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Original Article

Optimization of Biogas Production by Anaerobic Digestion using Laboratory Waste

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Abstract

There is increasing international interest in developing low carbon renewable energy technologies. Biomass is increasingly being utilized as an energy source throughout the world. Several modern technologies have been developed that convert biomass to bioenergy. Anaerobic digestion is a mature energy technology for converting biomass to biogas, which is a renewable primary energy source. Experiments were conducted in a small scale anaerobic batch digester under mesophilic range (28-35 ^{o}C) for 21 days. Comparative studies of biogas gas production were performed using different ratios of waste with cow dung as well types of waste. Garden waste and paper waste were used with the ratio 1:1 and 2:1 with cow dung, respectively. By considering direct natural resources as inoculums, maximum gas production was found with a mixture of leaf and paper waste and cow dung (1:1:1) reactor.

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1. Introduction:

Biogas is a biofuels' type that originates from biodegradable materials. It is typically a gas released by catalytic action of fermentation of bacterial organic materials in the absence of oxygen (anaerobic digestion condition). It is the result of well-arranged biologically intervened system resulting from microorganism's digestion of plant and/ or animal in airtight containers called digester. Biogas is a composition of mainly methane (CH_4) (about 50–70%) and carbo-dioxide (CO_2) (about 30–50%). The percentage of methane and carbon-dioxide present in the biogas mixture is determined majorly by the type of the feedstock. Beside from methane and carbon-dioxide, there are traces of N_2 (0–3%), H_2S (0–10,000 ppm), O_2 (0–1%), H_2O (5–10%), and NH_3 in the mixture. Biogas production is an alluring alternative energy source with regards to energy yield. Although biogas generation from plant residues has been tremendously studied and demonstrated, based on profitability and sustainability, the economics of digesters treating plant residues has been found to be unsatisfactory, because of the low biodegradability of substrates and low yield of biogas as compared to food waste and other highly biodegradable wastes [1].

Biogas can be a game changer for hiked prices of Liquid Petroleum Gas (LPG) in India from the last six years as it is a renewable source of energy. A number of studies have been conducted to increase a biogas yield in the anaerobic digestion. An attempt to improve the biogas conversion efficiency and biogas yield are abundant. These include pre-treatment of manure by separating solids from digested materials, improving substrate composition by co-digesting with other substrate [2].

Organic wastes such as kitchen waste, garden waste, are regarded as wastes. These are thrown outside the home which then becomes the source of pollution. This pollution results in many environmental problems as well as health problems leading to suffer from many diseases. For the management of the food waste, environment friendly individuals may compost the waste for using it as manure in the farm and ignore the energy that could be obtained from the waste [3].

2. MATERIALS AND METHODS:

2.1 Waste sample procurement:

The lignocellulosic waste was collected from the laboratory area of Department of Biotechnology, Shivchhatrapati College, Aurangabad and the college itself. The samples were collected in the form of paper waste (cardboard, used paper) and leaf waste.

Cow dung collection:

The fresh cow dung was collected from local farm house of located in CIDCO area of Aurangabad.

Activation of waste decomposer:

The waste decomposers were activated by adding 1 grams of decomposer in 1000 ml of sterile distilled water with 5 grams of jaggery. The mixture was allowed to activate for 7 days at room temperature.

Pretreatment of lignocellulosic waste:

The paper waste and garden waste were finely grinded into powder form and treated with activated decomposer solution. The slurry was prepared and kept for 7 days to decompose the waste. The slurry was further used for a biogas production.

Optimization of biogas production using different ratios of substrate:

In this study, experiments were conducted in a small scale anaerobic batch digester under mesophilic range (28-35 ^{o}C) for 21 days. The experiment was carried out in two stages. In the first stage, the cow dung and water was mixed in 1:1 ratio. In the second stage, the treated slurry of waste with decomposer was mixed with activated cow dung in different ratios. Paper waste: cow dung slurry (1:1), Paper waste: cow dung slurry (2:1), Leaf waste: cow dung slurry (1:1), Leaf waste: cow dung slurry (2:1).

In the digester (3 Liter capacity), 2000 ml slurry of different substrate mixtures was filled. Air tight sealing of the digester was done by using M-seal (epoxy compound). The volume of biogas produced in digester was measured by the water displacement method.

3. Result:

3.1 Production of biogas:

The optimized conditions were considered and the biogas production was performed at the laboratory level. The designed bio digester was filled with 25L of slurry of cow dung and lignocellulosic waste (1:1 ratio). 370gm of jaggery was added in the bio digester. All the openings of the digester were sealed tightly. Only the gas pipe opening was kept opened. The gas production was checked.

