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Comparative Studies on Biogas Production using Six Different Animal Dungs

Janet Olowoyeye
Department of Agricultural Education, College of Education – Ekiti State
Email: Olowoyeye janet@rocketmail.com

Abstract
This study was carried out to compare the rate of and amount of gas produced from six different animals' dung under anaerobic conditions. 50 grammes dry weight of each animals dung was weighed out in duplicates digested under anaerobic conditions in the laboratory, sheep dung was found to produce the greatest amount of gas (1.15 litres) followed by chicken, pig, goats, cow and horse dung respectively which had total gas production records as 0.65 litre, 0.45 litre, 0.17 litre & 0.03 litre respectively.
Keywords: Anaerobic Digestion, Animal Dungs, Biogas

1. Introduction

Energy is a basic tool for development (Anushiya 2010). The dependence of man on fossil fuels as primary energy sources has led to global climate change, environmental degradation and human health problems (Budyono et al, 2001) According to Akogu (2010), the use of kerosene as fuel is very expensive for rural dwellers and the availability is a problem in some areas. Therefore charcoal from wood is a big business in the Northern parts of Nigeria, thereby putting a great stress on the forestation process in the Northern Nigeria.

In view of escalating Liquid Petroleum Gas (LPG) Costs, the main challenge of the present world is to harness the energy source which is environment friendly, and ecologically balanced (Anushiya 2010). This need according to Anushiya, (2010) has forced scientist to search for alternate sources of energy like the solar, hydro, wind etc. which however require huge economical value and technical power to operate. The use of biogas energy could be the one and only reliable easily available and economically feasible source of alternative and renewable source of energy which can be managed by locally available sources and simple technology.

The Chinese have long identified the importance of Biogas towards meeting the energy needs in rural areas. (Akogu, 2010)

Biogas refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Singh (2012) also defined Biogas as a clean biofuel produced by micro-organisms or bacteria during anaerobic digestion of organic matter (cattle dung, poultry droppings, pig excreta, human excreta, kitchen waste.

Anaerobic Digestion (AD) is a technology used for the treatment of organic waste for biogas production in the absence of oxygen (Budyono et al (2001), Zehnder (1972). Anaerobic decomposition will produce methane, carbon dioxide, some hydrogen and other gases in traces, very little heat and final product with a higher nitrogen content than is produced by aerobic decomposition. Singh (2010) reported that Anaerobic digestion produce biogas on renewable basis, and produces digested slurry which is good manure. According to him, the nutrient value of the digested slurry is better than ordinary farmyard manure.

Biogas is rich in methane (55-56%) and can be used directly for heating purposes, cooking, lighting and power generation (Times, 2010). It is Flammable and on combustion produces a blue flame which can reach a temperature of 1400^0c (Durani, 1980).

The use of biogas according to Simon (2004) is increasing rapidly today for these reasons; that Fuel costs have been rising steadily for a number of years and the taxation burden increases as well leading to a double load for the user to bear. Attempts are now being made to improve the use of renewable energy sources.

The gas produced, mainly methane is one of the major causes of the green house effect.

The production is possible in small scales sites, obviating theneed to supply energy in outlaying areas

A basic construction with commonly used materials will produce gas if a few simple design rules are followed.

Biogas is very important in today's world as it is pollution free source of energy at a very low cost. Akogu (2010). It does not produce any offensive smell

Various scientists with promising results have worked on different organic matter with great success. Francese et al, (2000) worked on anaerobic conversion of a mixture of pig manure, fish oil waste and waste from bentonite of edible oil filtration process reporting an average of methane content of 65% with a maximum methane production of around 74% in digests biogas.

While Kalia and Singh, (2001) worked on pure cattle dung and cattle dung mixed with 10% digested slurry. Bouallagui et al (2003) worked on fruit and vegetable waste, Parawira et al (2004) worked on potatoe waste, while Moller et al (2004) worked on manure, straw and solid fractions of manure. All showing successful results in biogas production. The purpose of this study was to compare the amount of gas produced by six different animal dungs under the same environmental conditions.

