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Generation of Biogas from Cow Dung

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Abstract

Four sets of 250 ml conical flasks (A-D), each containing two flasks, were used in triplicates as digesters to determine the possibility of laboratory-scale biogas production from cow dung under four different treatments. Equal volumes of slurry (3 g dung: 10 cm^3 water) in the digesters were subjected to anaerobic digestion over a four-week retention period, with weekly measurements of gas yields. Gas was collected by the water displacement method. Flasks A were kept at ambient temperature (25 ± 2°C) and gas was collected over water. The B-flasks were also kept at ambient temperature but gas was collected over lime water. Flasks C were exposed to sunlight outdoors. The D-flasks were kept at 40°C. At the end of the digestion, microbial analyses of the spent slurry were carried out. Gas was produced in digesters A, B and D. The B digesters had the highest total gas yield (15.60 cm^3). Differences in total gas yield were significant ($p<0.05$) for the different treatments. Gas production increased with increase in retention time. Week 4 had the highest percentage gas yield (53.85%) for the B digesters. For the A and D digesters, week 3 and week 2 had the highest percentage gas yields of 41.30% and 39.29%, respectively. The microbial isolates included *Bacillus licheniformis, Escherichia coli* and *Clostridium* sp. Cow dung demonstrated a potential for biogas generation.

Keywords: Cow dung; Biogas; *Bacillus licheniformis*; *Escherichia coli*; *Clostridium* sp.

Introduction

Biogas is a mixture of colourless, flammable gases obtained by the anaerobic digestion of plant-based organic waste materials [1]. Biogas is typically made up of methane (50-70%) carbon dioxide (30-40%) and other trace gases [2]. It is generally accepted that fuel consumption of a nation is an index of its development and standard of living. There have been increases in the use of and demand for fuel in terms of transportation and power generation in many nations including Nigeria. These have so far been met in Nigeria largely from the nation's stock of fossil fuel such as crude oil, which is finite in nature. Fossil fuels are not environmentally friendly and are also expensive. The use of alternative and more environmentally-friendly energy sources such as biogas has been advocated.

In Nigeria, the use of wastes from organic matter, though important, has been relegated to the background. There are abundant agricultural residues and municipal solid wastes, whose potentials are yet to be fully tapped for energy generation [3,4]. The possibility of using such wastes for biogas production should be explored. The raw materials used in commercial methane generation include plant residues, animal waste like cow dung and various urban wastes which are available in Nigeria. Biogas technology has advantages which include the following: generation of storable energy sources, production of a stabilized residue that can be used as a fertilizer, an energy-efficient means of manufacturing nitrogen containing fertilizer, a process having the potential for sterilization which can reduce public health hazards from faecal pathogens, and if applied to agricultural residues, a reduction in the transfer of fungal and plant pathogens from one year's crop to the next [5].

The two enormous problems that are increasingly threatening the good life of many nations include the task of waste management and inadequacy of energy supply. A nation's inability to dispose waste and to find enough energy greatly affects living conditions. The problem of fuel scarcity and sewage disposal in Nigeria and many developing countries is alarming. Energy generated from waste is therefore needful as it will serve the dual purpose of cleaning the environment and providing a cheaper source of energy. The aim of this research was to investigate the possibility of biogas production from a cheap raw material (cow dung) using a laboratory scale digester.

Materials and Methods

Sample collection

Fresh cow dung was collected from a cow market in Jos, Plateau State. A clean container with cover was used for collection of the waste. The cow dung was dried under the sun for four days and then pulverised using a pestle and mortar. The pulverised dung was sieved and dried again for a day.

Slurry preparation

Three grams each of the fine powdered cow dung was weighed and mixed with 30 cm^3 of distilled water in a 250 ml conical flask to give a ratio of 1:10 as recommended by Mattocks [6]. The mixture was thoroughly stirred with a glass rod to achieve homogeneity.

Anaerobic digestion

Four sets of 250 ml conical flasks, each containing two flasks were used as digesters. The flasks were labelled A1 and A2, B1 and B2, C1 and C2, and D1 and D2. Each set was replicated three times. A total of 24 flasks were thus used. Each flask containing equal volumes of the slurry (3 g dung: 10 cm^3 water) was connected by a rubber delivery tube, which conveys the gas, to a burette filled with water and placed in an inverted position in a glass trough containing water such that gas released from the digestion process was collected in the burette by water displacement method. The flask-end of each delivery tube was

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inserted into the mouth of the conical flask and held in place by cotton wool stuffed at the mouth of the flask. The connecting point of tube and flask was sealed with adhesive tape to prevent leakage of gas from the flask. Each of the four sets of flasks was subjected to a different treatment. Flasks A were kept in the laboratory at ambient temperature (25 ± 2°C) with gas collection carried out over water. The B-flasks were also left at ambient temperature but there water troughs contained lime water instead. Flasks C were exposed to the sun outdoors all through the period of the experiment. The D-flasks were placed on a heating unit and maintained at 40°C in the laboratory. The contents of the flasks were allowed to undergo digestion for a retention period of four weeks with weekly measurements of gas yields.

