streets in the city. The monthly variation of the waste is illustrated in Figure 2.

Table 1: Total Wastes Collected in Ibadan in 2012

Month	Total MSW (Tonnes)
January	9,800.43
February	17,292.92
March	19,656.96
April	23,529.99
May	32,591.87
June	36,178.48
July	51,862.68
August	45,821.40
September	57,942.28
October	37,888.62
November	64,388.13
December	50,482.50
Total	447,436.26

Source: Oyo State Waste Management Authority (OYOWMA)

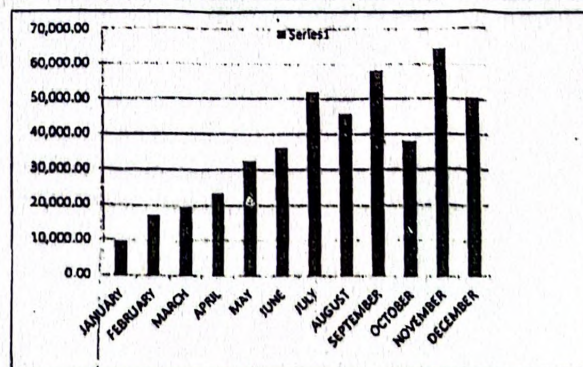


Figure 2: Monthly variation of MSW in year 2012 for Ibadan



Typical waste composition

The waste constituents at the two dumpsites were quite similar, and a general reflection of the socio-economic activities of the people in Ibadan. In Figure 3, typical compositions of representative waste samples are shown. Food wastes accounted for 39%; paper, plastic and nylon contributed 14%, 12% and 9% respectively.

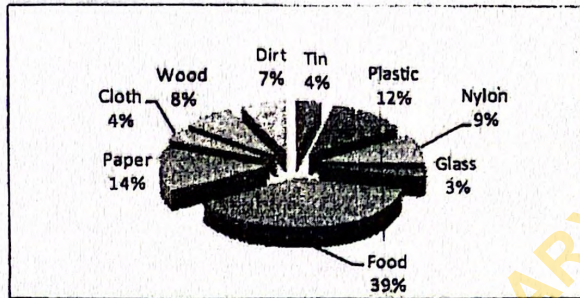


Figure 3: Typical composition of MSW

Evaluation of Energy Generation Potential of Municipal Solid Waste

The proximate analysis of the waste is presented in Table 2. The analysis showed that paper was the most volatile (78%) of the waste components with fixed carbon (dry basis) value of 22%.

Table 2: Proximate analysis

Components	%Ash (Dry basis)	% Volatile Matter (dry basis)	% Fixed Carbon (dry basis)
Food	4.57	62.59	32.84
Plastic	0.34	61.38	38.28
Polythene	0.18	62.86	36.96
Glass	0.26	68.54	31.2
Tin	0.62	65.28	34.1
Paper	0.13	77.89	21.98
Cloth	0.48	73.28	26.24
Wood	0.46	76.31	23.23
Dirt	1.21	65.26	33.53

The calorific values of various components of the waste oven dried at 85°C and their corresponding computed energy recovery potentials are presented in Table. The moisture content is evaluated as 26%.



Table 3: Energy Recovery Potentials

Components	Calorific Value (kcal/kg)	Energy Recovery Potential (KW)	Power Generation Potential (KW)	Net Power Generation Potential (KW)
Food	4,823	978,648,118	40,777,005	10,194,251
Plastic	5,421	338,427,069	14,101,128	3,525,282
Polythene	5,339	250,015,236	10,417,301	2,604,325
Paper	5,562	405,102,772	16,879,282	4,219,821
Cloth	6,066	126,238,669	5,259,945	1,314,986
Wood	5,084	211,591,527	8,816,314	2,204,078
<i>Net Calorific Value, NCV = 5,382 kcal/kg = 22.5MJ/kg Moisture content = 26%</i>			Total	24,062,744

Food wastes contributed the highest net power generation value of 10,194,251 KW while plastic & polythene (combined) has 6,139,607 KW illustrated in Figure 4.

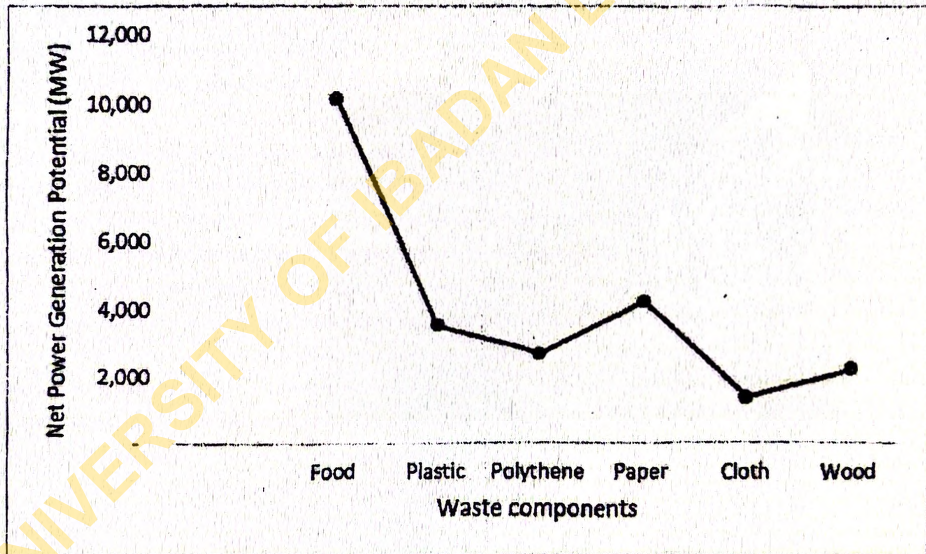


Figure 4: Power generation potential of MSW components

4. CONCLUSION

The study shows that approximately 447 thousand tonnes of municipal solid waste were generated and disposed in Ibadan in year 2012. The net calorific value of MSW in Ajakanga and Aba-Eku dumpsites is evaluated as 22.5 MJ/kg with average water content of 26%. Further analysis of the waste showed that energy generation potential of over 24 GW could be derived from Ibadan municipal solid waste through incineration technique. The energy should be harnessed to address the power challenges presently confronting the metropolis.

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