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Evaluation of Effect of Temperature on the Rate of Bio Gas Production

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Abstract: Nigeria is a country with abundant, diverse and unexploited renewable energy resources that are yet to be used for improving the livelihood of the vast majority of the population. The production of biogas via anaerobic digestion of large quantities of agricultural residues, municipal wastes and industrial waste (water) would benefit Nigeria society by providing a clean fuel from renewable feed stocks and help end energy poverty. There is a consensus that achieving the Millennium Development Goals (MDGs) in Nigeria will require asignificant expansion of access to modern and alternative renewable energy. The study examines the effect of temperature on the rate of biogas production using cow dung and rice husk as substrates. The anaerobic digestion process was conducted at laboratory scale using an aspirator bottle and tins as digester with capacity of 2.4 litres. The efficiency of the anaerobic process is governed by a number of factors. The effect of temperature on production of biogas from organic waste was investigated for a period of 30 days. The digestion temperatures of 25^0C, 37^0C and 45^0C were used during this investigation. The result of the anaerobic digestion indicates that temperature of 45^0C recorded highest volume of biogas (1224cm^3), followed by 37^0C (715cm^3) and 25^0C recorded the lowest (345cm^3) respectively. It was concluded that temperature have great effect on the rate of biogas production and also on the type of substrate used at this temperature.

Keywords: Anaerobic digestion, Biogas, mesophilic, temperature, Rice husk, Cow dung.

1. Introduction

Anaerobic fermentation of organic residues and agricultural wastes is of increasing interest.In order to reduce environmental pollution, greenhouse gas emissions and to facilitate a sustainable development of energy supply, biogas production provides a versatile carrier of renewable energy, as methane can be used for replacement of fossil fuels in both heat and power generation and as a vehicle fuel. The composition of biogas and the methane yield depends on the source of feedstock type, the digestion system, and the retention time (1). In spite of the great benefit in energy generation from organic wastes, Nigeria has not been able to harness this alternative source of energy adequately. This may be attributed to the different variety of energy sources in the country, as well as inability to study adequate optimum conditions required for maximum gas production from waste.

Nigeria rich in terms of fossil fuels such as crude oil, natural gas, coal, and renewable energy resources like solar, wind and biomass. The urban poor and the rural households however still depend on biomass for their energy needs. In developing country like Nigeria, identified feedstock substrate for an economically feasible biogas production includes water lettuce, water hyacinth, dung, cassava leaves, processing wastes, urban refuse, solid (including industrial) wastes, agricultural residues and sewage (2;3; 4; 5).

.Biogas is a gas produced by the biological breakdown of organic matter in the absence of oxygen (6). Biogas is flammable if the methane content is more than 50% (7), it burns with pale blue flame and has a calorific value between 25.9-30J/m^3 and this value (25.9-30J/m^3) depends on the percentage of methane content within the biogas. The gas is called by several other names, such as: dung gas, marsh gas, gobar gas, sewage gas and swamp gas (8).

Biogas comprises about 50-70% methane, 30-40% carbon dioxide and low proportions of other gases such as H_2, N_2 and O_2 (9; 10), the composition of the mixture of biogas depends on the source of biological wastes and management of the digestion process (11; 12). Biogas originates from biogenic material and is a type of bio-fuel (13).The slurry of this process is a residue rich in essential inorganic elements needed for healthy plant growth known as bio-fertilizer which when applied to the soil enriches it without negative effects on the environment (14). Rice husk is an agricultural waste which remains after the processing of the crop. This waste can be changed either by chemical and/or biological means into biogas (15). The biological process may be accomplished either aerobically or anaerobically, depending on the availability of oxygen. The composition of rice husk varies widely as follows: Crude protein, 1.7 - 7.26%; Crude fat, 0.38%; Nitrogen free extract, 24.70 - 38.79%; Crude fiber, 31.71 - 49.92%; Ash, 13.16 - 29.04%; Pentosans, 16.94 -21.95%; Cellulose 34.34 - 43.80%; Lignin 21.40 -46.97% (13). Cow dung and rice husk have potentials for biogas production; large quantities of cow dung and rice husk are produced as processing wastes in Northern parts of Nigeria, which can be used as source of renewable energy.

