Assessment of the Effect of Mixing Pig and Cow Dung on Biogas Yield

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ABSTRACT

Household energy is increasingly becoming a scarce resource in developing countries. In these countries, cooking accounts for about 90% of all household energy consumption. Motivated by the need to meet the ever-increasing energy demand and sustainability consciousness, many Governments have promoted renewable energy technologies such as biogas. However, further development of biogas technology in Uganda is constrained by insufficient gas production due to lack of enough feedstock. This paper presents the findings of a research that was carried out to determine the effect of mixing pig and cow dung on biogas yield. Fifteen plastic bottles of capacity one and half liters were used as digesters and each fed with 1 kg of pig and cow dung mixture in proportions of 1:0, 3:1, 1:1, 1:3 and 0:1 with three replications.

Results from this study show that co-digestion of cow dung with pig manure increased biogas yield as compared to pure samples of either pig or cow dung. Comparing to samples of pure cow dung and pig manure, the maximum increase of almost seven and three fold was respectively achieved when mixed in proportions of 1:1. Ultimately, co-digestion of pig and cow dung is one way of addressing the problem of insufficient gas production in this country.

Key words: Biogas, cow dung, pig manure, co-digestion, Uganda

1. INTRODUCTION

The use of advanced forms of energy, such as electricity, has improved the quality of public lives around the world. However, the majority of the people in developing countries do not easily access such forms of energy and, therefore, they entirely depend on solid fuel forms like wood to meet their basic needs such as cooking and lighting. According to GTZ (2007), cooking accounts for about 90% of all household energy consumption in developing countries. At the same time Okure (2005) observed that over 60% of the total wood produced in Uganda is used as wood fuel in form of either charcoal, especially in the urban areas, or firewood mostly in the rural areas. MEMD (2007) reported that in this country, wood fuel still remains the most affordable source of energy to most rural and urban households. This has resulted in depleting forests at a faster rate than they can be replaced (see Figure 1 as an example). According to the FAO-Worldwide Deforestation Rates report (2003), during the period between 1999 and 2000, Uganda experienced a deforestation rate of 2 per cent. This rate is among the highest in the world.

Figure 1. An example of a depleted forest in Uganda.

Biogas (a mixture of approximately 60% methane and 40% carbon dioxide) is a well-established fuel that can supplement or even replace wood as an energy source for cooking and lighting in developing countries. Table 1 shows some of the typical applications and equivalents for a cubic meter of biogas. During its production, any drastic change in temperature should be avoided since methanogens are very sensitive to thermal changes (Garba, 1996). At the same time, Jain et al. (1998) reported that the efficiency of methane production was more than 75% when the slurry pH was above 5.0. Furthermore, Sahota *et al.*, (1996) had observed that biogas production was only significantly affected when the pH of the slurry decreased to below 5.

Table 1. Some biogas applications (Kristoferson and Bokalders, 1991)

Application	$1m^3$ biogas equivalent
Lighting	Equal to 60 – 100 watt bulb for 6 hours
Cooking	Can cook 3 meals for a family of 5 - 6 members
Fuel replacement	0.7 kg of petrol
Shaft power	Can run 1 hp motor for 2 hours
Electricity generation	Can generate 1.25 kW h of electricity

Currently as the fossil-based fuels become scarcer and more expensive, the economics of biogas production is turning out to be more favourable. At the same time, Pound *et al.*, (1981) observed that biogas production units provide a decentralized fuel supply and waste management system, both of which are very attractive particularly in rural areas of developing countries.

The majority of the work done in Uganda to promote the use of biogas technology has used cow dung as the raw material. This falsely made people especially in rural areas to generally believe that biogas can only be derived from cow dung. According to Silayo (1992), a typical peasant farmer rearing a few cattle in a free range system cannot sustain a biogas digester due to insufficient manure. Furthermore, Nabuuma and Okure (2005) reported that biogas production technology in Uganda is constrained by insufficient gas production due to lack of enough feedstock.

Insufficient biogas production necessitated this study, with the ultimate goal of assessing the effect of co-digestion of cow dung and pig manure on biogas production. Many farmers in Uganda rear cattle and other livestock, especially pigs and goats. Co-digestion of one or more substrates has been reported to increase biogas production (Misi, *et al.*, 2001, Nabuuma and Okure, 2005). It was therefore hypothesized that "mixing of pig manure with cow dung had no effect on biogas production".

2. MATERIALS AND MEHODS

2.1 Substrate preparation

This study was conducted at Makerere University in a green house to minimize the effect of day and night temperature fluctuations. Samples of fresh cow dung and pig manure were obtained from Makerere University Agricultural Research Institute-Kabanyoro (MURIK). The cows were being fed on elephant grass and the pigs on formulated feed. The pig manure and cow dung were each mixed with water in a ratio of 1:1 (v/v) before being mixed in varying proportions indicated in Table 2.

