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Research Article

Effect of pH on the Rate of Biogas Production using Cow dung and Rice husk

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Abstract

This study examines the biogas yield and methane production using cow dung and rice husk. The anaerobic digestion process was conducted at laboratory scale using an aspirator bottle and tins as digester with capacity of 2.4 L. The efficiency of the anaerobic process is governed by a number of factors. The effect of pH on production of biogas from organic wastes (cow dung and rice husk) was investigated for a period of 30 d. The starting hydrogen ion concentrations (pH) of the slurries used in the study were 5, 7 and 9 during this investigation. The result of the anaerobic digestion indicated that the slurries with starting pH 5, recorded lowest cumulative gas yield (182 cm^3), pH 9 recorded 683 cm^3 while pH 7 recorded highest cumulative gas yield (938 cm^3) respectively. The qualitative analysis of biogas produced was evaluated by flame test. It was concluded that pH had a great influence on the rate of biogas yield of substrates.

Keywords: Biogas yield, cow dung, rice husk, organic wastes, hydrogen ion concentration, cumulative gas yield.

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 (Braun, 2007). Biogas is a product of anaerobic digestion of biodegradable wastes materials. It is composed of methane (45-65%), carbon dioxide (35-45%), nitrogen (0-3%), hydrogen (0-1%) and hydrogen sulfide (0-1%) (Kangmin, 2006). Anaerobic digestion is mainly associated with the treatment of animal manure and sewage sludge from aerobic wastewater treatment. Most of the agricultural biogas plants were co-digested with animal manure to increase the content of organic material for achieving a higher gas yield. Biogas technology brings multiple benefits in environmental protection, additional income in rural areas, creating new jobs, besides production of renewable clean energy. Biogas sector is strong connected with agriculture and residues from agricultural produce can be anaerobically fermented and converted from pollutant into organic manure and into green energy.

As at 2007, it was reported that animal and agricultural wastes in Nigeria stood at 0.781 and 0.256 million tons per day respectively (Sambo, 2007). Vindis *et al.* (2009) reported that from animal waste alone, Nigeria can generate 4.75 x 10^9 MJ per annum. Ugwuh (2009) reported that an average Nigerian generates about 0.48 kg of municipal solid waste daily. Ovueni *et al.* (2010) also predicted that the municipal solid waste generation in Nigeria to reach 58 million tons daily by 2050. In spite of this great benefit in energy generation, Nigeria has not being 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. This study, seeks therefore to evaluate the effect of hydrogen ion concentration (pH) on biogas production from cow dung and rice husk, with a view to establishing an optimum condition with regards to this factor for biogas generation from cow dung and rice husk.

Materials and methods

Collection of samples: Cow dung was obtained from the animal house of Faculty of Veterinary Medicine, Ahmadu Bello University Zaria and 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.

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Fig. 1. Digesters setup of the experiment.

The samples thus collected were sundried over a period of 10 d and ground using wooden pestle and mortar. Sieve (2mm size) was used in order to obtain powdered samples which were stored in a separate black polythene bags.

***Digester setup*:** Laboratory scale batch digesters were used made from aspirator and tins. A whole (0.7 cm in diameter) was made at the center of the cover of the tins and aspirator bottle which has a capacity of 2.4 L (digester) by a drilling machine, and rubber tubing (which serves as a delivery tube for the gas) 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. The diagram of the setup is shown in Fig. 1.

Slurry preparation: From the prepared samples 200 g each of Cow dung and Rice husk was weighed and mixed with 800 cm^3 of water in a beaker to obtain slurries of 1:4 substrates: water ratio, similarly 100 g each of the substrate was also weighed and mixed with 800 cm^3 of water to obtain 1:4 substrates: water ratio. The slurry prepared was stirred and allowed to equilibrate over 24 h.

Table 1. Total volume of biogas (cm^3) produced at different pHs.

Substrates (200 g)	pH 5	pH 7	pH 9
Cow dung	126	775	510
Rice husk	2.0	47	9.0
Cow dung + Rice husk	182	938	683

Data are means of triplicates.

