

PRODUCTION OF BIOGAS FROM CATTLE WASTE AT LOW TEMPERATURE

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ABSTRACT

Production of Biogas from cattle waste and other biomass is now considered as one of the major routes to obtain gaseous fuel for sustainable development. In tropical countries like India thousands of rural families in villages are using 3 to 5 M³ biogas plants to suffice their daily cooking fuel need. All these plants are run on cattle waste. Since these plants are operated at ambient temperatures, effect of temperature variation affects daily gas yield. The effect becomes very prominent during winter season. In general about 50-60% reduction in daily biogas yield is observed when ambient temperature is around 15°C as compared to that produced at around 30-35°C. A low cost and simple to operate technique to enhance biogas yield from the biogas plant during winter season shall help to get optimum biogas yield from these plants during the winter season. We thought of a simple technique of filtering the digested effluent slurry of biogas plant through a triple layer muslin cloth to obtain a filtrate, hence-forth called as clarified digested slurry (CDS), rich in cell mass and then adding it back to the biogas plant along with the influent slurry. Experiments were carried out on 25 L capacity cattle dung biogas plant operated at 15°C to see effect of recirculation of CDS. Addition of 25 and 40% v/v CDS in daily influent resulted in 15% and 37% increase in daily biogas yield. Recirculation of 40% v/v CDS supplemented with Diammonium phosphate(DAP) increased the biogas yield by 75% v/v. In another experiment use of clarified rumen fluid (CRF) to prepare influent slurry and added exclusively for one day enhanced the daily biogas yield by 70% v/v for a period of two months. Popular daily wears in India called cotton dhoti or cotton sari can be used for the filtration of the slurry.

KEYWORDS

Biogas production; Low temperature; Cattle dung; Clarified digested slurry

1. INTRODUCTION

In India cattle dung is commonly used as a substrate for biogas production. Over 2.8 million biogas plants are set up in the country [1]. One major problem in operating and obtaining

optimum biogas yield from these plants is lowering of efficiency of anaerobic digestion and biogas yield in winter season when the ambient temperature goes below 20 °C.

Attempts were made to maintain the temperature of these biogas plants in winter season by providing insulation, heating or circulating hot water outside the plants. However, these methods are impracticable and are not economical. These attempts have failed to enhance biogas production in winter season. Researchers have tried to adapt the microorganisms at low temperature and use these in biogas plants [2, 3, 4, 5, 6, 7]. However, completely satisfactory solution has not been obtained.

One of the alternatives to overcome the loss of efficiency is to increase the number and activity of anaerobic bacteria including methanogens present therein. The effluent slurry of biogas plant running at low temperature is rich in all essential anaerobic bacteria. These microorganisms are exposed to low temperature for 30 days or so, are considered well adapted to 15 °C. With a view to take advantage of temperature adapted microbial cell mass, simple procedure to separate microbial cell mass from the effluent slurry was derived. In this process the effluent slurry was filtered through a triple layer (approximately 20 mesh no.) cotton cloth (muslin cloth), popularly called as dhoti. The filtered slurry was called as clarified digested slurry (CDS) and had total solids (TS) 1.80% volatile solids (VS) 1.54% and volatile suspended solids (VSS) 1.50%. The CDS thus had less substrate and more VSS.

2. METHODS

2.1. Biogas Plant

Biogas plants used in the study were 25 L capacity, non-stirred, floating dome digester of KVIC design [8]. Three plants were kept and run in the cabinet having constant temperature of 15°C.

2.2. Feed material

Cattle dung was obtained from one specific nearby dairy. It was diluted with tap water to have 10% total solids (TS).

2.3. Experimental set up

All the plants were run on fresh cattle dung slurry at 15 °C having 30 day hydraulic retention time (HRT) normally used for biogas plants run on cattle dung in India.

2.3.1. Effect of recirculation of clarified digested slurry (CDS)

The effluent slurry from biogas plant was filtered through triple layered muslin cloth, called as 'dhoti' to get homogenous clarified digested slurry hence-forth called as CDS. This retained the active biomass from the effluent slurry adapted at low temperature in the CDS however; the undigested substrate was removed during filtration. The CDS thus obtained contained more VSS.

