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Production of Biogas from Saw-Dust and African Dwarf Goat Excreta

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***Abstract**: Due to energy availability been expensive and ecological disasters in the environment and aquatic life caused by organic waste disposal, numbers of renewable energy sources such as Biogas which is a colourless and flammable gas generated by the depletion of plant and animal waste by microorganisms under an anaerobic condition have been researched on.This study was launched into the construction of an Anaerobic batch-digester system using local technology and the production of biogas from Saw-dust and African dwarf goat excreta. The result showed that the feeding of 250grams of Slurry into the digester resulted to the evolution of 3.5cm^3 volume of Biogas on the sixteenth day at a temperature range of 22^{0}C-32^{0}C and pH range of 6.0-8.0 respectively. There was an increase in the biogas yield as the days increased from 1-22 days. The micro flora isolated from the substrates included Escherichia Coli, Staphylococcus spp, Bacillus spp, Clostridium spp, Pseudomonas spp and Enterococcus spp. Microbial digestion of the combined matrix of African dwarf goat excreta and saw-dust yielded biogas significantly. Developing countries in Africa especially Nigeria should also invest into an alternative energy source such as Biogas which could be used to an extent to resolve her energy scarcity, environmental disaster and enhancement of poor soils.*

***Key Words:** Biogas, microorganisms, anaerobic digestion, saw-dust and African dwarf goat excreta.*

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I. Introduction

The depletion of organic materials such as manures, green waste, biomass, sewage, energy crops and animal waste leads to the formation or the production of a biogas at pH between 6.0-8.0 and ambient temperature between 28^{0}C – 40^{0}C in a bioreactor (digester) under anaerobic condition (Ntengwe *et al.,* 2010). Biogas production sources can be from any organic material of plant or animal which can be bio-degraded easily.Crops residue, wet cow dung, vegetable wastes, water hyacinth, algae, poultry or piggery droppings, human etc are the main sources of biogas production (Soranthia *et al.,* 2012).Biogas composition depends on the type of substrate used. Human excreta or soil based biogas contains 65-66% CH_4, 32-34% CO_2, by volume and other gases in traces. While municipal solid wastes contain 68-72% Methane, 18-20% Carbon dioxide, and 8% Hydrogen Sulphide(Elango*et al*., 2007).Sawdust can be used based on special physical properties which includes absorbent, nonconductive, bulky fibrous, and granular for textured surfaces as fuel, fiber, wood, chemical uses and based board and can be explored as a biogas source using the required techniques. Biogas is collected in a gas drum which rises or falls according to the amount of gas that is produced. It can also be done through the downward displacement of water in the Laboratory using measuring cylinder as the gas collector (Olusola and Omojola, 2013).

Many micro-organisms affect anaerobic digestion including acetic acid forming bacteria (acidogens) and methane-forming bacteria (methanogens), these bacteria support chemical processed in converting the waste to biogas. There are four biological and chemical stages of anaerobic digestion as shown in fig.1:- Hydrolysis, Acidogenesis, Acetogenesis and Methanogenesis (Onojo *et al*., 2013).

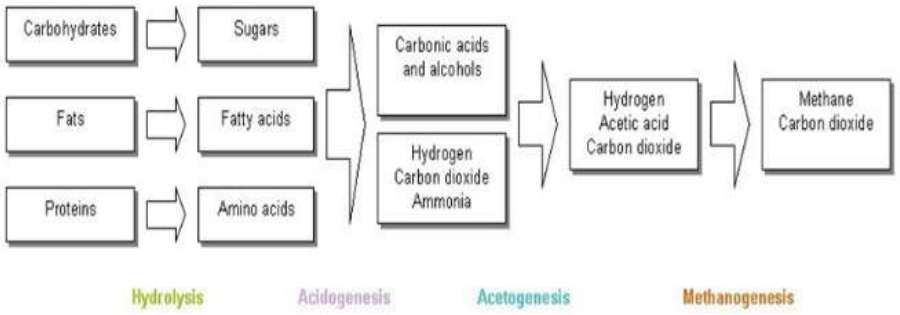

Figure 1: Stages Of Biogas Production(Kozani,2014).

Biogas plant performance can be controlled by studying and monitoring the changes in parameters like pH, temperature, inoculums, retention time when change drastically can affect it biogas production. Certain factors like substrate, volatile fatty acids (VFA). Loading rate can also affects the production of biogas but few would be mention (Diho*et al.,* 2013)

II. Materials and Methods.

SAMPLE COLLECTION

Sawdust was collected from Bori timber market and the African dwarf goat excreta used was collected from Looyoo community all in Khana Local Government Area of Rivers State, Nigeria. The samples were taken to the school laboratory for further analysis.

SAMPLE PREPARATION

The African dwarf goat excreta was dried in a crucible and grinded with the aid of a clean mortar and pestle and stored in a cool dry place.

