Pakistan J. Sci. Ind. Res., Vol. 30, No. 3, March 1987

BIOGAS FROM AGRICULTURAL AND MUNICIPAL SOLID WASTES

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(Received October 24, 1985; revised December 28, 1986)

Dry matter content of the crop residues, cow dung, poultry droppings and municipal wastes varied from 20.0 to 37.4%. Adjustment of solid content (as 10 %) of the waste materials by dilution with water and anaerobic fermentation resulted in maximum production of biogas. Biogas produced from cow dung, bagasse pith mixed with dung, poultry droppings and municipal wastes was 0.35, 0.29, 0.16 and 0.22 m^3/kg of the dried material respectively. The rate of production of biogas was effected adversely during the winter season.

Key words: Biogas; Cow dung; Agricultural waste.

INTRODUCTION

The developing countries are facing serious problems in disposal of solid wastes [1]. Pakistan produces annually about 52 million tonnes of agricultural and animal wastes [2]. These wastes are a potential source of energy and can be used as fertilizer and fuel after anaerobic fermentation [3,4].

This paper deals with the design of family size biogas plant and production of biogas by anaerobic fermentation from crop residues, cow dung, poultry droppings, and municipal wastes.

MATERIAL AND METHODS

Cow dung was collected from the campus of PCSIR Laboratories, Lahore. Poultry droppings were supplied by the National Poultry Farm, Multan Road, Lahore. Municipal solid wastes were procured by the Municipal Corporation, Town Hall, Lahore. Bagasse pith and waste wheat straw were provided by the Crescent Sugar Mills, Faisalabad and the Packages Limited, Lahore respectively.

Cow dung, poultry droppings, crop residues and putrescible organic matters present in municipal solid wastes were separately fermented anaerobically, in a modified Indian type family size biogas plant (Fig. 1).

The waste matters were homogenized and representative samples were taken from it for analysis of dry matter, crude protein, crude fibre, fat, ash and total carbohydrates. In case of municipal wastes before homogenising, the non-putrescible fractions like brick bats, iron and tin metals, glass and plastic materials were separated and discarded.

Analysis

a) Total solid content was the per cent dry weight of the waste material obtained after drying at 102°C for 24 hours.

b) Total nitrogen was estimated according to the Kjeldhal method [5].

c) Crude protein was calculated by multiplying the total nitrogen with 6.0.

d) Total lipid was the quantity of fat extracted with hexane.

e) Nitrogen free extract was the fraction containing carbohydrates obtained by method of difference.

Biogas plant design. Four biogas plants each of 2m^3 capacity and having continuous fed digester and floating gas holder were used for generation and collection of biogas (Fig. 1).

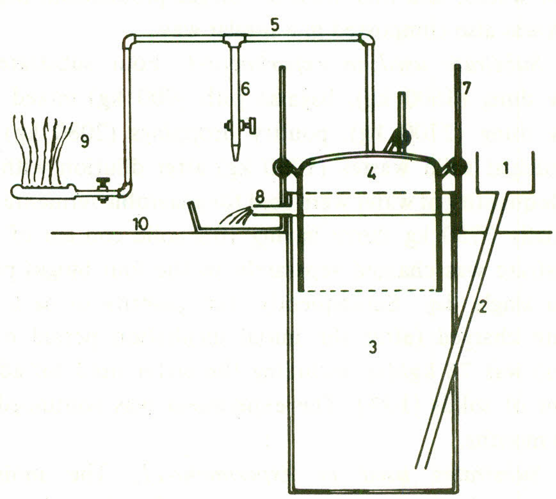

Fig. 1 Modified Indian type biogas plant.

[1. Maxing tank; 2. Inlet pipe, 3. Digester, 4. Moveable gas holder, 5. Gas line, 6. Water trap, 7. Iron guide for movement of gas holder 8. Out let pipe, 9. Stove, 10. Ground level.]

Digestion chamber. The digestion chamber was like a well having inner dia 1.53 m and depth 3.66 m made with bricks and mortar. The base of the digester was made with compressed brick balls and mortar. The digester wall was plastered inside to check seepage of water.