3.2 Gas analysis:

CH_4, CO_2 and CO was analysed by using portable multigas analyser with a micro air pump Technovation (model 2012). H_2S gas was analyzed using portable H_2S analyzer (model SR87).

3.3 Flame test:

Biogas production was checked after eight days and the production was confirmed using flame test. As the lignocellulosic waste was used for the production process which is recalcitrant to the degradation, it was finely powdered and the waste decomposers were used for faster degradation. The partially degraded lignocellulose waste (paper waste and leaf waste) were used in co digestion system which helped increasing the productivity of a gas yield.

Co-digestion contributed to enhance the activity of the biomass involved in the anaerobic digestion process. The co-digestion enhanced the carbon-nitrogen ratio. It played a role in dilution of the toxic compounds like organic-nitrogen, ammonia, VFA (volatile fatty acids) and other intermediate products; those can inhibit the bacteria cells within the digester [3].

From various production reactors, the bioreactor having leaf waste and cow dung slurry in the ratio 1:1 showed maximum water displacement about 296 ml at 21st day. However, when the mixture of leaf waste, paper waste and cow dung slurry was used, the water displacement started on the second day and it showed maximum water displacement up to 252 ml on 21st day. The biogas produced in all of the treatment groups increased as observation days increased which corroborated with the findings of Nopharatana A et al. 2007 [5] that observed a very slow rate of biogas being produce at the beginning of the experiment.

4. Discussion:

4.1 Production of gas:

The gas chamber was filled within 7 days and the flammable gas was produced in the bioreactor on 8th day of production at room temperature which was around 30 °C - 32°C.

4.2 Gas analysis :

The methane content in the gas was analyzed by using portable multigas analyser with micro air pump Technovation (model 2012). The gas analysis results showed that the CH4 gas was produced in maximum amount (69.6%). The amount of H_2S was also high. These results were better than the biogas production using saw dust where methane content was 52.85%. [6].

4.3 Confirmation of gas:

The gas produced in the bioreactor of leaf waste, paper waste and cow dung slurry (1:1:1) showed flammable gas after 8 days of production. It may be due to the presence of lignocellulosic matter which is recalcitrant to degradation. On the other hand, Manimuthu, M *et al* 2015 [7] reported the flammable gas production on 4th day of production from the agar and the rumen waste which can be degraded much faster than the lignocellulosic material.

4. Conclusion:

Slurry made by leaf waste and paper waste demonstrated a high yield potential for energy recovery. Anaerobic digestion using sludge seeded with cow dung showed methane production. Bioreactor with mixed (paper and leaf waste) slurry shows high results from earlier than other bioreactors. Uncontrolled temperature and primary and secondary sludge combined are also two additional advantage of this process which makes it more applicable to industries.

Authors' Contributions: SK, AZ, PK, SA: Developed an idea, AAS: Verified the manuscript.

Competing Interest: Authors declare that no competing interest exists.

Ethical statement: This work did not violate ethical laws. As result, no ethical permission required.

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Appendix

Figure 1: Waste Decomposer

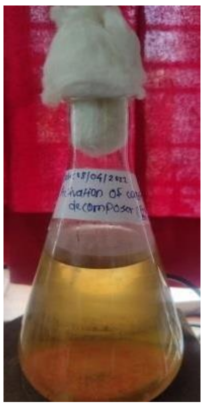

Figure 2: Activation of Decomposer

Figure 3: Processing of Waste Sample

Figure 4: Flame test

Table 1: Optimisation of substrate ratio for biogas production

Day	Paper waste: cow dung slurry (1:1) ratio (ml)	Leaf waste : cow dung slurry (1:1) ratio (ml)	Paper waste: cow dung slurry (2:1) ratio (ml)	Leaf waste : cow dung slurry (2:1) ratio (ml)	Leaf +paper waste: cow dung slurry (1:1) ratio (ml)
1.	0	0	0	0	0
2.	0	0	0	30	120
3.	0	56	0	0	0
4.	0	34	0	30	190
5.	0	70	0	0	0
6.	17	100	0	67	50
7.	23	115	0	0	0
8.	10	125	0	60	40
9.	17	160	0	80	236
10.	21	190	0	75	110
11.	22	180	0	90	150
12.	20	195	0	95	165
13.	20	200	0	110	180
14.	25	230	0	80	220
15.	29	225	0	95	236
16.	21	240	0	100	210
17.	31	230	0	110	230
18.	170	240	20	110	225
19.	96	230	25	125	235
20.	0	256	28	120	240
21.	94	296	30	130	252

Table 2: Gas analysis

CH4	CO2	CO (ppm)	H2S
69.6%	24.2	0007	>1.03