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AGRICULTURAL BY-PRODUCT: A SOURCE FOR THE PRODUCTION OF BIOGAS

E. J. ETERIGHO

Abstract

Agricultural by-products, rice husk and maize bran were used anaerobically in this study to produce biogas. The suitability of these substrates as source of biogas and comparative study of the two substrates were investigated. Various analyses were carried out to determine the ash content, moisture content, volatile solids and fixed carbon content present in each substrate. The biogas produced was analyzed using a gas chromatograph and was found to contain oxygen, nitrogen and methane in various proportions. From the results of the analyses, rice husk produced a larger volume of gas than the maize bran, though the maize bran's gas has a higher content of methane than that of rice husk (about 60.90%). The experiment was carried out under mesophilic temperature range and a pH of 6.2 - 7.6.

Introduction

Fuels are substances that can easily combine with oxygen and heat to release energy. The importance of fuel cannot be over emphasized as it finds wide range of uses; e.g. cooking, lighting. There are various types of fuels and they could be classified as; solid, liquid and gaseous fuels. After the war in 1945 to early periods of 1973, the increasing availability of petroleum products of which cooking gas is one, solved the problem of inadequacy of fuel to some extent. This did not last long because of the unilateral hike in the prices of crude oil in the middle of 1973 to date (Akinwanju, 1978). Since then industrialized nations of the world have been looking for alternative source for energy generation.

Biogas generally means "all-organic matter that grow by the photosynthetic conversion of solar energy (Glazer, 1995). The biomass produced annually by photosynthetic conversion of sunlight is estimated to contain 3 x 10^{21} joules of energy, which is about ten times the worldwide human consumption (Stout, 1984). There are various types of biomass; these include agricultural waste, plant waste, animal waste, and algae complex strain. Stout (1984) found the constituent of biomass to be polysaccharide, proteins, non-protein nitrogenous compounds, lipids, volatile fatty acids and water (if fresh). The percentage of each of these varies from one type of biomass to another. Biogas can be produced from biomass through different processes; Biochemical conversion and thermo chemical conversion. In the process of anaerobic digestion, microorganisms digest biomass directly to produce methane and carbon (iv) oxide. Anaerobic digestion requires temperature of 30°C to 45°C for mesophilic bacteria (Glazer, 1995). Methane production from biomass is a sensitive method of microbial process because no single bacterial species is able to carry out the entire conversion of a biomass component such as cellulose to methane. The biological polymers, which are present in biomass such as polysaccharides, proteins, lipids must be broken down to simpler substances; before they could be converted to methane (Stout 1984).

J.E. Eterigho is with the Department of Chemical Engineering, federal university of technology, Minna Nigeria

Generally the process of conversion is in three phases with various stages:
Phase one is primarily hydrolysis involving enzymatic conversion of insoluble organic compounds such as cellulose by enzymes to soluble organic. These enzymes are actually a mixture of three major enzymes; Endo-β-1, 4-glucanase, which randomly hydrolyses cellulose chain. Cellulobiohydrolase, this splits off cellotoiose from ends of cellulose chains. Glycosides hydrolyse cellulose to two glucose molecules. Phase two involves fermentation of the degradable components and phase one end products. (i.e. carbohydrates, proteins, lipids, alcohol etc) by non-methanogenic organism to simpler organic substrate such as organic acid (predominantly acetic and propanoic as well as lactic and butyric acids), ethyl alcohol and hydrogen. Phase three occurs in two stages; one involves the reaction between hydrogen and carbon (iv) oxide to give methane by the bacteria, Methanobacterium fomicum (Anderson1979), while stage two involves the decarboxylation of acetic acid and other organic acids into dissolved methane and carbon (iv) oxide by the bacteria Methanobacterium. These dissolved gases finally undergo transfer from the liquid to gaseous phase (Anderson, 1979). The aim of this study is to produce biogas from agricultural by – products, rice husk and maize brain.

