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EXPERIMENTAL STUDIES OF BIOGAS PRODUCTION FROM FEEDSTOCK OF COW DUNG

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ABSTRACT

The recent price rise and scarcity of fuels, has stimulated a trend towards the use of alternative energy sources like solar, wind, geothermal, etc. The global energy crisis has generated interest in the use of animal waste as a substitute to fossil fuel for biogas generation. Two treatments were set up consisting of: A. 6kg of cow dung in 13litres of water and B. 6kg of cow dung mixed with 0.5kg of food waste and 0.5kg of paper all in 13litres of water. The retention period was sixty days. Results obtained show that on the average treatment A generated 14.29grams (0.0119 m^3) and treatment B generated 15grams (0.0125m^3) of combustible gas per day. It was also observed that treatment B started the generation of methane on day sixteen while experiment A started on day twenty two. Ignition test conducted on the biogas generated produced luminous blue flame. Also gas analysis was carried out to know the percentage composition of each constituent in the generated biogas. It was discovered that the combustible biogas has a methane content of 60%.

Key words: Fuel, renewable energy, biomass, retention period, temperature.

INTRODUCTION

With the escalating rate of world population and the increasing global demand for affordable and available energy, the subject of energy has become a household topic in discuss on policy making, leadership conferences and scientific fronts the world over. The abundance fossil fuel and its prominent role as the pioneer energy drive for world industrialization the recent decades faces the threat of depletion coupled with the debilitating environmental effect on human health rooted to the non-renewable fossil fuel. The operations of exploration, refining and utilization of the fossil fuel has have been implicated in the emergence of a plethora of health issues. The Kyoto conference and other parallel deliberation has nominated renewable energy as the world energy sources in the close future. This declaration has triggered a number of research efforts on the subject of energy generation non-fossil fuels.

In Nigeria, despite the huge deposit of fossil fuel and the heavy exploration activity the scarcity of fossil fuel attended by non-functional refining plants is call for alternative energy sources. The recent wave of massive liquidation in the manufacturing sector is implicated to meager energy supply and heavy cost of energy. The surviving few industries operates nearly below break-even point and emerging industries get nib in the bud. The majority of rural dweller involved in the food production sub-sector of the economy has reported in literatures have no access to fossil energy and the effect of this is obvious in the scarcity of food witnessed in the country. To this end, a number of conferences in the home front has energy issues from renewable perspective as its focus; and the awareness of renewable energy is presently in the front burner. The attempt to salvage energy crisis in urban centers and affordability of energy for rural dwellers are the intents of studies on renewable energy. The advantage of environmental friendliness has endeared renewable energy as the future energy sources in the drive for clean-energy driven industrialization.

The spectrum of renewable energy though expanse, it ranges from atmospheric energy-solar and wind energy; biomass; fuel cell; geothermal. Solar energy harvest radiation heat from the sunlight while wind energy harvests the motion-energy in the body of air. Biomass entails energy from plant-derived material and feedstock. Fuel cell energy rely on the hydrolysis procedure water.. Geothermal energy entails the capture of heat energy stored the earth crust due to radioactive decay of minerals.

Biomass comprises all the living matter present on earth. It is derived from growing plants including algae, trees and crops or from animal manure. The biomass resources are the organic matters from which the biogas is formed. The component of biogas is made up of carbon, hydrogen, oxygen, nitrogen and sulphur in minor proportions. Some biomass also consists of significant amounts of inorganic species. Biomass has always been a major source of energy for mankind from ancient times. A number of energy studies reported in literatures holds the record that biomass contributes around 10– 14% of the world's energy supply and accounts for 80% of rural energy demand (Tchobanoglous et al. ,1991 ;Lovins, 1980; Sims, 2008; Steinhauser, 2008.). Traditionally, biomass had been utilized through direct combustion. Burning biomass produces pollutants including dust and the acid rain gases such as sulphur dioxide and nitrogen oxides but the sulphur dioxide produced is 90% less than that is produced by burning coal. The quantities of atmospheric pollutants produced are insignificant compared to other pollution sources. Biomass usage as a source of energy is of interest because it is renewable, potentially sustainable and relatively environmentally friendly source of energy (Munashinghe, 1992; Olugasa et al.2013). The energy obtained from biomass will augment the energy obtained from other resources and helps in the extension of the lifetime of the conventional resources of energy production. Biomass can be converted into a variety of bio-energy forms such as heat, steam, electricity, hydrogen, methane, ethanol and methanol (Steinhauser, 2008).

