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KINETICS STUDIES OF FUNGAL BIOGAS PRODUCTION FROM CERTAIN AGRICULTURAL WASTE

Bishir, U. * and M. M. Ekwenchi**
*Department of Pure and Industrial Chemistry, Bayero University, Kano, Nigeria
**Department of Chemistry University of Jos, Jos, Plateau State, Nigeria
Correspondence author: bishirbum@yahoo.com

ABSTRACT
Anaerobic degradation of sugar cane and rice husk by cellulolytic fungus was studied respectively at optimum operational condition of concentration, 1:5 w/v of the lignocelluloses: water and temperature of 33°C. The average rates of biogas production determined for sugar cane and rice husk were 57cm^{3}per day and 47cm^3 per day, while the yield of biogas evaluated appear to be high, 15.2% for sugar cane and 12.5% for rice husk. The yields from other agricultural wastes were lower than these values (0.8% cow dung – 11.6% water hyacinth). The compositional yields of the biogas were also assessed; 5.7% CH_4, 8.3% CO_2, and 1.2% H_2S for sugar cane and 4.9% CH_4, 6.1% CO_2 and 1.5% H_2S for rice husk. Results have shown that the biogas of rice husk is of better quality than that of sugar cane because of its lower content of CO_2. It was also found that when the amount of the substrates were respectively doubled, the average rate of the biogas production doubled, implying that kinetically, the degradation is probably first order. The yield of the bioliquid for sugar cane was determined as 94% and rice husk was 68%.
Key word: Biogas, Fungal Degradation, Bioliquid, Rice Husk, Sugarcane.

INTRODUCTION

The socio-economic development of a country largely depends on the availability and consumption of energy. The available sources of energy can be classified into two categories, renewable and non-renewable energy sources. The non-renewable energy sources which are also called fossil fuels are finite deposits of coal, natural gas, uranium and deuterium. The renewable sources of energy are photosynthetic materials, solar, hydroelectric and tidal energies. Renewable energy is deposited every day, whereas the non-renewable is continuously depleted by our withdrawals resulting from continual depletion in the natural resources and by an increased consumption of the energy alternatives of fossil fuels has to be searched out. Therefore, bioenergy could be the only alternative and cheap sources of energy which can be made available to the rural areas. (Shoeb and Singh, 2000)

The term biogas system is somewhat of a misnomer though biogas system is often viewed as an energy supply technology. Chinese regard their systems primarily a means to provide fertilizer and the sanitary disposal of organic residue, gas is considered as useful by-product (Richard et al., 1994). In India interest in biogas is due to its potential as fuel substitute for firewood, dung, kerosene, agricultural residues, diesel, and petroleum and electricity, depending on the particular task to be performed and on local supply and price constraints. Therefore biogas typically refers to biofuel. The gas is produced by anaerobic digestion or fermentation of organic matter, as well as manure, sewage sludge, municipal solid waste, or any other biodegradable feed stock under anaerobic condition (Richard et al., 1994). Biogas comprised primarily of methane (60-70%) and carbon dioxide (30-40%) depending on the material used. Biogas can also be called swamp gas, marsh gas, landfill gas, digester gas (Shoeb and Singh, 2000).

Biogas is a naturally occurring emission of bacteria that thrive without oxygen that occurs in three steps. First is the decomposition or hydrolysis of biodegradable material into molecules such as sugars. Next these molecules are converted into acid. Lastly the acids are converted into biogas. Anaerobic digestion harnesses the bacteria in its natural process in order to capture and utilize the biogas, all in a safer controlled environment.

Biogas produced in anaerobic digester is burned to generate clean renewable energy. released in uncombusted form is harmful to the environment (Prasad,1974).

Biogas system provides three products; energy, fertilizer and waste residue, the term biogas system in this study will refer to the technology of digesting organic waste anaerobically to produce an excellent fertilizer and combustible gas and to disposing agricultural residues, aquatic weeds, animal and human excrement and other organic matter (Prasad,1974).

This research is aimed at maximizing yield of biogas at optimal conditions. The objective of the research is to guarantee that the biogas can be reasonably produced at reproducible rate and also at a profitable and efficient rate using sugarcane (barck and pulp) and rice husk.

MATERIALS AND METHODS

Sample Collection and Processing

The experimental fungal degradation of lignocelluloses from sugarcane (barck and pulp) and rice husks at optimum condition to produce biogas was carried out in an anaerobic condition and the procedures with all the material, apparatus and reagent used are outlined below.

