
EVALUATION OF COW DUNG AND GOAT PELLETS FOR PRODUCTION OF BIOGAS IN UNIVERSITY OF MAIDUGURI, NORTH –EASTERN NIGERIA

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ABSTRACT: *Domestic energy is becoming more expensive in Nigeria, so efforts are being made towards sourcing for alternative, cheaper and more affordable energy sources especially those that are environmentally friendly. In view of this assertion, the present study was conducted to determine biogas production of cow dung and Goat pellets. The proximate composition of both raw-materials, and physiochemical characteristics were analysed and the results revealed that cow dung is richer in all the parameters analyzed except in total solids (TS) and calorific value than Goat pellets. The percentage (%) composition of organic elements in both raw-materials shows higher concentrations of N, P, K, Fe, Mn, Zn, C, Mg, and Ca, in cow dung and Na in Goat pellets. The digestion periods of cow dung and Goat pellets was 8days and the retention period was 36and 26 days respectively. The cumulative volume of biogas generated from both raw-materials was determined and it was observed that cow dung produced $0.57\text{m}^3 \times 10^{-6}$ of cumulative biogas, while Goat pellets produced only $0.26\text{m}^3 \times 10^{-6}$. Analysis of variance (ANOVA) result revealed that there were significant differences between the volumes of cumulative biogas generated from the organic materials. Higher volume of cumulative biogas was generated from cow dung which was an indication that cow dung had higher yield potentials for biogas production than goat pellets. Details of this finding are presented. It can be concluded that Cow dung generates more methane gas (biogas) than Goat pellets*

KEYWORDS: Biogas, Environment, Organic elements, Cow Dung, Goat Pellets

INTRODUCTION

The current accelerated growth in the world population is responsible for the generation of waste materials into the environment (Jeffrey *et al.*, 2010). The global understanding of sustainable energy supply as a critical factor for development is steadily increasing (Joseph, 2006). Many households in Africa depend on the use of biomass as source of domestic energy, which covers 70-90% of the primary energy supply (Guy *et al.*, 2005). The availability of traditional cooking fuels such as wood, agricultural residue, dried dung and charcoal is declining due to pressure on their persistent usage as source of fuel in many parts of the world (World Energy Council, 2006). All forms of life including that of man are dependent on energy and its level of industrial development. Energy consumption pattern in the world today shows that Nigeria and indeed African countries have the lowest (Ayodele, 1991). Nevertheless, Nigeria suffers from inadequate supply of usable energy due to rapidly increasing demand which is typical of a developing economy (Ayodele, 1991).

Nigeria is rich in conventional energy resource which includes oil, natural gas, lignite and coal, however there is generally low utilization of renewable energy despite the fact that it is also well endowed with renewable energy source such as wood, solar, hydropower and wind. Unfortunately, these sources of energy are grossly underutilized due to over reliance on non-

renewable energy sources. For instance, about 80% of the country's populace that dwell in the rural areas uses firewood as energy source (*Bdliya*, 1991). The inability to harness cost effective alternative fuel for both industrial and household usage in the various parts of the country has resulted in the nationwide domestic energy crisis, with a consequent deterioration of the industrial and economic sectors (*Badamose*, 1991). The increasing human population, industrial incapability, poverty, and lack of sound government policy put in place to take care of provision for cheap and affordable source of domestic energy, which led to majority of the people to patronize fuel wood and animal dung as a last resort as source of domestic energy (*Lusk*, 1998).

Dry animal dung is used as fuel in many countries of the world as source of green fuel used by more than two billion people (*Guy et al.*, 2005). The animal wastes have been identified as alternative energy source which provide clean fuel and numerous environmental benefits such as avoiding deforestation and making variable nutrients available to the soil as well as benefits in health and hygiene (*Dioha et al.*, 1986).

In the past cow dung has been the most reliable waste materials for the generation of biogas since it harbours the methenogenic bacteria. Similarly, a wide range of waste materials or products can be used as substrate for fermentation to produce biogas. Green et al. (1995) observed that about 0.5kg of animal manure can sustain a family's meal for a day or 20 liters of methane can be derived from 1kg of the refuse. Green et al. (1995), further indicates that, one cow in a year produces manure which can be converted to methane equal to 227 litres of petrol (one cow/day is 0.622 litres). Similarly, Taylor et al. (2007) reported that manure from one cow dung in a year can be converted to methane equivalent to over 277 litres of petrol.