This work, seeks therefore to evaluate the effect of temperature on biogas production from cow dung and rice husk, with a view to establishing an optimum condition with regards to these factor for biogas generation.

2. Materials and Methods

2.1 Collection of Samples

Cow dungwas obtained from the animal house of Faculty of Veterinary Medicine, Ahmadu Bello University Zariaand rice husk was obtained from Zaria metropolis.Two kilograms of each sample was collected in polythene bags and transported immediately to the Department of Microbiology for analyses.

2.2 Digester Set up

Laboratory scale batch digesters were used made from aspirator and tins.A whole (0.7cm in diameter) was made at the center of the coverof the tins and aspirator bottle which has a capacity of 2.4 litre (digester) by a drilling machine, and rubber tubing was then inserted into the hole. The digesters were sealed with araldite adhesive to prevent leakages and connected with delivery tube which conveys the gas from the digester to the inlet of a Buckner flask containing sodium hydroxide which served as a gas purifying unit. Another rubber tube was connected to the outlet of the Buckner flask and the other end of the tube was connected to separate 1000 cm^3 capacity measuring cylinders which was filled with water inverted into a bowl. The downward displacement of water in each measuring cylinder was taken as a measure of the volume of biogas produced for each digester(16).

2.3 Slurry Preparation

From the prepared samples 200g each of Cow dung and Rice husk was weighed and mixed with $800cm^3$ of water in a beaker to obtain slurries of 1:4 substrates: water ratio, similarly 100g each of the substrate was also weighed and mixed with $800cm^3$ of water to obtain 1:4 substrates: water ratio. The slurry prepared was stirred and allowed to equilibrate over 24 hours. Ten ML of fresh rumen content (liquid portion) obtained from the abattoir was added to serve as starter culture. The effect of temperature digestion was carried out in the laboratory using thermostatically controlled water bath (model DK-420) at temperatures of 25^0C, 37 ^{0}C and 45 ^{0}C The experiments were conducted for a period of 30 days at natural pH of the slurry prepared. Readings were recorded daily and the gas produced was collected by downward displacement of water in measuring cylinder ($1000cm^3$).

3. Results

Table 1 shows results in respect of biogas yield as affected by temperatures. The observation from the Table (1) shows that, the total volume of biogas produced at temperature of 25^0C by cow dung fed digester was $255cm^3$ while rice husk fed digester did not produce any gas at this temperature and cow dung blended with rice husk produced $345cm^3$ this observation revealed that temperature of 25^0C had negative effects on the rate of biogas yield of substrates. Similarly, Table 1 also presents result of biogas yield at temperature of 45^0Cand the observation from the result shows that the total volume of biogas yield from cow dung fed digester was $1104cm^3$ while that of rice husk digester was $24cm^3$ and cow dung blended with rice husk digester was$1224cm^3$, while at temperature of 37^0C, cow dung digester produced $581cm^3$, rice husk produced $8.0cm^3$ while cow dung blended with rice husk produced $715cm^3$. From these results temperature of 45^0C and 37^0C contribute positively to the rate of biogas yield of substrates. The daily yield of biogas in digesters charged with the individual test substrates and the combined substrates was shown in figures 1, 2 and 3 (trends of biogas yield).

Table 1. Total Volume of Biogas Produced at Different Temperatures

Substrates (200g)	**Volume (cm^3) of biogas produced at**		
	25^0C	37^0C	45^0C
Cow dung	225	581	1104
Rice husk	0.0	8.0	24.0
Cow dung + Rice husk	345	715	1224

