Asian Journal of Chemistry Vol. 17, No. 2 (2005), 934–938

Studies on Efficiencies of Bio-gas Production in Anaerobic Digesters using Water Hyacinth and Night-soil Alone as well as in Combination

SUNIL KUMAR

Department of Civil Engineering, Muzaffarpur Institute of Technology, Muzaffarpur-842 003, India

Water-hyacinth and night-soil alone as well as in combination with each other in various proportions (1 : 3 and 3 : 1) have tremendous potential to produce bio-gas (rich in methane content) through anaerobic digesters. The sludge obtained from mixed feed was improved in terms of nitrogen, phosphorus and potassium in comparison to hyacinth alone. The sludge can be utilized as a very good manure. The technology is very simple and can be easily implemented in rural areas to fulfill the energy crisis especially for cooking.

Key Words: Water hyacinth, Night-soil, Digester, Bio-gas.

INTRODUCTION

Water hyacinth (*Eichhornia crassipes*), a wild growing weed in sluggish and polluted water is a dark green board leaf plant, floating freely in water. Harvesting method of water hyacinth plants is also very simple. It is with this idea that studies on the efficiency of bio-gas production in anaerobic digesters using night-soil and water hyacinth alone as well as in combination with each other have been undertaken. This study is aimed at utilizing water hyacinth as the major ingredient.

EXPERIMENTAL

Experiments were conducted with various raw materials collected from several places as per convenience at Muzaffarpur. The plants were initially spread on the ground for partial drying. Thereafter, the plants were manually cut into pieces (10–15 mm) by a chopper. Experiments were conducted in 10 Litre capacity digester in a semi-continuous digestion process. The digester was sealed and connected to a standard gas collecting arrangement to facilitate gas measurements. The gas was collected and measured by water displacement method. Samples of influent and effluent slurry before and after digestion were collected and analyzed for various physio-chemical parameters like pH, temperature, volatile solids, alkalinity, ammonia, nitrogen, volatile solids and volatile acids as per standard methods[1].

RESULTS AND DISCUSSION

The study was conducted in two different phases, *i.e.*, in summer (phase I) and in winter (phase II). Performance of all the digesters is shown in Table-1.

Phase I : Study in Summer

Volatile solids destruction and bio-gas production: It was found that volatile solids destruction increased in the digester I, VI and VII, receiving hyacinth alone and mixed feed of hyacinth and night-soil (1 : 0, 2 : 1, 3 : 1). This increase was observed to be with the increase of the hyacinth load in the mixed feed. A maximum volatile solid destruction of 39.81 ± 2.6 (%) was recorded in the digester I, receiving hyacinth alone whereas volatile solid destruction of 34.34 ± 3.2 (%) and 34.74 ± 3.6 (%) were found in the digester VI and VII receiving mixed feed of hyacinth and night-soil (2 : 1, 3 : 1). Since gas production will be proportional to volatile solid destruction, it is obvious to expect increased gas yield with increase in the proportion of water hyacinth in the mixture, which can be concluded from gas yield data (Table-1) at a ratio of 1 : 0, 2 : 1, 3 : 1. The volatile solid destruction was 36.87 ± 3.4 (%) in the digester II, receiving mixed feed of hyacinth and night-soil (1 : 1) whereas volatile solid destruction of 38.51 ± 3.5, 41.72 ± 4.27 and 42.87 ± 4.74 were observed in the digesters III, IV and V receiving mixed feed of hyacinth plus night-soil and night-soil alone (1 : 2, 1 : 3 and 0 : 1). This increase in volatile solid destruction clearly showed that it improves with the increase in the night-soil load. Thus bio-gas production can also be increased by the addition of night-soil load in the mixed feed (Table-1).

