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EFFECT OF C:N RATIO ON THE BIODIGESTION OF WASTES IN BIOGAS PRODUCTION

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ABSTRACT

Comparative evaluation of biodigestion of wastes viz. Saranai, nutgrass, subabul leaves, rain tree leaves after mixing with cowdung and swine manure to obtain a C:N ratio of 20:1 and 30:1 in relation to biogas output and microbiological activities were carried out. Maximum destruction of total solids (TS) and volatile solids occurred in treatment containing swine manure, cowdung and saranai mixed to arrive to final C:N ratio of 27:1, which recorded the highest gas output of 79.4 litres over twelve weeks period. Maximum methanogenic population of 128.5 x 10^4/g was also observed in the same treatment. A judicious combination of wastes to arrive at a C:N ratio between 27:1 and 30:1 seems to be the optimum mix for enhancing gas yield.

KEY WORDS: Wastes, Biodigestion, C:N ratio, Microbe, Biogas.

Anaerobic biodigestion is essentially a microbiological reaction. The microbes require specific substrates and other essential nutrients for their activity. The carbon and the nutrients like nitrogen and phosphorus have to come from substrates fed. If too little nitrogen is present, the bacteria will be unable to produce the enzyme required to utilise the carbon. Too much of nitrogen will inhibit the growth of bacteria. Hence a study was undertaken to identify the best suited C:N ratio for maximum microbiological activity resulting in higher gas output. Failure of digesters due to feeding in of substrates with C:N ratio of 52:1 was also reported early (Sathinathan, 1975).

MATERIALS AND METHODS

The wastes employed in this experiment were saranai (**Trianthema portulacastrum** L.), nutgrass (**Cyperus rotundus** L.), subabul leaves (**Leucaena leucocephala** (Lam) DeWit.), rain tree leaves (**Samanea saman**) (Jacq.) Merrill), swine manure and cowdung. The total organic carbon and nitrogen were estimated following the standard procedure detailed elsewhere

(Ilamurugu, 1985) and based on the results obtained calculated quantities of wastes were mixed in such a way as to obtain a final C:N ratio from 11.8:1 upto 30:1 and accordingly the various treatments planned were as under:

For the treatment T1 calculated quantities such as 150 g of subabul leaves, 250 g for saranai and 400 g of cowdung were mixed first and then with equal weight of water (800 g) to obtain a C:N ratio of 25:1. The details of other treatments employed are as under: T_2-100 g subabul leaves; 300 g of saranai; 450 g cowdung (C:N of 30:1), T_3-175 g subabul leaves; 225 g of nutgrass; 400 g of cowdung (C:N of 25:1), T_4-125 g subabul leaves; 275 g of nutgrass; 440 g of cowdung (C:N of 30:1), T_5-250 g of rain tree leaves; 140 g of saranai; 410 g of cowdung (C:N of 25:1), T_6-210 g rain tree leaves; 150 g saranai; 460 g cowdung (C:N of 27.07:1), T_7-260 g of rain tree leaves; 120 g nutgrass; 420 g of cowdung (C:N of 25:1), T_8-230 g rain tree leaves; 160 g nutgrass; 420 g cowdung (C:N of 27:1), T_9-150 g swine manure; 250 g saranai; 400 g cowdung (C:N of 25.45:1), T_{10}-100 g swine manure; 300 g saranai; 400 g cowdung (C:N of 27:1), T_{11}-200 g swine manure; 225 g nutgrass; 375 g cowdung (C:N of 20.5:1), T_{12}-175 g swine manure; 250 g nutgrass; 375 g cowdung (C:N of 22.3:1), T_{13}-400 g subabul; 400 g cowdung (15:1), T_{14}-400 g rain tree leaves; 400 g cowdung (20:1), T_{15}-400 g swine manure; 400 g cowdung (11.8:1) and T_{16}-800 g cowdung alone (27.3:1).