Microbial analysis

The spent slurry in the digesters was subjected to microbial analyses at the end of the anaerobic digestion. Small portions of digested slurry (sludge) were serially-diluted and subjected to microbial analysis using the plating method of Harrigan and McCance [7]. The 10^{-5} dilution was cultured on nutrient agar, MacConkey agar and blood agar. Also, small portions of the sludge were placed in meat infusion (a special growth broth for *clostridium*) and incubated at 37°C for 24 hours. This was followed by sub-culturing onto lactose egg yolk milk medium. Triplicate plates were used for all the isolations. The plates were incubated at 37°C anaerobically for 24-48 hours, after which they were observed for growth. Sub-culturing was done to obtain pure cultures. Bacterial isolates were characterised on the basis of their colonial morphology, microscopic and biochemical characteristics and by making reference to the identification manual by Cowan and Steel [8].

Results

The mean weekly biogas yields for the different sets of digesters are presented in Table 1. The highest total gas yield (15.60 cm^3) was observed in the B digesters which were left at ambient temperature and in which gas was collected over lime water. The least total gas yield (4.60 cm^3) was observed in the A-digesters which were also left at ambient temperature but with gas collection carried out over water. The content of the C digesters which was exposed to the sun dried up and no gas was produced. In digesters A, B and D, gas yield increased as retention time increased. Weekly monitoring of gas yields showed that for the B digesters, week 4 had the highest percentage gas yield (53.85%). For the A-digesters, week 3 had the highest gas production (41.30%). Highest weekly gas production for the D digesters (39.29%) was observed in week 2. The observed differences in the total gas yields for the different treatments were significant ($P<0.05$). The microorganisms isolated from the different digesters were similar. The isolates and their physicochemical characteristics are presented in Table 2.

Discussion

The highest total volume of biogas produced (15.60 cm^3) was in digesters B which were left at ambient temperature and in which gas was collected over water (Table 1). The differences in total biogas production for the different treatments were significant ($p<0.05$). The gas yield figures from this study are lower than the 2500 cm^3 of biogas generated from the anaerobic digestion of the contents of sheep colon reported by Wahyudi et al. and Bagudo et al. [9,10] reported a biogas volume of 8772 cm^3 from cow dung. The observed higher gas yields recorded in these two studies were probably because of the use of larger digesters, higher volumes of slurry and larger gas collection apparatus in their experiments. Exposure of the C digesters to the sun led to the drying up of their contents and to non production of gas. The moisture content of the substrates in these digesters was probably too low for any significant microbial activity that could have brought about biogas production. It is not clear why the gas yield of the A digesters (4.60 cm^3) was much lower than that of the B digesters (15.60 cm^3) considering that digestion in both cases were carried out under the same temperature conditions. The lower gas yield observed in the D digesters (5.60 cm^3) which were maintained at 40°C could be as a result of non optimal temperature conditions. Since the bacterial isolates were mostly mesophilic organisms, it is possible that temperatures as high as 40°C could have limited their activities. The highest percentage weekly

Retention Time (Weeks)	Mean Gas Yields from Digesters (± SD) (cm^3)			
	A	B	C	D
1	1.20 ± 0.05^a	0.00 ± 0.00^b	0.00 ± 0.00^b	1.60 ± 0.05^c
2	2.00 ± 0.04^a	2.90 ± 0.06^b	0.00 ± 0.00^c	3.80 ± 0.13^d
3	3.90 ± 0.03^a	7.20 ± 0.18^b	0.00 ± 0.00^c	4.60 ± 0.09^d
4	4.60 ± 0.07^a	15.60 ± 0.18^b	0.00 ± 0.00^c	5.60 ± 0.05^d

Figures in the same row having different superscripts are significantly different ($P<0.05$).

Table 1: Mean weekly biogas yields from anaerobic digestion of cow dung.

Gram stain	Spore position	Motility	Catalase	Urease	VP	OPNG	Nitrate	Citrate	Indole	Gelatin	Glucose	Maltose	Sucrose	Lactose	Manitol	Growth (50%)	PO
GPR	C	-	-	-	+		+		-	+	+	+	+	+			PO1
GNR		+		-				-	+	-	+		+	+	+		PO2
GPR	S	+	+	-	+	+	+	+	-		+					+	PO3

+=Positive Reaction; GPR=Gram Positive Rods; P=Vogues Proskaver; C=Central; PO=Probable Organism; PO2=*Escherichia coli*; -=Negative Reaction; GNR=Gram Negative Rods; OPNG=O-nitrophenyl-B-D-galactopyranoside; S=Subterminal; PO1=*Clostridium sp.*; PO2=*Bacillus licheniformis*.

Table 2: Microbial isolates and their physicochemical characteristics.

biogas productions of 53.85%, 41.30% and 39.29% were observed in digesters B, D and A respectively. These periods of higher gas production were periods of higher microbial activity following the period of acclimatization for the microorganisms. The high gas production in week 2 recorded for the D digesters is comparable with the finding of Rabah et al. [11] who reported highest biogas production in week 2 for anaerobically digested abattoir waste. A retention time of four weeks brought about better biogas yields in the present study. The microbial isolates from the digesters included *Bacillus licheniformis*, *Escherichia coli* and *Clostridium* sp. (Table 2). These were probably responsible for the breakdown of complex organic substances to intermediates such as volatile fatty acids which were ultimately converted to biogas. Rabah et al. and Baki [11,12] reported the isolation of *B. licheniformis* and *E. Coli* from biogas digesters. Oluyega et al. [13] reported that *Bacillus*, *Yersinia* and *Pseudomonas* species were responsible for biogas production in cow dung.

Conclusion

The findings of the study show that cow dung could be used as a suitable substrate for biogas production. Biogas production, if carried out at commercial scale, would not only provide an alternative source of energy but would also be a means of waste disposal for Nigeria.

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