Pathe *et al.*[2] observed a maximum of 39.79 ± 2.3% of volatile solids destruction in digester receiving water hyacinth alone and is nearly equal to the mixture where cattle dung to fresh water hyacinth is in the ratio of 1 : 3.

pH variation: From the results of pH, it can be seen that digesters III, IV, I and VII provided better buffering capacity in comparison to others. It is a well known fact that methane bacteria are very sensitive with change in pH. Ghosh and Klass[3] found that the optimum pH for the fermentative acidification stage of their small scale two-stage digestion of sewage sludge or glucose was 5.7. The alkalinity is a measure of buffering capacity of the contents and acts as a safe guard against pH fluctuation.

According to Hobson *et al.*[4] and Hobson and Peilden[5], a digester usually runs naturally at a pH of 7 or just over, about 7.2. This pH is about optimum for the methanogenic bacteria.

During the digestion period, the digesters III, IV, VI and VII were found to be more stable than the other digesters which was quite evident from the range of their variation.

Alkalinity variation: The alkalinity values were found to be decreased in the case of digesters I, VI and VII but rate of decrease of alkalinity is faster in the case of hyacinth alone in comparison to the mixed feed of hyacinth and

TABLE-1
PERFORMANCE OF DIGESTERS RECEIVING WATER HYACINTH ALONE/NIGHT-SOIL ALONE AND MIXTURE OF WATER HYACINTH AND NIGHT-SOIL

Digester	Hyacinth : Night-Soil	pH	Total alkalinity as $CaCO_3$ (mg/L)	Volatile acids as CH_3COOH (mg/L)	Total ammonia-nitrogen as N (mg/L)	Volatile solids destruction (%)	Gas production (m^3/kg VS added)	Gas composition ($CH_4 : CO_2$)
I	1 : 0	6.7–7.2	2725–2182	99.42–45.67	7.2–10.70	39.81 ± 2.6	0.295	56.2 : 43.8
II	1 : 1	6.6–7.3	2711–2772	414–55	14.7–22.00	36.87 ± 3.4	0.171	57.8 : 42.2
III	1 : 2	6.8–7.3	2782–3328	504–84	26.40–35.8	38.51 ± 3.5	0.201	59.0 : 41.0
IV	1 : 3	6.9–7.3	3095–3784	795–75	29.80–42.0	41.72 ± 4.27	0.221	65.7 : 34.3
V	0 : 1	5.2–6.9	2798–3718	2538–141	446–721	42.87 ± 4.74	0.287	65.7 : 34.3
VI	2 : 1	6.9–7.2	2639–2497	195–65	11.4–16.7	34.34 ± 3.2	0.231	57.6 : 42.6
VII	3 ; 1	7.0–7.2	2584–2404	290–70	9.7–13.3	34.74 ± 3.6	0.232	57.6 : 42.4

Organic loading rate : 1.6 kg/VS/M^3/day
Digestion period : 30 days
Average temperature during experimental period : 22 to 35°C

night-soil (2 : 1, 3 : 1). That means alkalinity values decreased as the proportion of fresh water hyacinth increased in the mixed feed digester. In digesters II, III, IV and V in which mixed feed of hyacinth and night-soil alone (1 : 1, 1 : 2, 1 : 3, 0 : 1) were digested, the alkalinity values were found to be in increasing order. The increase in alkalinity was observed with the increase in night-soil load.

Deshpandey *et al.*[6] also recorded increasing trend in alkalinity in the anaerobic digestion of cattle dung and night-soil.

Volatile acid variation: The volatile acid variation in the digesters I, VI and VII receiving only hyacinth and mixed feed of hyacinth and night-soil (1 : 0, 2 : 1, 3 : 1) were low as compared to the digesters II, III, IV and V.

In case of digesters II, III, IV and V receiving mixed feed of hyacinth and night-soil alone (1 : 1, 1 : 2, 1 : 3 and 0 : 1) there was no alarming increase in volatile acid concentration.

