Journal of Engineering and Applied Sciences 3 (2): 207-210, 2008
ISSN: 1816-949X

Improving Biogas Yield Using Media Materials

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Abstract: The effects of media material on biogas yield was investigated using poultry (layers) drop (PD) in a laboratory and anaerobic digester. Cassava peels (CP) and obeche wood (Triplochiton Scleroxylon) were used as media material. The quantities of media material used in this investigation were 0% CP 25% CP without obeche wood, 50% CP seeded with obeche wood, 100% CP (macerated) and 100% CP (unmacerated). The waste water ratio (slurry) used in this study was 1:3. The volume of biogas produced ranged from 90-2590 cm^3 with different concentration of cassava peels and obeche wood in poultry drops. Fifty percent (50% w/w) of the Cassava peels seeded with obeche wood in poultry dropping yielded the highest volume of biogas (2590 cm^3). The wood medium used (obeche) exhibited good medium characteristics in accelerating biogas yield.

Key words: Biogas, media, material, digester, poultry dropping

INTRODUCTION

Society is today confronted with dwindling sources of fossil fuels and chemical feed stock and their proliferation of waste generated by municipalities, agriculture and industries. The conversion of renewable resources or waste to chemicals and fuels by microbial fermentation through a biogas reactor represents a tremendous challenge for engineers in present day and more-so in the nearest future.

Anaerobic bio-degeneration of cellulosic materials is a biological-engineering process (Adeyemo, 2003) in which a methane rich gas (biogas) is produced and a slurry that is of proven value as a fertilizer and animal feed is left as residue. Several works have been undertaken in improving biogas yield such as the pretreatment of waste feedstock (Itodo *et al*., 1992). Such pretreatment includes preheating, milling and chemical treatments with sodium hydroxide. One of the major and relevant components of the process is the micro-organisms that are responsible for the enzymatic breakdown (Velsen and Lettinga, 1979) of the feedstock and the subsequent conversion to methane, carbon dioxide and traces of hydrogen sulphide (Maramba, 1973).

The use of media materials to ensure a greater concentration of these micro-organisms (Azollo China, 1978) will serve to accelerate the rate of yield by ensuring that the phases of gas production are undertaken throughout the digestion simultaneously. The positively affects the start-up characteristics of the process by acting as the seeding micro-organism in different locations during feedstock reloading (Norsteat and Thomas, 1985). It also replaces stirring mechanism in digesters. Stirring is recognized as being harmful in that it reduces the air tightness of digester tanks and this is largely at the research stage (Stout, 1983). A few media that have been used (Azollo China, 1978) include synthetic materials, wood species, limestone and so on. The appropriateness of different media materials in one of the aspects being actively researched on.

The quality of media materials expressed as percentage of total volume is also important, especially since a higher percentage means a lower input of cellulosic material as feedstock which in turn affects biogas yield.

Generally, the organic matter must be highly degradable in order to achieve such yields. Lower gas production rates will results from less biodegrable waste (Bolte *et al*., 1986). Economically, the extensive utilization of biogas for the energy needs especially in the rural areas of Nigeria would reduce dependence on commercial energy. Similarly, biogas production reduces faecal pathogens and pollution of the environments and also improve public health condition (Botte and Prince, 1986).

Methane which is the major component of biogas produced from organic wastes is also used in the production of methanol which is important industrially (Charemin *et al*., 1980).

The chlorination of methane through photo-catalysts yield chloroform and carbon tetrachloride which is used in dry cleaning and production of fire-extinguisher (Van-Buren, 1980). This work will introduce the use of cassava peels and local Nigerian wood species Triplochiton Scleroxylon (obeche) as media material for improving the yield of biogas during production.

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MATERIALS AND METHODS

Collections and processing of experimental materials: Organic samples used for anaerobic digestion were collected from Ado-Ekiti metropolis. Freshly voided poultry waste was collected from a poultry farm whereas fresh cassava peels were obtained from a gaari-processing unit in a nearby locality. Triplochiton Scleroxylon (obeche wood) was also collected from nearby sawmill. This tree was chosen as source of wood mainly on the basis of availability and concentration of cellulose material in the wood content.