In Nigeria there are abundant animal wastes such as cow dung, goat pellets, camel, sheep, donkey and horse as animal wastes whose potentials are yet to be fully tapped for energy generation (*Igoniet al.*, 2007). The raw materials used in commercial methane generation includes plant residues and animal wastes such as cow dung and various urban wastes which are available in Nigeria (*Olurunnisola.*, 2007).

This research studied the yield potentials of Cow and Goat pellets for production of biogas for sustainable usage as alternative source of domestic fuel in the University of Maiduguri, North Eastern Nigeria.

MATERIALS AND METHODS

Location of study

The study was conducted in Maiduguri, Borno state Nigeria Biological Science. Department. University of Maiduguri which is located on latitude $11^{\circ} 48' - 11^{\circ} 55'$ and longitude $13^{\circ} 04' - 13^{\circ} - 14'E$ in the city of Maiduguri.

Population

Maiduguri is estimated to have a population of 1, 907,600, as of 2007. Its residence are mostly Muslims including Kanuri, Hausa, Shuwa, Bura, Margi and Fulani ethnic group. Census result, 2006.

Climate

The climate of Maiduguri has semi-arid climatic conditions with a temperature variation of 25°C to 45°C and mean precipitation rate of 350mm/yr to 700mm/yr depending on the season. (Thambyaphillay, 1992).

Vegetation

The vegetation of Maiduguri is similar to that of Sudan savanna. The major plant diversity in this environment are *Azadirachta indica*, and *Adansonia digitata* (Boabob) *Balanites aegyptiaca*, *Acacia* Spp etc, which are being used for many purposes, (David, 2010).

Live stock

The livestock commonly found are cattle, goat, sheep and camels, which serve as the livelihood of the people for various domestic activities such as farm power, source of meat, milk or farm manure. The livestock of Borno state was estimated at 9.3 million heads which constitutes 8.2% of the national sheep, goats, cattle and camel's population of 88 million heads (Anon, 1980).

Sources of Cow and Goat pellets

Dried cow dung and Goat pellets were obtained from the Maiduguri abattoir dumping site. This waste material was dumped indiscriminately without treatment by constituting a health hazard and environmental pollution.

Types of anaerobic digester

Three 75 litres capacity of floating batch fed anaerobic digesters were constructed using 200 litres of ungalvanised metal drums were used to carry out the experiment.

Determination of Physiochemical Parameters

Moisture content

Ten grams (10g) each of dried cow and Goat pellets were separately spread evenly on heating aluminum pan of the mettler LP 16 and LJ 16 moisture analyzer to avoid heat exchange. The LJ 16 moisture analyzer was calibrated from 0-100% according to *Mettler infrared Dryer's* (1992) Method.

Total Solids (TS %)

The percentage (%) total solids were determined using 50 grams of cow and Goat pellets which were heated in an oven for 12 hrs at 105°C. After heating, the samples were cooled in a desiccator for 12 hrs and weighed to obtain the % TS (Dioha et al., 1989).

Ash Content (AC %)

The samples of total solids obtained above were heated in muffle furnace at 540°C for 3 hrs. The difference in weights obtained after heating to ash and cooling in the desiccators represent the % AC (Dioha et al., 1989).

Volatile Solids (VS %)

The percentage (%) volatile solids was obtained from the difference in the weight of ash content and total solids (*Dioha et al., 1989*)

Calorific values of Cow and Goat dung (CV,s)

The calorific values of the raw materials were determined using calorimetric method (*Green et al., 1993*).

Cow and Goat pellets Extracts Preparations

Fifty grams (50g) of dried cow and Goat dung each were dried in a muffle furnace at temperature of 500°C for 2hrs and the ashed samples were removed and cooled at a room temperature (37°C) to enable the organic elements to be released in fine powdered form (ashed).

Digestion of ashed sample

The ash was digested by using the methods of *Mittal et al., (1981)* and *Fernando et al., (1989)*. Briefly, 10g of each of the ashed samples of the raw-materials were held in 250ml of beaker and 10ml of 6M hydrochloric acid was added into the content of the beaker to obtain solution of the ashed samples of the raw materials. The solutions of the ashed samples were heated on a hot plate for 15mins and was later removed from the source of heat and cooled at a room temperature. Furthermore, 1ml of concentrated trioxonitrate (v) acid was added to the solutions of the ashed samples and heated to complete dryness to enable silica to be hydrated and 1ml of 6M hydrochloric acid with 10ml of distilled water were added to the hydrated samples. The mixture was heated again to attain absolute dissolution. The solutions were filtered out and the volumes were made up to 100ml by adding distilled water, this makes up a solution of suspended organic elements of the raw materials (Cow and Goat pellets).

