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PRODUCTION AND PURIFICATION OF BIOGAS FROM COW DUNG AS A POTENTIAL DOMESTIC FUEL

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ABSTRACT

The production and refining of a biogas to reduce its carbon dioxide and hydrogen sulphide was undertaken. This was done to improve the combustion characteristics of the biogas produced to serve as an alternative to the petroleum based products in use. This paper also reported the effect of temperature and pH on the production of biogas. The biogas samples were passed through a gas chromatography column to determine their percentage compositions (mol % dry basis). The results obtained showed that the biogas samples before refining contained 53.02 mol % dry CH_4, 41.42 mol % dry CO_2 and 0.75 mol % dry H_2S and after refining these percentage compositions are 53.02 mol % dry CH_4 2.50 mol % dry CO_2, 0.02 mol % dry O_2, 0.04 mol % dry NH_3, 0.04 mol % dry H_2S, 0.5 mol % dry H_2, and 2.45 mol % dry N_2. These determined value are consistent with the literatures of 50 - 65 mol % dry CH_4, 20 - 45 mol % dry CO_2 and 0.1 - 1.0 mol % dry H_2S.

Keywords: *Biomass, Biogas, Refining, Production, Diethanolamine solution*

INTRODUCTION

Biogas produced from biomass is a mixture of methane and carbon dioxide and other gases (Austin, 1984).Biogas provides energy for cooking, lighting, drying of farm produce and generation of electricity (Odunaiyi, 2000). Since ancient times, biogas is produced by the decay of vegetable and animal origin, and was earlier identified as combustible swamp gas (Ronald *et al.*, 1982; Bailey and Ollis, 1977).This highly desirable fuel was obtained by fermentation of sewages as early as in 1934 and was used for heating an internal combustion engine for pumping (White and Plaskette, 1981). Though the total amount produced may be small but of great significance locally in Nigeria and parts of the world. It is on record that several large demonstration plants are already in operation and many other smaller units are installed daily (Malcolm and Chris, 1979).Biogas as an alternative source of energy is renewable. But petroleum is non renewable and it has been confirmed that non renewable source of energy could only last for about another 25 years or more (John and Twidell, 1987).This uncertainty has created a lot of anxiety for industrialized and developing nations like Nigeria. They are now looking back to the past and alternative methods of using biomass as one of the most viable solutions in the energy sector to avoid a complete breakdown should the fossil fuel be depleted suddenly. Presently, countries like India, United States, Pakistan and China have actualized this idea and are still thriving well (John and Twidell, 1987).In Nigeria biogas can be produced from animal and human excreta, crop residue, poultry droppings, but in this work cow dung was used because there is no specific application use of cow dung for biogas in Nigeria today. Therefore, the aim of this work is to produce and purify biogas from cow dung for domestic purpose using aqueous solution of diethanolamine.

MATERIALS AND METHODS

Collection and Preparation of Samples

The cow dung was collected from the farm of School of Agricultural and Agricultural Technology at Federal University of Technology Minna. The cow dung was sun dried for five days after which it was ground and sieved. Total solid concentrations of 50, 60, 70 g/cm^3 of solution were prepared using the sieved cow dung. Each of the four litre laboratory sized batch digesters of three and half litre were filled with each of the mixture to their 3000 cm^3 mark. The slurries were warmed using steam bath with constant stirring to remove air bubbles. The pH was measured and adjusted to 7.0 ± 5. The remaining air bubbles were removed by aspiration and subsequently by application of pressure to compress the plastic digesters. The outlet was immediately closed tightly to prevent the entrance of air into the digesters. Delivery tubes were connected from the digester to a 1000 cm^3 conical flask containing 400 cm^3 of twenty percent concentration of diethanolamine solution for carbon dioxide and hydrogen sulphide absorption. The gas collection bag was connected to the flask containing water for gas collection over water. The digesters were maintained at room temperature and the contents were shaken daily and pH was monitored through a pH meter connected to a sampling point. In this study, for the production of biogas, the cow dung was allowed to decompose anaerobically at room temperature. This produced a gaseous product which on analysis contained methane, carbon dioxide and hydrogen sulphide on adequate proportions.

The effect of temperature and pH on biogas production was carried out using metal tank digester. A total solid concentration of 100g/cm^3 of solution was prepared using the sieved cow dung. The slurry was heated at the temperature of 20°C for 30 minutes. The pH of the slurry as well as the amount of gas produced was recorded. This procedure was repeated at different temperatures and their corresponding pHs and amount of gas produced recorded.

