Biogas from an industrial waste[1]

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1. Introduction

Coconut is one of the most commercially important crops in India. It is extensively sown all along the coast, as well as in the favourable inland plains of the southern peninsula, where the tropical climate favours the growth of the palm [Coconut Development board, 1989]. To a major coconut-producing country like India, where many uses of the coconut are a long tradition and are well known, the possibility of economic exploitation of waste products of the coconut industry is of great significance. Coir pith is a waste product obtained during the extraction of coir fibre. Approximately 1.54 to 1.7 kg of coir pith per 100 coconuts is produced at defibring units. Coir pith is very light and hygroscopic. It can absorb 8 times its own weight of water. The high quantum of its production in the defibring units and the difficulties experienced in its disposal have tended to create a major problem of pollution of large areas of land in and around these units. The major problems could be the generation of sewage in the rainy season, air pollution and fire hazards in summer. If a suitable commercial use for the daily output of coir pith in a defibring unit can be found, it will be of great advantage to the industry.

Most of the work done so far in the field of biogas pertains to cowdung digestion only. Very recently, attention has turned to digestion of vegetable and other agricultural wastes [Nagasudnder et al., 1998; Reddy, 1990; Nyns, 1986]. The results obtained are very encouraging. Biogas can be generated from all organic materials that are rich in cellulose.

In view of the national priority accorded to the development of alternative sources of energy to supplement the conventional ones, it was considered appropriate to concentrate on the possibility of developing a suitable system for the utilization of coir pith as an energy resource.

2. Objectives

The objectives of the present work are:

to conduct experiments on coir pith to yield biogas in a mini-biogas plant; and

to study the characteristics of by-product (effluent) of the biogas plant.

3. Experimental procedure

The mini-biogas plant as shown in Figure 1 consists of a digester, a gas - holder and a gas circuit. The digester as

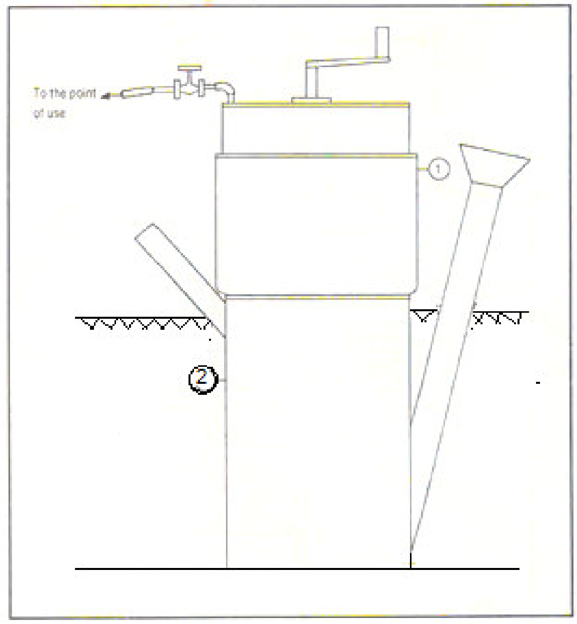

Figure 1. Mini-biogas plant
Key: 1. Gas-holder 2. Digester

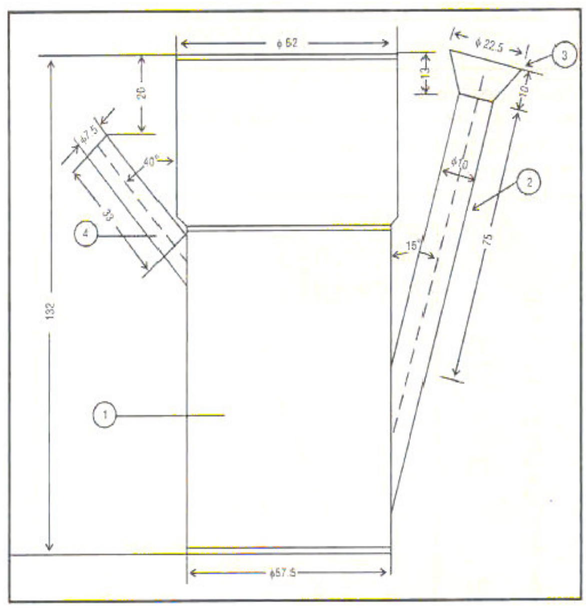

Figure 2. Digester
Key: 1. Digester 2. Inlet pipe 3. Funnel 4. Outlet pipe
All dimensions are in cm.

