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Evaluation of HPKVV Plug Flow Biogas Digester for Bio-Methanation of *Lantana camera*

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Abstract

Utilization of biomass feed stock other than cattle dung is a potential source for biogas production. The weed *Lantana camera* was tested as a source of raw material for biogas production in HPKVV, Palampur designed plug flow biogas plant. Two biogas plants of 1 M^3 size were constructed and stabilized for two months with cattle dung slurry. Later, one of the plants was fed with aerobically pre-digested *Lantana camera* and cattle dung at 1 : 4 ratio and the other with cattle dung slurry alone at 10% TS. The plant fed with *Lantana camera* (5 kg) and cattle dung (20 kg) at 1 : 4 ratio performed at par with the plant fed with cattle dung (25 kg) alone. The biogas yields were marginally high in pre-digested *Lantana* supplemented biogas plant against CD alone fed plant during low temperature days.
Key words : Plug flow digester, Lantana, Biogas.

Conventional biogas plants like KVIC and Deenbandhu are designed to utilize cattle dung as a source for biogas production. Equal quantities of water mixed with cattle dung (CD) to prepare homogenous slurry having total solids concentration between 8 and 12 and fed to the digesters. These plants operate semi-continuously since they are fed once in a day plants discharge digested slurry corresponding to amount of cattle dung slurry charged -in without any settling or floating problem. With urbanization and decreasing cattle population, availability of required quantity of cattle dung to operate biogas plants has become a serious problem. Considering the short fall in availability of cattle dung, attempts were made to supplement biomass materials viz. water hyacinth, farm weeds, leaf litter with cattle dung. However, these conventional biogas plants could not be operated continuously when biomass materials rich in cellulose are used, instead they formed thick floating scum or settled down at the bottom as biomass feed stocks differ physically, chemically or microbiologically (1). Many workers have tried different biomass feed stocks for biogas production in different biogas plants. Semi-continuous biogas plant for ageratum weed (2), solid state fermentation of biomass (3), two phase digestion of water hyacinth (4) and plug flow digester for leafy biomass (5) are few citable examples. AICRP on RES, HPKVV, Palampur, designed a plug flow biogas plant that operate on lignocellulosic biomass to substitute cattle dung up to 25% with cattle dung. This substitution will partially meet the future energy demands. *Lantana camera* is one such lignocellulosic weed extensively spread in southern parts of India and the supplementation of *Lantana* would reduce the dependency on cattle dung. In this context, an adaptability evaluation of plug flow biogas plant of Himachal Pradesh Krishi Vishva Vidyalaya (HPKVV), Palampur design was taken up under Dharwad condition during 2000 and 2001 with a mixture of *Lantana camera* and cattle dung at 1 : 4 ratio at Main Agricultural Research station, University of Agricultural Sciences, Dharwad.

Methods

Two plug flow model biogas digesters of capacity 1M^3, designed by HPKVV, Palampur were constructed at the biogas yard of university of Agricultural Sciences, Dharwad. The plug flow biogas plants are shallow, horizontal and partially underground structures designed to utilize biomass for biogas production. The construction was carried out following

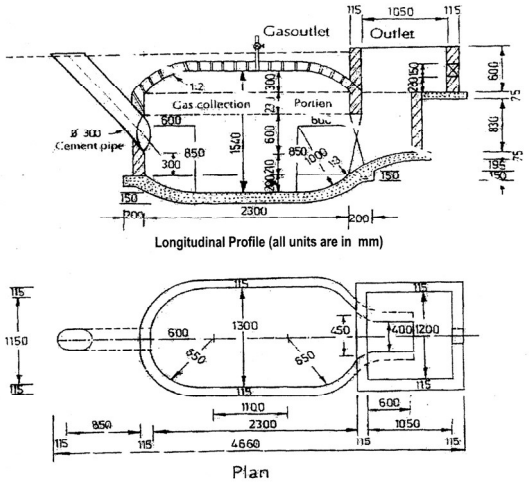

Figure 1. One cubic metre semi-continuous plug flow biogas plant.