The fresh sugarcane (Substrate) was collected from Karfi, in Malumfashi district Katsina State and the rice husk (substrate) was collected from a farm in Kura, Kura Local Government Council, Kano State. The sugarcane bark was removed and pulp was pressed removed the juices. The rice husks were removed from fresh rice and both of these samples were dried in an oven at a temperature of 40°C for about 48 hours. The oven dried sugarcane and rice husk was grinded to fine powder using mortar and pestle and subsequently sieved with a sieve of mesh size (100 microns). The powdered substrates were stored in reagent bottles and kept away from sunlight and moisture.

Generation of Biogas

Four sets of 250cm^3 round bottom flask digesters were used for the generation of the biogas. The digesters were properly stoppered in order to avoid leakages. Each digester contained sugar cane or rice husk, yeast (fungus) and water in order to produce the necessary biogas required in the respective experiment.

Keeping the amounts (4g) of lignocellulose and yeast (0.06g) constant, the amount of water was varied in the range of 15,20, 25 and 30cm^3 in order to find out the amount of water required to produce the optimum yield of biogas. Next, the amounts of lignocellulose (4g) and water (25cm^3) were kept constant and the amount of yeast was varied in the range of 0.06g, 0.12, 0.18 and 2.40g in order to establish the amount of yeast to produce the optimum yield of biogas. After obtaining the required amounts of water and yeast with the known amount of lignocellulose used in producing the biogas at a known temperature, next set of experiment involved varying the temperature in the range of 28, 33,36, and 40°C while keeping the amounts of lignocellulose (4g), water (25cm^3) and yeast (0.12g) constant. In this set of experiment involves the digesters A, B, and C for the Compositional analysis of biogas generated for sugarcane as.

A: 8g of sugar cane + 50cm^3 H_2O + 0.24g fungus. Biogas passed through H_2O (gas collected CH_4+CO_2+H_2S)

B: 8g of sugar cane + 50cm^3 H_2O + 0.24g fungus. Biogas passed through 1M NaOH (gas collected CH_4+H_2S)

C: 8g of sugar cane + 50cm^3 H_2O + 0.24g fungus. Biogas passed through lead acetate solution (gas collected = CH_4 + CO_2).

Similarly in table 2 the digesters A,B and C for the Compositional Analysis of biogas generated from Rice husk as

A: 8g of rice husk + 50cm^3H_2O + 0.24g fungus. Biogas passed through H_2O

B: 8g of rice husk + 50cm^3 H_2O + 0.24g fungus. Biogas passed through 1M NaOH

C: 8g of rice husk + 50cm^3 H_2O + 0.24g fungus. Biogas passed through lead acetate solution (gas collected = CH_4 + CO_2)

In each case at the end of biogas production, the pH of the digester content was taken, and the content was also dried appropriately to constant weight, then the dried content was exhaustively extracted with soxhlet extractor for 74 hours in order to obtain the liquid component of the residue left in the round bottom flask (bioliquid), using the rotor evaporator. The extract was dried to constant weight by obtaining its weight.

Effect of lignocelluses, water and yeast on yield of Biogas

In the next set of experiments, the amounts of lignocelluloses, water and yeast were doubled in order to see its effect on the yield of biogas.Proper set-ups were done in this work to separate the biogas into CH_4, CO_2 and H_2S using appropriate reagents, NaOH, which will dissolve CO_2 and $Pb(CH_3COO)_2$, which will remove H_2S as a precipitate of PbS. By the arrangement the respective amounts of CH_4, CO_2 and H_2S in the biogas produced could assess. The reactions involved in the separation are as follows, and the volume of biogas and its component was collected by upward delivery.

$$CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O \quad - \quad - \quad - \quad (1)$$

$$(CH_3COO)_2Pb + H_2S \rightarrow 2CH_3COOH + PbS \quad - \quad - \quad (2)$$

Then the volume of methane was evaluated as follows

$$V_{Biogas} = V_{CH_4} + V_{CO_2} + V_{H_2S} \quad - \quad - \quad - \quad (3)$$

$$V_{CH_4} = V_{Biogas} - V_{CO_2} + V_{H_2S} \quad - \quad - \quad - \quad (4)$$

$$V_{CO_2} = V_{Biogas} - V_{H_2S} \quad - \quad - \quad - \quad (5)$$

Where

$V_{Biogas}, V_{CH_4}, V_{CO_2}, V_{H_2S}$ are the respective volume of biogas, CH_4, CO_2 and H_2S, the percentage composition of the gas generated was evaluated as follows.

$$CH_4\% = \frac{V_{CH_4}}{V_{Biogas}} \times 100 \quad - \quad - \quad - \quad - \quad (6)$$

$$CO_2\% = \frac{V_{CO_2}}{V_{Biogas}} \times 100 \quad - \quad - \quad - \quad - \quad (7)$$

$$H_2S\% = \frac{V_{H_2S}}{V_{Biogas}} \times 100 \quad - \quad - \quad - \quad - \quad (8)$$

(Ekwenchi et al., 1989)

The same procedure was applied to rice husk.

