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REVIEW ARTICLE

Study and survey on biogas and biomass generation: a review

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Abstract

The shortage of Fossil Fuels has become a national issue. In rural and urban areas Biogas technology has gained interest at national level. India has great potential to produce biogas to meet its energy demands. This work of study and survey briefly explain the advantages, drawbacks, methods and, the challenges behind the proliferation of the biogas technology at national level in India. Biogas production from anaerobic digestion of biodegradable raw materials such as solid waste (food waste), Animal dung and biomass has been explained. Study reveals that biogas generated from a mixture of cattle dung and food waste provides more efficiency in terms of biogas generation as compare to cattle dung only. Biogas provides most environment-friendly energy source. Biogas is a combination of 50-70% Methane, 30-40% of carbon-dioxide, and traces of other gases such as Hydrogen-sulphide, Nitrogen, Ammonia, oxygen and Hydrogen. Biogas production provides the function of garbage disposal system, and stops the spreading of pathogens or disease-causing microbes in environment. As a residue biogas production provides organic fertilizers for farms. This study also describes the process and amount of organic fertilizer produced in the form of residue from biogas production process. Hence the process of biogas production also accommodates for environment cleanliness.

1. Introduction

Biological degradation of raw decomposable material in anaerobic conditions is the process enclosed by the natural metabolism of ecosystem. The term is frequently used for energy generation, garbage management system and correlated with the methane generation. Anaerobic process could occur in a controlled habitat such as in a bio digester or could naturally occur in environment [1]. Biogas technology is the most environment-friendly source of energy generation and even so biogas also provides organic compost or digestives as fertilizer [2]. In general, anaerobic digestion of animal dung resolves mainly three problems, annoying odor of dung (odor management), and inauguration of a new source of bio-energy, reduction of gases that cause Greenhouse effect [3, 4]. Anaerobic decomposition is a three stages process (hydrolysis, acidification and methanogenesis) of biochemical processes with release of energy rich biogas [2]. In the third stage of anaerobic digestion methane producing bacteria are involved in decomposition of compounds having low molecular weight to form methane and carbon-dioxide. These gases usually measured by adding anaerobic microorganisms and calculating the amount of CH4 that are produced [4-5]. Biomass is a very postulate source of renewable energy. It includes firewood, agricultural residues, animal dung and human waste. In India during 2013, a total of 57 EJ Energy was generated from the use of biomass. India derives about 26% of its total primary energy consumption demand from biomass but only 24% from oil. One of the main requirements of energy in rural India is for cooking. In rural India, about 60% of total energy demand is

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for cooking food [6]. On the report of census 2011, about 80 million rural households' own cattle in India, fig. 1 Shows the different cooking fuel usages in India. Out of which more than 25 million households own enough number of animals that generate enough waste to produce biogas that can meet their need of energy for cooking, and bio manure for fertilizer [7].

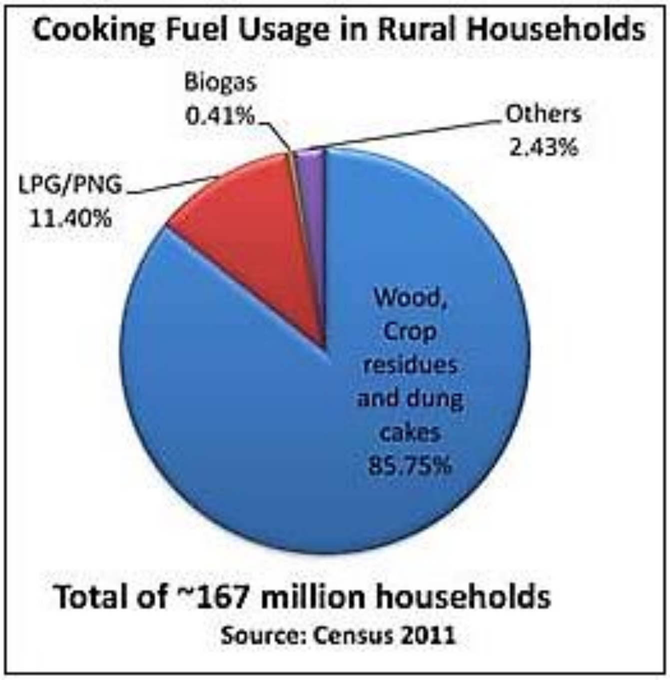

Figure 1: Trend of cooking fuel usage in the rural India [7]