Table 1. Physico-chemical properties of different biomass feeds used.

Biomass	TS (%)	VS (%)	Organic C (%)	N (%)	C : N
Cattle dung	20	84	45.80	1.25	36.64
Lantana	28	78	46.30	1.60	28.93
Glyrecidia	28	79	46.80	1.68	27.85

the specifications provided by HPKVV, Palampur (Fig.1) so as to have 55 days hydraulic retention time (6).

After sufficient curing, the plants were charged with cattle dung slurry at 10% total solids and stabilized for gas production (two months). later, 5 kg of *Lantana camera* was chopped to 1′—(2.5 cm) bits, aerobically pre-digested for 4 to 6 days to get brown

Table 2. Average biogas yields from 1M³ HPKVV, Plug flow biogas plants fed with *Lantana camera* + Cattle dung and Cattle dung alone at 10%TS.

	Plant 1 (cattle dung : *Lantana camera* slurry 4 : 1)				Plant 11 (cattle dung slurry alone)				Monthly weather data			
Month	Biogas production (l/day)	Dry matter fed/ day (kg)	Biogas production kg DM (l)	Biogas production kg DM (M^3)	Biogas production (l/day)	Dry matter fed/ day (kg)	Biogas production kg DM (l)	Biogas production kg DM (M^3)	Variation (%)	Max temp (C)	Min temp (C)	RH
2000												
Jan	517.40	5.0	103.40	0.103	524.70	5.0	104.94	0.104	–1.46	30.60	15.10	48
Feb	656.48	5.0	131.29	0.131	676.25	5.0	135.25	0.135	–2.92	32.20	15.70	52
Mar	612.70	5.0	122.55	0.122	675.00	5.0	135.00	0.135	–9.22	35.20	18.50	47
Apr	746.40	5.05	149.28	0.149	781.70	5.05	154.79	0.154	–3.55	37.30	21.50	57
May	779.12	5.05	154.28	0.154	796.09	5.0	159.21	0.159	–3.09	33.90	21.10	67
Jun	830.00	5.05	164.35	0.164	838.36	5.0	167.67	0.167	–1.98	29.00	21.30	79
Jul	732.38	5.03	145.02	0.145	646.74	5.0	129.30	0.129	12.15	26.80	20.40	81
Aug	653.20	5.03	129.86	0.129	578.60	5.02	115.03	0.115	12.89	27.20	20.20	81
Sep	632.70	5.01	125.64	0.125	552.19	5.0	110.43	0.110	13.77	29.00	20.40	76
Oct	684.16	5.01	134.11	0.134	588.20	5.0	117.60	0.117	14.03	29.50	20.50	77
Nov	682.40	5.03	136.21	0.136	666.20	5.0	133.25	0.133	2.22	30.40	16.90	63
Dec	628.54	5.05	124.45	0.124	605.20	5.0	121.04	0.121	3.23	28.30	13.40	58
2001												
Jan	682.90	5.02	135.23	0.135	651.50	5.01	130.03	0.130	3.99	29.90	15.00	55
Feb	849.50	5.04	169.22	0.169	836.60	5.0	167.32	0.167	1.13	34.00	16.80	50
Mar	865.16	5.05	172.00	0.172	871.90	5.10	170.94	0.170	0.60	35.30	18.50	45
Apr	859.33	5.0	170.50	0.170	862.40	5.04	171.10	0.171	–0.35	35.70	22.00	55
May	830.90	5.0	164.53	0.164	831.29	5.0	166.25	0.166	–1.04	34.80	21.50	59
Jun	793.60	5.0	159.00	0.159	787.80	5.01	157.00	0.157	1.27	30.30	21.30	75
Jul	716.90	5.0	143.30	0.143	696.77	5.0	139.35	0.139	2.89	26.80	21.10	81
Aug	696.00	4.93	141.11	0.141	670.74	5.0	134.14	0.134	5.19	27,20	29.00	81
Sep	681.90	5.0	136.38	0.136	682.20	5.0	136.44	0.136	–0.04	30.10	20.20	72
Oct	710.22	5.04	140.91	0.140	735.00	5.02	143.41	0.143	–1.74	30.10	19.90	66

