Journal of Industrial Technology, 2018, 3 (1): 41 - 46
Journal Homepage: www.erjournals.com
ISSN Online: 0184-7937

EVALUATION OF SAWDUST CONCENTRATION ON BIOGAS PRODUCTION FROM SAWDUST WASTE, COW DUNG AND WATER HYACINTH

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ABSTRACT
In today's energy demanding life style, there is always a need for exploring and exploiting new sources of energy which are renewable as well as eco-friendly. Sawdust, generated by numerous sawmills situated along rivers, poses a great problem, as it gradually encroaches into the river causing environmental menace to aquatic life. This work proposes the utility of sawdust, co-digested with cow dung and water hyacinth to generate biogas as a means of its reuse and misuse. Varying amounts of sawdust waste complimented with a fixed amount of cow dung and water hyacinth was anaerobically fermented in batch-fed digesters, in the laboratory, at the same operating conditions. Biogas was measured for a period of 64 days at an average ambient temperature of 30^{o}C. The results show that efficient biogas production rate was maximum (0.046litres/TS fed) when about 11.58 g of sawdust waste was digested in a fixed amount of cow dung and water hyacinth (7 g).This corresponds to about 8 to 9.6% total solid content in the anaerobic digester which lies within the recommended percentage range for optimum biogas production.

Keywords: Saw Dust, Biogas, Anaerobic Digestion, Biomass.

Citation: Madu, K. E. and Onwuamaeze, P. I. (2018). Evaluation of Sawdust Concentration on Biogas Production from Sawdust Waste, Cow Dung and Water Hyacinth. *Journal of Industrial Technology*, 3 (1): 41 - 46

1. INTRODUCTION

Biogas is a gas produced via the breakdown of organic matter in the absence of oxygen. It is produced by the anaerobic digestion or fermentation of such biodegradable materials as biomass, manure, sewage, municipal waste, green waste, plant material and crops (National Non-Food Crops Centre). Biogas is also generated by converting cow manure via anaerobic digestion into methane biogas (State Energy Conservation Office, Texas). One cow can produce enough manure in one day to generate three kilowatt hours of electricity whereas only 2.4 kilowatt hours of electricity is needed to power one hundred watt light bulb per one day State Energy Conservation Office, Texas). In some parts of the world, like Nepal, biogas is a reliable source of rural electricity. Also, by converting cow manure into methane biogas instead of letting it decompose, global warming gases could be reduced by 99million metric tons or 4% (Webber and Amanda, 2008). Furthermore, biogas can be utilized for electricity production on sewage works in a combined heat and power engine (CHP), where the waste heat from the engine is conveniently used for heating the digester, cooking, space heating, water heating and process heating (Davies, 2009). If compressed, it can be used as fuel in internal combustion engines or fuel cells

Renewable energy plays an important role in reducing the greenhouse gases; particularly energy from biomass could contribute significantly as it is a 'carbon neutral' fuel (Fantozzi and Buratti, 2009). This process involves four major steps: hydrolysis, acidogenesis, acetogenesis and methanogenesis (Nwuche and Ugoji, 2008; Jagadish, Lourdu, Gavimath and Mali, 2011a).

