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Fabrication and Performance Evaluation of Paddy Straw Based Biogas Digester

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ABSTRACT
The present paper reports the fabrication, installation and performance evaluation of lab scale bio-digester made of HDPE plastic (124.33 litre capacity). The trial was conducted with a mixture of 10 kg paddy straw, 20 kg cattle dung slurry, 20 kg cattle dung and 20 litre water. The chemical and proximate analysis of the feed was also done and biogas production profile was studied over a month's period. The result indicated that 182 litre biogas /kg of paddy straw was produced. Lot of variation in daily biogas production was also observed due to fluctuating environmental conditions.

Key words: **Bio-energy, Bio-digester, Biogas, Proximate analysis**

1. Introduction:
In developing countries like India, the energy economy plays a very important role in determining the growth and development. The total energy demand is increasing day by day. A large part of our rural population is dependant upon the traditional fuels such as firewood, animal waste and agriculture waste. Increasing total energy demand is reflected in excessive wood consumption, in short term and erosion of agriculture land, inadequate food supply, permanent climate change and reduced water availability, in long term.

One of the most abundant lignocellulose wastes on earth is paddy straw. Annual production of rice is about 136.5 million tones (Anonymous, 2010). About 1-1.5 kg of straw is produced per kg of grain harvested (Maiorella, 1985) and thus, 136.5 million tones of paddy straw is estimated to be produced annually. In India, approximately 70-80 million tones of paddy straw is disposed off by burning. Jenkins and Bhatnagar (2003) reported that one tonne of straw burning releases 3 kg particulate matter, 60 kg CO, 1460 kg CO_2, 199 kg ash and 2 kg SO_2 which causes lung and respiratory diseases and adversely affect public health (Jun and Christopher, 2003). Repeated burning of paddy straw also results in soil erosion.

Biogas can be produced from paddy straw by anaerobic fermentation using cattle dung as a source of inoculum. Biogas generation involves consortium of microorganisms which is a group of hydrolytic, acidogenic and methanogenic bacteria. Hydrolytic bacteria degrade the complex organic matter (carbohydrates, proteins and fats) into simpler forms (sugars, amino acids, fatty acids and glycerol). Acidogenic bacteria breakdown these simpler forms (sugars, amino acids, fatty acids and glycerol) into CH_3COOH, H_2 and CO_2 which is further utilized by methanogenic bacteria to produce biogas. Biogas is mixture of CH_4 (50-60%), CO_2 (30-40%), H_2 (1-5%), N_2 (0.5%), CO, H_2S and water vapors.

Anaerobic fermentation of biomass for methane production has been considered as three in one system; providing energy as methane, protecting the environment by reducing the pollutants and yielding good amount of spent solids, which can be used as manure or animal feed (Nand, 1999). As the calorific value of biogas is about 6 kWh / m^3 (this corresponds to half a litre of diesel oil), this process would lead to saving of an enormous amount of fuel/year (Kashyap *et al.*, 2003).

No doubt, scientists are working seriously for developing technologies for biogas generation from paddy straw. However, there is no report of a robust and a user friendly technology which can be adopted either at farmers or industrial level. Keeping in account, all these aspects and importance of paddy straw for energy and power generation along with combating the environmental pollution. The present paper depicts the method of fabrication of paddy straw based digester (124.33 litre capacity) and its performance evaluation for biogas production.

2. Materials and Method
2.1 Procurement of the materials: Paddy straw was procured from the Research field of Punjab Agricultural University, Ludhiana after harvesting of the crop in the month of October and November. The paddy straw was chopped to 3-5 cm with a Toka machine and was stored at room temperature. Cattle dung was procured from the dairy farm of Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana and was used as inducer for biogas production from paddy straw. Digested cattle dung slurry was procured from a working biogas plant in biogas field laboratory of School of Energy Studies for Agriculture, Punjab Agricultural University, Ludhiana

and was used as inoculum for biogas production. All the chemicals used for chemical and proximate analysis were of analytical grade and were purchased from Hi-Media, Loba-Chemicals and S.D. fine chemicals Pvt. Ltd.