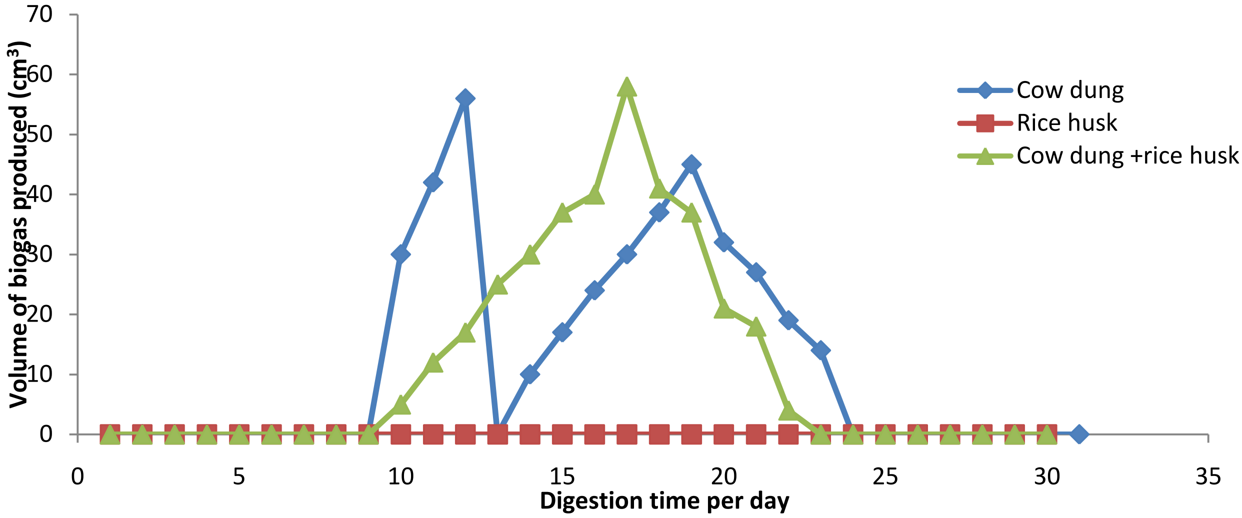

Figure 1: Trends of Biogas Production in the three Digesters at temperature of 25^0C and natural pH of the Slurry

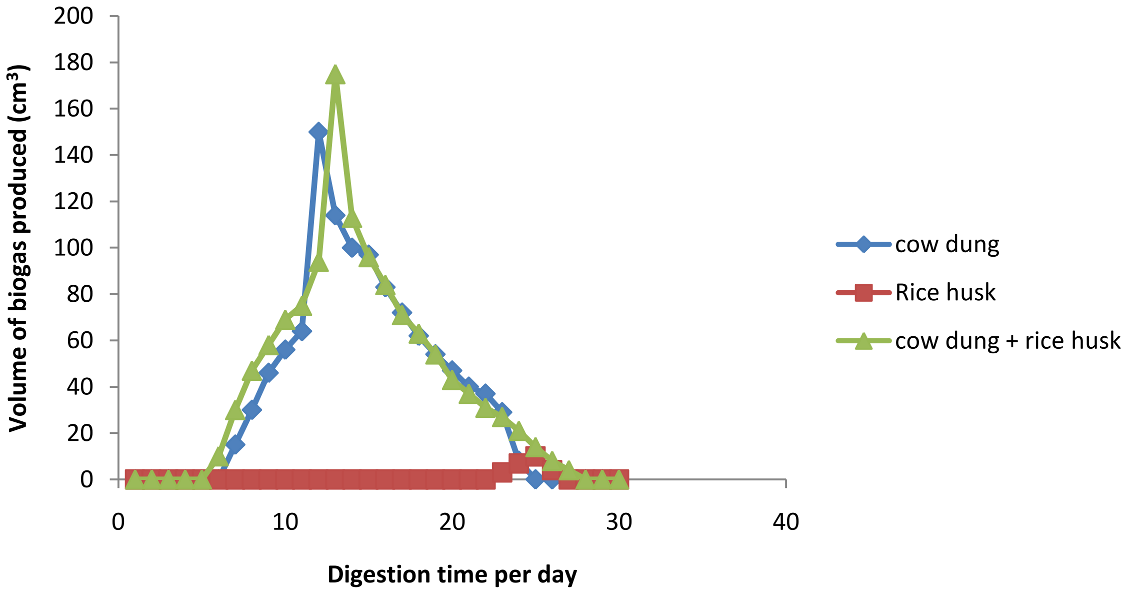

Figure: 2: Trends of Biogas Production in the three Digesters at temperature of 45^0 and natural pH of the Slurry

