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Comparative Study of Biogas Generation from Chicken Waste, Cow Dung and Pig Waste Using Constructed Plastic Bio Digesters

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Abstract: *Biogas generation in Nigeria has been an alternative area of research towards energy generation due to the energy problem faced by the country and an alternative method for waste management through waste to wealth programme of the government. In this research work, three bio digesters were constructed using locally sourced materials and fed with waste in the ratio 1:2 (i.e. waste: water) for chicken waste and pig waste and 1:3 for cow dung to obtain homogeneous mixture. The parameters such as temperature within and outside the digesters, volume of gas generated by each waste were observed and recorded. The graph of average daily temperature of the bio digesters and ambient were plotted against retention time/day. The gas chromatography of the gas generated from each digester was also carried out to determine the constituent of the gas. The results show that chicken waste generated 71.39% methane gas, 0.48% Ammonia, 1.75% Carbon II Oxide, 0.65% Hydrogen Sulphide and 25.73% Carbon IV Oxide. Cow dung generated 62.68% methane gas, 0.38% Ammonia, 1.39% Carbon II Oxide, 0.13% Hydrogen Sulphide and 35.42% Carbon IV Oxide. Pig waste generated 61.07% methane gas, 0.48% Ammonia, 1.73% Carbon II Oxide, 0.16% Hydrogen Sulphide and 36.56% Carbon IV Oxide. Also, Chicken waste generated the highest volume of gas followed by pig waste and cow dung generated the least volume with the same retention time as evident in the size of the tyre tubes used as gas collector from the dryers*.

Keywords: *Ambient, Biogas generation, Bio digester, Chromatography, Methane gas, Retention time, Waste to wealth.*

1. INTRODUCTION

The importance of energy in national development cannot be over-emphasized. Energy is the hub around which the development and industrialization of any nation revolve. It is a fact that any distortion in energy supply chain at any point in time results into serious economic and social hardship [1]. Therefore provision of adequate, affordable, efficient and reliable energy services with minimum effect on the environment is crucial. Many countries depend on fossil fuels for their energy needs. However, this is increasingly becoming unsustainable because fossil fuels cause ecological and environmental problems [2] and are depleting rapidly. Problems associated with non-sustainable use of fossil fuels have led to increased awareness and wide spread research into the accessibility of new and renewable energy resources [3],[4].

Biogas is a combustible gas consisting of methane, carbon (IV) oxide and small amount of other gases and trace elements. It is a biomass resource which is said to be ideal in deciding alternative sources of energy. It is obtainable for other purposes such as heating, lighting of lamps and small scale generation of electricity.

Biogas technology is a renewable, alternative and sustainable form of energy which decomposes waste to produce energy, fertilizer and reduce environmental pollution. Biogas is energy generated from organic materials under anaerobic conditions. Feed stocks for biogas generation include cow dung, poultry droppings, pig manure, kitchen waste, grass faecal matter and algae. Countries where agriculture sector is an important component to the growth of economy, have found biogas as a useful replacement for wood fuel and dung as fuel for cooking, and heating [5].

Considerable numbers of poultry and animal husbandry industries exist in Nigeria today. Substantial quantities of wastes (droppings and remains) arising from them pose serious environmental pollution and disposal issues. These wastes can be recycled to produce biogas through a process called anaerobic digestion or fermentation. Anaerobic digestion involves the breakdown of complex carbohydrates to form fermentable substrates which is converted to biogas in a biodigester.

A bio digester is an anaerobic tank which digests or decomposes organic material biologically to yield Methane (a potent greenhouse gas) which is not released into the atmosphere but instead used for the purpose of cooking, lightning, and heating [6]. Biodigester play important role in the recycling of organic wastes, producing methane-rich gas for cooking, with positive impacts on the environment, human and animal health.

Agricultural bio digesters are seen as a viable means to reduce greenhouse gas (GHG) emissions while generating clean energy for on-farm consumption and to sell to power companies. Through anaerobic digestion, bio digesters decompose organic compounds in waste material to methane (CH_4) and carbon dioxide (CO_2). The subsequent capture and combustion of CH_4 can result in a reduction in GHG emissions compared to traditional waste management [7]