The slurry was prepared as detailed above and 50 g of biodigested slurry was added as inoculum to all the treatments. Then the slurry was carbonated and poured to 2.5 1. amber coloured bottles and sealed air tight. In each treatment two replications were maintained. The bottles were kept at room temperature (27 ± 2°C) and allowed to progress for 12 weeks

The gas output was recorded daily over a period of 84 days. The other parameters studied were total and volatile solids, pH, cellulose, hemicellulose, lignin, volatile fatty acids amd microbiological properties at various stages of digestion by employing standard procedures described elsewhere (Ilamurugu, 1985). The gas constituents were analysed for its CO_2 content. The biodigested slurry specimens were also

Table 1. Physico-chemical properties of wastes

Parameters	* Saranai	*Nutgrass	** Subabul leaves	** Rain tree leaves	*Swine manure	Cowdung
Moisture %	69.86	68.14	20.39	66.59	80.25	81.60
Total Solids %	30.14	31.86	29.61	33.41	19.75	18.34
Volatile solids %	19.23	12.43	16.73	14.89	15.89	16.87
% of VS to TS	63.80	38.95	56.47	41.56	80.45	91.98
Total organic carbon %	34.55	39.00	36.60	38.70	29.20	27.57
Nitrogen %	0.39	0.34	3.36	2.24	3.80	1.01
Phosphorus %	0.26	0.56	1.26	1.08	0.92	0.79
Potassium %	0.35	0.48	0.86	0.92	0.82	0.67
Cellulose %	21.20	19.50	36.81	38.12	20.66	21.62
Hemicellulose %	26.70	31.82	43.23	42.13	36.35	19.36
Lignin %	8.48	13.23	4.94	5.56	2.30	9.80
C:N ratio	88.39:1	116.07:1	10.89:1	17.68:1	7.68:1	7.29:1

* Raw, fresh samples were taken for analysis.

** A week-old deciduous leaves were taken for analysis.

Table 2. Degradation of total and volatile solids, cellulose and hemicellulose at two levels of C:N ratio

Treatment	Per cent degradation of (End of 12th week i.e 84th day)				
	Total solids	Volatile solids	Cellulose	Hemicellulose	Total gas produced over 12 weeks (ml)
T1	33.54	36.04	20.35	33.26	53795
T2	45.11	36.04	24.45	40.67	59577
T3	32.77	30.81	24.20	31.62	49385
T4	37.06	33.27	22.13	32.02	55342
T5	26.69	29.05	29.69	33.12	49098
T6	47.32	36.43	24.61	41.69	71953
T7	34.47	31.71	27.35	30.93	52150
T8	35.64	28.52	28.22	32.36	53123
T9	40.72	33.88	31.90	47.37	62048
T10	60.28	48.44	41.05	32.89	83286
T11	44.93	37.28	38.33	40.09	64218
T12	51.47	38.97	35.30	41.78	79387
T13	27.20	36.50	25.12	18.02	36250
T14	21.94	22.76	24.07	17.77	36127
T15	27.69	24.50	19.98	22.51	37492
T16	43.67	21.21	25.85	31.76	34090

analysed for their nitrogen, phosphorus and potassium contents at the final stage of digestion.

RESULTS AND DISCUSSION

The experiment was conducted at different C:N ratio level ranging from 12:1 and upto 30:1 and the results obained are discussed below. The total solids, volatile solids and other physicochemical properties of raw materials employed in this study are presented in Table 1. The degradation percent of total and volatile solids, cellulose, hemicellulose and lignin contents after 12 weeks period are presented in Table 2. The distribution of acid forming cellulolytic, methanogenic organisms besides the gas output recorded are present in Table 3. The total solids destruction ranged from 21.94 percent (T14) to 60.28 percent (T10). Higher the destruction of total and volatile solids, more will be the quantity of gas output. Maximum destruction occurred in that treatment which recorded the maximum gas output. Similarly, the maximum destruction of volatile solids (92.48%) was observed in cowdung, swine manure and saranai incorporated treatment. The destruction of highest amount of cellulose (41.85%) and hemicellulose (52.89%) were observed in T_{10} treatment with a C:N ratio of 27:1 as compared to that of T_{13} (15:1), T_{14} (20:1) and T_{15} (12:1). Barnett **et al.** (1978) and Pyle (1978) recommended an optimum C:N ratio of 30:1 for anaerobic digesters. The results obtained are in line with the findings reported by Schellanbach (1980) with cattle waste digestion.