Ten mL of fresh rumen content (liquid portion) obtained from the abattoir was added to serve as starter culture. To determine the effect of the pH, in digesters after being charged, were buffered with pH 5.0, pH 7.0 and pH 9.0 buffer solutions respectively. The digesters were firmly closed after buffering to attained anaerobic conditions and allowed in this states for 30 d. The amount of gas produced was monitored at daily intervals by downward displacement of water in the measuring cylinder (1000 cm^3). The experiment was conducted under mesophilic temperature range of 37-40°C (Machido *et al.*, 1996).

Results

Effect of pH on biogas yield by substrates: Results obtained in respect of the pH on biogas yield by the substrates are presented in Table 1. It was observed that at pH of 5 cow dung blended with rice husk digester had a higher volume of biogas (182 cm^3) compared to cow dung fed digester which had total volume of (126 cm^3) and rice husk fed digester which yielded a total volume of (2 cm^3). Similarly, at pH of 7, Cow dung blended with rice husk digester produced a total volume of (938 cm^3) while cow dung fed digester yielded a total volume of 775 cm^3 and rice husk digester produced a total volume of 47 cm^3. The observation from these results shows that biogas yield by the substrates was greatly improved at pH of 7 better than at pH of 5. At pH of 9, the volume of biogas produced by cow dung blended with rice husk digester was 683 cm^3 while cow dung fed digester produced total volume of 510 cm^3 and rice husk digester produced a total volume of 9 cm^3, the observation from these results shows that pH 9 had great influence by the biogas yield of substrates because the volume of biogas yield of the substrates was reduced compared to pH 7. The trends of daily yield of biogas in digesters charged with the individual test substrates and the combined substrates are shown in Fig. 2-4 (trends of biogas yield) respectively.

Combustibility of biogas (Flame Test): Plates 1-3 shows the flame produced from digester fed with rice husk (RH), cow dung (CD) and digester blended with cow dung and rice husk. The results indicated that there were differences in the intensity of flame produced in the digesters. Digester blended with cow dung and rice husk produced more intense flame as compared to digester fed with either CD or RH.

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Fig. 2. Trends of biogas production in the three digesters at pH of 5 and at mesophilic temperature (37°C).