The digester was about 3.05 m under-ground to avoid excessive loss of temperature. Inlet pipe (dia 0.154 m and length 3.66 m) was fixed in the wall about 0.38 m above the bottom of the digestion chamber for charging the digester. Outlet pipe (length 0.618 m and dia 0.154 m) was fitted 0.154 m below the top of the digester for discharge of the effluent.

Gas holder. A gas holder diameter 1.37 m and height 1.45 m was made of 14 quage steel sheets. The top of the gas holder was fitted with a gas vent made from (25.4 mm dia) G.I. pipe and equipped with a valve for controlling the flow rates of biogas. Three iron bars (dia 25.4 mm and length 2.14 m) were fixed vertically at equal distance near the brim of digester to control the vertical movement of the gas holder.

Anaerobic digestion of biomass. The fermentable material containing 10 % solids was charged in the digester through an inlet pipe. The pH of the fermenting material was maintained (7.4 ± 0.2) by adding lime, when needed. The biogas produced was collected in the gas holder and its volume was measured (m^3/day) with a sui-gas meter.

Procedure for making compost. Wheat straw was mixed with biogas plant effluent to raise its moisture content to 80%, covered it with polyethylene sheet for eight weeks, and then used for biogas production. Bagasse pith was also composted in a similar way.

Substrate used in experiment-1. Four substrate i.e. cow dung (3600 kg), bagasse pith (900 kg) mixed with cow dung (2700 kg), poultry droppings (2080 kg) and municipal solid wastes (1080 kg) after dilution with suitable quantity of water were used for anaerobic fermentation. Initially 3750 kg slurry having 10% solid content of each substrate was charged separately in the four biogas plants in a single day. Subsequently, the quantity of each substrate charged (after the initial incubation period of 21 days) was 76 kg/day including the water used for adjustment of solids (10%). The experiment was continued for five months.

Substrates used in experiment-11. The moisture content of wheat straw compost was first brought to the level of 80 % equal to the cow dung. Then the three substrates i.e. cow dung (4750 kg), wheat straw compost (1187 kg) mixed with cow dung (3562 kg) and the wheat straw compost (2375 kg) mixed with cow dung (2375 kg) were used for biogas production after dilution with suitable quantity of water. 3750 kg slurry of each of the substrates containing 10% solids was fed separately in 3 biogas plants in one day. The remaining quantity of each substrate, was diluted with water daily and charged @ 76 kg/day after waiting for 21 days of initial loading. The experiment was continued for ten months.

RESULTS AND DISCUSSION

The experiment conducted on laboratory scale showed that cow dung slurry having 10 % solids produced maximum quantity of biogas (Fig. 2). Therefore, it was considered necessary that for optimum production of biogas by anaerobic fermentation solid content of the biomass should be adjusted by addition of suitable quantities of water, because the dry matter of the waste materials varied during the season. [6]

Table - 1 shows the composition of the solid wastes used for production of biogas. The dry matter content of cow dung, poultry droppings and municipal waste was found 20.0%, 42.0% and 73.4% respectively. The crude protein content of poultry droppings was 21.0% as compared to 9% in cow dung and 4.8% in the municipal solid wastes. The yield of biogas from poultry droppings on adjustment of solid content (10%) and by anaerobic fermentation in family size biogas plant was 0.162m^3/kg whereas in case of municipal solid wastes was 0.22 m^3/kg. of the dried material. The results indicated that the quan-

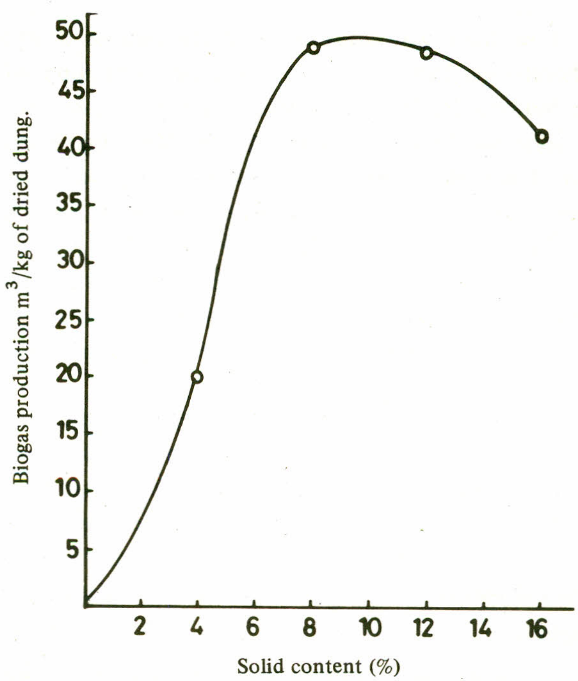

Fig. 2. Effect of solid content on biogas production.

