Laboratory Investigation of Biogas Production Using Cow Dungs and Kitchen Wastes Otta

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Abstract: One of the significant factors that dictate human advancement is energy. This study examines biogas production through anaerobic digestion, a non-conventional type of wastes. Cow dung and biodegradable kitchen wastes types of energy generation were examined. This was carried out using a 120 liters capacity plastic floating drum type biogas plant constructed to examine biogas' anaerobic digestion. A mixture of cow dung and kitchen wastes in the ratio of 1:2 of water was carried out in the digester. This experiment was monitored daily, with daily methane gas production yield recorded for 22 days. This study shows that gas production began on the fourth day with 0.0032 liters until the attainment of 1.439Ltrs on the twenty-second day.

Keywords: Biogas, Wastes, Methane, Bio Digester

1. INTRODUCTION

A renewable energy source can be referred to as a sustainable energy source. 1. posted that man to his life advances utilised many energy sources. Non-conventional energy sources are clean and inexhaustible as they are primarily sourced from the sun, wind, ocean, and earth. Man's activities require energy. The energy demand is increasing in geometric proportion. In contrast, Fossil fuels that provide the majority of the world's primary sources of energy are non-renewable sources and may soon get depleted.

Hydrocarbon natural resource (natural gas and crude oil) is available in large quantities in Nigeria and generate about 80% of the nation's revenues, but has not translated to economic development or made significant the energy mix. Ceaseless increase in crude oil prices has made kerosene unaffordable by Nigerian's numerous rural dwellers [2]. leading the masses to search for utilisation of alternative energy continually. For example, 5.5% surge in reliance on wood fuel for cooking between [3].

In Africa, health challenges, including humans and the environment, are experienced due to water pollution and lack of energy. According to [4]. in more than 21 sub-Saharan countries, electricity access is less than 10%. Therefore, the essential requirement for energy should include renewable energy sourced from various local. Furthermore, applying new technology to energy generation will lead to cheaper and proper waste management for environmentally friendly ways of energy production.

The pressure of all and sundry for energy usage for development has led to adverse weather and climate change. [5]. Underdeveloped nations like Nigeria confront challenges concerning natural insurance because of significant reliance on biomass and petroleum derivative. Using biogas energy will prevent areas produced from underground water and environmental pollution. [6]. [2]. Furthermore, it is better to improve on new energy generation sources like biomass and less on fossil fuel. [7].

The effluent coming out of the plant is utilized for making organic fertilizers. Besides, Biodigesters can be utilized to treat municipal waste and electricity creation. A suitable option for utilizing biogas is to produce electric power using a gas engine or gas turbine [8]. Biogas production by anaerobic energy generation is cleaner and better energy than pyrolysis and other types [9]. coupled with the fact that Nigeria is blessed with both conventional and non-conventional energy sources. [4]. The technology can provide energy for households, rural communities, farms, and industries. Nigeria's power supply system is epileptic and unreliable [10].

In Nigeria, waste is created at 0.44 kg/head in a day, and 59% to 81% of this waste is natural. Research activities on biogas production are ongoing with average waste production of 0.44/kg/head/day and containing nitrogen, phosphorus, potassium, and other chemical materials.

2. RESEARCH METHODS

Inside the biogas reactor, the act of fermentation is very gradual. In practice, microbes feed on the organic matter, such as proteins, carbohydrates and lipids, resulting in methane and carbon dioxide production commonly refers to as bogas; This`is due to an unconventional energy source which occurs due to the reaction of bacteria with organic materials under anaerobic conditions after fermentation. It can be pressurized into natural gas. Biogas is an alternative or renewable source of energy because production to use cycle is continuous. In general, biogas consists of 54-65% methane and 25-44% carbon dioxide, with other gases such a hydrogen sulphide 0-3%, 0-0.7% hydrogen, nitrogen, and ammonia.

Table 1: Composition of Biogas

Component	Concentration (%by volume)
Methane (CH_4)	60-70
Carbon dioxide (CO_2)	30-45
Water (H_{2O})	1-4
Hydrogen sulphide H_2SO	0.8
Ammonia	0.0-0.02
Nitrogen (N_2)	0-2 %
Oxygen (O_2)	0-3 %
Siloxanes	Traces
Hydrogen (H_2)	0-0.7%

Different types of organic matter lead to different gaseous compositions. Hydrogen sulphide, carbon dioxide, and water vapour make biogas very corrosive. Thus, the use of adapted materials is paramount. [11].