2. Materials and Methods

2.1 Raw Materials

Raw fresh organic waste (solid waste) and the cattle dung were used as the raw material. Fresh food wastes and the cow dung were collected and used for biogas generation.

2.2 Experimental Procedures

During this study, two methods of biogas generation are briefly observed,in first method the cattle dung was added and used as the slurry for biogas generation, once in the digester for the whole duration of 15 days and periodically food waste is added to the digester [2]. In second method only cow dung is used for the production of biogas. In the combined cow dung and food waste experiment was fed with 25 kilograms of cattle dung for 1 meter cubic of biogas plant and on daily bases approximately 2 kg of food waste is sufficient for effectively working of the plant, and produces around 1000 liter of methane gas which can be used for a single stove burner for up to 2 hours. Food wastes are mixed with water at a ratio of 1:1 respectively. In the single dung experiment 75g of the cattle dung and 75g of food waste was introduced into the digester in same ratio and the digester was provided with suitable arrangements for feeding, gas collection and for the draining of residues [2]. 3 meter cubic of biogas can be generated from this single dung process and is sufficient for a single day use in a family of 6 members. The slurry was allowed to ferment anaerobically for the duration of 15days under mesophilic temperature of 26-35°C.

2.3 Survey Record

Total numbers of cattle surveyed in this study are 1366 (475 cows', 891 buffalo's) and the amount of dung produced in 24 hours by cow and buffalo is 11 kg(Approx) and 15 kg(Approx) respectively as shown in fig. 2.

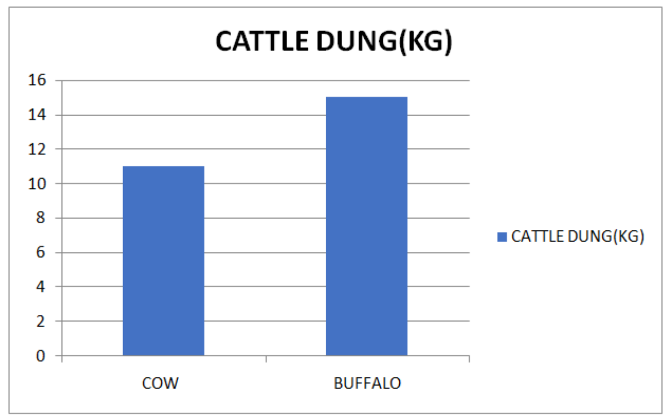

Figure 2: Amount of Cattle dung 475 cows', 891 buffalo's)

Number of cattle surveyed and the amount of cattle dung produced, the amount of biogas produced is sufficient for approximately 250 houses, shown in fig. 3.