RESULTS AND DISCUSSION

The results of the respective compositional analysis of the biogas yields for both sugar cane and rice husk are shown in Table 1 and Table 2 respectively. Sample A comprised a mixture of CH_4, CO_2 and H_2S. Sample B comprised a mixture of CH_4 and H_2S, while. Sample C comprised a mixture of CH_4 and CO_2.

By appropriate treatment of these biogas yields, the compositional amounts of CH_4, CO_2 and H_2S were determined. The results obtained for the respective different amounts of CH_4, CO_2 and H_2S are shown in Table 3. These results indicated that the biogas from rice husk was of a better quality than that of sugarcane because of lower CO_2 content found in the biogas from rice husk. The results of the conversion efficiency of the respective biogas and the components in the biogas evaluated, from the compositional analysis results, as well as, utilizing the general gas law, are shown in Table 4. The conversion efficiency results had shown that sugarcane produced more CH_4 than rice husk, however, the overall results still pointed to the fact that the biogas from the rice-husk is of a better quality than that of the sugar cane because of the lower CO_2 content of the rice husk biogas. Comparison of the result of this study with a previous study (Ekwenchi et al., 1989) on other agricultural wastes are shown in Table 5. These results had shown that both sugar cane and rice husk have higher conversion efficiency than the other substrate. This is probably because of the compositional differences in the material utilized in the degradation. Sugarcane and rice-husk have better components that are easily accessible to the fungal degradation. The result of the bioliquid (liquid component of the residue) and biogas yields presented in Table 6 has a similar trend whereby the sugarcane produced more than rice-husk. The result of the calculated average daily rates is shown in Table 7. The results indicate that sugar cane has a higher average daily rate than rice-husk, implying that sugarcane is made up of lignocellulose better degradable than the lignocellulose of rice-husk.

From the results obtained there was evidence that energy could be renewed by using agricultural wastes in which the materials used in generating these gases were very good sources of biogas and biofuel and it can also reduce the over dependences on non-renewable source of energy. It also prevents environmental pollution there by making environment to be eco-friendly.

Table 1: Compositional analysis of biogas generated for sugarcane.

Time (Days)	Volume of Biogas Generated(cm^3) A	B	C
1	0	0	60
2	230	20	80
3	230	60	100
4	240	80	120
5	250	110	120
6	300	180	120
7	390	260	140
8	460	340	180
9	560	520	220
10	680	590	240
11	740	620	280
12	810	690	320
13	870	710	490
14	920	710	560
15	960	710	780
16	1040	710	840
17	1110	710	930
18	1170	710	1020
19	1170	710	1040
20	1170	710	1095

Table 2: Compositional Analysis of biogas generated from Rice husk. Cumulative volume of biogas generated (cm^3)

Time Day	Volume of Biogas Generated (cm^3) A	B	C
1	30	50	100
2	60	50	140
3	140	100	180
4	180	100	240
5	180	190	280
6	200	230	320
7	220	290	360
8	230	320	440
9	260	390	480
10	280	450	520
11	280	480	630
12	290	560	745
13	300	630	830
14	305	630	890
15	380	710	890
16	490	710	890
17	520	710	890
18	530		
19	560		
20	570		
21	570		
22	650		
23	780		
24	840		
25	890		
26	960		
27	990		

Table 3: Composition of the biogas

Material	Yields in %		
	CH_4	CO_2	H_2S
Sugar cane	61.1	32.5	6.4
Rice husk	62.5	28.3	9.2

Table 4: Conversion efficiency in %

Material	Biogas	CH_4	CO_2	H_2S
Sugar cane	15.2	5.7	8.3	1.2
Rice husk	12.5	4.9	6.1	1.5

Comparison to other sources of agricultural wastes

Table 5: Conversion efficiencies of biogas in %

Material	% Biogas	Reference
Sugar cane	15.2	This work
Rice husk	12.5	This work
Cow dung	0.8	* Previous work
Water hyacinth	11.6	* Previous work
Maize	9.9	* Previous work
Maize stalks	9.3	* Previous work
Elephant grass	3.4	* Previous work

* Ekwenchi et al., 1989

Table 6: Biogas average daily rate in cm^3 per day

Material	4g substrate	8g substrate
Sugar cane	5.7	11.2
Rice husk	4.7	9.2

Table 7: Bioliquid and Biogas Yield

Material	Bioliquid yield in %	Biogas Yield cm^3
Sugar cane	94	1200
Rice husk	68	990

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