Proximate composition/Chemical characteristics of cow and Goat pellets

The Proximate composition/Chemical analysis of cow and Goat pellets were each analyzed using inductivity coupled plasma (Optical Emission Spectrometer) machine (*Optical Emission Spectrometer Method, 2009*).

Biogas Production:

Pretreatment of raw material:

Twelve (12kg) of each of cow dung and Goat pellets each was weighed separately and soaked in 12 litres of tap water in a 250 litres plastic bowls. These were allowed to stay for 24hrs to undergo partial aerobic hydrolysis.

Feeding of Anaerobic Digester

Fifty kilogram (50kg) of cow and Goat pellets was separately mixed with tap water in equal proportion (1:1) and the mixture was fed into the digester. As an alternative, 1000cm³ of

previously prepared slurry from an old digester was added to serve as inoculum to trigger the methanogenesis.

PH values of anaerobic digesters content

The daily PH value of the anaerobic, digesters was determined using HANNA microprocessor-based bench pH/MV/°C meter (1999). Briefly, the instrument was calibrated by deeping the pH electrode into the standard calibration buffer solution at values of pH 4.01, 6.86, 7.01, 9.18 and 10.01. Two-point calibration methods were adopted for this analysis (*Hanna, 1978*).

Determination of Slurry Temperature (°C)

The slurry temperature was determined using Mercury bulb thermometer (0-100°C) as described by Gareth, 1987.

Retention Periods

The retention periods for gas production by cow dung and Goat pellets were obtained at 36 and 26 days respectively.

Statistical Analysis

GraphPad Instat statistical software was used for the statistical analysis appropriate completely randomized block design (CRBD) with 3replicates means were separated at the 5% level of probability or least significant difference (LSD).

RESULT AND DISCUSSION

Proximate Composition:

The result of the proximate composition of both raw materials (cow dung and Goat pellets) determined, was expressed in terms of total solids (TS), volatile solids (VS), and Ash content (AC) Total solids comprises of all the degradable and non-degradable materials, while volatile solids constitutes the organic constituents which tend to have high vapor pressure on partial or complete degradation which converts to biogas *Bailey et al., (1986)*

Table 1: Proximate composition of cow dung and Goat pellets

Composition	Cow dung	Goat pellets	Significance level
Total solids (TS)%	7.7	26.5	**
Volatile liquids (VL)%	33.9	35	**
Moisture content (MC)%	27.3	25	**
Ash content (AC) %	41.6	30.8	**

Density (Kg/m ³)	600	600	NS
Calorific value (mj/kg)	8	10.76	**
PH	7.5	7.42	NS

Key:

* - Significant at P=0.05%

NS - Not Significant

The result of the study as indicated in Table 1 revealed that cow dung has the following proximate composition, Total solids (7.7%), Volatile liquids (33.9%), Moisture content (27.3%) and Ash content (41.6%), while Goat pellets has Total solids (26.5%), Volatile liquids (35%), Moisture content (25%) and Ash content (30.5%) see (Table 1). The study observed that the values of the parameters analyzed between cow dung and Goat pellets were significant at 5% LSD except density and PH which were not significant but the variations observed has impacted positively to gas production between the two raw materials. In a related study *Bailey et al.*, 1986, revealed that the percentage (%) total solids is higher in organic wastes; this also entails increase in biogas production. The raw materials were broken down by the anaerobes through complex physiochemical and biological processes involving three stages namely hydrolysis, acidification and methanization of raw material (*Karki*, 1984). Similar processes were equally followed in the present investigation to achieve biogas production Al Seadi, 2001.

Density

The density of cow dung and Goat pellets were found to be different with a value of 600kg/m³ and 200kg/m³ respectively. Thus, slurry indicating that cow dung was of higher density than Goat pellets. Thus, slurry of both raw materials has different chances of solubility within the content of the digester during fermentation periods, and the study observed that there was variation in digestion periods for both raw materials; this might be accounted for by the variations in moisture content, total solids and densities of both materials. Similar observation was made by (*Dioha et al.*, 1989)

Calorific values

The calorific values of both raw materials presented revealed that cow dung has a calorific value of 8mj/kg, while Goat dung has 10.76mj/kg. The study revealed that cow dung with the least calorific value yet gave the higher rate of biogas. This result is in agreement with what *Green et al.*, (1993) reported.