shown in Figure 2 retains the feed materials inside for fermentation. It is provided with an inlet feed pipe for feeding raw material into the digester and an outlet pipe for discharging digested slurry. This arrangement automatically discharges the digested slurry through the outlet pipe when the fresh charge is fed in through the inlet pipe. The digester has a capacity of 250 litres (1). The gas- holder as shown in Figure 3 is used to collect the gas produced by the fermentation process and to create anaerobic conditions inside the digester. The gas-holder is provided with a stirrer assembly which helps to mix the slurry properly. The meshed vanes of the stirrer help to

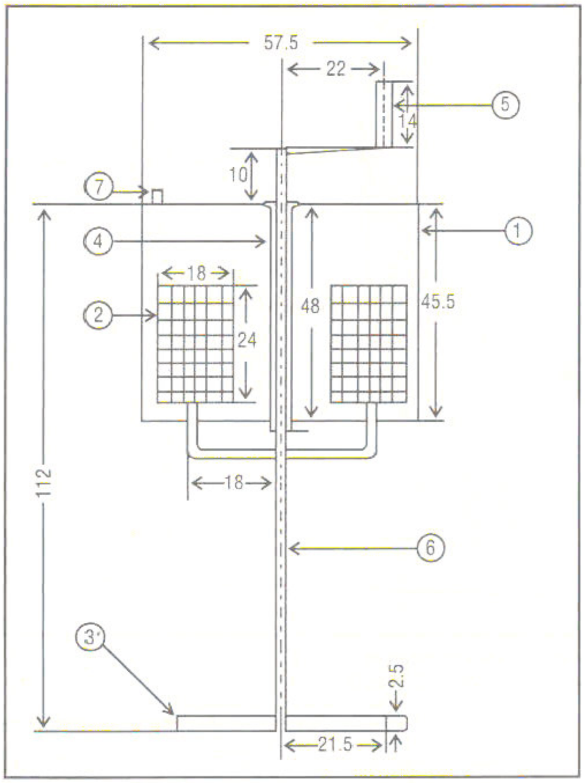

Figure 3. Gas holder
Key: 1. Gas-holder 2. Scum-breaker vane 3. Stirrer vane 4. Casing pipe 5. Stirrer handle 6. Stirrer rod 7. Gas outlet
All dimensions are in cm.

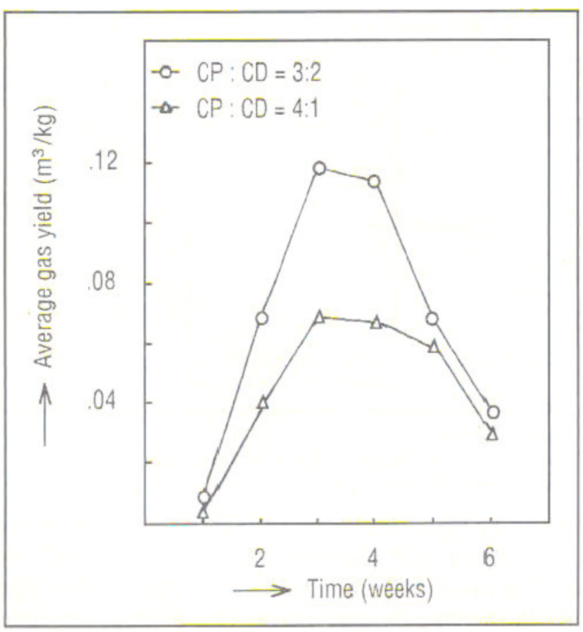

Figure 4. Average gas yield and coir pith: cowdung ratio

break up the scum formed at the top of the slurry. The gas-holder has a volume of 0.106 m^3. The gas circuit involves a cast iron elbow pipe, a cast iron gas valve to regulate the gas flow, a manometer to measure the pressure in the gas holder and the stove.