2. Materials and Methods

Fresh dung of six different animals were collected in cellophane bags from in and around the University (Ahmadu Bello University) and brought to the laboratory. A little of the six different dungs were placed in 6 different crucibles & dried to a temperature of 104.4^0c (Fry & Merril, 1973). The dry weight of each dung was obtained (Table 1). An equivalent of 50 grams dry weight of each dung was then weighed out.

The apparatus for digestion and gas collection consisted of a 1-litre aspirator bottle connected to a 2-litre aspirator bottle by means of glass tubes and rubber bungs. The 2-litre aspirator bottle was then connected to a measuring cylinder with the aid of a rubber tube. From the top of the 2 litre aspirator bottle runs a tube through which gas can be collected and tested. Another 5-litre aspirator bottle filled with water was kept nearby. The tube leading to the measuring cylinder was connected to this 5-litre bottle whenever gas was to be burnt while a Bunsen Burner was connected at the end of the tube which runs from the top of the Aspirator bottle.

The 50g equivalent of the 6 different fresh animal dungs were placed in separate 1-litre aspirator bottles. Tap water was added to make the volume a little above 1-litre. The mixture was then stirred manually with the aid of a glass rod to form slurry. A rubber bung was then placed tightly over the bottle preventing the entrance of atmospheric oxygen and possible leakage of gas produced.

During digestion, gas released from the digester flask (1-litre bottle) enters the 2-liter bottle containing water and displaces water equal to the volume of gas produce. The displaced water collects into the measuring cylinder. This volume of water was read daily and at times reading was taken twice a day. Daily temperature reading was also taken.

The gas produced was tested regularly with a lighted match stick

The experiment was carried out in duplicates.

3. Result

A change in colour of the various dungs was observed during the second week of digestion. Also a reduction in volume of water in the collection bottle was recorded as more and more gas was produced.

There was a gradual rise in gas production up to the 3rd week where the peak was reached in the the Horse, Sheep, Goat dungs, 4^{th} week in the Pig and 5^{th} week in the cow dung after which there was a gradual decline in gas production in the cow. The other dungs however, showed alternate rises and fall in gas production except in horse dung that gas production was nil at 5 weeks and beyond.

The chicken dung, however, produced a high amount of gas in the first week, this was then followed by a sharp decline by the 3rd week, subsequent weeks showed alternate rises and falls in rate of gas production. This could be seen as shown in table 2 and figure 1.

The total amount of gas produced by the various dungs differed greatly. Table 2 shows that sheep produced the greatest amount of Gas totaling an average of 1.15 for the 8 weeks with a capacity to produce as much as 2.8litres in a single week (3^{rd} week, table 2) Next to it, was the chicken which produced as much as 1.03litres during the 8 weeks with a capacity to produce as much as 3.02 litres in the 6th week (Table 2). The pig, goat, cow and horse dungs followed respectively with gas production over the 8 weeks recorded as 0.65litre, 0.45litre, 0.17litre & 0.03litre respectively.

The gas produced by all the dungs were combustible and odourless.

4. Discussion

The initial rise and gradual fall in gas production observed, in the cow, horse goat, sheep and pig dungs (Table 2) was due to carbon dioxide produced by the aerobic bacteria which used up the available oxygen trapped in the mixture to breakdown complex compounds to simpler forms. As the amount of oxygen available in the digester was being used up, the amount of carbon dioxide being produced decreased until all the oxygen was used up. At this point, the activity of the aerobic bacteria was halted and anaerobic activity of methanogenesis took over (Karakara, 1982). The methane forming bacteria has a very slow growth rate (Kirsh and Sykes, 1971) hence explaining the gradual rise in gas production after the initial fall

Methane gradually builds up as shown in the following reaction

Steps

1	Complex organic compound	$C_2H_3COOH + H_2$
2.	$CO_2 + 4\ H_2$	$CH_4 + 2H_2O$
3.	CH_3COOH	$CH_4 + CO_2$

The hydrogen used to reduce carbon dioxide was obtained from the degradation of organic compounds.