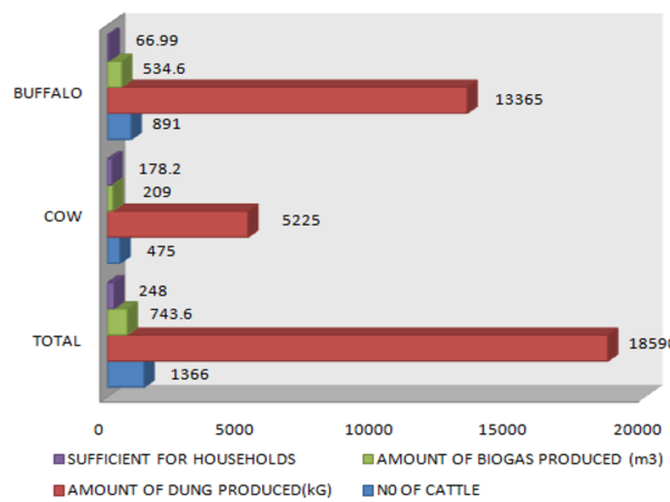

Figure 3: Amount of cattle dung produced

It has been observed during survey in the villages of Meerut, biogas plant majorly is used for the purpose of cooking food for 1-2 times on daily basis and the raw material used for biogas generation is cattle dung. Hence most of the plant sizes are less than 6 meter cubic and the slurry used is cattle dung for biogas generation. Solid waste like food waste is not used as raw material for biogas generation, although solid waste in combination with cattle dung provides better efficiency in biogas generation.

2.4 Bio Slurry

Approximately Bio slurry contented with 1.1 to 2% of phosphorus, 0.8 to 1.2% of potassium and 1.4 to 1.8% of Nitrogen, and this nutrient content makes bio slurry a perfect combination of N, P, K fertilizer. By mixing solid waste, cattle dung and kitchen waste Bio slurry can be easily composted, as India is a developing country, cattle dung, crop residue meant to be produced in very large amount and as a consequence it is possible for producing Bio slurry and Bio gas as by products. Nitrogen and Carbon content which are present in organic bio slurry is sufficient and provides a balanced nutritional value for both plants and soil. Consequently, Bio slurry can easily and practically replace the synthetic fertilizers. About 730 MT of cattle dung is generated by India per annum, from which about 60% of the cattle dung is recoverable. On utilizing 1 kg of cattle dung about 3g of Bio slurry is extracted as organic manure. Bio slurry contains toxic materials but in traces when it is compared with the other chemical fertilizers available in market. Hence the bio slurry will have less toxicity as compared to synthetic fertilizer and it will straightforwardly replace the inorganic fertilizers (Chemical based) [8].

3. Result and Discussion

Some of the recent studies shows that production of biogas is partially dependent on the volume of slurry, methods of production and types of solid waste used [2].

Table 1: Production of Cow dung and combined waste.

Days	Cow Dung	Combined Waste
1	1.2	2.4
2	3.6	4.25
3	7.6	8.53
4	9	12.2
5	10	15.3
6	10.3	16.45
7	11	19.25
8	14.8	21.18
9	14.4	24.25
10	15.5	25.58
11	16.1	26.68
12	16.9	27.28
13	17.2	28.12
14	18	28.82
15	19.2	30.58

Composition of animal dung and food waste showed energy yielding nutrients but are at varying concentrations. The notable concentrations of energy yielding nutrients in the food wastes put forward that food wastes use as feedstock would provide more energy for the microorganisms to live and undergo the process [2]. It is noted that the biogas amount produced in the span of 15 days is more (30.58ml) in the case of combined feedstock that is cattle dung with solid waste and is less (1920ml) in case of cattle dung, table 1. Show the data of 15 days with the amount of biogas produced on daily basis. Education level plays a critical role in the biogas plant adoption basically in rural areas, data shows that 46% of non-biogas users are post metric or metric and about 35.9% of biogas users are pre metric. The Data proves that biogas usage is more when it comes to the large size families, 70% of interviewee with a family categorize of 2 to 4 members are not user of biogas incompatible only 2.8% of interviewee with a family size of 8 and above are the users of biogas [9, 10].

3.1 Biogas production potential of cow dung

Raw and treated cow dung's biochemical methane potential test reveals that cumulative biogas output increases from 210 to 238 mL/g VS after 170°C/1 h hydrothermal processing. The biogas volume curve becomes smooth after 14 days of anaerobic digestion, suggesting that the biodegradable components of the organic matter have been digested. Peak biogas generation occurred on the first day for all cow manure samples, at 130 mL for the treated supernatant, 45 mL for the treated example, and 25 mL for the raw instance. After determining biogas composition, methane production is computed; the ultimate methane productions for treated supernatant, treated sample, and essential sample were 262.1 mL/1.5 g COD, 130.2 mL/g VS, and 139.8 mL/g VS, respectively. The methane output declined by 6.9 % after hydrothermal processing rather than increasing. Cow manure has the lowest protein content of any biomass waste. Figure 2 depicts the creation of biogas from cow dung [11].

