Study Of The Energy Potential Of Solid Waste In Bauchi Town

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ABSTRACT:
The study of the energy potential of solid wastes in Bauchi Town was carried out, on the average the combination of plastics, rubber, polyethene bags constituted about 33% of the wastes, followed by textile materials, leathers, wood 26%and combination of papers, cartons 15%. The heating values or calorific value of the wastes was determined to be about 6.83 MJ/kg almost one-third of the energy content of sub-bituminous coal which is 19.4 MJ/kg was as determined using a digital calorimeter.

SIGNIFICANCE OF THE RESEARCH
The research will come up with records of wastes disposed and their energy potential that is their heating value. This will sensitize the state to adopt the waste to energy incineration system. Further, if this system is implemented together with solid waste recycling in form of compost and re-use, the principles of sustainable development would be supported.

Keywords: *Energy potential, heating value, incineration, municipal solid waste and simulation*

I. INTRODUCTION

Bauchi lies between Latitude 9.3^0 and 12.3^0 North of the Equator and Longitude 8.5^0 and 11^0 East of the Greenwich meridian. It is one of the states in the Northern part of Nigeria that span two distinctive vegetation zones, namely, the Sudan Savannah and the Sahel Savannah. The former covers the southern part of the state.Here the vegetation gets richer towards the south , especially along water sources or rivers but generally the vegetation is less uniform and grasses are shorter than what obtains further south, which is the forest zone of the middle belt.While the latter also known as the semi-desert vegetation, becomes manifest from the middle of the state as one moves one moves from the south to the Northern part of the state. The characteristics of this type of vegetation comprise of isolated strands of thorny shrubs. The state has three main geological formations-the Basement complex in the south, keri-keri in north eastern part and chad formation in the north.(Bauchi State diary 2012).

The state capital is growing fast. Bauchi a major city center with a population of about 500 000 inhabitants and passers-by, is not left behind in generating heaps of refuse, that could be collected, processed and converted to useful energy as done elsewhere. That is why this research will conduct a study on the energy potential of these wastes.

Presently, most of the municipal solid wastes generated in Nigeria are dumped or disposed along road sides, causing danger to public health and to environment. The waste management system is below acceptable standards. Researchers have been making moves to find ways of developing techniques to manage these wastes in Nigeria and elsewhere.

This research tries to introduce another source of energy generation that was hither-to neglected .Nigeria is looking for investors but has no enough energy to power machineries and processes. It is worthy of note the abundance of wastes from agricultural activities. Farm produce like cereals and legumes (sorghum, maize, millet, wheat, cowpea and groundnuts as well as fruits and vegetables (oranges, mangoes, tomatoes, onions and so on) ,they all contribute solid wastes products. Added to them is the sugarcane bagasse which researches have shown that it has a good amount of energy in form of biomass (Adio, etal 2009.

About 13.9 million residents living in 2.96 million households generates approximately 7000 t d−1 of MSW at the rate of 0.500 kg−1capita−1 d−1 in Delhi (DUEIIP 2001) In year 1998, the population of Kuala Lumpur (KL), Malaysia was about 1,446,803, which ascended up to 2,150,000 in year 2005, however, solid waste generation was 2257 t d−1 in 1998 which is estimated to reach up to 3478 t d−1 in 2005 (Sivapalan K, et al 2002).

A Study conducted at the University of Port-Harcourt revealed that, the energy content of the solid wastes was observed to be 18.43MJ/kg which is significant and hence can be used for electric energy generation at the University campus. (JOST. 2010.1(1):29-36)

In that study on the energy content of solid waste it was found that if a combustion power plant were to operate at an assumed overall efficiency of 10% only, about 585KW of electricity would be generated daily. While at 50% efficiency about 2923 KW would be generated daily. (Momoh, O.L.Y., Odonghanro, B and Diemuodeke, 2010).

Another study conducted by Edward S.R (2001) found that about 18million tones of refuse was discharged annually in the United Kingdom and refuse contained sufficient energy to supply about 5% of its energy requirement, this potential together with forecasted depletion of non-renewable fossil fuel reserves led to a serious research into the possibilities of energy recovery from solid waste in our cities.

