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Performance of cattle dung at different total solids in prototype digesters for biogas production

RAJESHWAR MATHAD, VIJAYAKUMAR PALLED, S.R. DESAI, LOKESH AND **SUNIL SHIRWAL**

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See end of the Paper for authors' affiliation

Correspondence to :

VIJAYAKUMAR PALLED
AICRP on RES - ORP Activity, Department of Farm Machinery and Power Engineering, Colllege of Agricultural Engineering, University of Agricultural Sciences, RAICHUR (KARNATAKA) INDIA

ABSTRACT : An experiment was conducted to study the performance of cattle dung at different total solids (TS) *viz*., 10, 12, 15 and 18 per cent in three in prototype digesters of 1:0.5, 1:1 and 1:1.7 (H/D ratio) size for a retention period of 56 days under laboratory conditions. The results indicated that, at 10% TS, the cumulative gas production was maximum (345.8 litres) in 1:1.7 H/D size digester followed by 1:1 size digester (305.2 litres) and 1:0.5 size digester (255.8 litres) at the end of retention period of 56 days. While the maximum cumulative gas production of 393.9 litres was recorded in 1:1.7 H/D size digester followed by 1:1 size digester (358.1 litres) and 1:0.5 size digester (297.0 litres) at the end of retention period of 56 days at 12% TS . Whereas at 15 % TS, the maximum cumulative gas production of 474.5 litres was recorded in 1:1.7 H/D size digester followed by 1:1 size digester (419.3 litres) and 1:0.5 size digester (348.4 litres) at the end of retention period of 56 days. It was observed that the cumulative gas production was maximum in 1:1.7 H/D size digesters followed by 1:1 H/D size digester and 1:0.5 H/D size digester at all the total solids fed. The average percentage of methane content was maximum (57.09 %) in the gas produced from cattle dung at 15 per cent TS in 1:1.7 size (H/D ratio) digester, whereas a minimum of 52.48 percentage of methane content was recorded in the gas produced from cattle dung at 10 per cent TS in 1:0.5 size (H/D ratio) digester.

KEY WORDS : Biogas, Cattle dung, Prototype digesters

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Biogas is produced through anaerobic fermentation of animal excreta and other agricultural wastes. The methane gas generated in a biogas digester is used as a smokeless fuel for cooking, lighting and for running engine in combination with the liquid fuels. The residual slurry is used in the form of excellent manure. Thus, it also prevents environmental pollution. Most of the biogas plants installed in India are based on cattle dung and operated at 10 per cent total solids (TS) concentration. To achieve this, equal quantity of water is to be added with dung. The large quantity of water required for operation of a biogas plant is an important constraint in the propagation of the biogas technology, particularly in water scarce regions of the country. Due to additional water requirement, the practical application of technology could be questionable in the water scarce regions of the country. The handling and management of effluent in cattle dung based biogas plants under field conditions is the main problem faced frequently. The solid state anaerobic digestion process could be used as an effective tool for solving the above mentioned problems. By using solid state digestion technology, loading rate could be increased to the optimized level, the output rate of gas per unit digester volume could be increased, additional water requirement could be minimized and the digested sludge handling problem could be eliminated to a greater extent.

Anonymous (2000) carried out an investigation on solid state fermentation of cattle dung and gliricidia mix (3:1) in a multiple batch type digesters and reported that the biogas yield ranged from 0.201m^3 per kg of dry matter during winter months to 0.332m^3 per kg of dry matter during summer months. Shyam (2001) analysed the solid state digestion of cattle dung in biogas plants of modified designs. He reported that the modified biogas plants required very little or no water for mixing with the cattle dung and generated 50 per cent higher gas as compared to common biogas plants. Anonymous (2002) carried out an investigation on biomethanation of cattle dung at higher solid concentration in pilot size modified janata biogas plant and reported that

the volumetric gas production in solid state biogas plant was 0.388, 0.367, 0.338 and 0.323 litres per day at 50, 60, 70 and 80 days of retention time, respectively as compared to 0.163 litres per day in conventional plants.

Considering the above advantages of the process, the present investigation was undertaken to study the performance of solid state fermentation of cattle dung in prototype digesters of different size (H/D ratio) for a retention period of 56 days under laboratory conditions.

METHODOLOGY

In order to study the effect of temperature and pressure on biogas production, the three different height to diameter ratios of 1:0.5, 1:1 and 1:1.7 were selected in this study as suggested by Acharya (1935). A cylindrical shaped 75 litre capacity digester was chosen for feeding cattle dung at four different total solid (TS) concentration *viz*., 10, 12, 15 and 18 per cent with 10 per cent TS as control treatment. The details of different treatments are given in Table A.