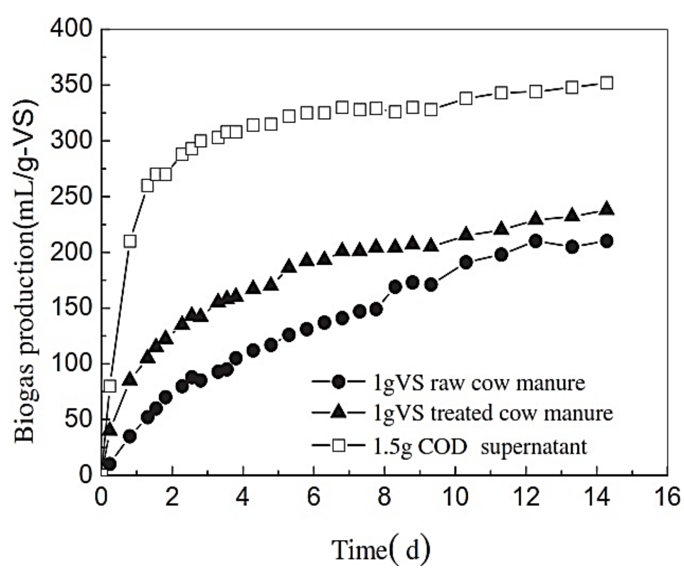

Figure 4: Cumulative biogas production of raw cow dung [11].

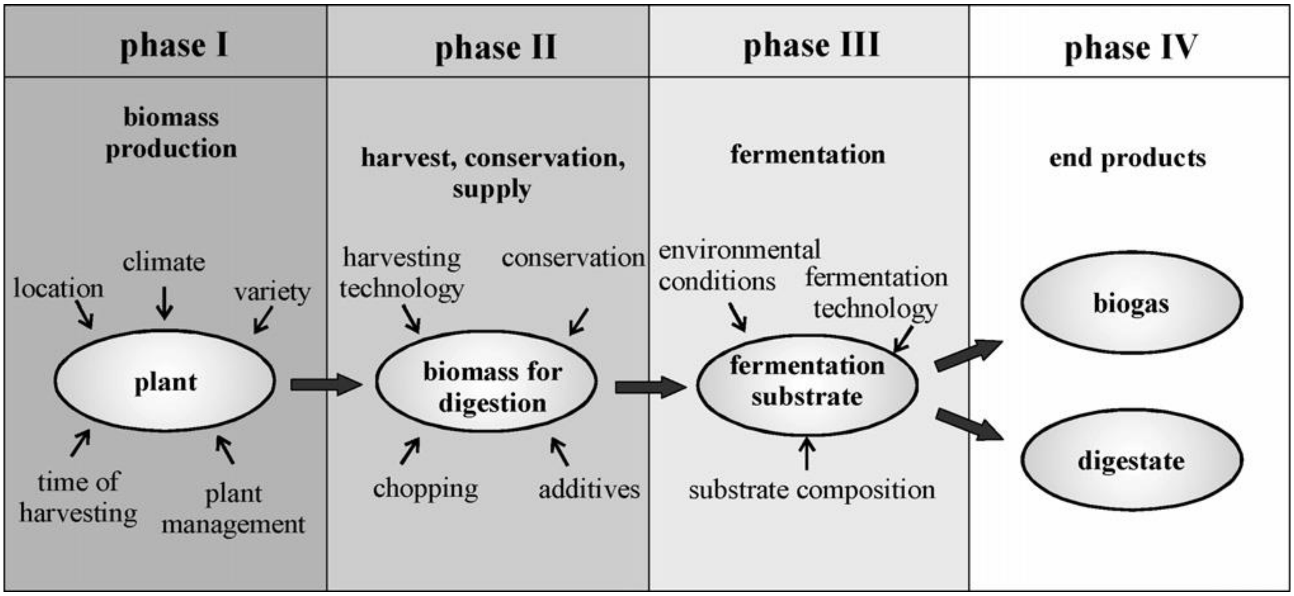

Figure 5: Effect on biogas production from maize along the production process [12].

