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Animal Waste Utilization for Energy Generation through Modified Biogas Technology

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ABSTRACT: *Ten units of modified biogas plants were installed at farmers' sites based on solid state fermentation technology under operational research demonstration project by Dr. Panjabrao Deshmukh Agricultural University, Akola. Average biogas production 203 liters per kg DM with methane content of 60 per cent was found in 2 m^3 capacity modified Janta biogas plant. The average percentage of nitrogen, phosphorus and potassium content in digested slurry were higher i.e., 1.40, 1.09 and 0.46 per cent in solid state fermentation of cattle dung. There was a saving in time for cattle dung feeding to biogas plant and it was also easier for removal of digested slurry from biogas plant outlet. All the plants were working satisfactorily without any problems. This user-friendly modified Janta biogas plant based on solid state fermentation technology needs minimum or no water for its operation, therefore it was recommended for water scarcity region.*

Keywords*: Biogas, digested slurry, renewable energy and solid state fermentation*

1. INTRODUCTION

More than 3.5 million family size biogas plants were installed in the country under National Programme on Biogas Development. These plants used cattle dung mixed with an equal quantity of water to get total solids concentration (TSC) of 8-10% of the slurry before feeding into the plant. The watery slurry discharged from these plants content 4-6 % total solids. It is spread on to the ground or collected into the open pits for drying over a period up to 45 days to facilitate its transportation to fields to use as manure. Because of non-availability of water round the year biogas technology is not propagating in drought prone and water scare regions of the country. Besides, the biogas plants installed in the country are the first casualty of water scarcity during summer months.

Anaerobic digestion of fresh cattle dung (without mixing water) and many other agro-residues at initial TSC varying between 16-25 % was demonstrated in laboratory scale and field scale digester by many Institutions.

This process is known as solid state anaerobic digestion of biomass. It requires much smaller quantity of water which makes handling of the digested slurry easier, utilizes a variety of agro-residue as substrate and conserves nutrients in the digested slurry which is excellent manure for crop cultivation. The site may look much cleaner than common biogas plants and may help overcome farmer's reluctance to locate the plant near their houses.

The Dr Panjabrao Deshmukh Agricultural University had modified and installed Janta biogas plant of 2-10 m^3 capacity at farmer's sites for digestion of cattle dung in solid state [1] and [2].

There was a need to demonstrate this type of biogas plant, which can meet fuel and good quality manure supply. Hence it was decided to install and commission a modified Janta biogas plant of under Operational Research Demonstration project (ORD). Operational research project aims to demonstrate technical soundness and economical viability of the available renewable energy technologies with objectives:

1. To install and commission of 2 m^3 modified Janta biogas plant for solid state fermentation.
2. To monitor the performance of biogas plant and make cost economics.

2. MATERIAL AND METHODS

Ten potential farmers in the different villages of Akola, Buldhana, Washim, Yavatmal district were identified to carry out the ORD trials to demonstrate the technical soundness of modified Janta biogas plant at user's site. Ten units of this modified plant of 2 m^3 capacity were constructed at Boargaon (3 Nos.), Boargaon khurd (2 Nos.) and each plat at Deoli, Bramhanwada, Digras, Uttarwadhona and Gorwha villages. The main modifications incorporated into the 2 m^3 capacity Janta biogas plant design for solid-state digestion of cattle dung include:

The inlet feed chamber of the Janta plant was replaced with a commercially available 30 cm diameter RCC

pipe as against 20 cm pipe in the traditional biogas plant. The outlet slurry chamber was enlarged to accommodate the total volume of slurry displaced from the digester. The step type construction of the outlet chamber of the Janta plant was changed to an inclined smooth surface for streamlined flow of the digested slurry. The outlet channel was widened from 20 cm to 45 cm for self discharge of the digested slurry on to the ground. The interior side of the gas dome was provided with an additional layer of 1:1 cements and mortar plaster of about 8 mm thickness to withstand higher gas pressure [3]. The schematic diagrams of the modified Janta biogas plant for digestion of non-diluted cattle dung is shown in Fig.1 Thereafter, the plant was fed every day with a mixture of 50 kg of cattle dung and 50 litres of water for a period of about two months. The operation of the plant gets stabilized during this period. The stabilised operation was indicated by a relatively uniform gas yield of 1500 to 2000 litre/day and a normal flow of well digested slurry through the plant and the outlet chamber / channel. After the plant operation becomes stabilized, the substrate was changed to fresh undiluted cattle dung. Every day, 50 kg of fresh cattle dung was poured into the inlet pipe of the modified Janta biogas plant. The dung should be free from foreign matter such as straw, grass, dust, etc and have TSC of less than 18%. (To determine whether the TSC is less than 18%, make a round ball of fresh cattle dung diameter around 12.5 cm and put it on a flat surface. If the ball does not retain its spherical shape, the dung is fit for feeding into the plant.) If the TSC of the cattle dung available is more than 18%, it is brought down to around 16% by mixing with a measured quantity of water. The cattle dung slowly slides into the digester under gravity and the digested slurry flows out through the outlet chamber into the outlet channel. Widening of the outlet channel from 20 cm to 45 cm facilitated flow of the digested slurry through the outlet channel under gravity. The digested slurry, which has a TSC of 10–12%, can be transported to the fields every 2–6 days interval a s required [4][5].