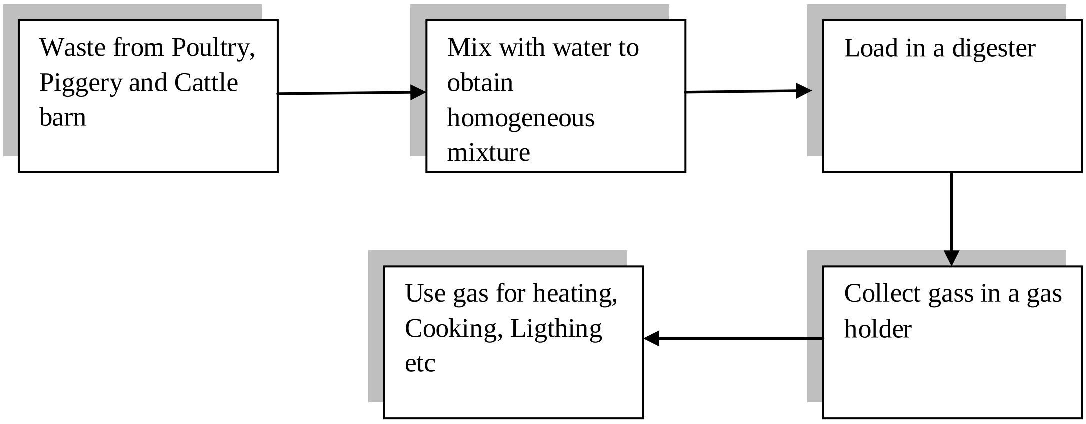

Fig 1. *Flowchart of biogas production from raw waste*

2. METHODOLOGY

The type of bio digester constructed for this research work is the floating drum type using plastic drum.

2.1. Materials for Constructing the Biodigester and Cost Implication

The materials used for the construction of the digesters are as follow:

Table 1. *Cost implication of materials used for the construction of bio-digesters*

QTY	MATERIALS	RATE	AMOUNT
1	Plastic drum	4500.00	4500.00
2	2” Air value	800.00	1600.00
3	2” Bend	300.00	900.00
1	¾ Air value	250.00	250.00
1	½ Air value	150.00	150.00
1	2” Tee	300.00	300.00
1	2” Thick Pipe	800.00	800.00
1	PVC cement(glue)	500.00	500.00
1	Nylon	1000.00	1000.00
1	16 yards of net	1000.00	1000.00
1	¾ pipe	300.00	300.00
4	Thermometer	500.00	2000.00
2	4 minutes	400.00	800.00
1	Round file	150.00	150.00

3	Pressure gauge	1500.00	4500.00
2	One High quality Teflon tape 19mm by 0.2mm by 15m.	150.00	300.00
3	Gas storage device	700.00	2100.00
TOTAL			**21,050:00**

Dimensions of the plastic drum used is tabulated below

Table 2. *Dimension of drum used for the construction*

MEASUREMENT	HEIGHT/cm	DIAMETER/cm	¾ OF THE HEIGHT/cm	VOLUME/ litre
A	90	60	67.5	243.3
B	90	60	67.5	243.3
C	90	60	67.5	243.3

Volume of Drum = $= \pi r^2$h

∴ Volume of Drum = (3.142 x $(30cm)^2$ x 90cm) = 243300 cm^3 = 243.3 litres = 2.433 m^3

2.2. Construction Methods

The plastic drum was perforated and drilled on the top and at the bottom using hot iron rod of diameter approximately equal to that of the PVC pipe and round file was used to file the hole until the PVC pipe tightly fitted into the hole. On the top, four holes were drilled as thermometer opening, gas outlet opening, waste inlet and overflow opening. At the inlet and overflow opening, a pipe measuring 30cm in height was inserted into it from the top. This served as the inlet and overflow of slurry. The hole drilled at the bottom served as the outlet of sludge. The pipes were tightly fitted to the holes of the drum with aid of braces, PVC cement glue and four minute glue. This did not only make the pipes tight-fitted but also aided as a sealant to avoid escape of gases that will be generated during the course of fermentation in the digester. The thermometer was inserted into its opening, a pipe with gas tap was also inserted into the gas outlet opening, which was further connected to the manifold tester to trap the gas and measure its pressure while transferring the gas into the gas collector.

2.3. Source of Waste Used

The wastes used in this study were chicken waste, cow dung and pig waste which was obtained from the Department of Animal Production, School of Agricultural Technology, Lagos State Polytechnic Ikorodu, Lagos State.

2.4. Measurement of Each Waste

10 liters (0.01 m^3) of water	9.8kg
10 liters (0.01 m^3) of Pig waste	11.66 kg
10 liters (0.01 m^3) of chicken waste	10.00 kg
10 liters (0.01 m^3) of cow dung	12.21 kg

2.5. Preparation of Samples

The drums were thoroughly washed with hot water, detergent and left for a week filled with clean tap water before feeding it with slurry. The slurry was prepared by measuring 60 litres (0.06 m^3) of pig waste and poured into the mixing drum. Tap water having a volume of 120 litres (0.12m^3) was added to the waste inside the drum (i.e. in ratio 1:2; waste to water) which also apply to the poultry waste and cow dung was mixed in the ratio 1:3. The slurry was fully stirred manually with a piece of wood until there were no lumps. The waste was transferred to the plastic digester. It was ensured that foreign materials like stone, stick, rubber, sand, gravel, paints, feathers etc. did not enter the digester.