In the study of energy conservation from municipal solid wastes in Nigeria (2011), analysis and Analysis and evaluation from the work showed that about 2.26 MW of electrical energy could be generated daily from waste per city. (NSE-Technical Transactions 2011.46 (3): 1-9) This is quite significant in the demand for alternative energy sources in Nigeria. (Ujile A.A and Lebele B.T.2011) **2.9** In the paper by Mehmet Melikoglu (2012) titled: 'Vision 2023: Assessing the feasibility of electricity and biogas production from municipal solid waste in Turkey'. Turkey imports most of its energy. However, according to the recently avowed vision 2023 agenda the country also plans to produce 30% of its electricity demand from renewable energy sources by 2023. Meanwhile, each year around 25 million tonnes of municipal solid waste (MSW) is generated nationwide . Not only MSW pollutes the environment handling, proes sing and storage requires precious labour and capital . In that context, a synergistic solution can be created between MSW management and energy supply. In this study , economics and environmental impacts of electricity generation from MSW via (i) direct combustion and (ii) biogas harnessing in 81 cities of Turkey is analysed in detail for a period between 2012 and 2023. Firstly, it is estimated that nationwide 8500 GWh of electricity could have been generated by direct combustion of MSW in 2012. This is predicted to rise 9700 GWh in 2023 . It is calculated that 3100 million m^3 of methane would be emitted from the landfills of Turkey in 2012. If no action taken this would rise to 3600 million m^3 in 2023. Furthermore, it is estimated that by capturing 25% of this methane via landfill bioreactors 2900 GWh or 0.5% of Turkey's annual electricity demand could be supplied in 2023. Simulations also showed that by realizing apposite landfill investments by 2023 annual energy savings worth 200–900 million h could be generated from MSW. Consequently, this could lead to greenhouse gas emission savings up to 11.0 million tonnes of CO_2 per annum. (Renewable and Sustainable Energy Reviews 19 (2013) 52–63).

METHODOLOGY

The method to be employed in carrying out this research is as follows:

- Literature review made from past work.
- Data determination with the Bauchi State Environmental Protection Agency (BASEPA) and the Cosmopolitan Cleaners.
- Practical determination and evaluation of the energy potential of the solid wastes collected per unit mass using a digital calorimeter.
- Analysis and evaluation of the data.

1.1DATA PRESENTATION AND ANALYSIS

The number of trips made to the final disposal sites for the three major areas of the town on a daily basis were recorded and presented in the table below.

TABLE 1: SOLID WASTE COLLECTON IN BAUCHI

Part of the town	Number of trips/day	Mass of waste disposed/day *(Kg/day)*	Volume of the waste *(m^3/day)*
Southern area	25	32,212.50	67,50
Central area	27	34,789.50	72.90
Northern area	23	29,635.50	62.10
Total	75	96,637.50	202.50

TABLE 2: WASTES COMPOSITION FOR SOUTHERN AREA OF THE TOWN

S/N	**Waste material**	**Composition by mass (kg/day)**	**Composition by percentage (%)**
1	plastics/rubbers/polyethene bags (A)	8,697.40	27
2	Textile materials, leathers, wood (B)	7,408.88	23
3	Grasses, sugar cane bagasse, crop stalks (C)	6,764.63	21
4	Papers, cartons (D)	4,831.88	15
5	Tins, cans, glasses bottles (E)	1,610.63	5
6	Animal bones/horns and dungs (F)	966.38	3
7	Ashes/Dusts/Dirt (G)	644.25	2
8	Remaining (H)	966.38	3
	Total	**32,212.50**	100