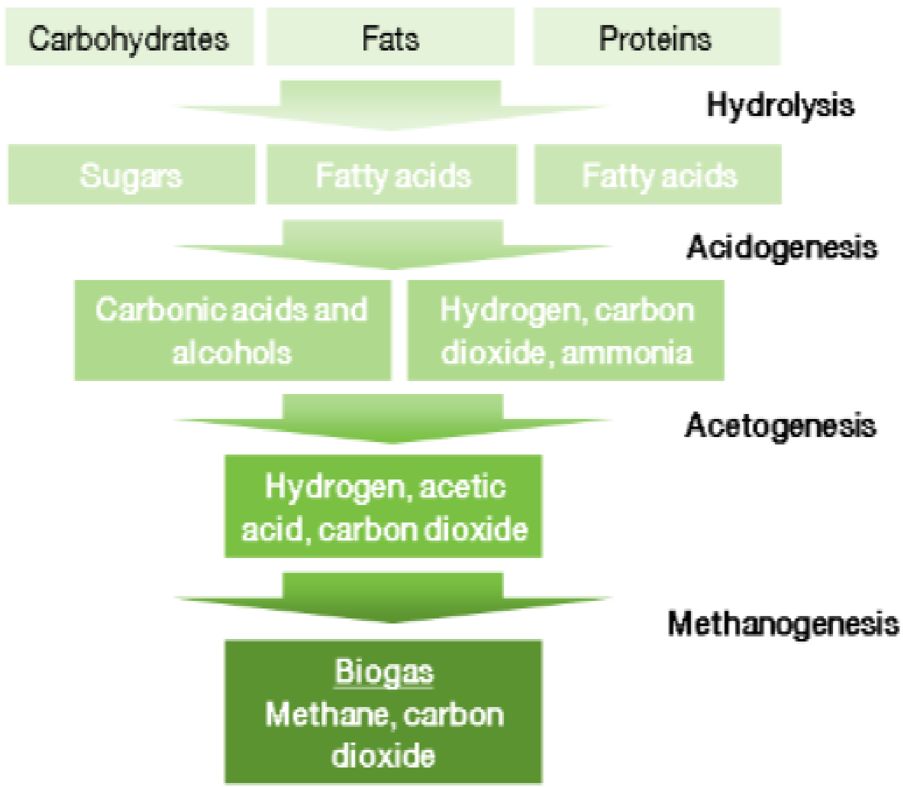

Figure 1: Processes involved in Biogas production. **Source:** www.clarke-energy.com

Hydrolysis is the first step in anaerobic digestion, which involves the enzyme-mediated transformation of lipids, polysaccharides, proteins, fats, nucleic acids into soluble organic materials such as Monosaccharides, amino acids and other simple organic compounds that are sources of energy and cell carbon [9]. This step is carried out by strict anaerobes such as Bactericides, Clostridia and facultative bacteria such as Streptococci etc.

Acedogenesis is the second step in which the soluble organic molecules from hydrolysis are utilized by fermentative bacteria or anaerobic oxidizers to produce volatile fatty acids (acetic acid, propionic acid and butyric acid), alcohols, aldehydes and gases like CO_2, H_2 and NH_3. In the third step, acetogenesis, the products of the acidification are converted into acetic acid, hydrogen, and carbon dioxide by acetogenic bacteria.

The terminal stage of anaerobic digestion is the biological process of methanogenesis. In this step, acetic acid, hydrogen and carbon dioxide are converted into a mixture of methane and carbon dioxide by the methanogenic bacteria (acetate utilizers like Methanosarcinaspp.and Methanothrix spp. and hydrogen and formate utilizing species like Methanobacterium, Methanococcus, etc.). A simplified generic chemical equation for the overall processes is represented as suggested by Yadvika *et al.* (2004)

$$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4 \quad [1]$$

Ogbo-Osisi in Onitsha, a renowned city in Anambra State, Nigeria, reputable for its timber and plywood resources, faces the menace of sawdust waste disposal. Also, deciduous rainforest areas, characterized by high rate of lumbering activities are faced with the same menace. Virtually all sawmills therein are located along the river banks, and disposal of the sawdust waste is by the riverside, where sometimes it is burnt. This action releases carbon dioxide (CO_2) to the atmosphere, resulting in environmental air pollution. However, due to the constant rainfall in the region, burning is often terminated, consequently increasing the concentration of heaps of sawdust which seriously encroach into the river as suspended solids reducing the width of the river and invariably becoming a nuisance to the aquatic environment.

In recent years, biogas systems have attracted considerable attention as a promising approach for organic wastes recovery. Developed and developing countries and several international organizations have shown interest in biogas systems with respect to various objectives:

a. Public health and hygiene**:** It reduces the concentration of pathogens considerably, thereby breaking the cycle of reification and leading to improved public health.
b. Waste recycling**:** It utilizes different kinds of wastes.
c. Biogas is a renewable source of energy which can relieve the burden of dependence on fossil fuels as bio fertilizer**.** Nitrogen, phosphorus and potassium are conserved in the process of biogas production and can be recycled into agricultural lands as fertilizer.
d. Environmental management**:** It is a multifaceted technology which can be applied to a variety of environmental and social milieus.
e. Also, due to eutrophication of tropical water bodies, water hyacinth (Eichhomiacrassipes) invades them and creates an imbalance in the lifecycle of these water bodies. In order to naturally control their invasive nature, water hyacinth could be harvested and used for anaerobic digestion (Lucas and Bamgboye, 1998).

