Detection of Nature and Content of Bioenergy From Aquatic Macro Weeds

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ABSTRACT
The present work highlight the fact that already the recurring cost of biogas is far less than other fuels and use of abundantly available water weeds like *Eichhornia*, *Pistia* and *Salvinia* will further bring down the fuel cost. The final results of the study were confirmed as follows: Among the aquatic weeds tested, *Eichhornia* generated the highest quantity of biogas in litres per kg volatile matter (236.3) as well as litre/day/litre digester volume (1.4) when retention time was maximum in hot season. This was closely followed by *Pistia* in the descending order, while *Salvinia* registered the least quantity. Values in the case of cow dung (control) for same parameters were 186 and 0.73 respectively. Gas production rates varied with variation in retention time and loading rates.

Keywords: Aquatic Weeds, *Eichhornia, Pistia, Salvinia*, Biogas Production, Solubilisation, Acidogenesis, Methanogenesis.

1. INTRODUCTION

Initially biomass was the only source of energy available to and used by man. But the development of fossil fuels rapidly reduced the use of biomass as energy source especially in the developed countries. Economic and industrial development in the developing countries has contributed to an enhanced use of fuels which in any case are non-renewable and limited in supply that is depleting rapidly. These considerations have forced man to seriously consider the option bio-fuels as a replacement for fossil fuels. Most of the biofuels are derived from biomass which is renewable, of low cost and locally available. They lead to relatively low CO_2 emission than fossil fuels. Biomass is the total cellular dry weight or organic material that produces methane, ethanol, butanol and diesel and is referred to as biohydrogen, biomethane, bioethanol, biobutanol and biodiesel.

Biogas production takes place with the help of anaerobic bacteria. Anaerobic digestion is accomplished in 3 stages; solubilization, acidogenesis and methanogenesis. These stages are characterized by 3 groups of bacteria.

Typical composition of biogas

Methane, CH_4 (50 to 75%)
Carbon dioxide, CO_2 (25 to -50%)
Nitrogen, N_2 (0 to 10%)
Hydrogen, H_2 (0 to 1%)
Hydrogen sulfide, H_2S (0to 3%)
Oxygen, O_2 (0-2)

Many aquatic plants have become troublesome for aquatic animals and human as well. These also have much future prospects as source of biomass conversion in to biogas. In the present study we have taken up studies on biogas production from *Eichhornia*, *Salvinia* and *Pistia*, because they are readily available round the year and that too absolutely free of cost. Moreover, the hitherto status of these invasive weeds as useless menace may find a noble use as house hold cooking fuel.

2. MATERIAL AND METHODS

Eichhornia, Pistia, Salvinia and cow dung; pH metre, fibre made biogas tanks (dome model), water and gas stove were the materials involved in the present investigation. The substrates used for biogas generation were *Eichhornia*, other aquatic weeds, and cow dung. Here cow dung was used to initiate the process of methanogenesis. For the generation of biogas four biogas tanks with the following dimensions were used:

Diameter of the tank- 60 cm, Diameter of the dome - 56 cm, Diameter of the tube - 7 cm and Diameter of the tube mouth - 13 cm. All the experiments had minimum 3 replicates at a time and were repeated at least 3 times.

The experimental set-up for gas generation consisted of a field-scale biogas plant with a digester capacity of 200 litres (Fig- 1). The digester which was made of synthetic fibre, had an inlet and outlet placed on opposite sides. A gas outlet was provided on top of the dome of the digester. The dome is a freely inserted hollow cylinder with diameter slightly less than the digester. Arrangement of the whole apparatus is such that gas formed from the loaded matter lifts up the dome proportionately. The gap between the freely rotatable dome and the digester base was filled with water so that the gas generated does not escape through any other channel other than the gas outlet controlled by a valve. The gas outlet was directly connected to the stove with a wide holed burner whenever presence of flammable gas had to be tested. Experiments where carried out as a semi-continuous operation wherein loading frequency was at intervals of one day. The desired volume of digester contents was removed and replaced with the same volume of fresh slurry each day. Attempts were also made to study gas yields at different loading rates during monsoon season and hot season.