Fig 2. *Chicken waste*

Fig 3. *Cow dung*

Fig 4. *Pig waste*

The digester was stirred occasionally by all round mixing and shaking together of the plastic digester. A thermometer was used to measure the temperature. The temperature of the slurry was observed daily at 30 minute interval for 8 days from 8.00hrs to 17.30hrs through the thermometer that was inserted into the digester. The ambient temperature was also measured with another thermometer. The biogas generated was analyzed using a GC HP 68900 with HP ChemStation Rev A 09 01 [1206] Software to determine the constituents and percentage composition of each gas contained in biogas generated.

3. Results

The three digesters produced gas suspected to be biogas with chicken waste generating gases within 24 hours of loading, pig waste generating gases after three days of loading and cow dung generating gas after seven days of loading. It was also observed that Chicken waste generates the highest volume of gas(Figure 5) followed by pig waste (Figure 6) and cow dung generates the least volume of gas (Figure 7) as evident in the size of the tyre tubes after opening the gas valve. Pressure is also observed to be constant throughout the retention days.

Fig 5. *Biogas generated from chicken waste*

Fig 6. *Biogas generated from pig waste*

Fig 7. *Biogas generated from cow dung*

Table 3. *Table of average daily temperatures in digesters and ambient per day*

	AVERAGE DAILY TEMPERATURE / ^{0}C			
TIME / DAY	CHICKEN WASTE	COW DUNG	PIG WASTE	AMBIENT
1	32.66667	32.66667	32.42857	28.85714
2	32.00000	31.47619	32.57143	27.66667
3	30.52381	31.23810	31.23810	26.95238
4	33.90476	34.52381	34.42857	29.38095
5	32.14286	33.14286	32.66667	29.28571
6	34.47619	34.85714	35.33333	30.09524

7	29.57143	28.14286	27.85714	26.85714
8	30.47619	30.42857	31.52381	27.23810
AVERAGE	**31.97024**	**32.05952**	**32.25595**	**28.29167**

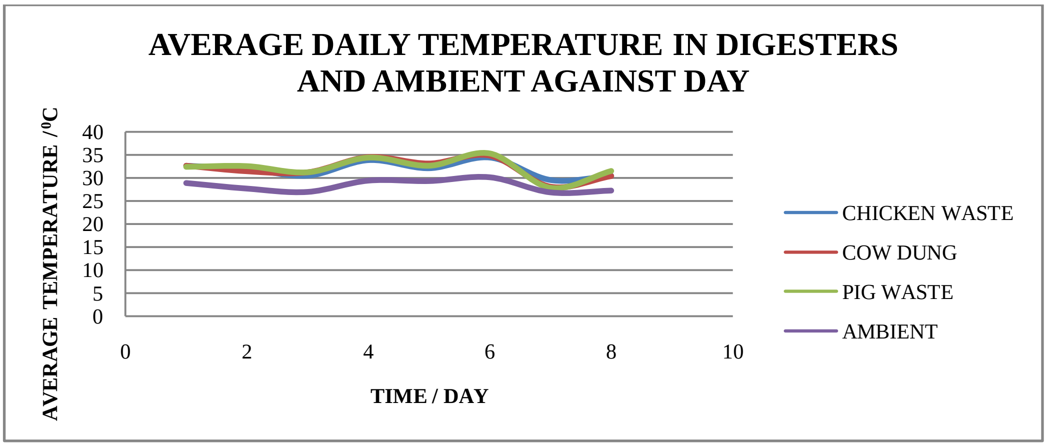

Fig 8. *Graph of average daily temperatures / ^{0}C in digesters and ambient against retention time / day*

Table 4. *Result of biogas analysis for the three wastes using gas chromatography*

WASTE	BIO GAS COMPONENTS / %					TOTAL %
	METHANE (CH_4)	AMMONIA (NH_3)	CARBON II OXIDE (CO)	HYDROGEN SULPHIDE (H_2S)	CARBON IV OXIDE (CO_2)	
Chicken Waste	71.39	0.48	1.75	0.65	25.73	100
Cow Dung	62.68	0.38	1.39	0.13	35.42	100
Pig Waste	61.07	0.48	1.73	0.16	36.56	100

4. Conclusion

In this research work, bio digesters were constructed to generate biogas and fertilizer. The chicken waste, pig waste, cow dung and ambient temperatures were recorded. The graph of average daily temperature in digesters and ambient was plotted against time. The gas generated by each digester was taken for gas chromatography analysis and we observed that the gas generated comprises of Methane, Carbon II oxide, Carbon IV oxide, Hydrogen sulphide and Ammonia. Also chicken waste generated the highest percentage of methane gas followed by cow dung and pig waste generated the least percentage of methane.

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