Biogas is a flammable gas produced by the anaerobic fermentation of organic waste material; it contains the mixture of methane (55 -70%), carbon dioxide (30-40%) and traces of other gases such as nitrogen, hydrogen, carbon-monoxide, water, ammonia, and hydrogen sulphide. The putrefactory bacteria decompose the organic material at suitable, stable temperature. Biogas burns readily and can be used directly as fuel for cooking, lighting or heating and indirectly to power electrical generators and agricultural equipments. The residue left after the production is a valuable fertilizer containing all the nutrients present in the original waste materials but in a finely processed state that is readily utilized by farmers as manure to be added to aid the growth of plants.

Co-digestion of different materials enhances the anaerobic digestion process due to better carbon and nutrient balance (Parawira, et al., 2004, Sims. R.E.H.2008). Digestion of more than one substrate in the same digester can establish positive synergism and the added nutrients can support microbial growth.

In Nigeria, fuel wood, petroleum, gas, kerosene and electricity constitute important sources but majority of the rural dwellers do not have access to gas or electricity (Matal et al. 2000), the recent global energy crisis has generated interest in the use of animal wastes for energy to substitute fossil fuel. This study was carried out to produce a renewable source of energy called biogas from animal wastes using available raw materials locally to make it affordable for the users (Lovings B. 180).

MATERIALS AND METHODS

A cylindrical metal tank digester where fermentation occurs was designed and fabricated for this work. The gas holder where the generated biogas would be stored was designed and attached to the digester. The capacity of the biogas digester was found to be 100 litres. High-grade steel was selected as the material for the digester and gas holder (see Plate1). Mild steel was selected for the stirrer shaft. The fabrication processes involved are: arc welding, bench work, drilling and tap-threading; turning operation on the lathe machine for stirrer shaft and milling operation for paddle blade of stirrer. The digester and gas holder were carefully welded to prevent gas leakage.. Additional components employed in the assembly process used to achieve air-tight are: rubber hoses of diameter 10mm and 15mm and adjustable clips of diameter 15mm. In the experimental investigation, reagents used as consumables are Potassium hydroxide, Acetic acid, lead acetate solution. Multi-meter and Pressure gauge were used for data collection.

The mechanically operated stirrer shaft with blades fitted into the key-way slot on the shaft served as paddle to agitate the slurry and prevent the formation of scum in the digester where fermentation occurred. The digester was made to be airtight with rubber tubes used as packing. The digester was half buried in the soil. The soil acted as the insulating medium which allows the slurry temperature to be kept constant for gas production to take place.

Treatments

Cow dung was collected from a nearby cowshed. Two treatments were set up ,the first was made of 6kg of cow dung in 13litres of water, while the second had additional substrate, namely, 6kg of cow dung : 0.5kg of food waste : 0.5kg of paper: 13litres of water. The Digester solid content was 46.15% .Gas formation took place for a specified period of time and was observed. The retention period was sixty days.

Analysis of Biogas Collected

Gas analysis was carried out to know the composition of each constituent in the produced biogas. Biogas was collected in tubes. Constituents were separately tested by absorption in reagent solutions of potassium hydroxide for carbon dioxide (CO_2), lead acetate solution and acetic acid to determine the Hydrogen Sulphide (H_2S) content. The experiment was carried out for treatments: A (cow dung with water) and B (cow dung with food waste and paper waste.)