PH

The study on pH values of slurry for cow dung and Goat pellets revealed 7.5 and 7.4 respectively for the two. This is adequate for the anaerobes to survive and be productive because they require neutral or low alkaline environment. Thus, a pH value between 7 and 8.5 is good for fermentation and normal gas production. Similar result was reported by *Lusk*,

(1998). The slight differences in PH observed in two substrates could be attributed to the type of organic feeds given to the animals as ruminants.

Concentration of organic elements in cow and Goatpellets

The percentage (%) concentrations of organic elements in the two raw materials were, N, P, K, Ca, Mg, Fe, Mn, Zn, Na, Cu and C, (Table 2). From the table all the elements were higher and the macro-elements, N, P and K were significantly higher in cow dung than in the Goat pellets. However, Ca, and Mg were observed to be significantly highly in Goat pellets than in cow dung. This attributed to their capacity and status as ruminants.

Table 2: Percentage (%) Composition of Organic Elements in Cow and Goat pellets.

Raw-Materials	Suspended Organic Elements in Raw-Materials											
	N	P	K	Ca	Mg	Fe	Mn	Zn	Na	Cu	C	
Cow dung	2.69	1.720	11.20	0.87	0.22	0.32	0.81	0.51	0.22	0.75	5.52	
Goat dung	1.24	0.51	1.24	0.45	0.12	0.15	0.6	0.42	0.7	0.6	2	

Furthermore, these elements as Macronutrients (N, P and k) and micronutrients (Fe, Mn, Cu, Mo, and Zn) are found in the animal feeds as essential for biological metabolism (*Argun et al.*, 2008). Often the nutrient needs of the anaerobes are defined by an analysis of cells chemical composition and the substances necessary for the vital functions of a microorganism, as limiting factors (*Madigan et al.*, 2005). Thus, excess or insufficient levels of nutrients in the medium might affect the biological activity and microbial diversity causing variations in the predominant fermentation products (*Argun et al.*, 2008). The study observed that concentrations of organic elements in raw materials contribute the viability of raw materials for biogas generation.

Table 3 showing the pattern of Biogas generation over a period of 36 days

Assessment	Cow dung	Goat dung
Volume of raw material fed into the digesters	12kg	12kg
Volume of waste gases evacuated (M ³)	0.16 x 10 ⁻⁶	0.53 x10 ⁻⁶
Volume of cumulative biogas generated (M ³)	0.57 x 10 ⁻⁶	0.36 x 10 ⁻⁶
Digestion periods (days)	36	36
Retention periods (days)	30	23
Fermentation (first day of gas production within the digestion periods).	8	15

The result in the table above (table 3) indicates that biogas was produced within 8 days and 15 days of digestion for cow dung and goat pellets respectively. The delay in the gas produced for goat pellets was a result of the lower moisture content of (12.2%) content than cow dung moisture content of (27.3%) . High moisture content is required in the raw material

for hydrolysis by the anaerobic bacteria to degrade them through the process of fermentation, hydrolysis, and methenation to produce methane gas. This observation was also made by Velson , et al ,(1985).The study also observed that during the digestion periods, $0.53 \times 10^{-6} \text{ m}^3$ of wastes was evacuated from slurry of the digester of goat pellets which might be associated with the volume of impurities present in goat pellets while cow dung has only $0.16 \times 10^{-6} \text{ m}^3$ as volume of wastes evacuated (Table 3).Both raw materials had 36 days each as their digestion periods but their retention periods varied to 30 and 23days, for cow dung and goat pellets this was an indication that gas production lasted in cow dung more than goat pellets digester (Table 3). The study also observed that cow dung gave the highest volume of gas $0.57 \times 10^{-6} \text{ m}^3$ than Goat pellets which produced $0.36 \times 10^{-6} \text{ m}^3$ gas. The difference might be associated with their variation in organic contents.

Table 4: Showing the Effects of Temperature and PH on Biogas production.