2.2 Fabrication of Digester: A cylindrical container 124.33 litre capacity made up of HDPE plastic was modified to use as biogas digester (Figure 1). The dimensions of digester and gas holder are shown in line

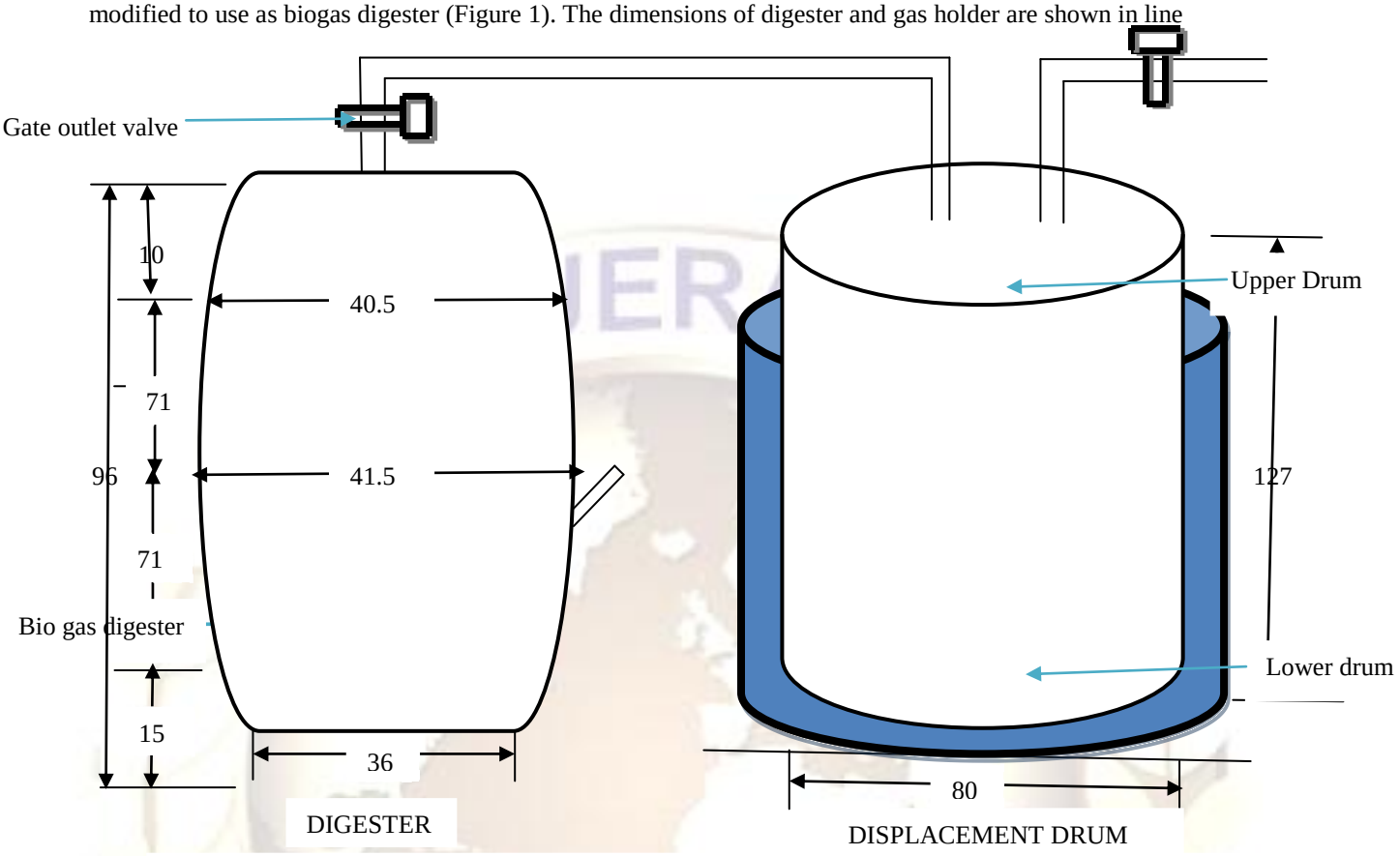

Fig 2: Line Diagram of Digester and Displacement Drum

Fig 2: Biogas digester (Two 124 litre capacity) along with displacement drum

diagram 1. Gas holder consists of lower and upper drum of different diameter. The lower drum is filled with water and upper drum is placed on lower drum and it act as gas holder.

The mouth of the digester was sealed using a plastic lid and steel clamp after filling of the paddy straw- cattle dung mixture and made it airtight. The centre of the lid was provided with a gate valve and plastic pipe, which was connected to the upper displacement drum for gas measurement.

2.3 Biogas Production from paddy straw: The composition of paddy straw mixture, which was fed in digester, was 10 kg paddy straw +20 kg cattle dung + 20 kg digested cattle dung slurry + 20 litre water. The cattle dung act as an inducer for biogas production. The digested cattle dung slurry was used as an inoculum. The mixture was properly mixed and initially analyzed for pH, total solids, volatile solids, cellulose, hemicellulose, lignin and silica by standard methods by AOAC (2000). The biogas produced from paddy straw mixture was collected in gas holder and amount of gas was measured by water displacement method.