Experimentals

The rice husk and maize bran were collected from a local market mill in Bosso, Niger State, Nigeria. The two substances were subjected to decomposition for about eight days by exposure to moisture and ambient air under the action of aerobic micro-organisms. The compost were dried, pulverized and sieved. Particle size of 500 μm was used for the experiment but before usage, it was dried in an oven at 105°C until a constant weight was reached. 10%, 7% and 5% of slurry were prepared using the treated rice husk and maize bran. The prepared slurries were heated in a steam bath to remove air bubbles. The pH were measured and adjusted to a range of 6.2 - 7.6. Plastic containers were used as the reactors with various labels. Screw clips were used to prevent air from entering. The gas produced was collected over water and analyzed.

Results and Discussion

There was a decrease in mass of each substrate after heating at 350°C, which accounts for the volatile matter, while the fixed carbon is a polynuclear aromatic hydrocarbon residue present in both substrates as indicated in Table 1. The moisture present in both substrates was removed before forming slurry with the samples. The ash is the remains of the samples that were used for the slurry formation. The determinations gave the values recorded in Table 2. Various percentages of the slurry feed that was used gave different milliliters of gas mixture as indicated in Table 3. From chromatographic analysis the gas mixture was found to contain oxygen, nitrogen and methane in various proportions as indicated by the area and height of the peaks (Table 4). The various millilitres of gases produced from rice husk at different concentrations and temperatures are shown in Table 5 while Table 6 shows the reaction. These are the various milliliters of gases produced from maize bran at different concentrations and temperatures shown in the table. Reading started on the eight day to allow for reaction.

Table 1. Volatile matter and fixed carbon content present in rice husk and maize bran

Substrate	Volatile matter (%)	Fixed carbon (%)
Rice husk	34.87	15.31
Maize bran	39.38	30.28

Table 2. Moisture and ash content of rice husk and maize bran

Substrate	Moisture content (%)	Ash content (%)
Rice husk	5.57	44.25
Maize bran	5.59	24.75

Table 3. Total volume of gas produced by different slurry concentration

Substrate	Quantity of slurry feed used (ml).		
	10%	7%	5%
Rice husk	1409	1376	809
Maize bran	904	748	536

Table 4. Gas Chromatographic analysis of the gas mixture

Variable	Peak 1		Peak 2		Peak 3	
	Rice husk	Maize bran	Rice husk	Maize bran	Rice husk	Maize bran
Component	Oxygen (O_2)		Nitrogen (N_2)		Methane (CH_4)	
Retention time	0.683	0.693	1.063	1.090	1.580	1.563
Area	15150	14604	12048	89571	48058	71349
Height	12162	2061	9549	7727	2282	3303
Moles (%)	5.27	5.15	40.67	34.76	54.06	60.09
Factor	2.13	2.13	2.03	2.03	2.36	2.36

The various analyses that were carried out on the substrate, which are volatile matter, ash content, moisture content and fixed carbon content was to determine the suitability of the substrate as a feed for the generation of biogas. The values as indicated in Tables 1 and 2 were found to fall within the acceptable range (Nicholas *et al* 1989). Analysing the data collected over a period of thirty-one days, it is observed that rice husk produced a larger volume of gas than the maize bran. The reduction in the biogas produced from maize bran could be associated with the high moisture content (collected during raining season), which could result in the production of alcohols that can serve as inhibitors (Nicholas *et al* 1989). The rate of gas production is dependent on the number of cells present in the substrate, meaning that the rate of gas production is directly proportional to the cell growth if other physical factors such as retention time, temperature, concentration and pH are kept constant. This was evident from the results. From Fig. 5 it can be seen that the graph of rice husk follows an exponential growth from point A to B, a transitional phase from point B to C while C to D is the stationary phase. This is in accordance with literature (Nicholas *et al* 1989). The maize substrate exhibits a similar characteristic but with a shorter exponential phase. Figure 3 shows a point of inflexion, which suggests that either the death phase sets in immediately after the exponential growth phase or that there is a multiple carbon source and the first carbon source cannot sustain the cell population growth before another metabolic pathway of utilizing the second carbon source (John, 1987). Figure 4 shows the two substrates exhibiting similar characteristics and to some extent similar to Fig. 2 and Fig. 1. It can be seen in Fig 3 that after the point of inflexion there is a very steep exponential decay phase from point P to Q for the rice husk and R to S for the maize substrate. The rice husk shows a slight stationary phase between point O and P. The decay phase suggests that the nutrient level can no longer support the cell population and toxic level of cell waste has built up, thereby causing the death of the cell population (Atiku, 1996). From the results of the gas chromatographic, analysis carried out on the biogas produced by the two substrates, the maize bran contained about 60.90% methane and the rice husk about 54.06% methane. The values got fall within the range as generally biogas is reported to contain about 50% - 70% methane (Glazer, 1995).