2. MATERIALS AND METHOD

Buckner flasks and measuring cylinders were employed in the experiment. They were properly washed with soap solution and washing brushes, and allowed to dry by standing over night in the laboratory. The corks, connecting pipes, cheesecloth were washed with soap solution and also allowed to dry as above. Sodium chloride (NaCl) was employed as the saturating agent. Distilled water was used for all dilutions. Also weighing crucibles and evaporating dishes were employed and properly cleaned before use.

2.1 Experimental Set-Up

The experiment was based on batch-type digester, being the simplest and easiest form of digestion. Biomass was added to the reactor at the start of the process in batches and was sealed for the duration of the process. 500-ml capacity. Buckner flask digester was used as the batch reactor and biogas collection was done via water displacement method.

3. RESULTS AND DISCUSSION

The general results obtained from the experiment show that varying the amount of saw dust blended with a fixed amount of cow dung and water hyacinth in water is very important for producing maximum amount of biogas in a period of 64 days with an average ambient temperature of 30^{o}C. The results indicated that there was the presence of biogas-producing bacteria and that the conditions for biogas production were attained within the given period of the experiment. The values obtained at the end of the experiment were different for each system which is an indication that the micro-organisms acted on the basis of the availability of the volatile fatty acids readily available for biogas production during the methanogenesis stage.

Table 1: Cumulative Biogas Production of Digesters with retention time.

Cumulative Biogas Production(ml) of Digesters Retention Time (Day)

A	B	C	D	E	F	
0	0	0	0	0	0	0
8	120	200	160	200	140	10
15	290	350	370	370	180	20
20	420	500	620	580	300	30
26	580	700	840	880	500	40
30	700	780	970	1080	600	50
40	800	980	1100	1200	650	60
42	820	1100	1140	1200	680	64

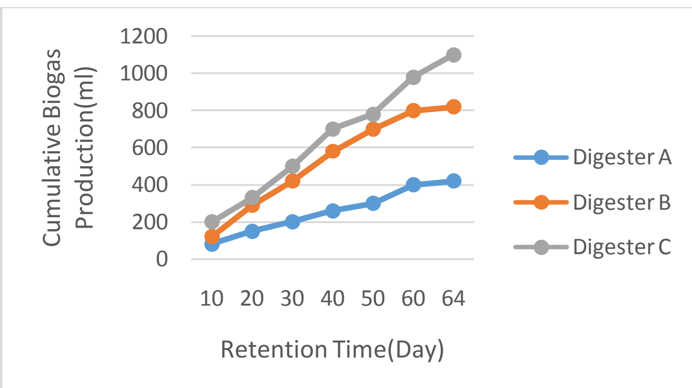

Figure 2: Graph of Cumulative Biogas Production cum Retention Time

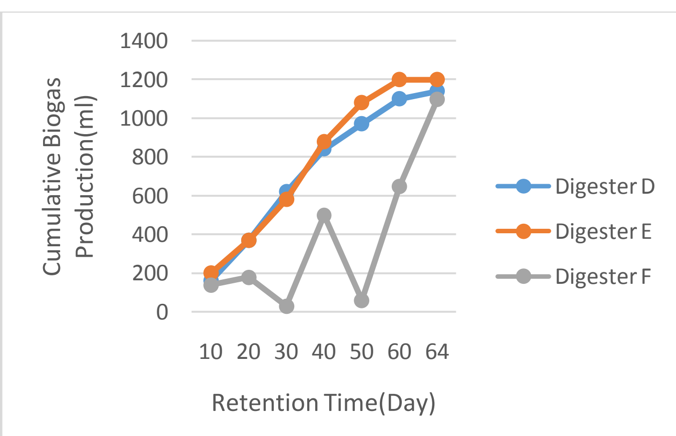

Figure 3: Graph of Cumulative Biogas Production cum Retention Time

The graphs show a progressive increase in the cumulative biogas production for digester A to F. This could be attributed to the fact that anaerobic digestion of organics proceed best if the fermentation slurry consists roughly of about 8% total solid content (Davies, 2009). The gradual decrease observed in F could be ascribed to the fact that the total solid content in the digesters is beyond the specified range for optimal biogas production.