Experiment was carried out using three-biogas plants.. In one plant 25% (v/v) CDS was added in daily feed, in second plant 40% (v/v) CDS was added in daily feed. Third plant receiving only

fresh cattle dung slurry served as control. The experiment was carried out over a period of 50 days.

2.3.2. Effect of supplementation of Diammonium phosphate (DAP) to CDS

After completion of the above experiment 80 mg of Diammonium phosphate (DAP) was added in daily feed of one plant having 40% CDS. In another plant 40% recirculation of CDS was continued. The control plant in the above experiment was continued as a control for this experiment. The experiment was carried out over a period of 28 days.

2.3.3. Effect of addition of clarified rumen fluid (CRF)

For this experiment rumen fluid was obtained from a nearby slaughterhouse and it was clarified as described above and hence- forth called as CRF. The rumen fluid is rich in anaerobic bacteria including methanogens. After clarification the filtrate contained active biomass. Three biogas plants were used. Two experimental plants received 40% CDS in daily feed. In one of the experimental plants in daily feed instead of water 415ml of CRF was added one time only. Third plant receiving fresh cattle dung slurry served as the control. Experiment was carried out over a period of 60 days.

2.4. Analysis

In all the experiments biogas produced daily was measured with wet gas flow meter (Toshniwal, Chennai) and analyzed for its methane content on gas chromatograph [9]. Volatile Fatty Acids (VFA) were analyzed on a gas chromatograph equipped with flame ionization detector [10] Total solids (TS), VS, VSS were estimated as per the procedures described in Standard methods [11].

3. RESULTS AND DISCUSSION

3.1 Effect of recirculation of CDS

Results on effect of recirculation of CDS are given in *Table 1* and *Figure 1*. It is seen from the result that there was 14.6% and 36.5% increase in biogas production with recirculation of 25% and 40% (v/v) of CDS, respectively over the control. Methane content in the biogas produced in all the plants was in between 44 to 47%. The pH of the fermenting slurry of these plants was 6.5-7.2, which is favorable for methanogenesis. During preparation of CDS the undigestible substrates are removed and the CDS contained biomass, which is active as well as well adapted to low temperature. It also contains the active extracellular enzymes produced during anaerobic digestion, which ultimately resulted in enhanced biogas production. The results also showed that the increase in biogas production is directly proportional to the volume of CDS added in daily feed.

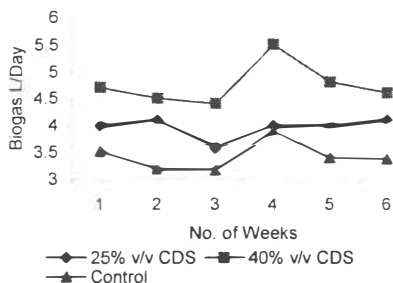


Table 1. Effect of recirculation of CDS.

Average Biogas Produced	With 25% v/v CDS	With 40% v/v CDS	Without CDS (Control)
L/Day	3.99	4.76	3.49
L/Kg dung/Day	9.5	11.3	8.3
% Increase	14.6	36.5	-
Methane%	45.7	46.5	43.6

Figure 1. Effect of recirculation of CDS.

3.2. Effect of supplementation of Diammonium phosphate to CDS

Results on effect of supplementing DAP with 40% recirculation of CDS are given in Table 2 and Figure 2. The results showed that merely adding 80 mg DAP daily in the plant having 40% CDS resulted in 75% increase in biogas production over the control. There was no much change in methane content (46 - 48%) and pH of the fermenting slurry (6.5-7). Addition of DAP provided nitrogen as well as phosphorus as nutrients to the biomass which ultimately resulted in increase in biogas production by 75% over the control.