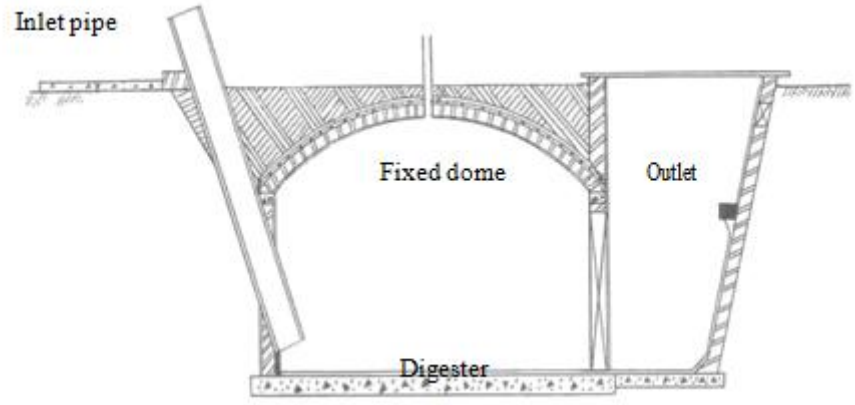

Fig.1 Schematic view of modified Janta biogas plant

3. RESULTS AND DISCUSSION

3.1 Quantity of biogas generation

The weekly and cumulative gas production in modified Janta biogas plant is given in Table 1.

Table 1. Weekly and cumulative gas production in modified Janta biogas plant

Weeks	Gas Production			
	Weekly		Cumulative	
	Lit/Week	m^3/m^3 of DV/week	Liters	m^3/m^3 of DV
2	4867.8	1.22	4867.8	1.22
3	8546.6	2.14	13414.4	3.36
4	10923.5	2.73	24337.9	6.09
5	11678.2	2.92	36016.1	8.82
6	11482.4	2.87	47498.5	11.69
7	11306.7	2.83	58805.2	14.52

The cumulative gas production of 58805.2 liters (14.52 m^3/m^3 of DV) was recorded for the period of seven weeks. The average gas production per day for the period from second week to seventh week worked out to be 1400.12 liters. The average monthly biogas production and methane content produced in modified Janta biogas plant is given in Table 2.

Table 2. Average monthly biogas productions and methane content from modified Janta biogas plant

Months	Temperature, ^{0}C		Quantity of gas		Methane content	
	Max	Min	Liters/kg DM	m^3/ m^3 of DV	%	Liters/kg
Jun 11	39.8	27.9	204.7	12.00	58.20	119.07
Jul 11	31.6	24.0	215.50	12.30	59.35	127.90
Aug 11	28.8	22.3	214.00	12.25	60.25	128.93
Sep 11	31.2	23.0	193.80	12.20	60.35	116.96
Oct 11	31.9	18.8	189.00	11.70	61.50	116.24

The fluctuation in the monthly gas production may be due to the fluctuations in the environmental conditions, like temperature, Rh and the stage of digestion. On an average 203 liters of biogas per kg DM was produced in modified Janta biogas plant with an average methane content of 60 per cent.

3.2 Analysis of Digested slurry

The quality of digested slurry was analyzed and is given in Table 3.

Table 3. Monthly average biochemical analysis of digested slurry

Months	Gas	Biochemical content		
	Liters/kg DM	N (%)	P (%)	K (%)
Jun 05	204.60	1.38	1.08	0.48
Jul 05	215.50	1.45	1.12	0.45
Aug 05	214.00	1.42	1.10	0.50
Sep 05	193.80	1.40	1.02	0.43
Oct 05	189.00	1.35	1.13	0.42
Average	203.38	1.40	1.09	0.46

It is seen from the table 3 that the N: P: K content of the digested slurry was higher than that of fresh cattledung. Hence the solid-state fermentation of cattle dung results in rich nutrient fertilizer (Table 3). All the biogas plant installed based on solid state fermentation technology were running satisfactorily. The biogas produced meets their fuel requirements for cooking and had replaced fuel, which they were using earlier. The beneficiaries expressed several advantages, such as; saving in fuel, soot free utensils, smokeless atmosphere in kitchen and availability of fuel all the time. They also expressed that:

- There is saving in time in feeding of biogas plant
- There was no obstruction in the flow of inlet while feeding wet dung as such
- The removal of digested slurry from outlet was easy due to less moisture content; therefore, drying of digested slurry becomes easy.

  Beneficiaries were fully satisfied with the operation of the modified biogas plant.

4. CONCLUSION

The modified biogas plant generates approximately 30% more biogas and makes the handling of both input slurry as well as the digested slurry far easier than the common biogas plant. The cost of the plant was almost the same as that of the common Janta plant. This user-friendly modified Janta biogas plant based on solid state fermentation technology needs minimum or no water for its operation, therefore it was recommended for water scarcity region.

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