Table 5. Rate of gas produced (ml) from rice husk (ml/day) at different concentrations of slurry feed

Time (Days)	10% of Slurry feed	7% of Slurry feed	5% of Slurry feed	Room temperature (°C)
8	12.5	33.125	12.5000	28.5
9	ND	ND	ND	ND
10	ND	ND	ND	ND
11	14.0909	37.4545	17.3636	28.5
12				
13	15.3077	42.3077	23.7672	28.5
14				
15	17.6667	48.0667	26.4667	28.0
16				
17	29.7059	49.9412	29.8235	28.0
18	ND	ND	ND	ND
19	ND	ND	ND	ND
20	565	425	440	28.0
21				
22	625	480	475	28.0
23				
24	679	546	505	29.0
25				
26	737	620	520	29.0
27				
28	800	676	530	29.0
29	ND	ND	ND	ND
30	ND	ND	ND	ND
31	904	748	556	29.0

ND: Not determined.

Table 6. Rate of gas produced (ml) from maize bran at different concentrations of slurry feed

Time (Days)	10% of Slurry feed	7% of Slurry feed	5% of Slurry feed	Room temperature (°C)
8	19.00	12.7500	9.7500	28.5
9	ND	ND	ND	ND
10	ND	ND	ND	ND
11	20.9091	18.5455	12.2727	28.5
12				
13	22.4615	16.1539	14.4615	28.5
14				
15	24.000	20.2667	17.000	28.5
16				
17	27.2941	21.0588	22.7647	28.5
18	ND	ND	ND	ND
19	ND	ND	ND	ND
20	28.2500	21.2500	22.000	28.5
21				
22	28.4091	21.8182	21.5909	28.5
23				
24	29.2917	22.7500	21.0417	29.0
25				
26	28.3462	23.8462	20.000	29.0
27				
28	28.5714	24.1429	18.9286	29.0
29	ND	ND	ND	ND
30	ND	ND	ND	ND
31	29.1613	24.1290	17.9355	29.0

ND: Not determined.

Conclusion

The use of agricultural by-products to produce biogas has been studied. The agricultural by-products are maize bran and rice husk. The process was carried out in a mesophilic bacteria temperature range and a pH range of 6.2 – 7.6. From the data, maize bran produced lesser volume of biogas than rice husk but had higher methane content than rice husk. This can be attributed to less biodegradability of rice husk, which is due to the presence of lignin in its structure. Generally, from the results it can be concluded that slurry concentration is an important factor in the generation of biogas. Besides, from the analysis of the biogas, oxygen and nitrogen gases were found to be present in addition to the methane gas.