Fresh cow dung is obtained from abattoirs containing digested residues of consumed matter which has passed through the cow's gastrointestinal system [12]. in the following proportion: cow nitrogen (N_2) 1.80-2.40%, phosphorus (P_{205}) 1.00-1.20%, potassium (K_2O) 0.60-0.80% and organic humus 50-75%, carbon 39.17%, 53.10% oxygen (O_2)and fat content of 11.0%. [13].

Anaerobic digesters are modified containment vessels drafted to exclude air and encourage the growth of several bacteria, including methane rowing bacteria. [14]. Stated that many types of anaerobic biogas systems have been utilised for waste treatment. The various types of simple biogas plants include balloon plants, tunnel plants, fixed dome plants, floating-drum plants, and prototype bioreactor plants made with a galvanized metal pan.

[15]. Proposed that inhibition by the presence of deadly substances in anaerobic digestion can ensue to variable levels, instigating upset in production yields and organic deletion and causing digester failure. [16]. Stated that antagonism, acclimation, and synergism during reaction in biogas production are highly responsible for the success or failure of gas generation.

The breakdown of organic material to yield useful biogas depends on the compound collaboration of about seventeen reactions of complex microbial species. [17]. [18].

2.1 The Table 2 presented below shows the material used in the fabrication of the bio digester and Plate 1 is the constructed biodigester.

Table 2: Materials used in the study

Materials	Uses
Funnel	Used for efficient feeding of slurry into the digester
PVC sealant	Used to glue fabricated parts to avoid leakages
60L drum	Used as water jacket to keep gas holder afloat
Weighing scale	Used in measuring relevant parameters
Water jacket	Used to hold gas collector
Hose	Used for the gas inlet to the gas collector
	Used for a gas outlet to gas storage
Water	Used in mixing the feedstock
Substrates	Used as feedstock
Rubber tube	Used for gas storage
Tap	Used for the slurry outlet
120 litres drum	Used as digester

Plate1: Biodigester Design

The total volume of the digester (V_T) = 120 litres

The theory involved in the biogas fermentation process is stated below:

Volume of fermentation chamber $= \frac{2}{3}$ of 120litres =80litres

Diameter of digester (D) = 460mm

Height of the digester (h) = 630mm

Operating Volume=$V_O < VT$ by 0.25%

Also, the quantity of substrate= S_d (Must be $\leq$ 90% of V_o)

Retention Time=RT=Time taken by the substrate to decay, determined by the plant's temperature and type of material.

Digester Dimension=V_T = $\pi r_d^2 h_d$

$V_O = S_d \times RT$ [kg= kg/day ×Nos of days] (1) [2].

If V_O= 30 liters

Therefore $V_T = \frac{V_O}{0.25}$

$= \frac{30}{0.25}$ = 120Litres

The retention time is when the substrates are allowed to decay in the digester tank. The retention time, in turn, is determined by the preferred digester temperature and the amount of biomass resource available.

Substrate input (S_d) = Biomass (B) + Water (W) (litres) (2)

Substrate input (S_d) =12+18=30 litres

Having determined the total volume of the digester, a ratio for the dimensions can be adopted, depending on the chosen geometric shape of the digester. For a cylindrical digester, the chosen geometry for this work, During the construction of Anaerobic digester, consideration was given to the cost of material without trading off the efficiency in performance in the course of design and construction of the digester system. Two different types of substrates were selected for the experiment, namely cow dung and kitchen waste was based on: Cost-effectiveness, availability, and durability. Human fesses can also be used. Biogas produced from human fesses by method of anaerobic organic decomposition is slightly different from LPG [19]. A geomembrane plastic drum guarantee proper inhibition of the total biogas harvest and avert air from entering the digester by employing a plastic drum for the gas holder, while geomembrane plastic with good tensile strength was used for the water jacket.