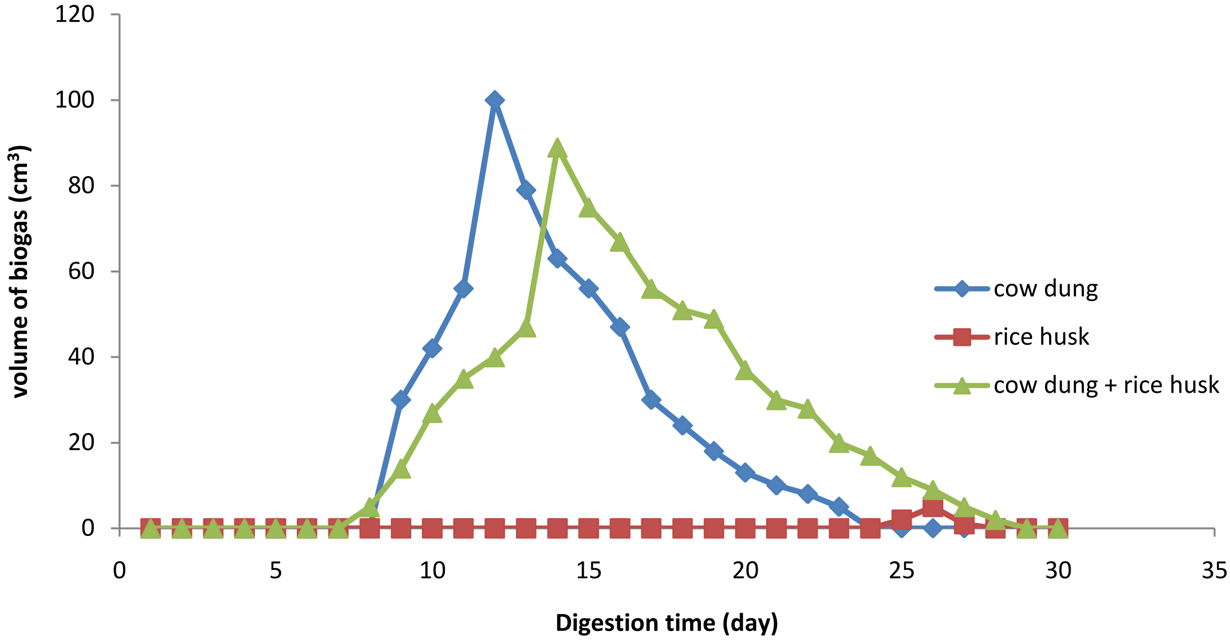

Figure 3: Trends of Biogas Production in the three Digesters at mesophlic temperature (37^0C) and natural pH of Slurry

4. Discussion

The effect of temperature on biogas yield of substrates as showed in Table 1higher quantity of biogas was recorded at temperature of 45^0C (figure 2) follow by temperature of 37^0C (figure 3) and least was temperature of 25^0C (figure 1) this observation shows that anaerobic bacteria are very sensitive to temperature because it has a great effect on the growth, activity and survival of bacteria. At temperature of 45^0C all the reactions inside microorganism like chemical, biological reaction and bacterial' growth rate is speed up to the optimal range which account for high volume of biogas recorded. This finding agree with report of (17) who said thermophilic anaerobic destruction of organic matter is more effective and requires less time therefore thermophilic digester provide a higher biogas yield. Operation at temperature of 37^0C is more stable, digester is easy to maintain at this temperature, produce high quality sludge and requires less energy input as compared to operation at temperature of 45^0C which results in to higher degree of digestion. Operation at temperature of 25^0C which produce low biogas during digestion may due to the fact that psychrophilic or ambient temperatures, the methanogens are not sufficiently activated for enhanced biogas production which may probably lead to low biodegradation of the substrates and poor gas yield as reported by(18).(19)Also reported that temperature fluctuations can cause an imbalance between bacteria and resulting in build-up of volatile acids, therefore temperature have great effect on the rate of biogas generation.

5. Conclusion and Recommendation

5.1 Conclusion

The result denotes that temperature affect the biogas yield in an anaerobic digestion. The biogas production is influenced by many factors, of which the temperature of the anaerobic digester process is the most important and type of substrates used.

5.2 Recommendations

From the analyses carried out and the results obtained in this study, it would be of paramount importance if the following recommendations would be taken into consideration: -

1. For the generation of biogas rich in CH_4 with low environmental hazards, Cow dung and Rice husk could be used as substrate.
2. The substrate (Cow dung and Rice husk) could be used for the generation of biogas of good fuel value.
3. For rapid and high production of biogas the use of high temperature should be adopted.

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