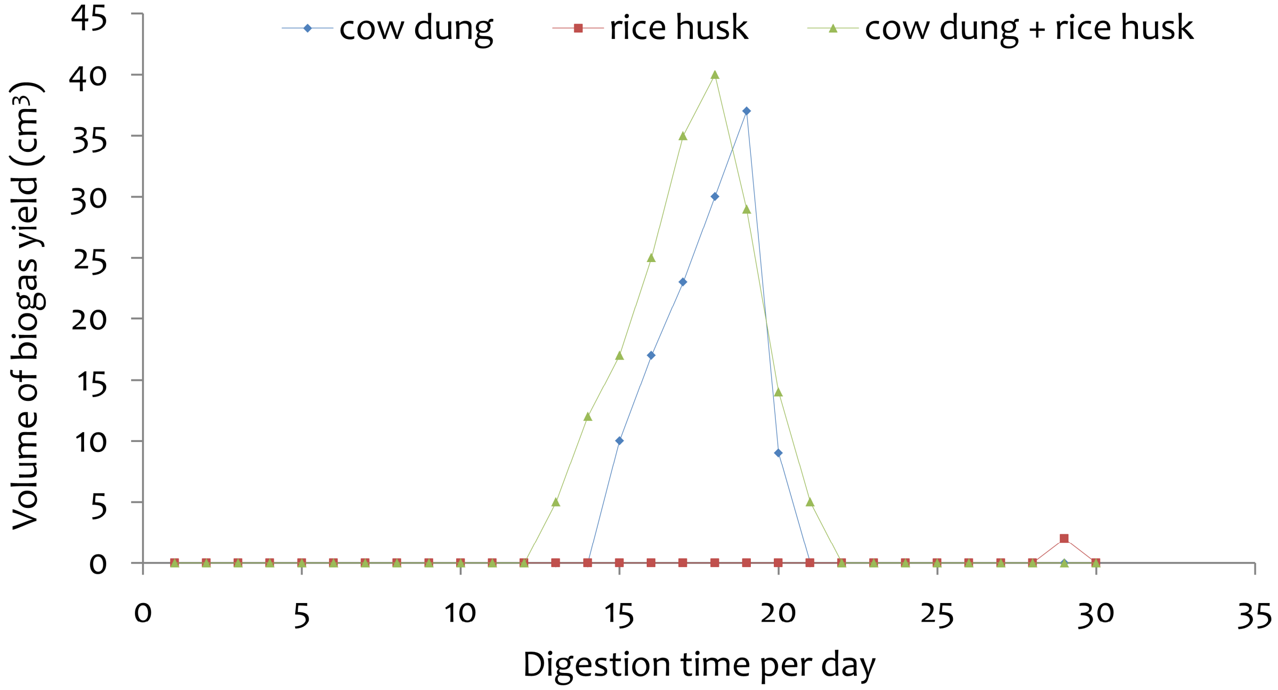

Fig. 3. Trends of biogas production in the three digesters at pH of 7 and at mesophilic temperature (37°C).

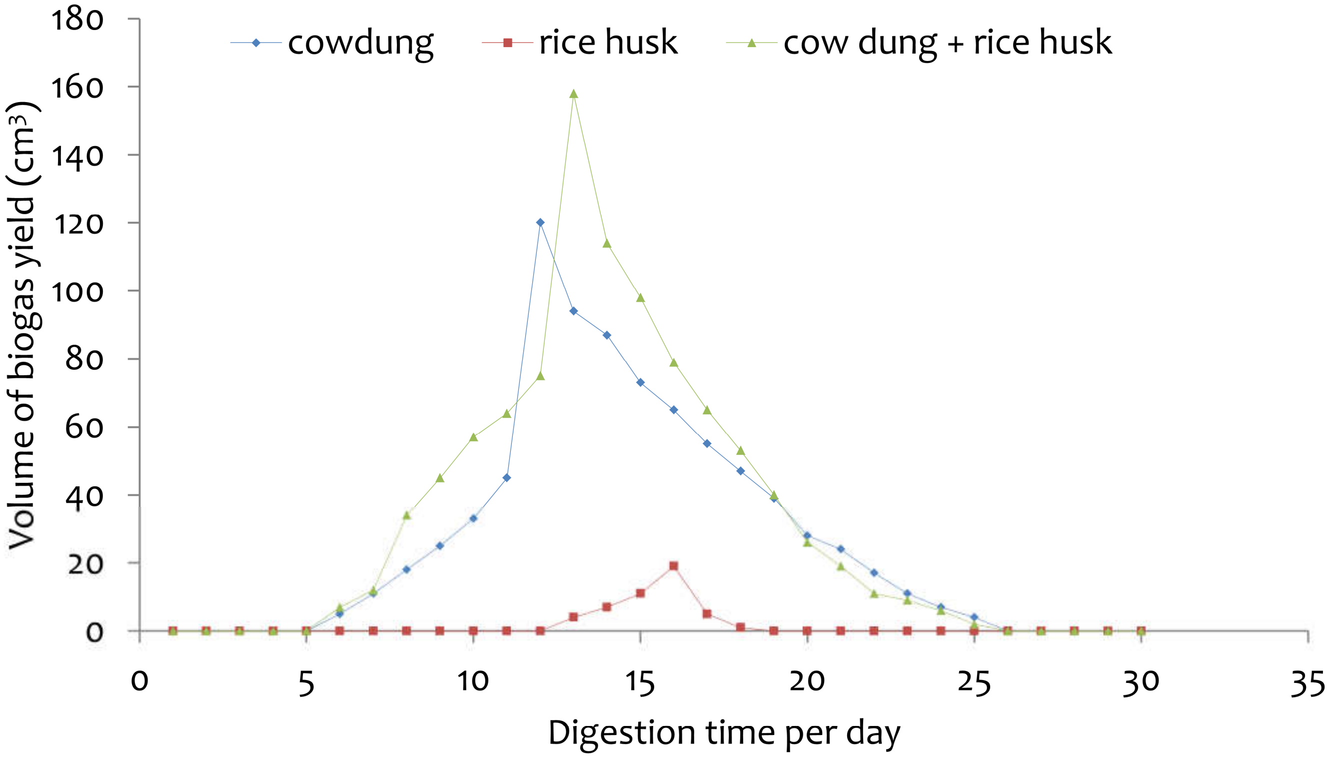

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Fig. 4. Trends of biogas production in the three digesters at pH of 9 and at mesophilic temperature (37°C).