Materials for the gas holder and water jacket Table 2.1 and Plate 1 consist of the gasholder which is a plastic drum, while the water jacket is a membrane plastic. It was selected to meet the following requirements: Low cost. Good tensile strength and is easy to roll by machine to required design geometry. Efficient gas tightness to store biogas. Having selected the materials to be used, machining of parts was carried out using the proper instruments and hand tools at the ground floor of the college of science and technology, Covenant University, Ogun state. The main construction is made up of a plastic digestion tank which is adequately durable to hold out against the weight and pressures of the enclosed mixture of cow dung and kitchen waste. The digester tank was made to seclude air, and it is placed on the ground, just at the edge of the shed, to enable heating to occur partially. A gas holder tank made from plastic temporarily stores the biogas for onward transfer to the rubber tube for storage.

Cow dung and kitchen waste from an abattoir in otta, ogun state. Kitchen wastes collected from the covenant university cafeteria. The experiment was conducted at Covenant University, Otta, Ogun State. Nigeria. 6kg of cow dung and 12kg of water were mixed using a turning stick, and the slurry was fed into the 120litres airtight biodigester. After two days, 6kg of kitchen waste is mixed with 6kg water. The total substrate quantity fed into 0.75 capacity of the digester is 30kg and mixed thoroughly to avoid scum. The flexible plastic pipe that connected the gas outlet from the reactor to the gas holder was detached before feeding the reactor, leaving the gas exit from the tank exposed. This was done to avoid negative pressure build-up in the plant. The gas was collected from the digester through an 8mm flexible pipe host attached to the top of the gas collector system from the digester. The gas is allowed to pressure build-up in the plant for 22days.

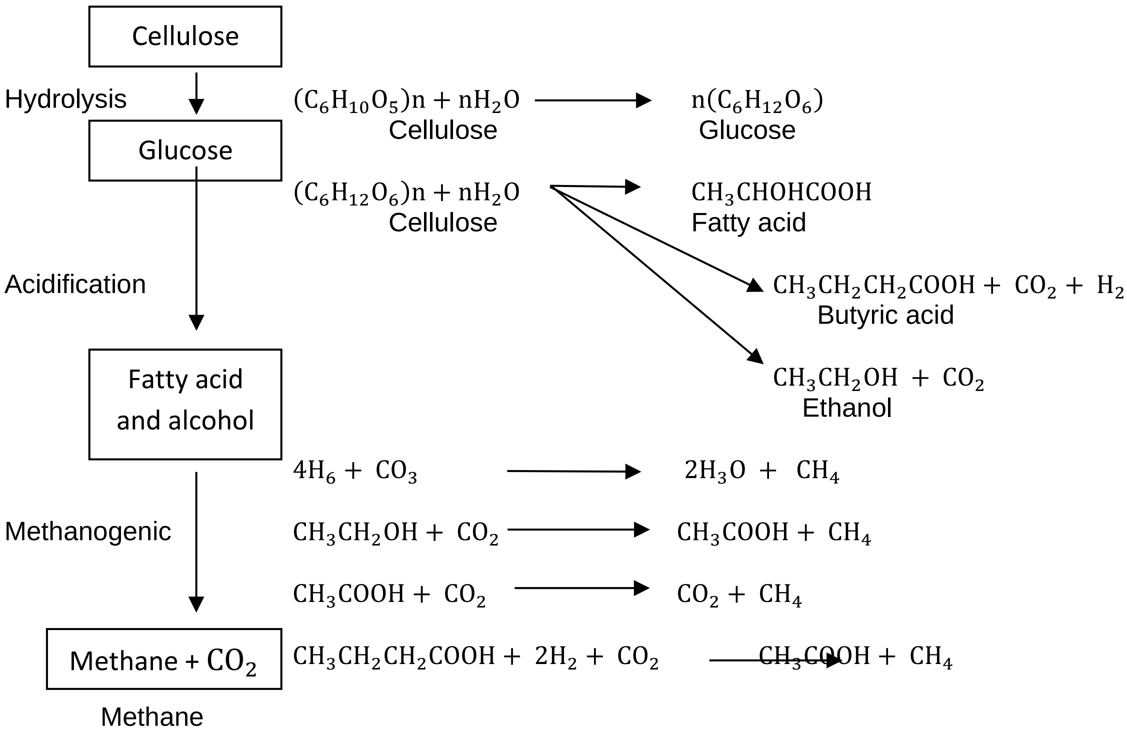

Figure 1: Fermentation process. Source [19]