Ammonia nitrogen: The ammonia nitrogen concentration in the digesters II, III, IV and V which contained mixed feed of hyacinth and night-soil (1 : 1, 1 : 2, 1 : 3, 0 : 1) also showed increasing trend. This increasing trend was observed with the increase in night-soil load. That means in case of digester V which contained night-soil alone the ammonia-nitrogen concentration will be highest in the effluent. The increased concentration of total ammonia nitrogen in the effluent may be due to the fact that night-soil is rich in protein which on deamination produced ammonia.

Pathe *et al.*[1] also observed that ammonia-nitrogen values in the mixed feed (water hyacinth plus cattle dung) and fresh water hyacinth digester when compared to cattle dung indicated efficient nitrogen retention in the sludge from the mixed feed digester. In digesters I, VI and VII which contained water hyacinth alone and mixed feed of water hyacinth and night soil (1 : 0, 2 : 1, 3 : 1), the ammonia nitrogen concentration was not so high as was seen in digesters II, III, IV and V (Table-1). However, the total ammonia-nitrogen concentration was found to be in increasing order which resulted in the digested slurry which was rich in nitrogen retention. It was also clear that there was no adequate level of alkalinity which can increase the toxic level of ammonia-nitrogen. Trivedi[7] observed that 10,000 mg/L of alkalinity as the upper limit for night-soil digester. In this study, the maximum alkalinity values of 3784 mg/L and total ammonical nitrogen values of 42 mg/L and 721 mg/L were found in the digesters IV and V respectively, receiving mixed feed of hyacinth plus night-soil and night-soil alone. In other digesters I, II, III, VI and VII total ammonia nitrogen values were recorded low.

Satyanarayan *et al.*[8] also conducted similar type of studies and observed that cowdung has a potential to suppress ammonia toxicity since the quantity of ammonical nitrogen release into the slurry was low in the mixed feed of cattle dung and night-soil as compared to night-soil alone.

Conclusions

- Water hyacinth and night-soil can be mixed in various proportions for the bio-gas production. In case of 3 : 1 ratio, the bio-gas production efficiency is quite high. So the water hyacinth can be used as a major ingredient for bio-gas production.
- Water hyacinth alone and night-soil alone have tremendous potential to produce bio-gas.
- Methane content of the bio-gas produced was found to be increasing in the mixed feed of water hyacinth and night-soil.
- Sludge obtained from mixed feed containing hyacinth and night-soil was improved in terms of nitrogen, phosphorus and potassium in comparison to hyacinth alone. The mixed sludge is supposed to have higher percentage of fibres which provides enough porosity to the soil mass which is essential for high yield of various crops.
- The bio-gas production takes place in winter also but its efficiency is very poor. The stabilization of the digester also takes too much of time.

REFERENCES

1. Standard Methods for the Examination of Water and Wastewater, American Public Health Association, Inc., 13th Edn., New York (1971).
2. P.P. Pathe, S. Satyanarayana, C.V. Deshpandey, M.V. Srinivasan and P.V.R. Subrahmanyam, Feed Supplement in Cattle Dung Biogas Plants (NEERI Report), Paper presented at the International Conference on Water-Hyacinth, Hyderabad (February 1983).
3. S. Ghosh and D.L. Klass, *Proc. Biochem.*, **13**, 15 (1978).
4. P.N. Hobson, S. Bousifield and R. Summers, in: Andrew Porteous (Ed.), Methane Production from Agricultural and Domestic Wastes, Applied Science Publishers, Barking, England, p. 269 (1981).
5. P.N. Hobson and N.E.H. Peilden, *Proj. Energy Combus. Sci.*, **8**, 135 (1982).
6. C.V. Deshpandey, S. Satyanarayan, S.M. Kaul and S.R. Wale, NEERI Report, Nagpur (1987).
7. R.C. Trivedi, Studies of the ammonia nitrogen behaviour in anaerobic system with reference to digestion on night-soil and other organic wastes, Ph.D. Thesis, Nagpur University (1973).
8. S. Satyanarayan, *Indian J. Environ. Prot.*, **7**, 5 (1987).

(*Received*: 8 June 2004; *Accepted:* 24 December 2004) AJC-4029