At different levels of C:N ratios tested, the gas production was maximum at 27:1. This may be due to the optimum substrate level which favoured the maximum microbiological activities resulting in higher gas output. The findings of Barnett **et al.**, (1978), Ghose and Bhadra (1981) and Jain **et al.** (1981) seem to be in agreement with the results of the present study. The acid forming, cellulolytic, methanogenic population varied with the nature of substrates employed. A positive correlation was observed between gas production and acid forming, bacterial population estimated in various treatments. Significant variations were noted between cellulolytic bacterial population and wastes employed. Maximum methanogenic population of 128.5×10^4 /g was recorded in cowdung, swine manure, saranai incorporated treatment (T_{10}) of 27:1 C:N ratio that recorded the maximum gas output of 79.41 l over a 12 weeks period. Of the

Table 3. Relative distribution of anaerobic microorganisms and gas production in various wastes incorporated treatments at varying levels of C:N ratio.

Treatment	Acid forming bacteria ($\times 10^4$/g)			Cellulolytic bacteria ($\times 10^4$/g)			Methanogenic bacteria ($\times 10^4$/g)		
	I	M	F	I	M	F	I	M	F
T1	15.2	37.5	19.8	20.7	45.5	20.2	15.5	90.4	80.4
T2	11.4	49.4	24.5	16.9	51.5	21.4	18.5	91.9	89.0
T3	26.4	32.6	16.4	26.3	37.4	16.3	11.0	81.7	71.2
T4	12.4	41.8	17.8	10.3	46.5	20.6	20.5	91.4	85.1
T5	5.9	39.6	26.7	8.2	36.0	12.3	15.5	75.4	69.3
T6	11.4	43.4	32.1	18.8	59.5	35.4	17.5	102.6	97.3
T7	9.4	50.7	39.1	9.4	41.5	18.8	19.0	83.1	78.5
T8	15.7	64.5	48.3	15.6	42.5	21.8	23.5	89.1	80.4
T9	11.5	51.4	29.5	21.2	55.5	22.4	33.5	95.4	89.1
T10	19.7	69.4	50.3	17.6	73.2	39.6	22.0	128.5	115.4
T11	5.6	56.4	37.5	20.2	55.6	27.4	22.0	98.5	96.2
T12	15.3	61.6	40.1	20.6	64.3	38.5	29.0	100.8	99.1
T13	11.0	33.4	18.5	12.4	33.0	11.4	11.5	68.1	51.2
T14	15.1	30.5	19.8	26.1	32.5	12.5	19.5	63.5	46.2
T15	14.3	38.4	22.4	8.7	33.5	11.4	19.5	70.5	65.7
T16	9.8	21.8	11.5	10.2	25.5	8.5	18.5	54.7	41.8

I - Initial 'O' day; M - Middle 40th day; F - Final 84th day two wastes, saranai and nutgrass, the gas output was high in the saranai incorporation treatments. Among the swine manure, subabul leaves and rain tree leaves incorporated treatments. The gas output was high in the treatment mixed with swine manure followed by subabul and rain tree leaves. The examination of the slurry specimens for their pH indicated a drop in pH from 8.0 to 7.2 in all the wastes incorporated treatments at the middle stage of digestion. The CO_2 content of the gas ranged from 46.0 to 52.0 per cent during the second week and 32 to 39 per cent during the twelfth week. Fujita et al. (1980) attributed higher gas yield to a favourable C:N ratio. The maximum proliferation of different physiological groups of microorganisms both in quantity and quality might have contributed at the 30:1 C:N ratio level for the favourable generation of maximum quantity of gas output.

Thus the comparative evaluation of 25:1 and 30:1 C:N ratio obtained by mixing low nitrogen saranai and nutgrass with high nitrogen rich swine manure and leaves of subabul and rain tree recorded maximum gas output and microbiological activity at the C:N ratio of 30:1. A judicious combination of wastes to arrive at an optimum mix to contain C:N ratio at 30:1 will be helpful for maximising gas yield through favoured multiplication of desired types of microbial consortia.

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