The design, construction of the bioreactor is shown in plate 1 while the conversion of cellulose to gas is shown in Fig 1. Hydrolytic, fermentative, acidogenic and methanogenic are the four basic types of bacteria taking place during the cellulose anaerobic bio digester conversion [20]. The hydrolytic is the bacteria that break down organics matter into sugars and amino acids [21]. The fermentative bacteria convert sugars and amino acids into organics acid [22]. The acidogenic bacteria change organics acid to hydrogen, carbon dioxide and acetic acid [23]. The methanogenic bacteria transform hydrogen, carbon dioxide and acetic acid into methane [24].

The gasholder was standardized by using a tape rule to enable output gas of the anaerobic digester to be taken daily and as the total of content the gas in the gasholder. The produced biogas was measured by computing the volume of the gasholder floating over the water level in the water jacket daily. The water jacket has a base area of 0.330m, with a height of 0.521m. The gas holder is an inverted cylindrical drum with a base diameter of 0.279m, a base area, 0.49m. A meter rule attached to the gas holder was used to read the height of the cylinder above water level, which read 0.416m. The full setup for this study was the connection of the biodigester to the gas holder in the water jacket for the gas collection and then to the rubber tube setup for the methane gas collection, as shown in Figure 1. The upward displacement method of gas collection is a method in which gas is allowed to fill the gas holder, displacing water in the water jacket, the volume of gas produced equals the volume of water displaced minus the volume of water in the water jacket, and this is used to define the daily gas produced.

3. RESULT AND DISCUSSION

A floating drum anaerobic digester was designed and fabricated to digest the two substrates in this study. The daily production of biogas is represented in the table below. Substrate decomposition begins at day four, and volume gradually increases. Biogas becomes combustible when the methane content is at least 50%.The experimental results obtained during the retention period in the study were analyzed using statistical methods. They are outlined and discussed as follows.

The slow decomposition can be traced to cows' diet; feeding on fibrous materials, microorganisms degrade fibrous materials much slower. This finding is in line with that from the works of Babatola [24] in Akure, and Ukpai and Nnabuchi in Abakaliki [25], both in Nigeria. The absence of biogas production in the first three days could also be a result of various carbon sources in cow dung as each source of carbon is used up due to the change to an oxygen-free environment, the microbial cells divert their source of energy for growth to a new carbon supply.

A close examination of the findings of this study shows that biogas production was less and gradual in the first week of the study. This suggests that the biogas-producing microorganisms are in the lag phase of growth, where acclimatization or adaptations of the cells take place. This report aligns with that of Abubakar and Ismail [26]. It can similarly be deduced that the biogas production rate is equal to or dependent on the growth of methanogens. From the second week of the study, results show a progressive increase in biogas production, which continued to the third week of the study. This depicts that the methanogens are in their exponential stage of growth.

Table 2: Total Biogas Yield of Study Retention Time

Days	The daily volume of gas	The cumulative volume of gas
0	0.000	0.000
4	0.032	0.032
5	0.034	0.066
6	0.037	0.103
7	0.050	0.153
8	0.046	0.199
9	0.081	0.280
10	0.023	0.303
11	0.031	0.334
12	0.025	0.359
13	0.034	0.393
14	0.081	0.474
15	0.095	0.569
16	0.099	0.668
17	0.091	0.759
18	0.100	0.859
19	0.120	0.979
20	0.130	1.109
21	0.160	1.269
22	0.170	1.439