Materials used for digestion were cow dung (main control) and *Eichhornia crassipes*. Other aquatic weeds like *Pistia*, *Salvinia* and leaves of terrestrial angiosperm *Glyricidia sepia* were also tried as alternate substrates. The aquatic bio materials were collected from the fresh water ponds in the vicinity of SN College Cherthala campus. Fresh cow dung was mixed with water in the ratio 1:1 prior to loading in the biogas plant. The biomass was sun dried for 12 hours and made into coarse powder or cut into pieces of sizes 1x1x1 cm and 2x2x2 cm approximately. Prepared plant materials were mixed with water in the ratio of 1:3 before loading into the biogas plant. Digested slurry (about 2.5 litres) from previous experiments was always used for seeding at the start of a new experiment. The different feed stocks were dried at 100°C in oven and ashed at 500°C and the loss in weight on ashing was taken as the volatile matter content (Nair et al 1982).

2.1 Effect of agitation : Dome was agitated at specific intervals like once a week and once a month to know the effect of agitation on biogas generation.

2.2 Effect of loading quantity: For this the experiments are done with half kilogram, 1 Kg and 1.5 Kg of 12 hour sun dried eichhornia. Each experiment was repeated three times in each tank.

2.3 Effect of substrate size: Initially used the coarse powder form of the substrate made into paste by adding water, then 1x1x1 cm and 2x2x2 cm sizes were also tried for the long run.

2.4 Effect of quantity of water: Different ratios of water to substrate like 1:1, 2:1 and 3:1 were tried.
2.5 Analysis : For the biochemical analysis of nature and content of the biogas produced the samples of different experiments were sent to the poluchem lab, Ernakulam. The analysis were done for quantity of Methane and CO_2 in percentage and CO in ppm.

2.6 Dry matter content of plant material

The substrate was dried in an oven at 100^0C for 24 hours. These dried materials were ashed in muffle Furnace at 500^0C. Volatile matter was arrived at by subtracting the ash content from the dry matter. pH and Electrical conductivity were checked in the slurry using portable pH meters.

3. RESULTS

Effect of volatile matter loading, retention time and temperature on biogas production from:

3.1 Eichhornia

Experimental data on gas production at three different loading rates and two different seasons using Eichhornia as the feedstock are given in Table I.

A) Gas production during rainy season:

Results have shown that at a volatile matter loading of 1.98g/litre/day (retention time: 28 days) gas production per day and per kg volatile matter were 73 and 184 litres respectively. When volatile matter loading was doubled to 3.95g/litre/day (retention time:14 days), gas production per day increased by 40% although gas production per day per kg volatile matter has shown a 30% reduction, thus suggesting incomplete digestion of volatile matter loaded. When volatile matter loading was increased three times i.e. to 5.93g/litre/day (retention time: 14 days), the gas production per day increased by 99% and gas production per day per kg volatile matter decreased by 34 %. At trebling rates, 7 day retention time was not enough to tap maximum potential of the bioenergy locked up in hyacinth.

B) Gas production during hot season:

Gas production per day and per kg volatile matter at a volatile matter loading of 1.98g/litre/day (retention time: 28 days) were 83 and 210 litres respectively. Doubling the volatile matter loading with retention time of 14 days resulted in double increase in gas production per day. However, gas production per day per kg volatile matter remained about the same suggesting that efficiency of digestion was not affected on doubling the volatile matter loading. This was in contrast to similar situation during rainy season where gas production per day per kg volatile matter had shown a 30% reduction upon doubling the loading rate. When volatile matter loading was increased three times (5.93g/litre/day at retention time of 7 days), the gas production per day showed 237% increase and gas production per day per kg volatile matter 13% increase. This increase could not be explained but it becomes clear that three times increase in the loading rate does not adversely affect the efficiency of digestion when ambient temperature is higher that that of rainy season.
A comparison of the experimental data showed that at a volatile matter loadings of 1.98, 3.95 and 5.93 g/litre/day, during hot season, gas production per day and gas production per day per kg volatile matter showed an increase of 14, 60 and 93 per cent respectively as compared with that during the rains when general atmospheric temperature average is below 30°C.