Setting up the digester: Six reagent bottles measuring 2.8 L were used as digesters. In setting-up a digester, an appropriate ratio of waste and distilled water was transferred into a digester with the aid of a funnel. Mechanical grinding of cassava peels was done using a clean mortar and a pestle. Initially, 400 g of poultry drops were mixed with 1200 cm^3 of distilled water (1:3 w). The prepared slurry was then transferred to the digester A. Also, 200 g of poultry drops and 200 g of cassava peels were mixed with 1200 cm^3 of distilled water and the slurry transferred into digester B. Two hundred gram of poultry drops and 100 g of cassava peels seeded with 100 g of obeche wood were mixed with 1200 cm^3 of distilled water and the slurry transferred into digester C. Three hundred gram of poultry drops seeded with 100 g of obeche wood were mixed with 1200 cm^3 of distilled water and the slurry transferred into digester D. Four hundred gram of cassava peels mixed with 1200 cm^3 of water formed a slurry which was transferred into digester E. Three hundred gram of cassava peels mixed seeded with 100 g of obeche wood with 1200 cm^3 of distilled water to form a slurry was transferred into digester F. The digesters were made airtight using rubber corks overlaid with plasthecene cast. A hole was drilled on the rubber cork. With a tube fitted through the hole, the tube was passed into a measuring cylinder inverted over acidified water in a plastic bowl as shown in Fig. 1. The cylinder was used as a measuring scale as well as a gas collector. The acidified water was prepared by adding 0.06 mL sulphuric acid (H_2SO_4) with 11.2 g of sodium chloride (NaCl). This was used to prevent dissolution of the gas released into the water. The hole on top of the can was covered with glass funnel. The digesters were corked to generate anaerobic condition. Biogas production was recorded at interval of 5 days for a duration of 45 days. Rates of biogas production during the period were also recorded.

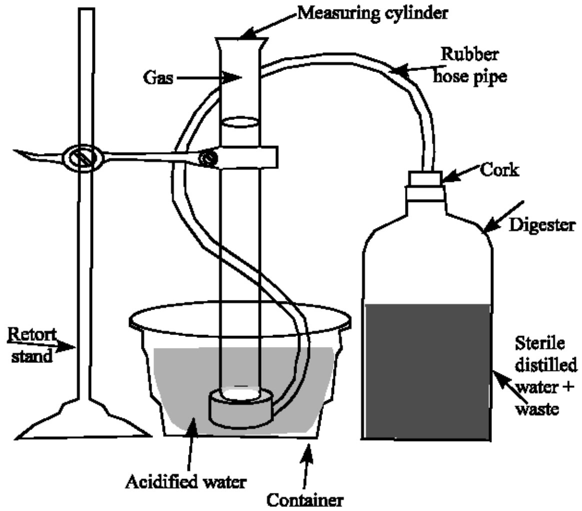

Fig. 1: Experimental set-up for biogas production

RESULTS AND DISCUSSION

The concentration of media material and water used in the digester is shown in Table 1. The amount of gas produced from anaerobic fermentation is recorded in Table 2. Low production of gas was recorded between 1-5 for digester A, B and F and no production for digester E. Digester C with 25% w w^{-1} of cassava peels in poultry droppings seeded with 25% obeche wood has a high production rate of 105cm^3 at start up and production of gas commenced in about 15 h after digestion, whereas in the case of digester A with 0% w w^{-1} of cassava peels in poultry droppings production commenced about 50 h after digestion. This result in the line with that of Itodo *et al.* (1992), where biogas production commenced about 18 h after the introduction of waste material into the digesters that contain media material while the biodegradation process commenced 48 h after the introduction of waste into the digester that had no media material. The peak period of gas production was between day 11-20, where digester A, B, C, D and F recorded 390, 725, 625, 670 and 140 cm^3, respectively.

The total volumes of biogas produced within 45 days of digesters A-F were 455, 925, 2590, 1944, 90 and 484 cm^3, respectively. The rate of biogas production appeared highest in digester C and this is due to the presence of obeche wood. It was also noticed that production of gas in digester with obeche as seed lasted for the period of 45 days and there was no deterioration noticed in any of the wood samples used. This may be due primarily to the abundant presence of lignin (which is not readily biodegradable by anaerobic organisms) in the

Table 1: Media composition of digester slurry

Digester	Poultry drops (g) PD	Cassava peels (g) CP	Obeche wood (g)	%Obeche wood as media mat'l	%CP as a media material	Volume of water (cm^3)	Weight of slurry (g)
A^g	400	-	-	0	0	1200	1600
B^i	200	200	-	0	50	1200	1600
C^h	200	100	100	25	25	1200	1600
D^h	300	-	100	25	0	1200	1600
E^{gi}	-	400	-	0	100	1200	1600
$F^{h,i}$	-	300	100	25	75	1200	1600

g = without obeche wood, i = macerated cassava peels, h = seeded with obeche wood, j = unmacerated cassava peels

Table 2: Biogas production from poultry drops with varying concentration of cassava peels and obeche wood (Biogas production in cm^3)

Period	Digester A	Digester B	Digester C	Digester D	Digester E	Digester F
Day 1-5	5	20	105	95	0	20
Day 6-10	20	115	445	105	0	70
Day11-15	390	725	550	450	0	140
Day 16-20	40	25	625	670	22	70
Day 21-25	0	20	315	188	10	58
Day26-30	0	20	120	176	18	68
Day 31-35	0	0	270	120	30	20
Day36-40	0	0	110	100	10	20
Day 41-45	0	0	50	40	0	18
Total (cm^3)	455	925	2590	1944	90	484
Mean (cm^3/day)	10.11	20.56	57.56	43.20	2.00	10.30