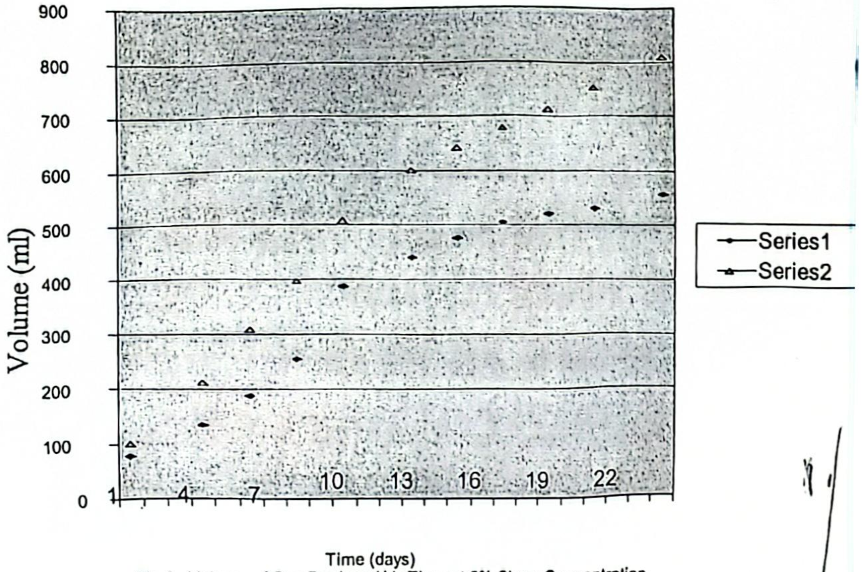

Fig 1 Volume of Gas Produced Vs Time at 5% Slurry Concentration

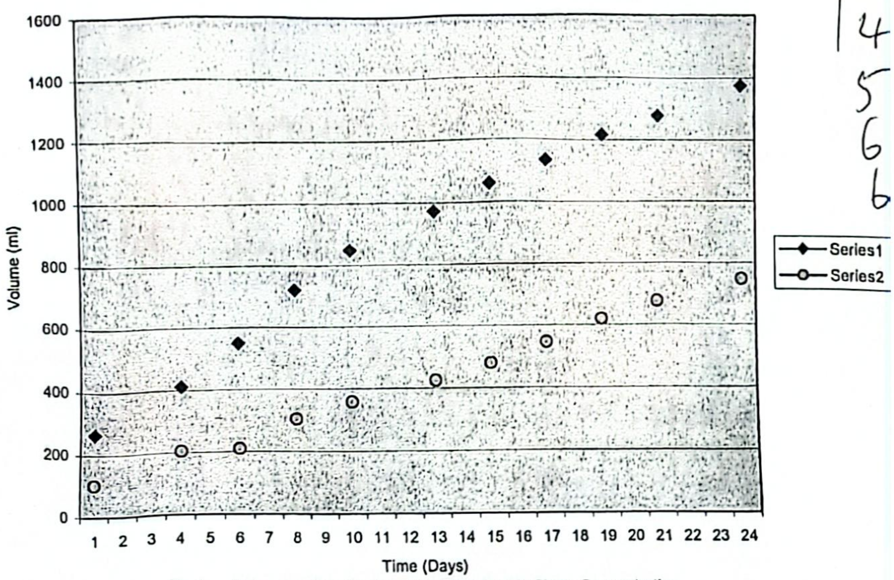

Fig 2 Volume of Gas Produced Vs Time for 7% Slurry Concentration

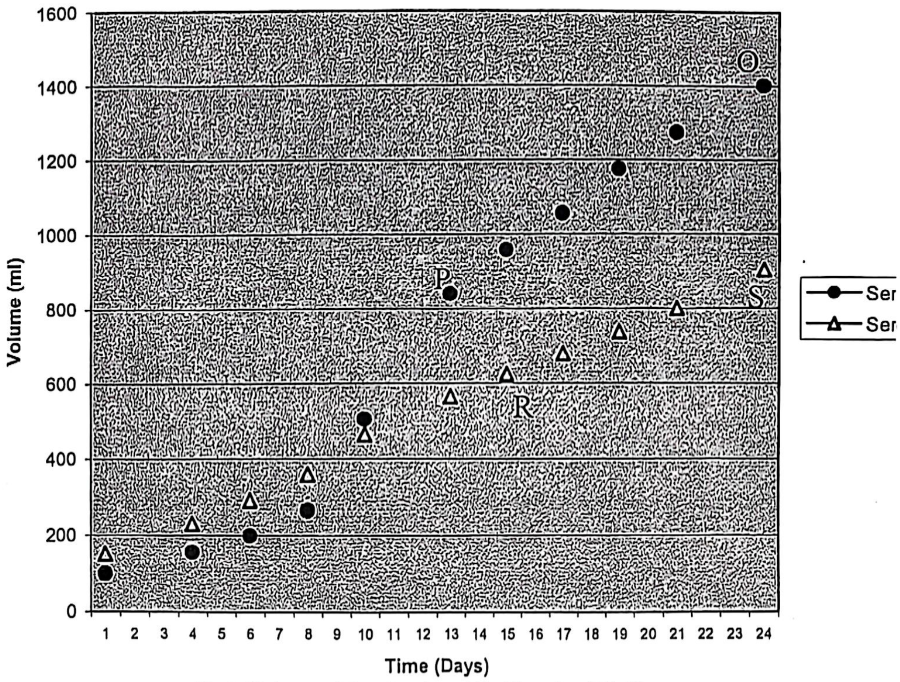

Fig 3 Volume of Gas Produced Vs Time for 10% Slurry Concentration.