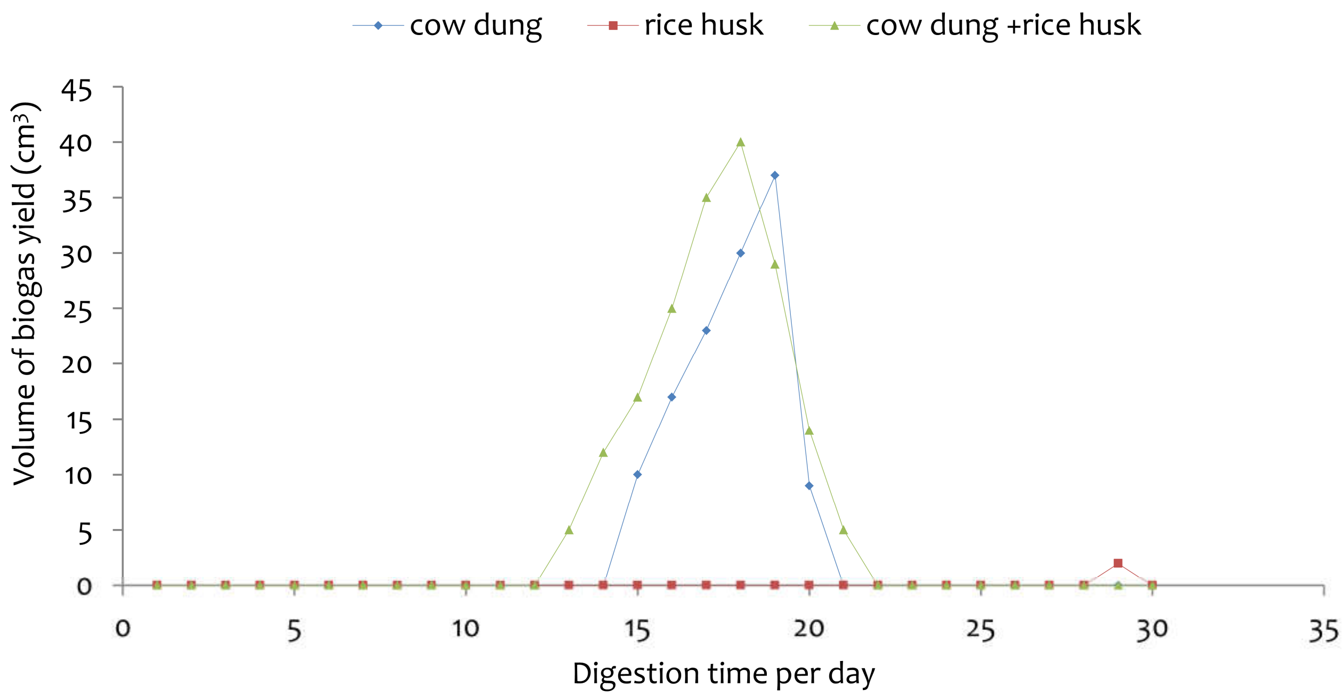

Plate 1. Combustibility of biogas (methane) produced from rice husk.

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Plate 2. Combustibility of biogas (methane) produced from cow dung.