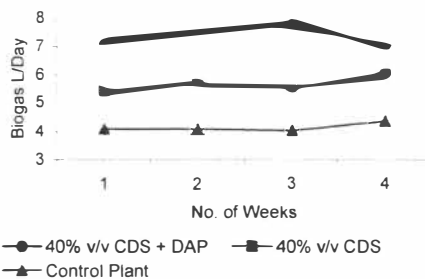


Table 2. Effect of supplementing DAP.

Average Biogas Produced	With 40%v/v CDS + DAP	With 40%v/v CDS	Without CDS (Control)
L/Day	7.23	5.65	4.42
L/Kg dung/Day	17.43	13.61	9.94
%Increase	75	37.1	-
Methane%	47.4	46.5	44.7

Figure 2. Effect of supplementing DAP.

3.3. Effect of Addition of Clarified Rumen Fluid (CRF)

The results of effect of addition of CRF are given in Table 3 and Figure 3. Results showed that addition of CRF, once only enhanced the biogas production by 70% and the effect remained for a period of 8 weeks. Methane content in biogas of these plants was between 46 to 49%. The pH of the fermenting slurry was 6.5-7.2. The CRF contains very active anaerobic bacteria including

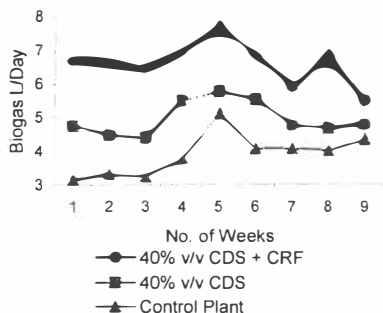


Figure 3. Effect of addition of CRF.

Table 3. Effect of addition of CRF.

Average Biogas Produced	With 40% v/v CDS + CRF	With 40%v/v CDS	Without CDS (Control)
L/Day	6.64	4.96	3.90
L/Kg dung/Day	16.01	11.96	9.40
% Increase	70	27.5	
Methane% \pm	49.1	47.0	45.6

methanogens and the active enzymes, produced in the rumen, which ultimately resulted in increase in biogas production. To have a constant increase in biogas production one has to add the CRF at an interval of every 8 weeks.

Thus, there was a definite and significant increase in biogas production due to the recirculation of CDS. The increase is directly proportional to the volume of CDS added in daily feed. Maximum 40% CDS can be obtained from the daily effluent slurry of the biogas plant. The digested slurry filtered through triple layer of muslin cloth contained more VSS and trace amount of undigested substrates. The bacteria from the effluent slurry retained in CDS could be considered as well adapted to low temperature at which the plants are operated. In addition the CDS might contain extracellular enzymes as well as co-factors required for the active growth of methanogens. The recirculation of CDS enhanced the number of adapted cells in the digester, which resulted in enhancement of overall microbial activity responsible for more biogas production from cattle dung.

When the CDS was supplemented with DAP it provided nitrogen as well as phosphorous as the nutrient to the biomass which increased the number as well as activity of the biomass and resulted in 75% more biogas over the control. DAP is used as the fertilizer hence it is always available with the farmer and the required quantity can be added in the daily feed to get enhanced biogas production.

The rumen of the animal is rich in anaerobic bacteria including methanogens. The CRF when added in biogas plant enhances the number as well as activity of methanogen. The CRF contains extracellular enzymes and might be providing the co-factors required for the growth of the methanogens, which ultimately enhanced the biogas production, and the effect remains for a period of 8 weeks. To have enhanced biogas production one has to add the CRF to the plant after every 8 weeks.

4. CONCLUSIONS

Using a simple method of filtration of effluent slurry a clarified digested slurry (CDS) rich in bacterial cell mass adapted to low temperature and containing extra cellular enzymes could be obtained. Recirculation of CDS enhances the biogas production at low temperature. Addition of DAP to CDS further improves the gas production. Clarified rumen fluid (CRF) added once in biogas plant with CDS increases the daily biogas production by 70% v/v and the effect remains for a period of 60 days. Thus recirculation of CDS offers a low cost easy to operate and reliable method to enhance biogas production in winter season.

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