3.2 Bio gas production process

Fig. 5 depicts the influences on biomass quality when maize is used in all stages of biogas production. When maize is produced in the field, key influences on maize quality for anaerobic digestion can be identified in phase I. It is critical to consider location, climate, and maize variety. To maximize methane yield, plant management and the stage of growth at which maize is harvested must be chosen appropriately. Farmers can positively influence methane yield in phase II (harvest, conservation, and supply) by selecting the best harvesting time and conservation technology and perhaps using additives. Energy in the organic substrates is converted into methane energy in the biogas during phase III. The methane yield is determined by digester environmental parameters such as pH, temperature, or inhibitors and the nutritional makeup of organic substrates. The effects described in phases I–III influence the amount and quality of biogas and digestate in step IV [12].

3.3 Biogas production potential of fruit/vegetable waste

According to the BMP test of fruit/vegetable waste, cumulative biogas generation improved by 18.5 percent following hydrothermal treatment, from 443 to 525 mL/g VS for raw waste. The biogas volume has not changed in the last few days, indicating that the biodegradable components of fruit and vegetable waste have been entirely digested. Peak biogas generation from raw, processed, and supernatants coincided. A minor amount of biogas was produced during the last days, indicating that hydrothermal treatment had little effect on digestion time. The daily biogas productions revealed that the first day made the most biogas. The supernatant had a volume of 205 mL, the treated sample had a volume of 200 mL, and the raw piece had a volume of 175 mL. The methane concentrations were determined, and the results showed that after heating the fruit/vegetable waste, methane output increased by 16.1 percent, from 280.9 to 326.0 mL/g VS. The supernatant produced 449.7 mL/1.5 g COD of methane. Methane yields accounted for 48.8, 56.6, and 85.7 percent of the predicted raw, processed, and supernatant values. Fruit and vegetable waste had medium fat and protein levels, and the range of crude fibers was the widest of any analyzed material. The biodegradable volatile solids in oil fibers were more significant than the refractory volatile solids. Fig. 6 depicts the creation of biogas from fruit and vegetable waste [11].

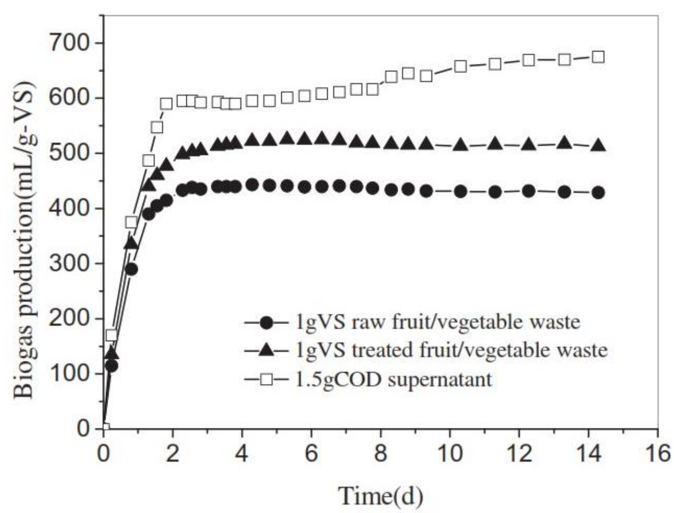

Figure 6: Cumulative biogas production fruit/vegetable waste [11].

3.4 Methane production and pretreatment influence

Table 1 shows the methane yields for each collection and the total cumulative methane generation for each treatment used.