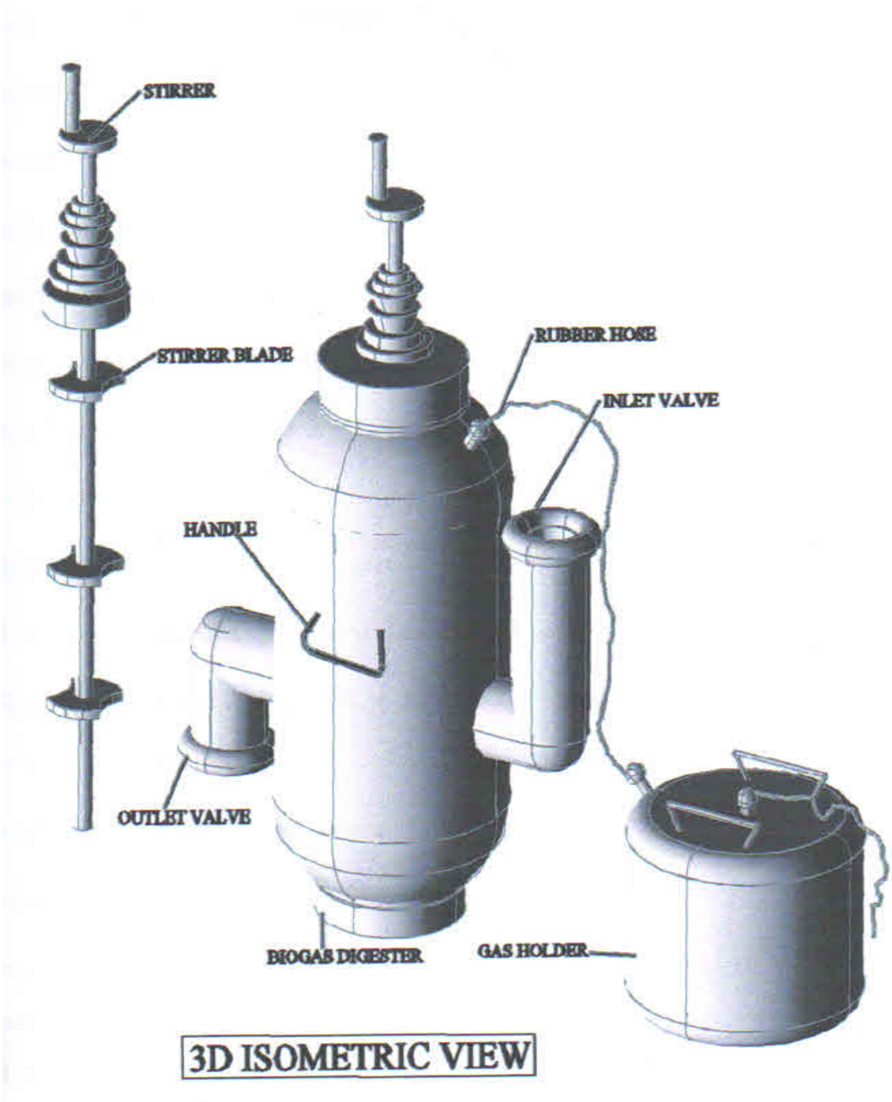


Plate 1: The Stirrer, Biogas Digester and the Gas Holder

Plate 2: Experimental set up for treatments A and B.

RESULTS

Results obtained show that treatment B started the generation of methane on day sixteen while treatment A started on day twenty two. It was also observed that on the average, experiment A generated 14.29grams (0.0119 m^3) and treatment B generated 15grams (0.0125 m^3) of combustible gas per day.

The rate of gas formation is sensitive to temperature. Optimal gas yield were between the mesophilic temperature range (30-38°C) and the thermophilic temperature range (44-57°C). The figures below show the mean weekly temperatures in degree Celsius and the retention time in weeks.