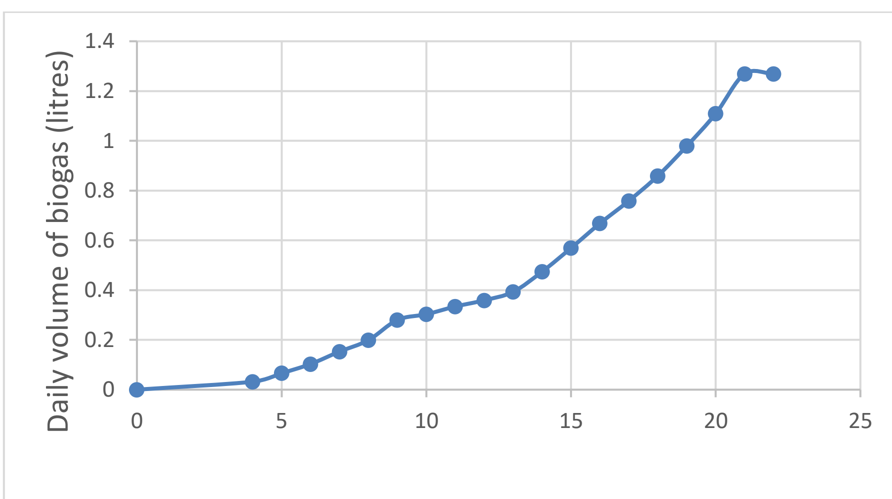

Figure 2: volume of biogas produced daily against retention time

Figure 2 shows the volume of biogas produced from the co-digesting of kitchen wastes and cow dung. In the co-digestion of cow dung and kitchen wastes, it was observed that biogas production started on day 4 by producing 0.032L and increased daily till day 9, after which gas production began to vary. Nevertheless, on day 22, it produced the highest volume of biogas, 0.17L.

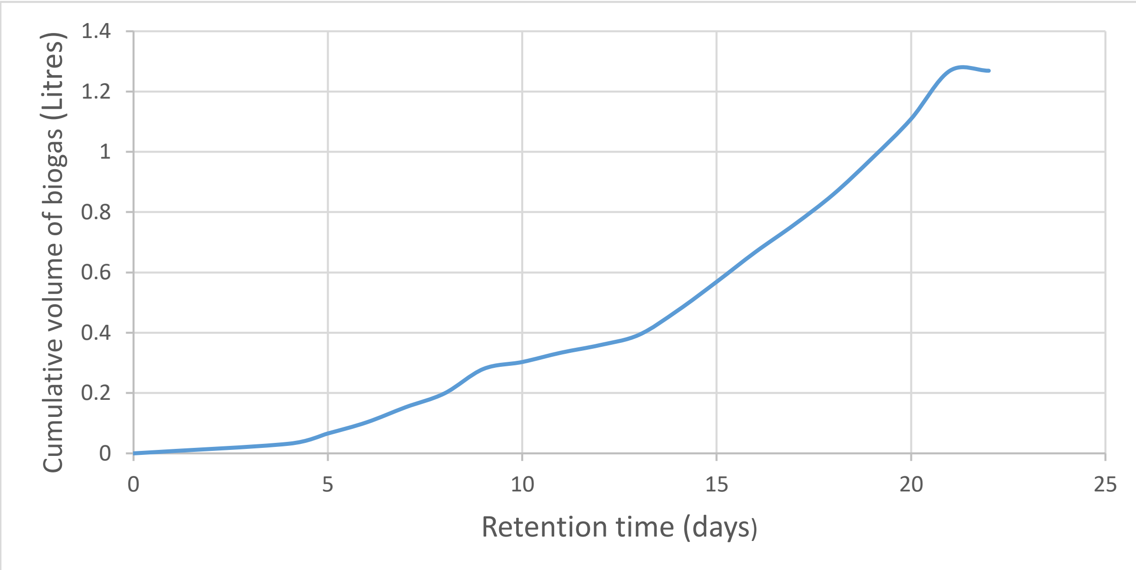

Figure 3: Cumulative gas production of the digested substrates

Figure 3 shows the cumulative volume of biogas produced from the co-digestion of kitchen wastes and cow dung. At the end of 22 days retention period, the cumulative volume of liters of biogas was produced from the co-digestion of cow dung and kitchen wastes. This experiment reveals that the volume buildup of the gas is directly proportional to time.

4. CONCLUSION

The study revealed that biogas could be produced from a mixture of both cow dung and kitchen waste. A 120 liters capacity plastic floating drum type biogas plant, constructed to examine the anaerobic digestion in biogas production. A mixture of cow dung and kitchen wastes in a ratio of 1:2 of water was carried out in the digester. This experiment was monitored daily, with daily methane gas production yield recorded for 22 days. This study shows that gas production began on the fourth day with 0.0032 litres until attainment of 1.439Ltrs on the twenty-second day.

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