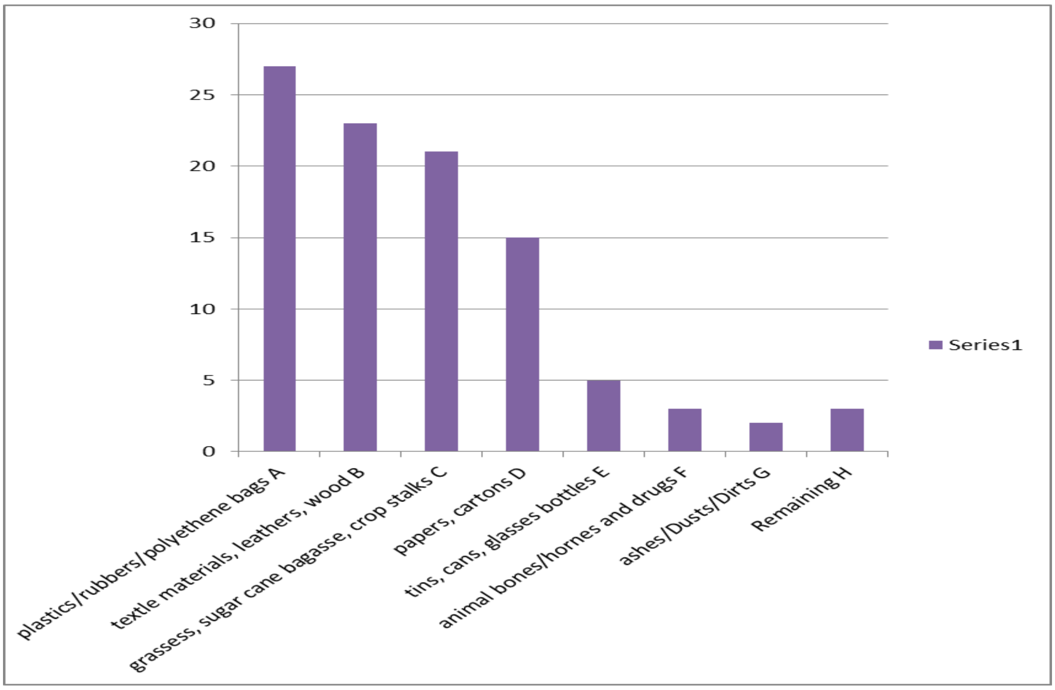


Figure 1.Waste composition for southern area

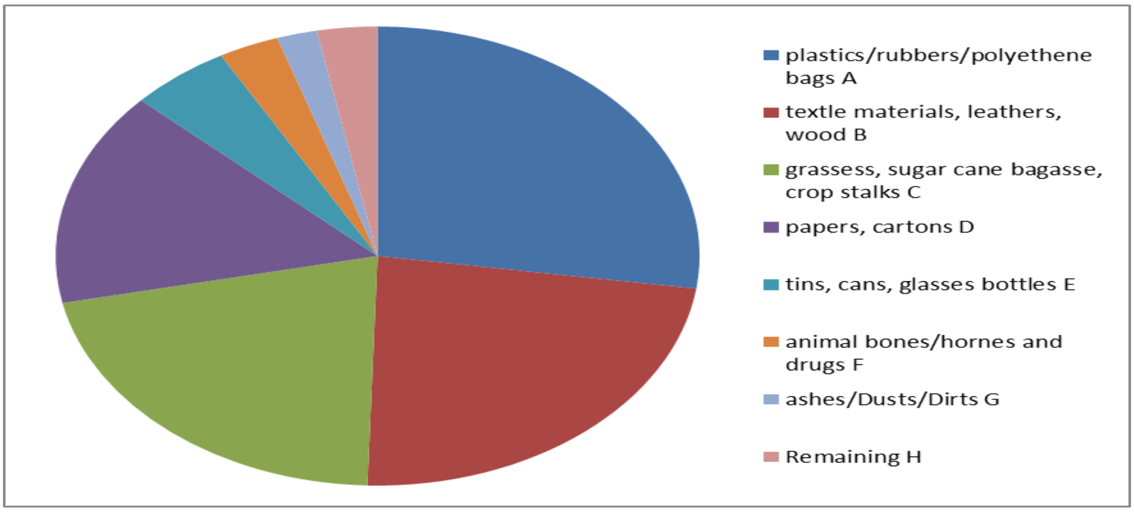


Figure 2. Waste composition for southern area

TABLE 3: WASTES COMPOSITION FOR CENTRAL AREA OF THE TOWN

S/N	Waste material	Composition by mass (kg/day)	Composition by percentage (%)
1	plastics/rubbers/polyethene bags (A)	9,741.06	28
2	Textile materials, leathers, wood (B)	8,696.38	25
3	Grasses, sugar cane bagasse, crop stalks (C)	6,610.00	19
4	Papers, cartons (D)	5,914.22	17
5	Tins, cans, glasses bottles (E)	2,087.37	6
6	Animal bones/horns and dungs (F)	347.90	1
7	Ashes/Dusts/Dirt (G)	1,043.69	3
8	Remaining (H)	347.90	1
	Total	**34,789.50**	100