Table A : Details of treatments

Sr. No.	Treatments	H/D ratios of digester	Cattle dung : Water proportion
1.	10 per cent TS (control)	1:0.5	1:1
2.	10 per cent TS (control)	1:1	1:1
3.	10 per cent TS (control)	1:1.7	1:1
4.	12 per cent TS	1:0.5	1:0.66
5.	12 per cent TS	1:1	1:0.66
6.	12 per cent TS	1:1.7	1:0.66
7.	15 per cent TS	1:0.5	1:0.33
8.	15 per cent TS	1:1	1:0.33
9.	15 per cent TS	1:1.7	1:0.33
10.	18 per cent TS	1:0.5	1:0.11
11.	18 per cent TS	1:1	1:0.11
12.	18 per cent TS	1:1.7	1:0.11

The quantity of gas produced in each prototype digester was measured using a standard wet type gas flow meter. Initially, the gas flow meter was filled with distilled water up to the indicated level given in the gas flow meter. A 6.2 mm diameter pipe was connected to draw the gas sample from prototype digester to gas flow meter. The amount of gas produced in 24 hours was measured from all the digesters daily up to fifty sixth day. The percentage of methane and carbon dioxide in the biogas produced under treatment using Orsat apparatus.

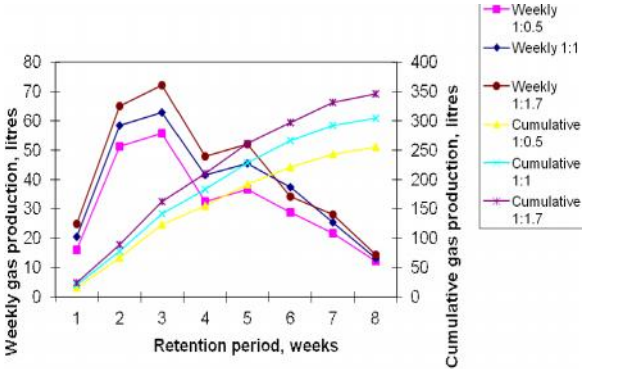
RESULTS AND DISCUSSION

The results pertaining to the quantity of biogas production from cattle dung at different total solid concentrations in three different sized (H/D ratio) prototype digesters are presented in Fig. 1.

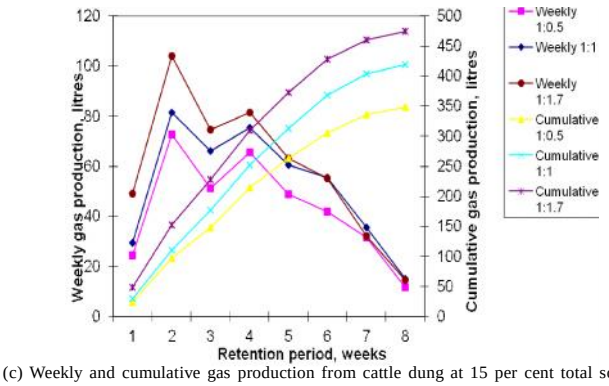
At 10 per cent TS, it was observed that cumulative gas production was maximum (345.8 litres) in 1:1.7 H/D size digester followed by 1:1 size digester (305.2 litres) and 1:0.5 size digester (255.8 litres) at the end of retention period of 56 days. The trends shown in Fig. 1a indicated that weekly gas production fluctuated marginally from first to fifth week and thereafter it decreased gradually till the retention period of eighth week in all the three prototype digesters. The maximum cumulative gas production of 393.9 litres was recorded in 1:1.7 H/D size digester followed by 1:1 size digester (358.1 litres) and 1:0.5 size digester (297.0 litres) at the end of retention period of 56 days at 12 per cent TS. Further, weekly gas production fluctuated from first to fifth week and thereafter it decreased gradually till the retention period of eighth week in all the three prototype digesters (Fig. 1b). While at 15 per cent TS, the maximum cumulative gas production of 474.5 litres was recorded in 1:1.7 H/D size digester followed by 1:1 size digester (419.3 litres) and 1:0.5 size digester (348.4 litres) at the end of retention period of 56 days. The trends in Fig. 1c revealed that weekly gas production fluctuated from first to fourth week and thereafter it decreased gradually till the retention period of eighth week in all the three prototype digesters. Whereas the cumulative gas production was maximum (410.4 litres) in 1:1.7 H/D size digester followed by 1:1 size digester (352.4 litres) and 1:0.5 size digester (295.1 litres) at the end of retention period of 56 days at 18 per cent TS. The