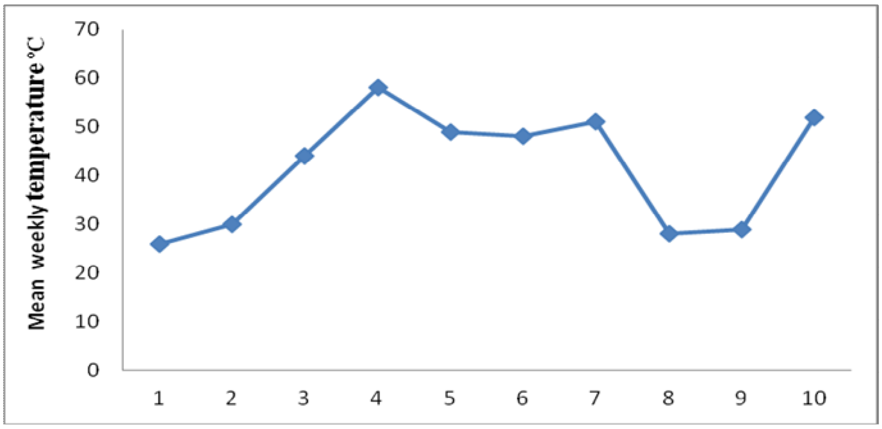


Figure 1: Mean weekly temperatures

Sufficient pressure was also generated within the digester. The table below shows the change n pressure with respect to the retention time.

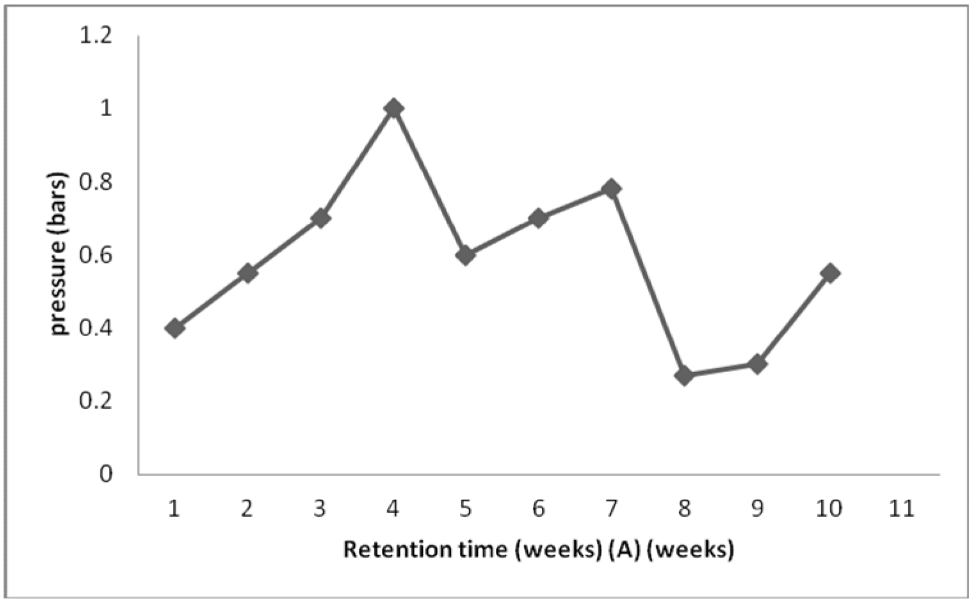
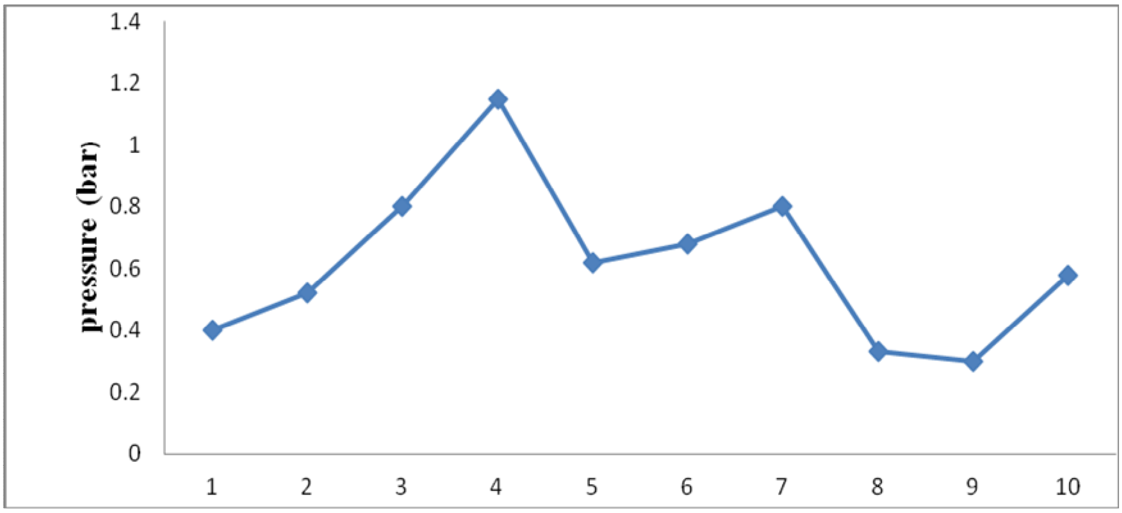