3. Results and discussion

3.1 Proximate and chemical analysis of paddy straw: Results from Table 1 indicate that pH of paddy straw alone was 8.2 while that of mixture was 7.6. The total solids were reduced to 75.3%. The cellulose, hemicelluloses, lignin and silica content of the mixture was found to be 31.8%, 25.8%, 16.5% and 8.3% respectively. Approximately, 25% moisture is required for solid state fermentation of biomass so that addition of cattle dung water helps in adjusting the solid content of the mixture. Materials having high cellulose and hemicelluloses are good for biological conversion process i.e. anaerobic digestion and alcoholic fermentation. High cellulose also favors the use of biomass for paper and board production (Jain, 1997).

3.2 Biogas production profile**:** Table 2 shows the biogas production data from paddy straw mixture along with temperature profile. A significant variation in daily biogas production was observed over a month time. This variation may be due to the fluctuation in digester and atmospheric temperature.

Table 1: Proximate and Chemical composition of paddy straw mixture

S. No.	Composition (%)	paddy straw	Paddy straw mixture
1.	pH	8.2±0.2	7.6±0.2
2.	Total Solids	93.7±0.5	75.3±0.55
3.	Volatile Solids	85.1±0.2	79.3±0.25
4.	Cellulose	36.8±0.3	31.8± 0.16
5.	Hemi-cellulose	26.5±0.24	25.8± 0.26
6.	Lignin	12.7±0.5	16.5± 0.23
7.	Silica	9.1±0.3	8.3± 0.2

Table 2: Biogas production data for paddy straw mixture

Day	Untreated paddy straw (l)	Cumulative gas production(l)	Temperature of digester (°C)
1	24.18	24.18	35
2	29.02	53.20	36
3	60.91	114.11	37
4	23.84	137.95	37
5	29.02	166.97	33
6	24.18	191.15	35
7	43.21	234.36	32
8	110.45	344.81	30
9	200.00	544.81	27
10	120.60	665.41	30
11	123.89	789.30	32
12	109.63	898.93	36
13	115.67	1014.60	31
14	119.14	1133.74	30
15	50.14	1183.88	32
16	56.87	1240.75	42
17	60.80	1301.55	30

18	80.00	1381.55	43
19	29.60	1411.15	42
20	58.80	1469.95	39
21	14.68	1484.63	32
22	35.55	1520.18	34
23	65.00	1585.18	32
24	58.90	1644.08	34
25	52.21	1696.29	30
26	45.20	1741.49	29
27	25.33	1766.82	32
28	22.67	1789.49	32.5
29	20.50	1809.99	34
30	10.5	1820.49	35
Total (10 kg paddy Straw)	**1820.49**		
Total Biogas /Kg Paddy Straw = 182.049 litre			

Sardar Patel Renewable Energy Research Institute (SPRERI) also reported to have produce 340-450 litre biogas / kg rice straw through thermophilic consortium utilization (Anonymous, 2006), however, when the experiment was conducted at mesophellic temp without using thermophillic consortium, the biogas production was reduced to approximately 180 l biogas/ kg paddy straw.

4. Conclusion:

From above studies it is concluded that the fabricated digester works well for biogas generation from paddy straw. This model can be used for construction and fabrication of bigger sized biogas plants. However, the daily fluctuation in atmospheric temperature is the main cause of concern, which needs to be controlled for maximizing biogas production.

REFERENCES

Jain, A.K. 1997. Correlation models for predicting heating value through biomass characteristics. *J Agricultural Engineering.* **34(3)**: 12-25.

AOAC, 2000. Association of Official Analytical Chemists, *Official Methods of Analysis*, 17th Edition, Maryland, USA.

Anonymous, 2006. Workshop report of *All India coordinated research project on renewable energy sources*, Sardar Patel Renewable Energy Research Institute, Gujarat, India.

Anonymous, 2010. Ministry of Agriculture, Ministry of External Affairs, Government of India.

Jenkins, B.M.; Bhatnagar, A.P. 2003. On electric power potential from paddy straw in punjab and the optimal size of power generation station. Bio-resource Technology **37**: 35-41.

Jun, W.; Christoper, S.A. 2003. Intercomparison between satellite-derived aerosol optical thickness and PM mass: Implications for air quality studies. Geophysics Research Letter 30.

Kashyap, D.R.; Dadhich, K.S.; Sharma S K. 2003. Biomethanation under psychrophilic conditions: a review. Bioresour Technol **87**: 147-53

Maiorella, B.L. 1985. Ethanol fermentation. In: Comprehensive biotechnol. Young M (ed), Pergamon Press, Oxford. Vol III, pp. 861-914.

Nand, K. 1999. Biomethanation from agro-industrial and food processing wastes. In: Joshi V K and Pandey A (eds) Biotechnology, Vol II, pp. 1349-72, Educational publishers and distributors, Kerala, India.