Table 1 : Average constituents of gas from cattle dung in three prototype digesters

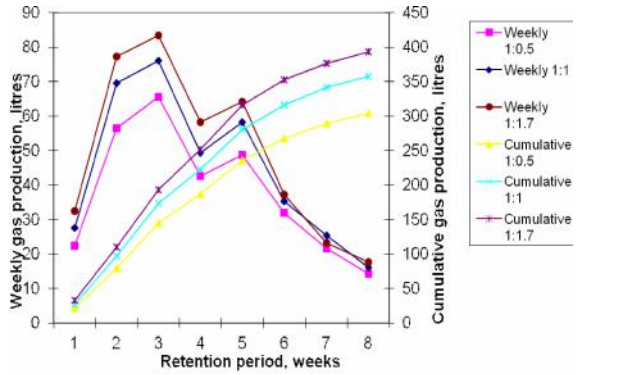
Solid concentration	Size of digester (H/D ratio)	Gas constituents		
		CH_4	CO_2	Other gases
10 per cent TS	1:0.5	52.48	40.30	7.22
	1:1	53.09	39.56	7.35
	1:1.7	54.19	38.29	7.52
12 per cent TS	1:0.5	54.03	39.40	6.57
	1:1	53.35	39.10	7.55
	1:1.7	55.45	37.73	6.82
15 per cent TS	1:0.5	55.30	38.49	6.21
	1:1	56.86	36.83	6.31
	1:1.7	57.09	36.80	6.11
18 per cent TS	1:0.5	54.25	38.56	7.19
	1:1	54.76	38.19	7.05
	1:1.7	54.56	37.89	7.55



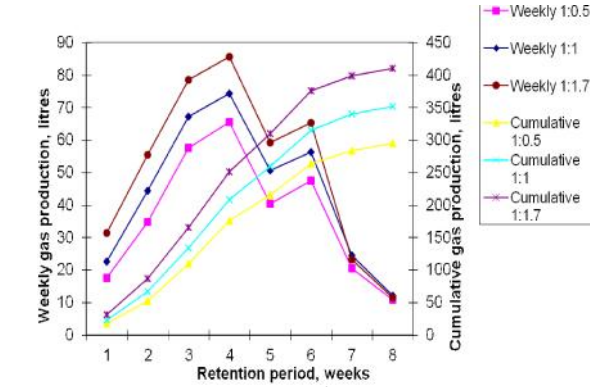
(a) Weekly and cumulative gas production from cattle dung at 10 per cent total solids



(c) Weekly and cumulative gas production from cattle dung at 15 per cent total solids



(b) Weekly and cumulative gas production from cattle dung at 12 per cent total solids



(d) Weekly and cumulative gas production from cattle dung at 18 per cent total solids

Fig. 1 : Weekly and cumulative biogas production from cattle dung at different total solids in three prototype digesters

weekly gas production fluctuated marginally from first to sixth week and thereafter it decreased gradually till the retention period of eighth week in all the three prototype digesters (Fig. 1d).

The average constituents of gas produced from cattle dung at different total solid concentrations (TS) *viz*., 10, 12, 15 and 18 per cent in three prototype digesters of 1:0.5, 1:1 and 1:1.7 (H/D ratio) size are presented in Table 1.

It was observed that the average percentage of methane content was maximum (57.09 %) in the gas produced from cattle dung at 15 per cent TS in 1:1.7 size (H/D ratio) digester. Whereas minimum of 52.48 percentage of methane content was recorded in the gas produced from cattle dung at 10 per cent TS in 1:0.5 size (H/D ratio) digester. Further it indicated that the maximum percentage of methane content was recorded in 1:1.7 (H/D ratio) size digester for all the treatments except in 18 per cent TS which recorded the maximum percentage of methane content in 1:1 (H/D ratio) size digester.

Authors' affiliations:

RAJESHWAR MATHAD, LOKESH AND SUNIL SHIRWAL, Department of Farm Machinery and Power Engineering, College of Agricultural Engineering, University of Agriculture Sciences, RAICHUR (KARNATAKA) INDIA

S.R. DESAI, Department of Agricultural Engineering, College of Agricultural Engineering, University of Agriculture Sciences, DHARWAD (KARNATAKA) INDIA

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