Table 2. Proportions for the different treatments

Mixture proportions	Treatment
100% cow dung,0% pig manure	A
75% cow dung ,25% pig manure	B
50% cow dung, 50 % pig manure	C
25% cow dung, 75% pig manure	D
0% cow dung, 100% pig manure	E

2.2 Experimental design and set up

One and half litre plastic bottles were used as digesters. This was a modification of a compact system digester that digests small volumes of manure to produce biogas. A thermometer was inserted in each digester to measure temperature. A U-tube was used to measure the gas pressures, while the pH of the mixtures was measured with a digital pH meter. Weighing was done using a digital weighing scale.

A completely randomized design was used in a 5 x 3 replicated experimental design. The digesters were charged once during the experiment duration of 24 days with 1 kg of the mixture in proportions indicated in Table 2. To test the null hypothesis, the collected daily mean biogas yield data was subjected to analysis of variation (ANOVA) while the Duncan's Multiple Range Test (DMRT) was used to determine the mixture proportion that produced the highest biogas. The experiment set up is shown in Figure 2.

Figure 2. Experiment set up.

2. RESULTS AND DISCUSSION

3.1 Results

Treatment D produced gas first on the 7th day of the experiment. Treatment C followed on the 8th day while treatments A, B and E gave off gas on the 11th day.

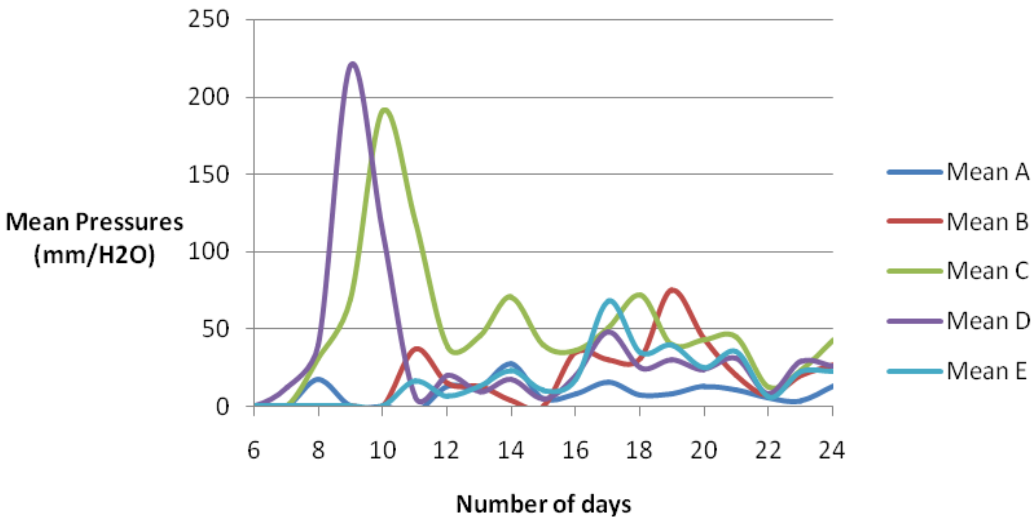

Figure 3. Daily biogas yield of the different treatments. For a constant volume of the container used, increased pressure was a result of increased volume of biogas generated.

The daily biogas yields and the cumulative gas production are depicted in Figures 3 and 4 respectively. Table 3 shows variation in pH for the different treatments.

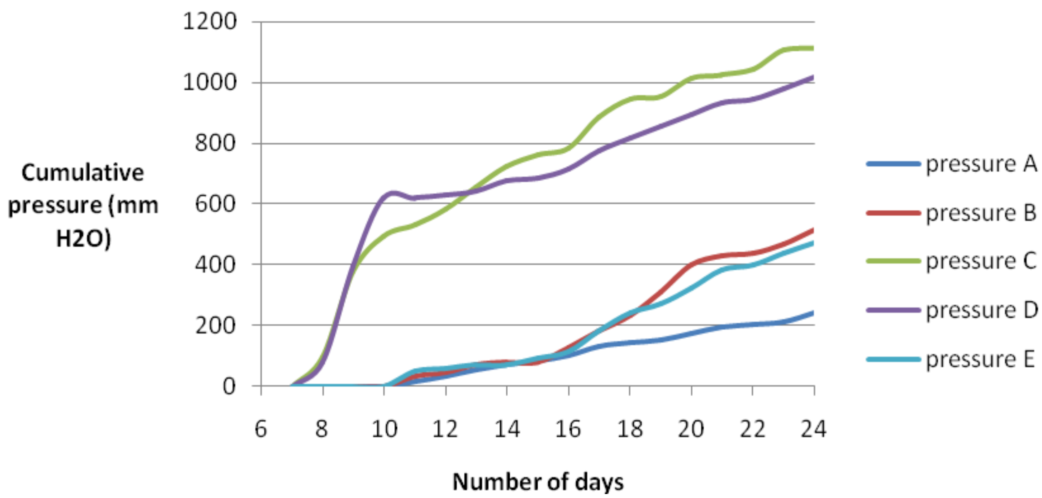

Figure 4. Cumulative biogas yields from the different treatments.