colored product, mixed with 20 kg cattle dung and 25 liter water, the homogenous slurry prepared was fed to one of the plants. The other plant was fed with cattle dung slurry alone, made out of 25 kg cattle dung and 25 liter water. When ever green *Lantana* was not available it was replaced with *Glyresidia.*Once in ten days the digester contents was mixed by using long bamboo pole as a precaution to avoid scum formation if any. The physico-chemical properties of cattle dung, *Lantana* and *Glyresidia* used in the experiment were estimated by using standard procedures and are given in Table 1. The total solids (TS) were estimated once in a week by oven dry method (7) for charging feed and the digested slurry . The dried slurry was further ignited in a muffle furnace to analyze volatile solids content (VS) at 550 C for charging feed and the digested slurry. The gas production was measured by using wet type gas flow meter (INSERF) and expressed in terms of M^3 gas yield/ kg dry matter (DM) per day.

Results and Discussion

The performance of the plug flow biogas plants were evaluated for about two years. Initially, the biogas plants were operated on cattle dung slurry alone for two months and the performance was found satisfactory. After stabilization, one of the plants was operated with *Lantana* and cattle dung slurry. The gas production ranged from 125.60 to 172.0 liter/kg DM in the plug flow digester fed with cattle dung and *L. camera* (4 : 1) at 10% TS (Table 2) compared to the digester fed only with cattle dung slurry at 10% TS (110.4 to 171.0 liter kg DM. The gas yield was high during summer when the ambient temperature was high. The increased gas yields during summer days was probably due to increased total solids conversion which is influenced by higher temperatures (1) and gas yields reduced during rainy and winter season due to low temperature, since the plants lose heat during chilled conditions resulting in poor biogas conversion (1). However, *Lantana* and CD fed plant showed slight increase in gas yield for most of the period of study compared to CD alone. It yielded more gas during low temperature period although the over all gas yields were similar in both the plants, this is perhaps due to better acclimatization of methanogenes on to partially degraded green biomass in the digester and better synchronization and conversion of volatile fatty acids into biogas. Chanakya et al. (8) also observed the incresed biogas out put when the biogas plant is supported with decomposed biomass to a certain level.

Table 3. Physico-chemical properties of the slurry of HPKVV digesters.

Parameters	*Lantana*+ CD slurry at 10%	CD slurry at 10%
TS destroyed (kg)	1.39—1.72	1.50—1.89
TS destroyed (%)	28.10—34.40	31.00—37.00
Average gas yield/ kg TS (l)	356.22—540.72	306.77—483.58
VS destroyed (kg)	1.26—1.38	1.34—1.50
VS destroyed (%)	28.10—34.40	31.00—37.00
Average gas yield/ kg VS (l)	472.96—631.86	409.02—586.66
Carbon (%)	47.40	48.20
Nitrogen (%)	2.04	1.70
C : N	23.43	28.35
Slurry pH		
Inlet	7.00—7.10	7.00—7.10
Outlet	7.10—7.20	7.10—7.30
Digester	7.00—7.20	7.00—7.10

The per cent reduction of dry matter in CD alone fed plant was maximum compared to the plant fed with CD and *Lantana,*still the average gas yield /kg DM destroyed was more in CD and *Lantana* fed plant. The difference observed may be due to the ideal C : N ratio and maximum conversion of VS to biogas in the *Lantana* fed plant. The physico-chemical properties of the digested slurry are presented in Table 3. There was more reduction in the C : N ratio in the digester fed with *Lantana* and CD. There was no significant variation in the pH of the digesters. From the study it was observed that 20% of the cattle dung can be substituted with *Lantana* in the plug flow digester without any major operational problems.

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