PREPARATION OF REAGENT

Acidified water was prepared in a basin by adding 0.03ml Sulphuric acid (H_2SO_4) into 3000cm^3 of water, this acidified water was used to prevent the dissolution of the biogas generated into the water. A measuring cylinder was inverted over the basin containing the acidified water. The measuring cylinder served as a measuring scale as well as a gas collector

DESIGN OF DIGESTER

The digester container was made of a two liters capacity plastic bottle.A cylindrical glass tubes were placed on the cover of the containers. A pencil was used t mark out the area of the glass tubes and with the aid of a hot nail, holes were made on the marked areas. The glass tube was connected to the hole and glued.A z-joint delivery tube was connected to the glass tube was connected to the glass tube with the aid of a 4cm gas hose to ensure tightness and the digester containers were labeled A and B.

METHOD

A weighted amount of saw dust 100grams was poured into the buckets labeled A and B. Distilled water of 50cm^3 volumewas poured into the buckets containing the sample to dissolved the saw dust.150g of goat excreta was weighed and turned into the buckets A and B and 120cm^3 of distilled water added to each of the buckets and properly stirred to obtain a homogenous mixture and that formed the slurry. Bucket A and B slurry were therefore fed into their labeled airtight digester bottles with the aid of a filter paper. Each of the digester bottles were connected to a measuring cylinder inverted over an acidified water in a trough as shown in **figure 2**.

PARAMETERS ANALIZED

VOLUME OF GAS PRODUCE DAILY:- As the experiment continuous, the volume of the gas is observed daily using measuring cylinder and water displaced by the gas during the production process.

pH OF THE DIGESTER :- A pH meter was used to check the pH of the digester at the beginning and at the end of the experiment.

TEMPERATURE OF THE DIGESTER CONTENT:- The temperature of the digester content were determined daily using a thermometer.

MEASURING THE RETENTION TIME:- The time between the commencement of the gas production and the termination of the experiment was determined using the measuring cylinder reading.

MEASURING THE AMOUNT OF GAS PRODUCED AT THE END OF THE EXPERIMENT; At the end of the experiment, the quantity of biogas produced was determined using the measuring cylinder reading.

Figure 2: Experimental Set-Up For Biogas Production

2.2 MICROBIAL ANALYSIS (BACTERIA)
STERILIZATION OF MATERIALS
All glass wares used in this work were sterilized in the hot air oven at 160^0c
For 1 hour. Inoculating wires were sterilized by flaming to re-hot using Bunsen flame while hockey stick or spreader was sterilized by dipping into alcohol and flaming.

MEDIA PREPARATION: The media used in this study was nutrient agar and was prepared according to manufacturer's instruction. The agar medium were sterilized in the autoclave at 120^0C for 15mins.
SAMPLE PREPARATION: From the three separate samples obtained, 1g of each of the samples were weighed and transferred into a sterile separate beakers labeled A,B and C, 9ml of sterile water was poured into each of the beakers to give a stock solution, the samples were mixed thoroughly and allowed stand for 10minutes.

SERIAL DILUTION
A five (5) fold serial dilution of each sample was carried out by pipetting 1ml of the homogenate into the first test tube labeled 10^{-1}containing 9mlof sterile water. A 1ml was also pipetted into the second tube labeled 10^{-2} and this continue till all the tubes were treated for all samples A, B and C.**ISOLATION OF ORGANISM**
The pour plating method of isolation was used in this project work. This was done by introducing an aliquot (0.5ml) of each of the serially diluted sample into the petri dishes containing prepared agar. This was done for all the serially diluted samples using an aliquots of 10^{-2},10^{-3}, 10^{-4} and 10^{-5} test tubes.

SUB/PURE CULTURING OF ORGANISM
Sub culture of each bacterial isolates was done using the streaking method. Each bacterial colony was collected with sterile wire loop and streaked on a freshly prepared nutrient agar and incubated at 37^0C for hour. From this sub-culture, the organism was made pure by streaking on another surface of freshly prepared agar in a slant bijou bottle and incubated at 37^0C for 24hours before morphological and biochemical characteristic of each isolate was carried out.

PREPARATION OF MICROORGANISMS FOR GRAM STRAINING

Using a wire loop – full of distilled water a drop was placed on a clean dry glass side. After flaming the wire loop and allowed to cool, the inoculate from the slant cultures were mixed with distilled water to make thin films. The smears were left to air dry in a safe place, protected from dust after which they

III. Result And Discussion

The volume of gas harvested per day, temperature and pH of the digester for a retention time of 22 days were tabulated as shown on the table 1.

TABLE 1: The volume of gas harvested per day, temperature and pH of the digester.