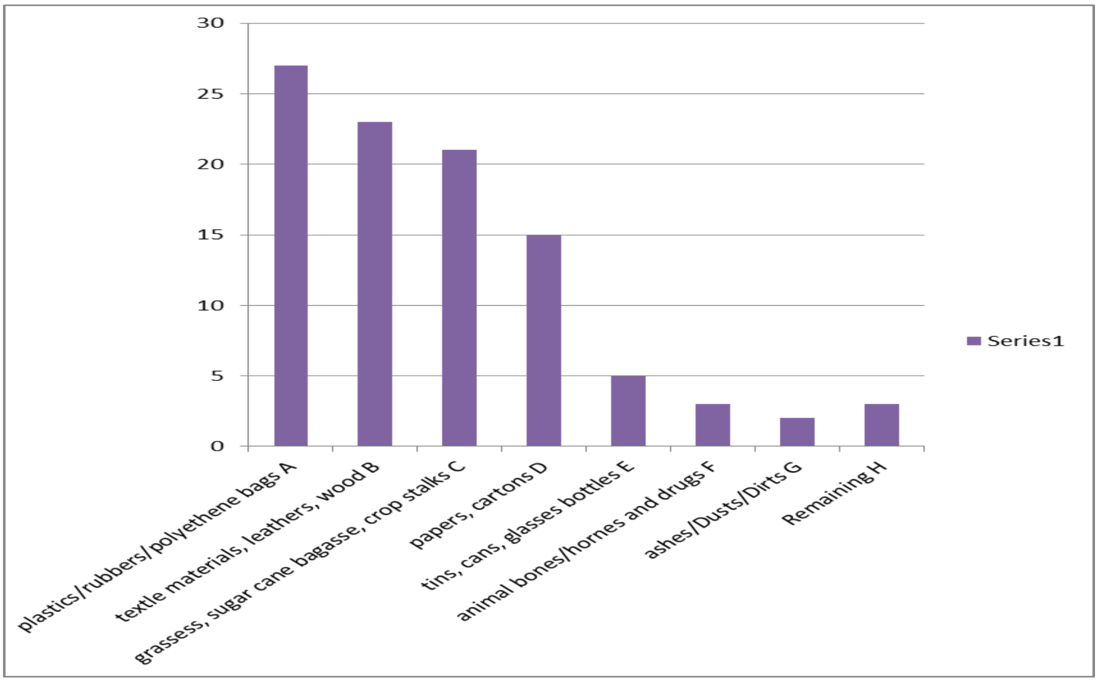


Figure3.Waste composition for central area

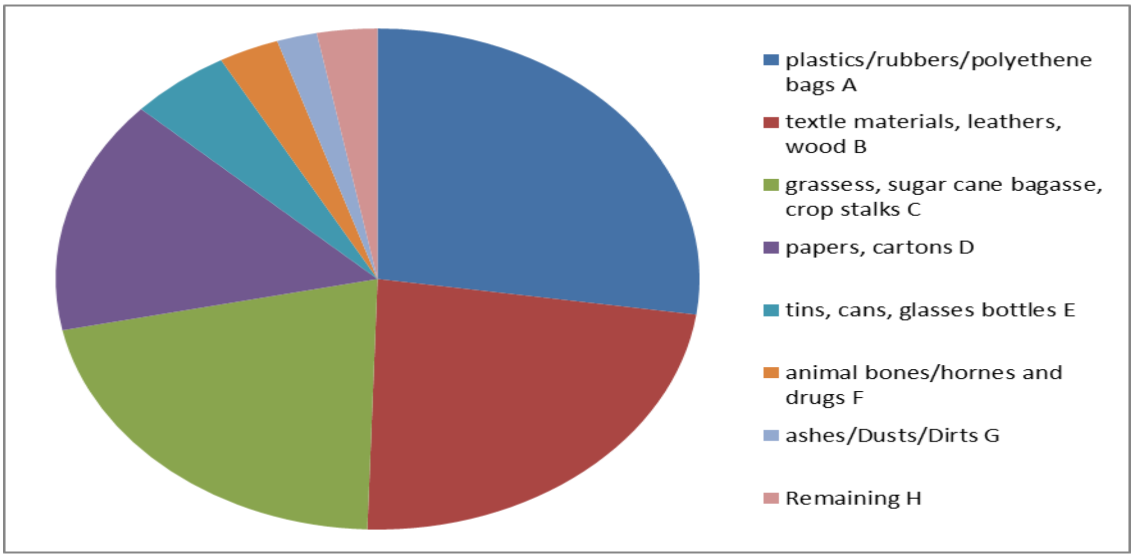


Figure 4. Waste composition for central area

TABLE 4: WASTES COMPOSITION FOR NORTHERN AREA OF THE TOWN

S/N	Waste material	Composition by mass (kg/day)	Composition by percentage (%)
1	plastics/rubbers/polyethene bags (A)	7,705.232	26
2	Textile materials, leathers, wood (B)	6,519.81	22
3	Grasses, sugar cane bagasse, crop stalks (C)	8,001.59	27
4	Papers, cartons (D)	4,741.68	16
5	Tins, cans, glasses bottles (E)	1,481.78	5
6	Animal bones/horns and dungs (F)	592.71	2
7	Ashes/Dusts/Dirt (G)	296.36	1
8	Remaining (H)	296.36	1
	Total	**29,635.50**	100