Table 2.Average Rate of Biogas Production cum Saw dust Concentration

Biogas Production Rate (ml/gm/days)	Retention Time (days)
0	0
0.08	10
0.17	20
0.19	30
0.30	40
0.20	50
0.17	60
0.15	64

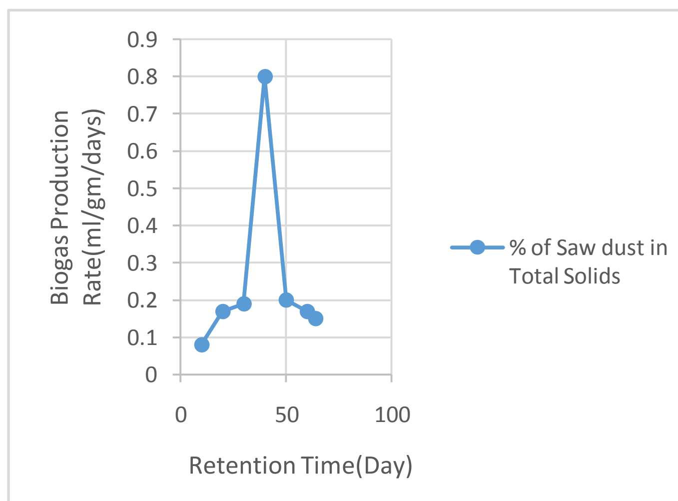

Figure 4: Plot of Average Rate of Biogas Production versus Saw dust Concentration

The graph of average rate of biogas production against saw dust concentration, in figure 4, shows that there was gradual increase in the average rate of biogas production as the concentration of saw dust waste is increased until a peak value is reached after which the average rate of biogas production starts falling. This can be attributed to the fact that as the concentration of the saw dust waste increases, the lignin content in saw dust, which is not easily degraded, also increases until a peak is reached when the anaerobic system will experience a lesser bacterial count to biodegrade the massive lignin form of carbon in the saw dust and consequently leading to gradual decrease in the amount of biogas production. The peak value obtained from the graph shows an average rate of biogas production of about 0.039 litres biogas per day with a corresponding saw dust waste concentration of 14.85 g. This is 51. 48% of saw dust waste in the total solid content of 7g each of cow dung and water hyacinth respectively.

4. CONCLUSION

a. The rate of biogas production increases as the concentration of saw dust waste increase until it peaks at 0.039litres per day (corresponding to 51.48% of saw dust concentration) when it starts decreasing due to decreasing number of methanogenic bacteria which are active only within a particular concentrate of cellulose substrates.

b. The utility value of sawdust can be harnessed from anaerobic digestion of it, leading to biogas yield.

c. A blend of 7 g each of cow dung and water hyacinth with 15 g of sawdust (indicating a total solid content of 8-9% fermentation slurry) is most suitable for biogas production.

d. The environmental menace of saw dust from lumbering activities can thus be curbed.

e. Water hyacinth can be harvested from water bodies and used for biogas production.

REFERENCES

Davies, A. (2009). Biomethane fueled vehicles the carbon neutral option" Claverton Energy Conference, October 24th 2009, Bath, UK.

Fantozzi, F. and Buratti, C. (2009). Biogas production from different substrates in an experimental continuously stirred tank reactor anaerobic digester. *Bioresource Tech.*, 100: 5783-5789.

Jagadish, H. P., Lourdu, A. R., Gavimath C. C. and Mali, B. M. (2011a). A Study on effect of volatile fatty acid on biomethanation of water hyacinth. *Int. J. of Adv. Biotech. and Research*, 2 (2): 257-262.

Lucas E. B. and Bamgboye A. I. (1998). Anaerobic digestion of chopped water hyacinth. *Nigerian. J. Renewable Energy*, 6 (1): 62-66.

National Non-Food Crops Centre. "NNFCC Renewable Fuels and Energy Factsheet: Anaerobic Digestion", Retrieved on 2011-02-16; Assessed on 1st June, 2013.

Nwuche, C. O. and Ugoji, E. O. (2008). Effects of heavy metal pollution on the soil microbial activity. *Int. J. Environ. Sci. Tech.*, 5 (3): 409-414.

State Energy Conservation Office (Texas). "Biomass Energy: Manure for Fuel, 23 April 2009. Web. 3 October 2009.

Webber, M. E. and Amanda, D. C. (2008). Cow Power. In the News: Short News Items of Interest to the Scientific Community. *Science and Children*, 46 (1): 13-23.

Yadvika, S., Sreekrishnan, T. R., Sangeeta, K. V. and Rana, A. U. (2004). Enhancement of biogas production from solid substrates using different techniques—a review. *Bioresource Tech*, 95: 1-10.