Figure 2: Change in pressure during digestion versus retention time



Retention time (weeks) (B)

Figure 3: Change in pressure during digestion versus retention time

The gas composition profile obtained are shown in table 3

Table 3 : Gas composition of Cow dung(Treatment A) and Cow dung with food waste and paper waste (Treatment B)

Constituents	Cow dung (%)	Cow dung with food waste and paper waste (%)
Methane(CH4)	60.38	60.61
Carbon Dioxide(CO2)	34.33	30.30
Hydrogen Sulphide (H2S)	5.28	9.09

DISCUSSION

From the experimental set up, the addition of paper waste and food waste to cow dung hastened the formation of methane gas and also allows more production of biogas per day. Co-digestion of different materials enhances the anaerobic digestion process due to better carbon and nutrient balance. Digestion of more than one substrate in the same digester highly supports microbial growth. During mesophilic anaerobic co-digestion of animal waste with fruit or vegetable waste, there is a percentage increase of methane yield. Food waste is a desirable material to co-digest with cow dung because of its high biodegradability (Mata-Alvarez et. al 2000).

Temperature as an important factor determines the rate of decomposition and gas formation. For the weeks in which the temperature range falls within the mesophilic (30 – 40 ºC) and thermophilic (40 – 50 º C) range, gas production occurred more. Therefore week two, three, four, five, six, and ten have high yield of methane. During week two the highest yield of biogas was obtained because at mesophilic temperature, gas production usually occurs more.

Pressure also varies with change in temperature. At a temperature range between 40 – 58 º C, there is high pressure within the digester but at a range between 30 – 40 º C, there is moderate pressure but at a lower temperature the pressure is also low and gas production is slowed down and very minimal.

CONCLUSION

The results above show that significant benefit is derived if conditions favoring gas yield are met. An important condition includes ensuring a determining factor like temperature which should be kept constant at the mesophilic and thermophilic stage for optimum gas yield. Also, pressure is necessary because once there is a generated pressure within the digester walls gas is produced. Furthermore, co–digestion of animal waste with paper waste improves the production of biogas and sustains its flammability. Cellulosic wastes are known to be poor biogas producers because of their poor biodegradability and so co- digesting them improves biogas production of various feed stocks. The usage of all these feedstock for biogas generation serves as a cheaper source of energy generation as well as a good waste management option.

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