DAY(S)	TEMPERATURE(^{0}C)	VOLUME OF GAS(Cm^3)	PH
1	22^{0}C	0	6.0
2	25^{0}C	0	
3	24^{0}C	0	
4	27^{0}C	0	
5	28^{0}C	1.0	
6	32^{0}C	1.5	
7	25^{0}C	1.5	
8	26^{0}C	1.5	
9	25^{0}C	1.5	
10	27^{0}C	1.5	
11	28^{0}C	1.6	
12	29^{0}C	1.7	
13	32^{0}C	2.6	
14	30^{0}C	3.1	
15	29^{0}C	3.1	
16	31^{0}C	3.5	
17	28^{0}C	3.5	
18	29^{0}C	3.5	
19	28.5^{0}C	3.5	
20	27.5^{0}C	3.5	
21	28^{0}C	3.5	
22	28.5^{0}C	3.5	8.0

Table 2: Biochemical characterization and identification of bacteria isolated from sample A(Saw-dust), sample B (Goat excreta)and sample C (Digested slurry).

SAMPLE CODE	CULTURAL CHARACTERISTICS	GRAM STAINING		OX	CA.	IN.	CIT.	PROBABLE GENERA
		GR	SHAPE					
AI_1	Milky tiny mucoid, round, smooth edges	+ve	Coci	+ ve	+ ve	+ ve	+ve	Staphylococcus spp.
AI_2	Milky pigment, flat, Rough edges that covers the petri dish	+ve	Rod with center spores	+ve	-ve	+ve	+ve	Bacillus spp.
AI_3	Pink pigment, moist surface, round and smooth edges.	-ve	Tiny rod	- ve	- ve	+ ve	- ve	E.coli spp.
BI_1	Tiny milk pigment, raised smooth edges, dry surface	+ve	Coci	+ ve	+ ve	+ ve	+ve	Staphylococcus spp.
BI_2	Large milk pigment, raised rough edges with moist surface	+ve	Rod with spores	+ ve	+ ve	- ve	- ve	Clostridium spp.
CI_1	Large milk raised rough edges with moist surface	+ve	Rod with spores	- ve	+ ve	- ve	- ve	Clostridium spp.
CI_2	Tiny milk, flat, moist surface, rough and smooth edges	-ve	Rod	+ ve	+ ve	- ve	+ve	Pseudomonas spp.
CI_3	Cream pigment, flat, smooth edges and moist surface	+ve	Oval	+ ve	+ ve	- ve	+ve	Enterococcus spp.

KEY: AI=isolates from sample A; BI= Isolates from sample B; CI= Isolate from sample C; GR= Gram reaction; +ve = Positive; -ve= Negative; Ox=Oxidase; CA=Catalase; CIT= Citrate; IN= Indole.

3.1 DISCUSSION

The pH range (6.0-8.0) showed an initial acidic value before assuming a value towards alkalinity level. Methanogenic and acetogenic bacteria are sensitive to pH variation,pH range of 6.0 and 7.8 are the best for Methanogens and acidogenas seen in this study which is in conjunction with the findingsof Gungor and Karthikeyan (2005) and Dahunsi and Oranusi (2013) in which the highest yields of biogas were observed at pH 8.

The temperature of the digester remained constant at a moderate range of (22^0C-32^0C) throughout the fermentation period as observed from table 1 temperature was so critical for an anaerobic digestion since methane producing bacteria are active mostly at mesophilic temperatures ranges (32^0C -42^0C) or thermophilic temperature ranges (49^0C -60^0C) (Akwaka *et al.*, 2014).

Gas production on started on the fifth day, it increased on the sixth day and gave on constant value until the tenth day. It kept a steady increase rate and reached the peak on the sixteenth day before been linear,or giving a constant reading of 3.5cm^{3}volume of biogas as shown on table 3 and the gas was soluble in water.It is in agreement with the findings of(Petronela *et al.*,2013) on the analysis and modeling of the solubility of biogas components in water for physical absorption processes.

The groups of bacteria isolated from the digester feedstock and digested slurry were *Staphylococcus spp, Bacillus spp, Clostridium spp, Pseudomonas, Enterococcus and Escherichia*coli some of which are acid formers. This is in agreement with the work of Dahunsi and Oranusi (2013) who reported a similar result when they isolated fungi,*Bacillus spp, Escherichia coli spp, Clostridiumspp* and other bacteria from co-digestion of food waste and human excreta for biogas production and Asikong*et al.*, (2016) who investigated micro-organism associated with biogas production using vegetable *(Telfariaoccidentalis)* waste, banana peel and pig-dung as substrates.Isolated anaerobic bacteria such as *Pseudomonaspp, Escherichia Colispp, Bacillusspp, Staphylococcusspp,* other bacteria and fungi.

IV. Conclusion

The result of this research has shown that organic waste materials such as Saw-dust and African dwarf Goat Excreta can be utilized by micro-organisms such as*Escherichia coli spp, Staphylococcus spp, Bacillus spp, Clostridium spp, Pseudomonas spp and Enterococcus spp* for Biogas Production.Also, temperature range of (22^0C-32^0C), pH range of (6.0-8.0) and 3.5cm^3 volume of biogas were observed.

From the result of the research carried out, it is recommended thatcertain factors like temperature, pretreatment and co-digest substrate should be given a proper attention to enable a proper yield of biogas from the substrates which can arrests energy scarcity and ecological disaster.

Further studies should be carried out on how to arrest the solubility of biogas in water from the digester through downward displacement of water.

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