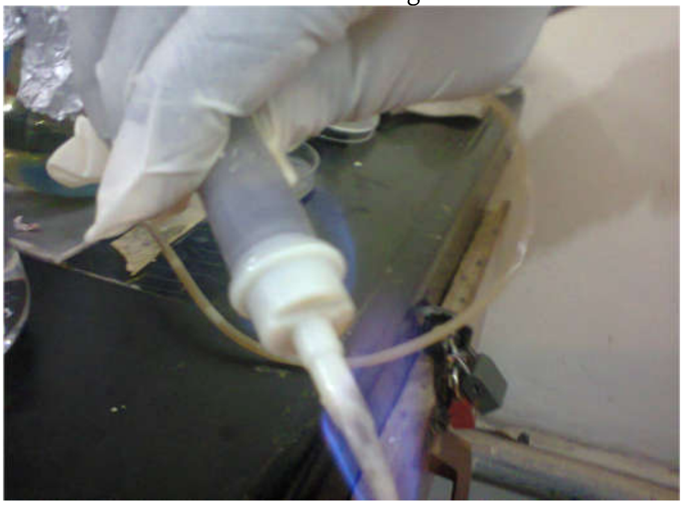
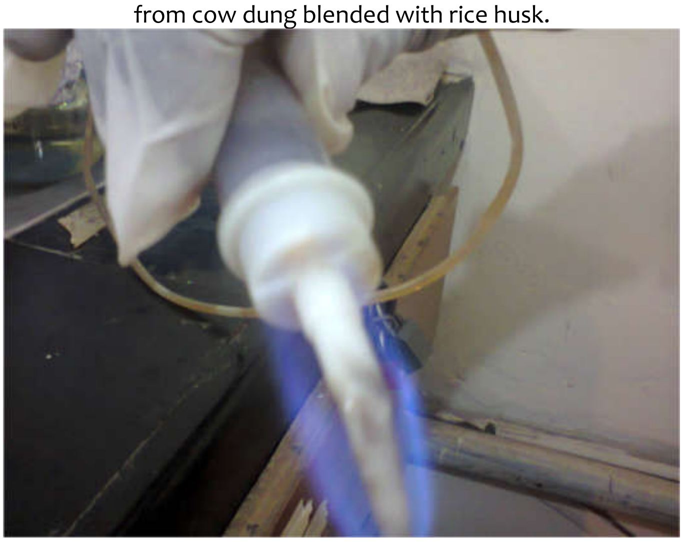


Plate 3. Combustibility of biogas (methane) produced from cow dung blended with rice husk.



Discussion

The effect of pH as shown in Table 1 revealed that higher biogas was recorded in digester with pH of 7 follow by pH of 9 and least was on pH of 5, the result suggest that anaerobic bacteria are sensitive to pH, when the pH drops below 7 there is a significant inhibition of methanogenic bacteria and acid condition of a pH 5 are toxic to these bacteria which result in to low biogas production. Antonopoulou *et al.* (2008) reported that optimum pH in the digester should be in the range of 6.5 to 8 which is suitable for acetogens and methanogens. This shows that all the principal bacteria in anaerobic reaction; hydrolysis bacteria, acid-producing bacteria and methane-producing bacteria are sensitive to pH ranges. For hydrolysis and acid-producing bacteria, the optimum pH value is both from 5 to 6; methane-producing bacteria need the pH range between 6.5 and 7.8 as reported by Gomez (2011).

The pH of a digester system is a function of the volatile fatty acid concentration, bicarbonate alkalinity of the system and amount of CO_2 produced (Chawla, 1986). Report of Sahota and Singh (1996) indicated that gas production was significantly affected when pH of slurry decreased to 5.0 due to reduction in methanogenic activity of the digester system. Their observations supported the trends obtained in this study (Fig. 2-4). The result on quality of biogas produced from the study (flame test) showed that the methane component of the biogas was above 45%. This finding was in agreement with an earlier report that for a biogas to be combustible; the methane content of the biogas must be above 45% (Anonymous, 2003). The flame test showed a bluish flame which glowed for several seconds (plate 1-3).

Conclusion

The result denotes that pH affect the biogas yield in an anaerobic digestion. The biogas production is influenced by many factors, of which the pH of the anaerobic digester process is the most important. Depending on the reaction medium pH certain groups of bacteria are stimulated, while others are inhibited. It can also be conclude that organic wastes of this type should be fed into biogas digester in such a way that conditions favoring the production of high volume of biogas are met, thus, the pH should maintained for high volume of biogas in anaerobic digesters.

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