Raw Materials	Temperature	PH	Biogas
Cow dung	36.5 ^a	7.05	0.57×10^{-6}
Goat dung	36.3 ^a	7.27	0.36×10^{-6}

It was observed that the temperatures for both cow dung and Goat pellets during the fermentation process were 36.5^{oc} and 36.3^{oc}. While PH values for the same materials were 7.05 and 7.27 respectively without any significant effects on the volume of biogas produced $0.57 \times 10^{-6} \text{ m}^3$ for cow dung and $0.36 \times 10^{-6} \text{ m}^3$ for Goat pellets. However, the volume generated was significantly different from each other. Difference in volume of biogas can be caused by a number of factors operating in and outside the digester.

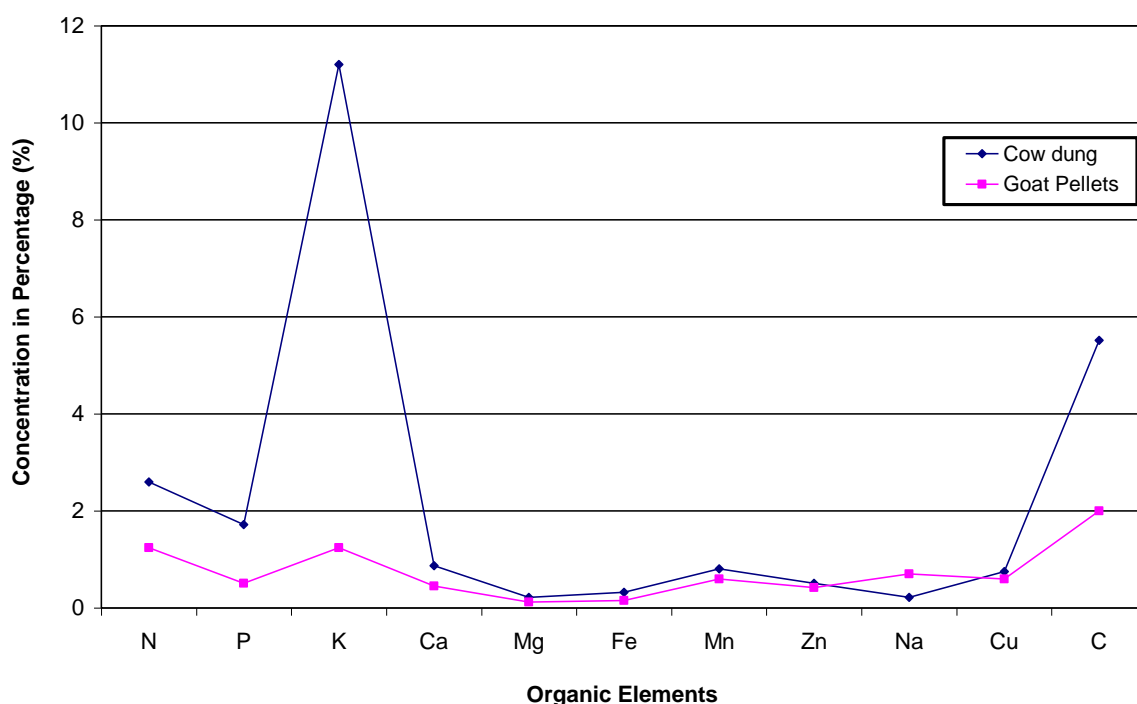


Figure 1 presents the percentage organic elements in the cow and goat pellets evaluated. It was observed that the elements N, P, K, Mn, Zn, Na and C are all higher in concentration in cow dung, while Ca, Mg and Cu only were higher in goat pellets. Probably the degree of elements presents in cow dung attributed to the production of higher volume of Biogas obtained.

CONCLUSION

The findings of this present research work are concluded as

1. The proximate composition and physiochemical parameters analyzed revealed that cow dung is richer than goat pellets except in total solids (TS) and Calorific values, where goat pellets revealed higher values of 21.1% and 11.76% respectively.
2. The digestion and retention periods revealed that cow dung has a lesser digestion period of 8th days only, while goat pellets has a higher digestion period of 15th, both raw materials have retention periods of 36 days.
3. Cow dung produced higher volume of cumulative biogas than goat pellets.

RECOMMENDATION

The following recommendations are offered to improve the production and utilization of biogas in the sub region.

1. Cow dung should be utilized as raw material for biogas production due to its higher substrate content
2. Further research work on reduction of moisture content the biogas to enhanced its calorific value is imperative

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