The p-values were less than 0.05 (Table 2), indicating that the differences in methane yields reported for each collection were most likely due to the various pretreatment used. Tukey's pairwise testing determined significant differences between pretreatments using the methane averages at each collection and the overall cumulative standards for each pretreatment [13]. Table 2 shows the results of the pairwise Tukey's tests. Only the Beating (BT) and microwave pretreatment (MW) pretreatments produced more methane than the untreated seaweed after three days of digestion. BT and MW, in particular, had 37% and 7% more methane, respectively, then the untreated. Only the methane generated by the BT sample was found to be considerably higher than the untreated sample in the pairwise comparison. This would imply that the BT pretreatment caused the increase in methane. The difference in methane measured between the treated and untreated samples after MW pretreatment was found to be "not significant." Ball milling (BM) samples at 1 mm and 2 mm produced less methane than raw seaweed. When the methane produced after BM at 2 mm was compared to the untreated sample, the difference was found to be substantial, indicating that the BM may have had a detrimental impact on methane generation by impeding the onset of digestion. The difference with the untreated was judged to be "not significant" in the case of BM at 1 mm sample, despite a p-value between 0.05 and 0.1 (p = 0.0864) indicating marginal significance. The methane percentage of all samples was discovered to range between 40% and 47%. (Table 1) [13].

Table 1: Data on cumulative methane production after 3, 13 and 25 days of digestion [13]

Pretreatment	Methane at 1st collection (Nml/g Vs)	Methane content at 3 days (%)	Methane at 2nd collection (Nml/g Vs)	Methane content at 13 days (%)	Methane at 3rd collection (Nml/g Vs)	Methane content at 25 days (%)	Cumulative methane (Nml/g Vs)
Untreated	93±4	41±2	212±2	67±4	23±3	60±1	328±9
BT	127±3	44±1	178±4	65±2	30±1	50±2	335±8
BM 1 mm	71±2	43±2	147±1	58±1	23±1	41±4	241±4
BM 2 mm	64±5	43±0	148±9	60±2	48±2	51±1	260±15
MW	99±7	46±1	68±2	61±4	77±2	55±2	244±11

Table 2: Tukey's pairwise comparisons after 3, 13, 25 days of digestion and on the cumulative methane production [13].

Treatment	P value 1st collection	P value 2nd collection	P value 3rd collection	P value cumulative data
Untreated vs BT	0.0162	0.0141	0.0893	0.9543
Untreated vs BM 1 mm	0.864	0.0007	0.9999	0.004
Untreated vs BM 2 mm	0.0356	0.0007	0.0006	0.0127
Untreated vs MW	0.8382	0.0001	0.0001	0.0048
BT vs BM 1 mm	0.0017	0.0171	0.0893	0.0027
BT vs BM 2 mm	0.0011	0.0195	0.0037	0.0078
BT vs MW	0.0382	0.0001	0.0001	0.0032
BM 1 mm vs BM 2 mm	0.8706	0.998	0.0006	0.5143
BM 1 mm vs MW	0.0332	0.0003	0.0001	0.9978
BM 2 mm vs MW	0.0152	0.0003	0.0003	0.659

4. Conclusions and recommendations

This work of study and survey inquire into Biogas production of cattle dung, food waste and the combination of cattle dung and food waste during anaerobic digestion process. The result shows that Biogas can serve as most environment friendly and easily available source of energy. Similarly, high calorific bio-fuel with high carbohydrates content such as food waste combined with the cattle dung could yield more biogas than dung alone. Hence the combined slurry method of biogas production increases the efficiency of a biogas plant. Beside bio slurry also contains sufficient nutrient values which are requires in both plants and soil (N, P, and K). Hence it will straightforwardly replace the inorganic chemical-based fertilizers. In spite of the fact Biogas can be used as a fuel, cooking and for other purposes such as energy generation, heating, steam production, vehicular fuel and as a pipeline gas. Residue can be used as organic compost which will also provide a garbage management system and also helpful for environment cleanliness.

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