3.2 .Cow dung (Control)

Experimental data on gas production at three loading rates during two seasons with apparent temperature difference using fresh cow dung as the feedstock are given in Table II.

A) Gas production during rainy season:
At a volatile matter loading of 1.6g/litre/day (retention time: 28 days) gas production was 53 litres per day and Gas production per day per kg volatile matter was 220 litres. Doubling the volatile matter loading with retention time of 14 days resulted in 17% increase in gas production per day. However, gas production per day per kg volatile matter showed a sharp 42% reduction suggestive of incomplete digestion of volatile matter loaded, similar to the observations using Eichhornia as the feedstock during rainy season where gas production per day per kg volatile matter had shown a 30% reduction upon doubling the loading rate. Similarly, When volatile matter loading was increased three times gas production per day showed 65% increase and gas production per day per kg volatile matter registered a decline of 45 when volatile matter loading was increased three times i.e. to 4.8g/litre/day (retention time: 7 days).

B) Gas production at 35°C:
At a volatile matter loading of 1.6g/litre/day (retention time: 28 days) gas production per day and per kg volatile matter were 6.2 and 194 litres respectively. Doubling and trebling the volatile matter loading resulted in an increase of gas production per day by 69% and 136% respectively. The gas production per day per kg volatile matter showed a 16% reduction on doubling the loading rate and a 22% reduction in when the loading rate was increased three times.

Results show that at a volatile matter loading of 1.6g/litre/day, during hot season, gas production per day and gas production per day per kg of volatile matter showed a marginal decrease (12%) from that of during rainy season. On doubling the loading rate during hot season, both gas production per day and gas production per day per kg of volatile matter have shown a 28% increase as compared to that obtained during the rains. When volatile matter loading was increased three times ie. 4.8g/litre/day, both gas production per day and gas production per day per kg volatile matter have shown a 26% increase during hot climate when compared to that of the performance in monsoon.

The results show that during hot season, cow dung digestion was slower and incomplete at loading rates of 3.2 and 4.8g/litre per day compared to that of Eichhornia.

C) Volatile matter content of different feed stocks.
The volatile matter in *Pistia* and *Salvinia* ranged from 70-75%, and highest in *Eichhornia crassipes* (79%), the common water hyacinth. In cow dung (control), it was 15.1%.

D) Composition of gas
Amount of methane was proportionately low and more or less same in all the tanks including the control (18-20%). Even after a span of one year active substrate feeding with occasional idle periods, the maximum methane proportion in any tank was up to 32.9%. In the initial stages, CO_2 production was to the higher side in the control tank compared to the experimental ones with any of the four selected substrates. CO (Carbon monoxide) was in trace amounts irrespective of the substrate.

The gas generated from all tanks was flammable @ 10 minutes duration for every 10 cm height attained by the domes due to pressure of accumulated gas.

4. DISCUSSION AND CONCLUSIONS

It was seen that at 28 days retention time i.e 1.98g/litre/day loading rate gas production from Eichhornia and cow dung were about the same i.e. 0.35-0.36 litre/day/litre digester volume. A doubling of volatile matter loading has resulted in a 17% increase in gas production per day from cow dung and a 40% increase in gas production per day from Eichhornia. A three fold increase in volatile matter loading showed a 65% increase in gas production from cow dung and a 99% increase in gas production per day from Eichhornia biomass. The higher gas production from Eichhornia biomass at increased loading rates as compared to cow dung, shows that digestion of Eichhornia biomass is faster as compared to cow dung. The higher rate of digestion of Eichhornia biomass could due to its high volatile solid content (Mital, 1996).

Further, a substantial reduction in digestive size can lead to considerable savings in the capital cost of family biogas plants.

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