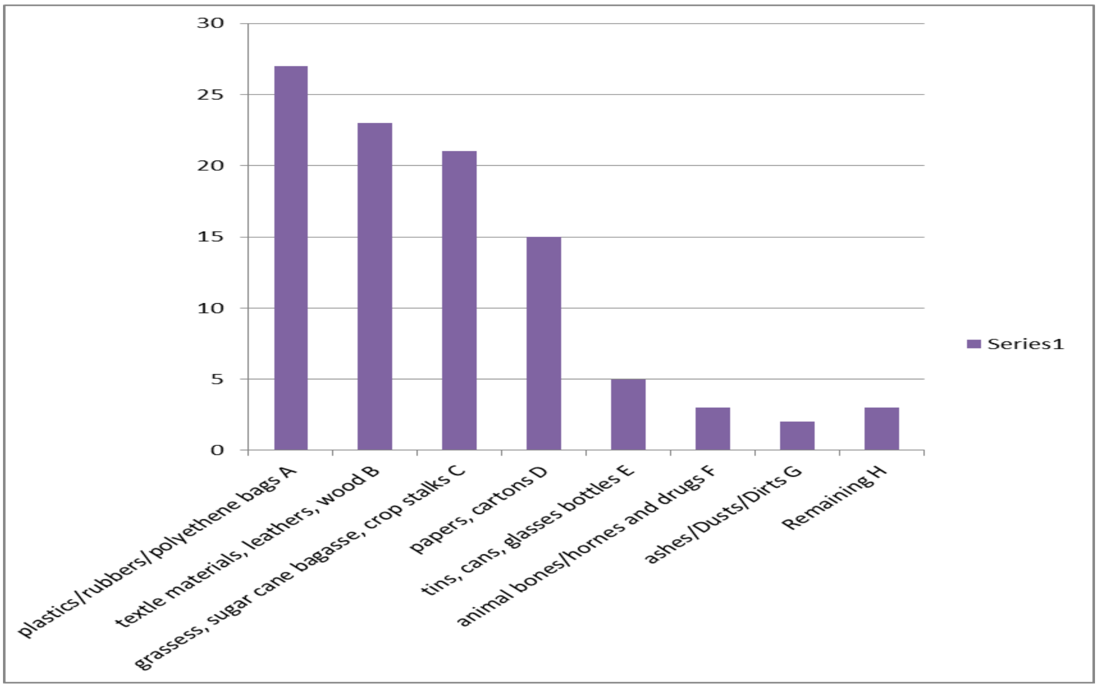


Figure 6. Waste composition for Northern area

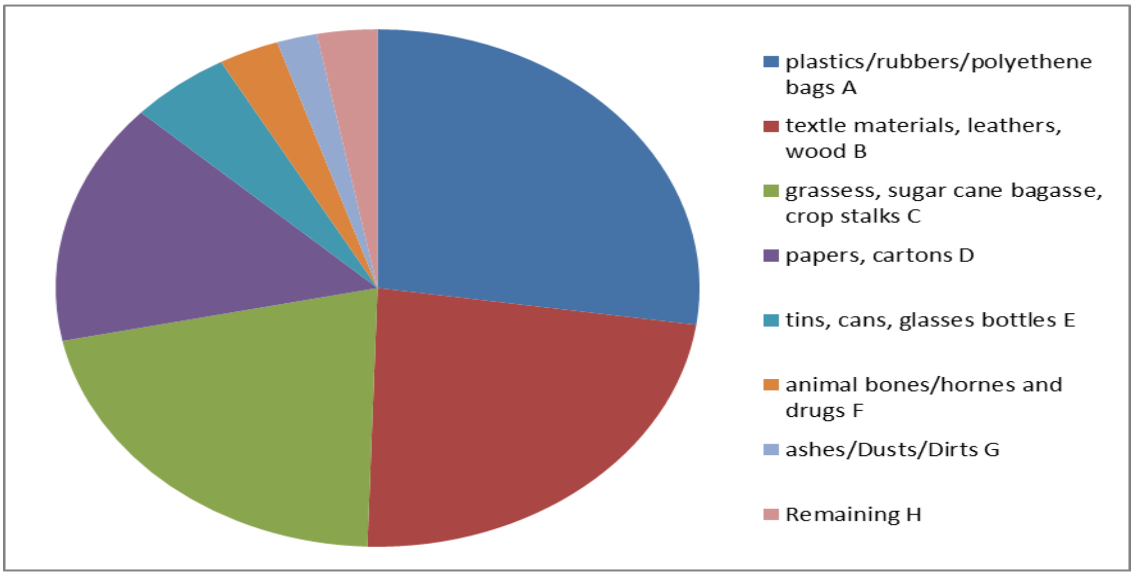


Figure 5 Waste composition for northern area

1.2 ENERGY POTENTIAL OF SOLID WASTE IN BAUCHI

The energy potential of solid waste disposed in Bauchi was determined practically and therefore can be ascertained whether it could be harnessed as a source of energy especially for electricity generation when burnt in a controlled incinerators whereby, the heat produce and from the combination of these wastes is utilizes in boilers that convert water to high pressure steam which in turn can drives turbine that convert mechanical energy to electrical power

1.3 SAMPLE DETERMINATION OF ENERGY POTENTIAL OF SOLID WASTES COLLECTED

Plastic, rubbers, polyether bags for the three areas were 8,67.40, 9,741.06 and 7,7,05.23kg/day respectively. Average would give 8,714.56 kg/day referring to table 4 for, moisture of plastics of about 2%, then the components would give = 8714.56 x (100-2)% =8714.56 x 0.98=8,540kg/day dry solid waste. Same procedure was followed to come up with the average dry solid component of solid waste collected.

TABLE 5: DRY COMPONENT OF THE SOLID WASTE COLLECTED.