Analysis of Gaseous Products

2000cm^3 of biogas was collected and pas through a gas analyzer of model P7450 to determ the percentage composition of the gaseous mixtu

Total Solid Analysis of Cow Dung

The evaporating dish was washed clean w detergent solution and rinsed with distilled wa It was ignited for an hour in the oven at 100°C. content was allowed to cool at room temperat and the weight taken again using an electro weighing balance. This was kept until ready for u Twenty five grams of the sieved cow dung w transferred to the preweighed evaporating di and weighed together and recorded. It was th dried at 105°C in the oven for two hours. The d with its content was then cooled at ro temperature and weighed again using the sa electronic weighing balance. This cycle w repeated in 5 days for a period of 30 days.

Volatile Solid Analysis of Cow dung

The dried sample was put in a petri dish and w transferred to the muffle furnace and heated 500°C for two hours. The loss in weight of t sample represents the volatile solids.

RESULTS AND DISCUSSION

The rate of gas production can be seen as shown Figure 1.0. From the Figure it can be observed th

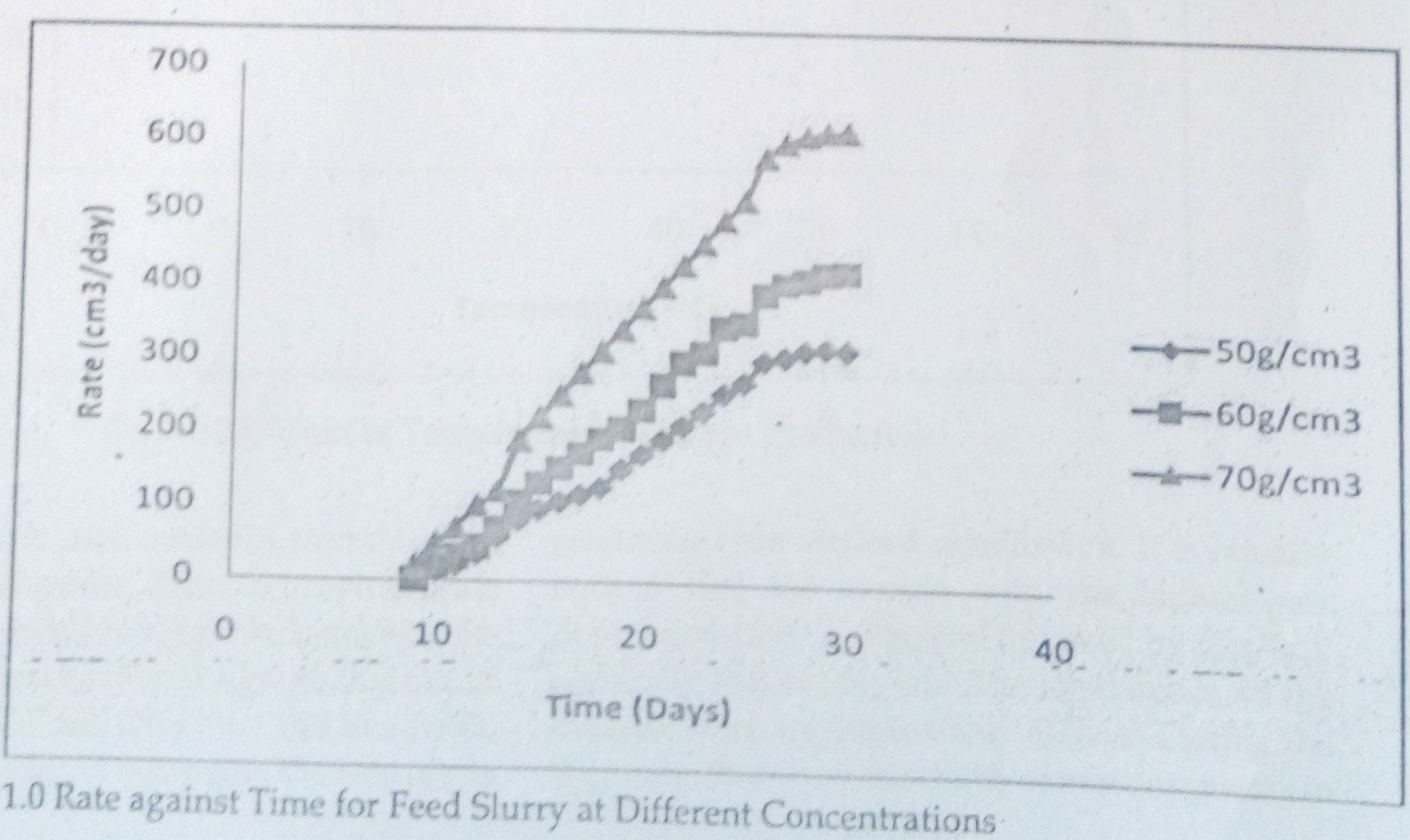

Figure 1.0 Rate against Time for Feed Slurry at Different Concentrations

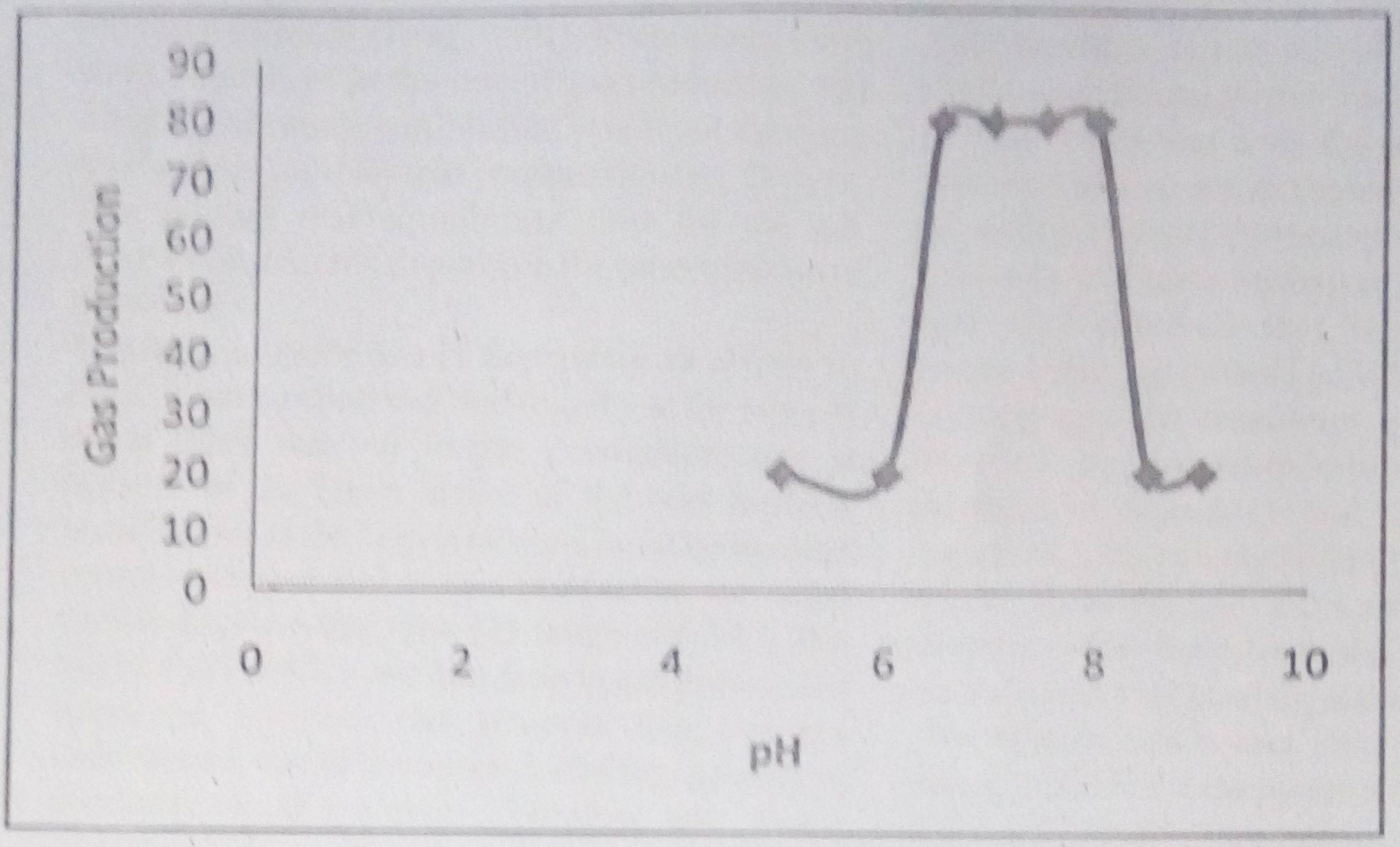

Figure 2.0 Effect of pH on Biogas Production

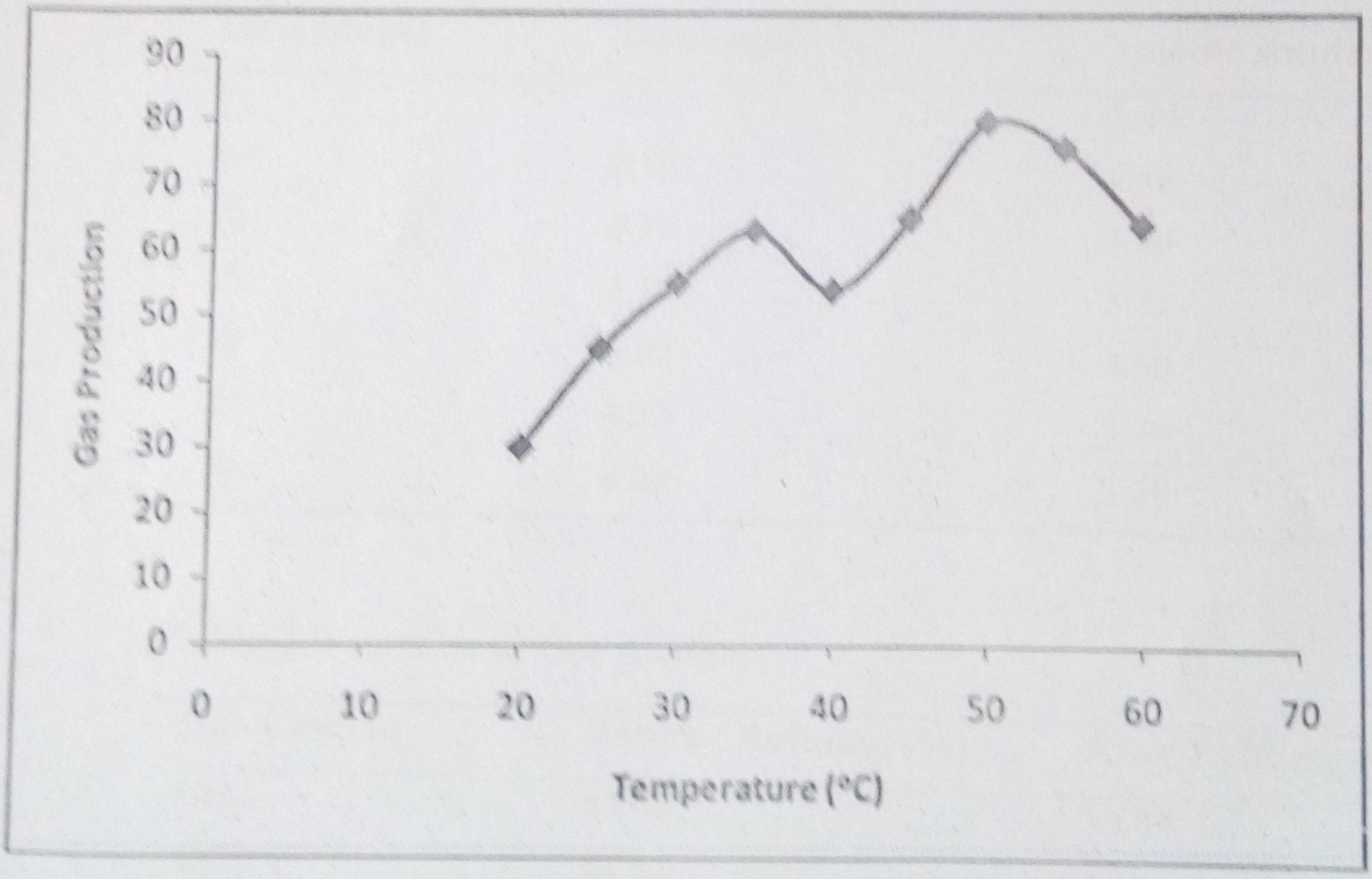

Figure 3.0 Effect of Temperature on Biogas Production

as the slurry concentration increases, the rate of gas production also increases. When a graph (Figure 1.0) of rate of gas production is plotted against time, it could also be observed from the graph that rate of gas production increases with time and at a point, the curve flattens out. At this point, the rate of gas production has attained equilibrium. It is equally noticed that the sample with the highest gas production rate i.e. 70g/cm³ followed by 60g/cm³ and lastly that of 50g/cm³ .The lag time for all the samples were approximately 8-9 days. During the lag phase, there was no activity of microorganism in the three samples (Tyagi, 1981). Even where there were differences in the rate of gas production, the time taken to attain equilibrium was about the same for the three samples that is approximately 22 days. This implies that equilibrium time for the gas production does not depend on the concentration of the slurry.