A = ratio 4:0:0 (poultry drops: cassava peel: Obeche wood), B = ratio 2:2:0 (poultry drops: cassava peel: Obeche wood), A = ratio 2:1:1 (poultry drops: Cassava peel: Obeche wood), A = ratio 3:0:1 (poultry drops: Cassava peel: Obeche wood), A = ratio 0:4:0 (poultry drops: Cassava peel: Obeche wood), A = ratio 0:3:1 (poultry drops: Cassava peel: Obeche wood), Total volume of biogas produced in cubic cm, (cm^3), means biogas production (cm^3/day)

wood samples. This result agrees with the observation of Itodo *et al.* (1992) who observed that the use of wood waste as a medium material for seeding, exhibited good characteristics in accelerating biogas yield. The wood medium used for this study-(obeche) exhibited good medium characteristics in accelerating biogas yield since biogas yield commenced 15 h after the introduction of waste into the digester containing obeche woods as against 3 days in digester without media materials. The trend of the production rates in the six digesters is as plotted in the graph of Fig. 2, with digester C with the media material showing a steady and better production rates than other.

The use of different media materials had some effect on the biogas production as shown in Table 2 as well as the plot in Fig. 3. Digester B, which has poultry drops and cassava peels but no obeche wood showed a low rate of biogas production, with starting value of 20 cm^3 had a total pf 925 cm^3 with a daily mean of 20.56 cm^3 with the highest value being 725 cm^3 between 11 and 15th day, with about 75% of the production days having between 0-25 cm^3 of biogas, indicating a low production throughout the period for this digester.

On the other hand, digester D which had poultry drops, no cassava peels, but seeded with obeche wood had a better production rate than that obtained in digester B, Digester D (with obeche wood) started biogas production with 95cm^3 and rose to a maximum of 670 cm^3 within 16-20th days, with a total production of 1944 cm^3 sand an average daily mean of 43.20 cm^3. It was observed that over 88% of the production days recorded rates

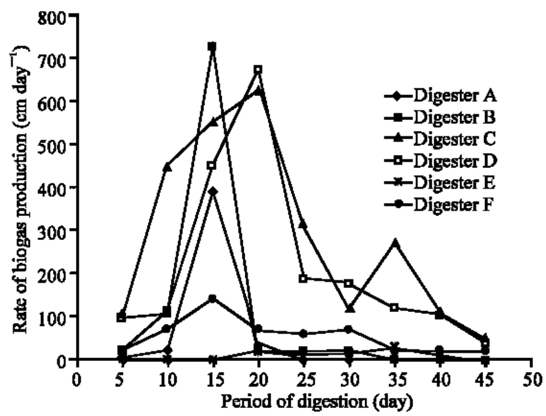

Fig. 2: Comparison of rate of biogas generation using different concentration of cassava peels and obeche wood

between 95 and 670 cm^3 indicating higher production rare throughout the period. The above analysis showed wood as a better medium for improving biogas production than cassava peels. However, digester C which has both media gave better production rate than the digesters with neither wood seed (B) nor cassava peels D. Figure 3 shows the production rate from the wood seeded digester D, cassava peels digester B compared with the digester with the two media, digester C.

Most importantly, the success of any biogas plant (Adeyemo, 2001) lies on its construction operation and maintenance. Several designs of biogas plants are in existence, bur the fixed dome and the floating shoulder types are more popular (Cowan and Steel, 1974) but the

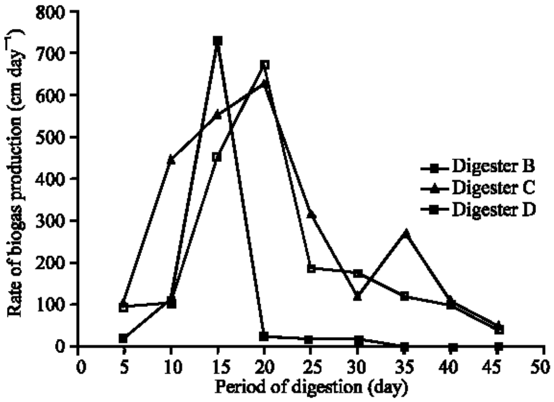

Fig. 3: Comparison of rate of biogas generation using different materials (cassava peels and obeche wood)

major operating parameters are the feed concentration and retention time (Garba and Samboo, 1992). Similarly, constant temperature, P^H and feeding of the digester promote methane production.

CONCLUSION

The increasing cost of conventional fuels in the urban areas necessities the exploration of other energy sources. Biogas can be produced from animal wastes, wood wastes and other wastes to substitute for fossils fuels. The search for alternative energy sources such as biogas should be intensified so that ecological disasters like deforestation can be arrested.

This study has shown an increase production of biogas through the use of media materials. The wood medium exhibits good and better characteristics in accelerating biogas yield than cassava peels, but the use of both media with the slurry yielded and reliable results.

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