Table 3. Variation in pH of the treatments and the mean biogas yield

Treatment	Initial pH	Final pH	Mean gas Yield (mmH_20)/day
A	6.6	6.3	26.8
B	6.6	6.8	59.7
C	6.5	6.5	185.7
D	6.5	5.5	113.9
E	6.5	5.7	56.9

3.2 Discussion

For all the treatments, pH for the initial slurry varied within the range of 6.5 and 6.6 while the final ranged between 5.7 and 6.8 (Table 3). Thus, the experiment was conducted within the pH range for optimum methane production and there was little temperature variation throughout the experiment. Accordingly, there was a negligible temperature variation effect on biogas production.

From Table 3, the 100% pig manure produced more gas per unit weight as compared to the 100% cow dung. This concurs with Hobson's (1981) findings that attributed the lower production to low biodegradable material in the cow dung. However, Yeole *et al.*, (1992) attributed the higher biogas yield from the pig dung to the presence of native micro flora in the pig dung while Fulford (1988) attributed it to the low carbon-nitrogen ratio. The higher production from the mixtures could be due to a proper nutrient balance, which is attained by mixing as suggested by Fulford (1988). The highest gas yields from treatment C was attributed to stable pH and it was hypothesized that the mixture was able to buffer its self; a pre-requisite for proper biogas production.

The F values as calculated and read from the tables were as given below:

$F_{5\%}$	$F_{1\%}$	Calculated F
3.48	5.99	11.4

Since the computed F was greater than both $F_{5\%}$ and $F_{1\%}$ then the treatment difference was highly significant. The null hypothesis was thus rejected. Additionally, the C mixture produced the significantly highest biogas and the production was in the order: C>D>B>E>A.

3. CONCLUSION

Comparing with the pure samples, mixing pig and cow dung generally increased biogas yield. The maximum biogas yield was attained with mixtures in the proportions of 1:1. At these proportions, there was a biogas yield increase of seven and three folds as compared to pure samples of cow and pig manure respectively. Co-digestion of cow dung and pig manure is therefore, one way of addressing the problem of lack of enough feedstock for biogas production in Uganda.

Secondly, the sizes of the digesters will be reduced since one needs less quantity of mixtures to produce the same amount of gas as compared to pure samples of either cow or pig manure.

5. REFERENCES

FAO. 2003. The state of the world's forests. *Forestry annual report.* Rome, Italy.

Fulford, D. 1988. Running a Biogas Programme: A handbook. *The Biogas Technology in China.* IT Publications No. 52.

Garba, B. 1996. Effect of temperature and retention period on biogas production from ligrocelluloscic material. *Renewable Energy Journal*, 9(1-4): 934-641.

GTZ, Uganda. 2007. Insights into fuel efficiency and the dissemination of mud and ceramic stoves in Southern Africa.

Hobson, P.N., S. Bousfield and R. Summers. 1981. Methane production from agricultural and domestic waste. *Applied science publication.*

Jain, S.R. and B. Maattiasson. 1998. Acclimatization of methanogenic Consortia for low pH biomethanation process. *Biotech Letter* 20(8): 771-772.

Kristoferson, L.A. and V. Bokalders. 1991. Renewable energy technologies – their application in developing countries. *ITDG Publishing*.

MEMD. 2007. Renewable energy resources policy. *Ministry of energy and mineral development.* Kampala, Uganda.

Misi, N.S. and C.F. Forster. 2001. Batch co-digestion of multi-component agro-waste. *Bio-resource Technology* 80:19-28.

Nabuuma, B. and M.A.E. Okure. 2005. Field-Based Assessment of Biogas Technology: The Case of Uganda. *In Advances in Engineering and Technology, ed. Jackson A. Mwakali and Gyavira Taban-Wani*. 481-487. Oxford, UK: Elsevier Ltd.

Okure. M. 2005, Biofuel Lecture Notes (Un Published). *Faculty of Technology*, Makerere University, Kampala, Uganda.

Pound, B., Done, F. and T. R. Preston. 1981. Biogas production from mixtures of cattle slurry and pressed sugar cane stalk with and without urea. *Tropical Animal Production* 6(1): 11-21.

Silayo, V.C. 1992. Small biogas plants- Design, management and use. *Agrotec publications.*

Yeole, T.Y. and D.R. Ranande. 1992. Alternative feedstock for Biogas. *Tropical Animal Production* 9(3): 10-16.