Biogas production is pH dependent as shown in Fig.2. It can be observed that initially at the low pH value there was no biogas production; this is because of the faster action of the acid forming bacteria. But as the biogas formers build up the acid content reduced and biogas production increased tremendously within the pH range of 6.5-7.5. But beyond pH of 7.5, a sudden drop in gas production occurred because the process has become unbalanced, due to the excess buffering capacity of alkalinity in the slurry. Therefore any slurry condition that is not within this pH range render both biogas former and acid former inac to such levels that even the acid formers wil inhibited and all action ceased. Such case can c be rectified by pH correction with chemicals, prevention of such mishap is a better solutior was also observed that biogas production temperature dependent Fig.3. From the graph it be seen that the maximum gas production v recorded at the temperatures of about 3! (mesophilic digestion) and 55°C (thermoph digestinn), respectively (Tebbutt, 1983). From th results it is evident that anaerobic process sensitive to temperature and pH and requi careful control for good digestion (Tebbutt, 1983)

The volatile solids and total solids removed shown in Table 1.0, decreases with time. The resu of the analysis of gases produced before and af

Table 1.0 Total Solids and Volatile solids of Cow Dung

Time (days)	Total solids (g)	Volatile solids (g)
1	6.22	5.80
5	6.19	5.58
10	6.16	5.40
15	5.10	5.32
20	5.02	4.60
25	4.50	3.74
30	4.20	3.38

Table 2.0 Results of Gas Analysis

Gas Content	Before Refining (%)	After Refining (%)
CH_4	53.02	53.04
CO_2	41.42	2.50
O_2	0.05	0.02
NH_3	0.90	0.04
H_2S	0.75	0.04
H_2	0.50	0.50
N_2	3.20	2.45
Others	0.16	41.48

refining are presented in Table 2.0.It can be observed from the results that the percentage composition of methane, carbon dioxide and hydrogen sulphide before refining are 53.02, 41.42 and 0.75 mole % dry gas, respectively. These values are in agreement with the literature values of 50-60, 20-45, and 0.1-1.0 mole% dry gas for methane, carbon dioxide and hydrogen sulphide, respectively. The results of gas analysis after refining shows a great reduction in carbon dioxide and hydrogen sulphide content present in the gas sample. The percentage compositions of the gases after refining are 53.02, 2.50 and 0.04 mole % dry for methane, carbon dioxide and hydrogen sulphide, respectively. And basically refining is all about the removal of carbon dioxide and hydrogen sulphide present in the gas sample by using diethanolamine solution (Dim, 2002). It is usually desirable to remove both gases to prevent corrosion problems and to increase heating value of the gas (Abdel-Aal *et al.*, 2003). The basic reactions for the absorption of CO_2 and H_2S by diethanolamine are given below as equations 1, 2 and 3.

$$2R_2NH + H_2S \,?\, (R_2NH_2)_2S \quad (1)$$

$$(R_2NH_2)_2S + H_2S \,?\, 2R_2NH_2SH \quad (2)$$

$$2R_2NH + CO_2 \,?\, R_2NCOONH_2R_2 \quad (3)$$

CONCLUSIONS

The analyzed cow dung sample showed that total solids and volatile solids content decreased from day 1 to 30, and it was observed that the best pH range for biogas production is within the range of 6.5-7.5.Thus it is important to control the conditions to suit the anaerobic bacteria responsible for slurry digestion. The result also showed that the bacteria prefer warm conditions which correspond to temperature of about 35°C to 55°C for good slurry digestion.

The result of biogas analysis showed that the concentration of diethanolamine solution used in the study removed, 93.96% and 94.66% of CO_2 and H_2S, respectively, which is a considerable amount of reduction for both gases.

Finally, the quality of biogas produced can be assumed improved by reducing greatly CO_2 and H_2S contained in it, meaning increase in the heating value of the gas. The energy obtained during biodegradation of biomass could be described as having modest thermal content (Aruh and Paul, 1986); therefore it can comfortably serve as cooking gas since energy requirement for domestic heating in small scale compared to industrial scale.

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