Because of the slow decomposition of coir pith, cowdung was added to accelerate the fermentation process in the plant. About 250 *l* of slurry containing 8% solid were taken as a charge for the digester. The scum formed in the digester was broken daily by gentle stirring.

In order to study the performance and characteristics of the gas yield, the pressure build-up in the gas-holder. Temperature of the slurry and the volume of gas produced were measured daily and the gas was analyzed using an orsat apparatus. A proximate analysis of cowdung, coir pith and effluent was also carried out. A high retention time (HRT) of 40 days was taken for the experimental analysis. The gas produced was methane (55 to 60%).

Table 1. Analysis of coir pith

Substance	Percentage
Lignin	30.50
Cellulose	27.04
Organic carbon	30.00
Nitrogen	0.26
Phosphorous	0.01
Potassium	0.78
Calcium	.36
Magnesium	0.31
Iron	0.06
Manganese	11.50 ppm
Zinc	8.50 ppm
C/N [1] ratio	115.38

Note
1.C/N = carbon/nitrogen

Table 2. Proximate analysis (figures in percentage)

Substance	Cowdung	Coir pith	Effluent	
			CP/CD[1] = 3/2	CP/CD = 4/1
Moisture	72	24	97.0	94.0
Total solids	28	76	3.0	5.0
Volatile solids	20	52	2.5	4.0
Fixed solids	8	24	0.5	1.0

Note
1.C/N = coir pith/cowdung

4. Results and discussion

Even though the cellulose and volatile solid concentration in the coir pith are high, as noted in Table 1, the average gas yield per kg of coir pith is 0,017 m^3/kg which is lower than that (0.20 m^3/kg) of cowdung. This is due to slow and incomplete digestion of coir pith, which is fibrous. A chemical analysis of coir pith is given in Table 2. The C/N ratio is 115.38/1. Since the C/N ratio is very high, the fermentation process is limited by nitrogen availability. To initiate and accelerate the fermentation process,

Table 3. NPK analysis

Element	Cowdung	Coir pith	Effluent	
			CP/CD[1] = 3/2	CP/CD = 4/1
N_2 (%)	1.4	0.26	0.37	0.28
P_2O_5 (%)	1.1	0.01	0.25	0.16
K_2O (%)	0.8	0.78	0.84	0.80

cowdung was added to coir pith while preparing the charge. It can be seen from Figure 4 that the average gas yield per kg is found to be greatest for the charge having a CP/CD ratio of 3/2. Te average gas production for the charge having CP/CD ratios of 3/2 and4/1 is 0.07 and 0.05 m^3/kg respectively. The maximum gas production during the third week for CP/CD ratios of 3/2 and 4/1 is 0.118 and 0.069 m^3/kg respectively.

Coir pith has a dry calorific value of 17,600 kJ/kg (4200 kcal/kg), where as the calorific value of biogas is 21,000 kJ/kg (5000 kcal/kg). The NPK (nitrogen-phosphorous-potassium) analysis of effluent is given in table 3. An effluent quantity nearly equal to the quantity of slurry charged containing 40 to 45% solids was available daily. The by-product effluent is dried and can be used as a fertilizer in farm soils proportions of sand/rocks.

The cost of a minimum plant is Rs.400 (about US$10). The mini-biogas plant can be scaled up to install it at a defibring unit. If cowdung is not available at the defibring unit, it can be transported in.

5. Conclusions

1. The waste, i,e., coir pit, from defibring units of the coconut industry can be used to yield biogas as it contains an adequate proportion of cellulose matter.
2. The use of cowdung in addition to coir pith accelerates the fermentation process in the biogas plant.
3. The effluent, a by-product of the biogas plant, can be used as a fertilizer in farms.
4. If further investigations are carried out to reduce the carbon/nitrogen ratio to about 30, then coir pith can be serve as a good raw material for yielding biogas. ■

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Notes

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