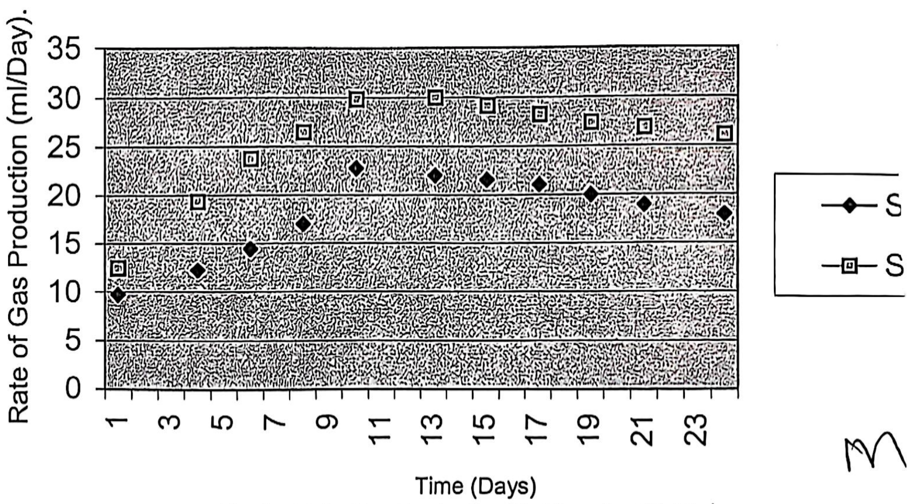

Fig 4 Rate Gas Production Vs Time for 5% Slurry Concentration

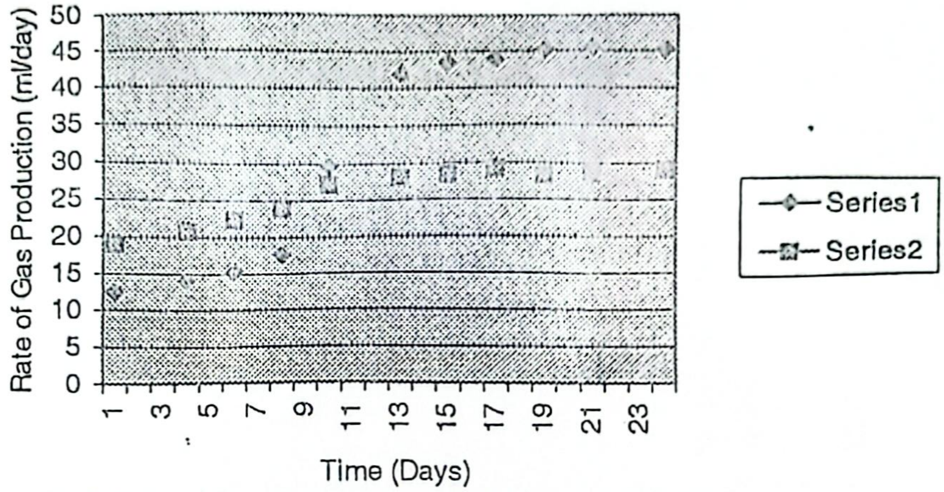

Fig 5 Rate of Gas Production against Time for 10% Slurry Concentration

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