Temperature is a major factor affecting the digestion process. It also influences the length of fermentation period. The higher the temperature, the shorter the fermentation period while the lower the temperature, the longer the fermentation period. This could be observed in table 2 and in figure1 where it was noticed that gas production which succeeded fermentation period, started both in weeks 1 and 2 . Gas production was affected by temperature due to the fact that the bacteria population responsible for both fermentation and gas production were known to carry out these activities better at temperatures ranging between 29.4 and 40.5^0 (Singh, 1973). In table 2, it was observed that the environmental temperature during the weeks the experiment was performed corresponded to the internal body temperatures of the different animals, therefore the species of bacteria excreted with the feaces could survive outside the body of the animals.

Kirsh and Sykes (1971) had noted that bacteria respond to changes in environmental temperature. If the change is sudden and so drastic so that the new temperature is outside of the range of metabolic activity of the bacteria, the result will be immediate cessation of activity, but if the temperature change is moderate, it only affects the metabolic and growth rate of the bacteria.

Looking at the effect of temperature within the various weeks it is observed that as temperature falls, gas production also falls. For example, in the 6^{th} to the 8^{th} week in table 2 gas production in the cow, Horse, Sheep and goat dung fell as the temperature fell. It was also observed that gas production fell in the cow and sheep dungs in the 7^{th} week due to a fall in temperature, but with a rise in temperature in the 8^{th} week, gas production rose. Certain factors such as age of animal, disease condition, feed source and composition, level of intake of food and rate of passage from the gastro-intestinal tract may be responsible for the varying differences in gas production between the various animal dungs. Another major factor which affects rate and amount of gas produced is gross energy in the feed. Some of this energy is lost as faecal energy in the faeces. The faecal energy which is what is converted to Biogas, differs with the various animals,

5. **Conclusion**

Power failure is a common phenomenon being faced by most developing countries. Animal wastes have been seen as a potential solution to the problem when fermented anaerobically. The use of sheep dung as evidenced in this study showed greater potential for biogas production compared to other animal dungs under investigation.

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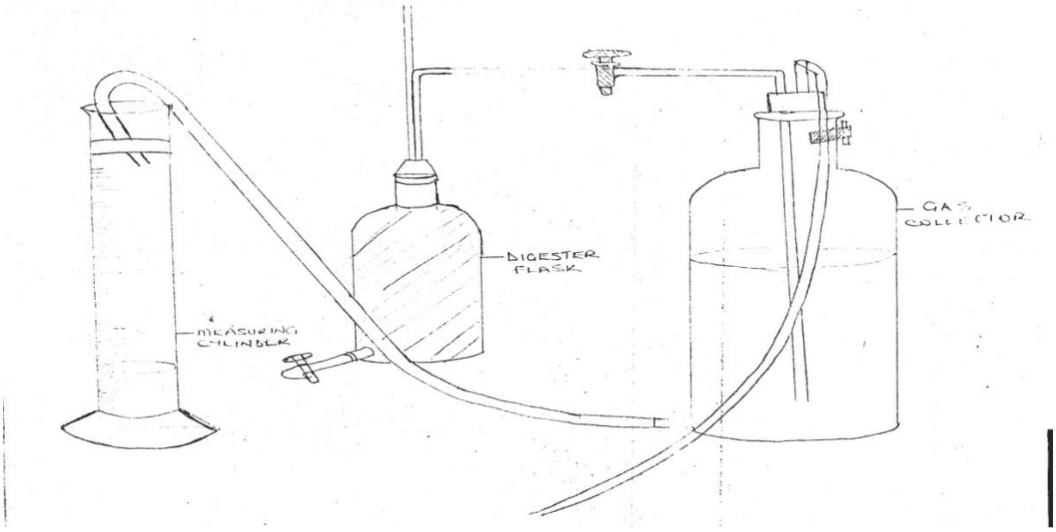
TABLE 1 DRY WEIGHT OF ANIMAL DUNGS