S/N	Waste material	average of the material (kg/day)	Average percentage (%)
1	plastics/rubbers/polyethene bags (A)	8,540	33
2	Textile materials, leathers, wood (B)	6,788	26
3	Grasses, sugar cane bagasse, crop stalks (C)	2,850	11
4	Papers, cartons (D)	4,853	19
5	Tins, cans, glasses bottles (E)	1,554	6
6	Animal bones/horns and dungs (F)	190	0.7
7	Ashes/Dusts/Dirt (G)	609	2
8	Remaining (H)	494	1.9
	Total	**25,878**	**100**

1.4 ANALYSIS OF THE RESULT

The value obtained is an approximation because there are variations in the nature and content of the wastes collected and that the mean of the waste is used. Never-the-less, a sufficiently high value is realized w/hen compared with the calorific value of sub-bituminous coal which is 19.4 MJ/kg (EPRT,1997) and (USDOE,1997), therefore with an average value of 6.43 MJ/kg and a total solid waste collection rate of about 96 tones per/day from the city of Bauchi as determined, if simulation of electrical output is carried out 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 (8)

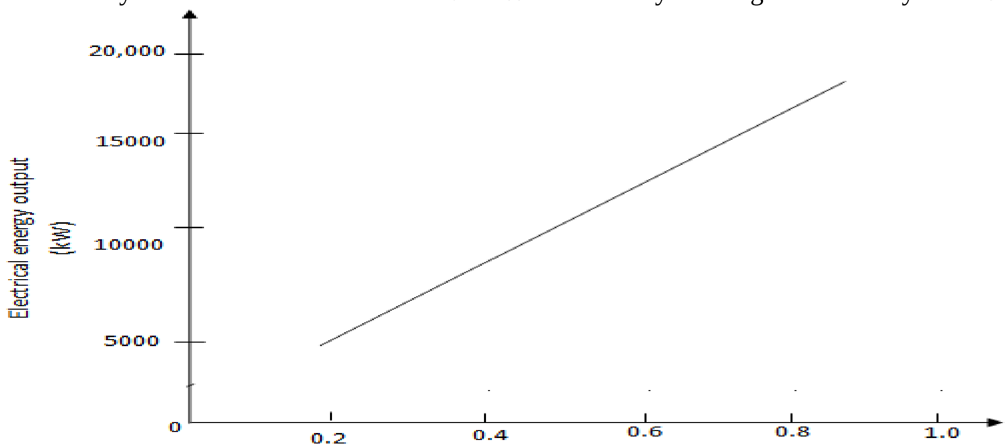
$$Efficiency\ \eta = \frac{Electrical\ energy\ output}{Energy\ input} \qquad \text{…………………………..(8)}$$

For the purpose of this study the energy input is the product of solid waste which is the fuel (about 96,637kg/day) and the calorific value of the waste in MJ/kg (Edward S.R2001).
That is energy input = mass flow rate of fuel x calorific value of fuel
Therefore, electrical output =efficiency x mass flow rate fuel x calorific value of solid waste.
Thus the potential for electrical energy generation for a fuel feed rate of 96,637kg/day, calorific value of 6.43MJ/kg and assumed overall efficiency values ranging between 0.1 and 1.0 can be projected as shown in figure (5) but 1MJ/s=1MWof electricity energy. For instance if the incinerator power plant were to operate as an assumed overall efficiency of 0.1 (10%), then the energy output would be as follows.

$$E = 96637\ kg/day\ x6.43\ MJ/kg\ x\ 0.1$$

$$E = 62{,}138\mathrm{MJ/day} = 0.72\ \mathrm{MJ/s}$$

It can be seen that if the plant was to operate at 10% efficiency, as much as 0.72 MW of electricity can be generated daily in Bauchi while as much as 3.6 MW of electricity can be generated daily at 50% efficiency



Assumed overall efficiency
Figure 6:. Relationship between simulated electrical energy output and power plant assumed efficiencies.

1.5 CONCLUSION

The solid waste generated in Bauchi was observed to be comprised largely of combustible materials, like plastics, polyethene, food waste and yard waste and so on. The average calorific value of the wastes was observed to be about one-third of sub-bituminous coal. The suitability of the solid waste generated in Bauchi as a source of energy in mass-fired incinerator was assessed to be a feasible source of electrical energy even if the mass-fired incinerator operated at an efficiency of 40%.

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