tity of the biogas produced/kg of poultry droppings was less than reported by other workers.[4] It could be due to the low C : N ratio (10:1). Biogas produced from cow dung at the same solid content was 0.35 m^3/kg and when bagasse pith was mixed 25% in cow dung the amount of gas produced was decreased to 0.29 m^3/kg of the dried material. Changes in the atmospheric temperature from 28°C to 40°C during experiments effected the biogas production and it varied according to the temperature (Table-2).

The composition of waste wheat straw and its compost is given in Table 3. The temperature inside the biomass during composting increased to 60°C and wheat straw turned blackish brown. Crude fibre content of the wheat straw decreased from 37.16% to 28.14% and crude protein content increased from 3.36 % to 4.56 % on making compost. This may be due to the microbial degradation. Similarly, the NFE also increased (51.94%) in composted wheat straw.

Table – 4 shows the effect of atmospheric temperature on biogas production from the substrates having 25% and 50% wheat straw compost mixed in cow dung. The substrate having 25% wheat straw compost produced biogas 1.2m^3/day and when mixed 50% the biogas produced was 0.8m^3/day at the temperature between 15 ro 28°C. The increase in the atmospheric temperature from 28 to 41°C maximum increased the production of biogas i.e. 1.8 and 1.6 m^3/day from the substrates having wheat straw compost 25% and 50% in cow dung respectively.

Table 1. Proximate analysis of substrates used for biogas production

Substrate	Dry matter (%)	Ash (%)	Lipids (%)	Fibre (%)	Crude protein (%)	N.F.E.* (%)
Cow dung	20.0	18.8	1.4	26.9	9.0	43.9
Poultry droppings	42.0	31.8	2.6	22.7	21.0	21.9
Municipal Solid wastes	73.4	36.8	1.6	47.0	4.8	9.8

* Nitrogen free extract which contain carbohydrate etc.

Table 2. Production of biogas from different substrates

Substrate	Total charge (kg)	Biogas production (days)	Average production of biogas/ 24 hr (m^3)	Yield of biogas on d.m. basis (m^3/Kg)
Cow dung	3600	90	2.80	0.35
Cow dung + Bagasse pith	2700 + 900	98	2.14	0.29
Poultry droppings	2080	110	1.28	0.16
Municipal waste	1080	94	1.79	0.22

Temperature varied from 28°C to 40° maximum and pH was maintained at 7.4 ± 0.1.

Table 3. Proximate analysis of wheat straw and its compost

Composition (%)	Wheat straw	Compost
Dry matter	19.90	30.00
Ash	15.20	14.00
Lipids	1.20	1.10
Crude fibre	37.16	28.40
Crude protein = (nitrogen x 6)	3.36	4.56
Nitrogen free extract	43.09	51.94

Table 4. Effect of the changes in atmospheric temperature on the production of biogas/day from wheat straw compost

Substrate	Total charges (kg)	Average biogas production m^3/day temperature 15 to 28°C	28 to 41°C
Cow dung	4750.0	1.8	2.5
25% wheat straw compost mixed in cow dung	(1187.5 +) (3562.5)	1.2	1.8
50% wheat straw compost mixed in	(2375.0) (2375.0)	0.8	1.6

pH of the fermenting material was maintained at 7.4±0.1

Fibrous material such as wheat straw compost more than 25% in the cow dung or any other fermenting material affected the efficiency of family type biogas plant. The fibrous material floating on the surface of substrate in the digester created difficulty in the vertical movement of gas holder. It was concluded that for substrates having large quantityies of fibrous tissue the design of biogas plant need to be changed, and some arrangement should be made to check the loss of heat from the digester during winter season. Studies are being carried out to overcome these problems.

Acknowledgement. The authors are highly obliged to Vice Chairman, Appropriate Technology Development Organization, Ministry of Science and Technology, Government of Pakistan for sponsoring these studies.

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