ANIMAL	WET WEIGHT OF DUNG TAKEN (Gms)	DRY WEIGHT AFTER DRYING IN OVEN (gms	WET WEIGHT EQUIVALENT TO 50 grams DRY WEIGHT
Cow	32.2	6.7	241.04
Horse	22.5	4.5	250
Sheep	19.75	5.13	192.5
Goat	26.35	8.29	158.9
Pig	25.29	8.39	150.7
Chicken	13.95	4.05	172.2

BASIC SET UP OF EXPERIMENT



WEEKLY GAS PRODUCTION
FRESH ANIMALS DUNG
Fig. 1

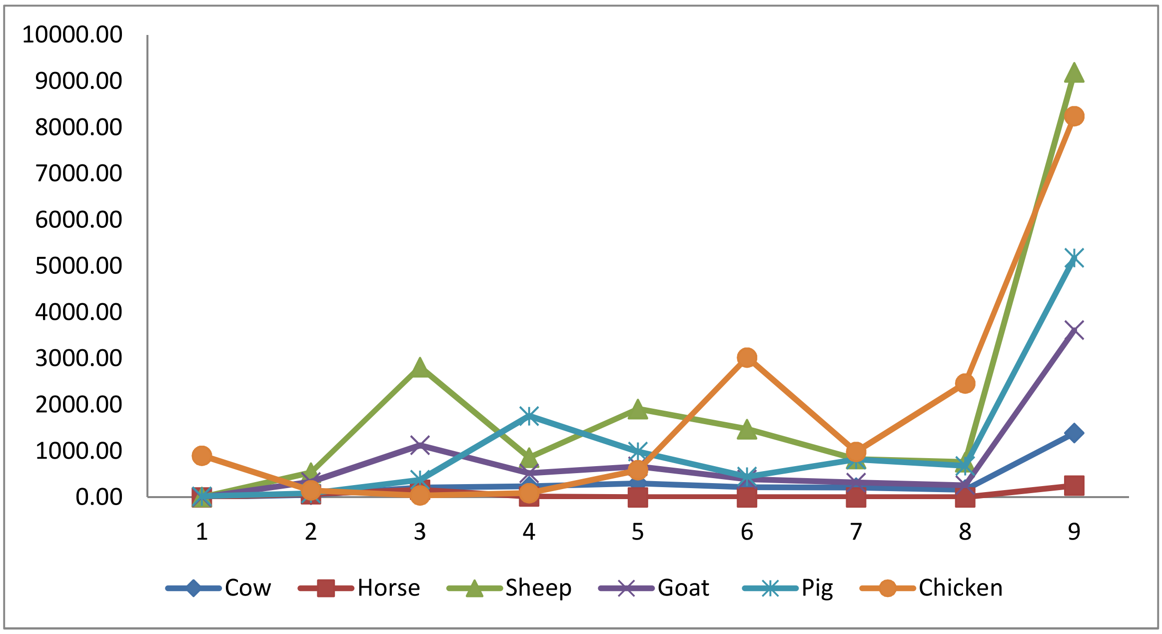


TABLE 2. WEEKLY GAS PRODUCTION

Week	Average temperature (^{0}c)	Cow	Horse	Sheep	Goat	Pig	Chicken
1	29.9	0	0	3.5	0.	20.8	899.8
2.	32.3	53.3	69	533.5	332.5	84.3	150.5
3.	32	210	165.5	2815.5	1125.5	379.9	38
4.	31	235.4	19	860.5	519.5	1758.8	93
5	31.2	301.8	0	1910	669	988.5	585.8
6	29.4	216.3	0	1474.5	387.8	447.8	3024.5
7	27.5	208	0	828	319.5	818.5	984.6
8	27.7	162.5	0	761.5	261.8	679.5	2464
Total average production (ml)		1388	253.5	9188.0	3615.6	5178.1	8240.2
Average weekly production (1)		0.174	0.032	1.149	0.452	0.647	1.03