JOURNAL OF PURE AND APPLIED MICROBIOLOGY, April 2010. Vol. **4**(1), p. 333-337

Effect of Seasonal Variation on Biogas Production from Different Food Waste

Poonam V. Shukla*, Tejomyee S. Bhalerao and S.T. Ingle

School of Environment and Earth Science,
North Maharashtra University, Jalgaon - 425 001, India.

(Received: 09 January 2010; accepted: 16 February 2010)

Biogas, a renewable source of energy which is also environmentally friendly, is generated via anaerobic digestion of biomass wastes (animal dung, plant residues, food waste, municipal solid waste etc). The effect of seasonal variation on the rate of biogas production from different food waste was carried out. The food waste used for the study are cooked food, wasted tomatoes, fruit waste(wasted bananas), vegetable cut outs (fenugreek) and waste from candy preparing industry. The substrates were monitored for biogas production; the parameters analyzed were pH, alkalinity, chemical oxygen demand, proteins and carbohydrates. The study was carried for summer season (March, April and May) and winter season (November, December and January). The pH variation in all the substrate as well the chemical oxygen demand reduction was observed. The maximum chemical oxygen demand reduction was observed in industrial waste in the summer season. The study confirmed that maximum biogas production occurs in summer season due to thermophilic reaction.

Key words: anaerobic digestion, biogas, kitchen waste, renewable source, season, temperature.

Food waste comprises a major portion of Municipal Solid Waste (MSW). The food from household and restaurants was estimated to be 23% of the municipal solid waste[1] Studies carried on anaerobic digestion indicate that the food waste has potential of biodegradation and can be treated anaerobically to produce biogas. Biogas, a renewable source of energy which is also environmentally friendly, is generated via anaerobic digestion of biomass wastes (animal dung, plant residues, waste waters, municipal solid wastes, human and agroindustrial wastes etc)[2].

Biogas production is a three stage biochemical process comprises of hydrolysis, acidogenesis/ acetogenesis and metanegenesis[2] . Due to this change in biochemical process the variation in pH, chemical oxygen demand (COD) and temperature occurs. Specific environmental and operational factors influence anaerobic conversion process[3] . Some of the more important factors responsible for affecting the rate of biogas generation are temperature[4] , ammonia level[5] and loading rate, which affects overall process

* To whom all correspondence should be addressed.
Tel.: 0257-2257428
E-mail: poonamvshukla@gmail.com

stability, generally as measured by the concentrations of volatile fatty acids (VFA) in the digester[6]. The anaerobic digestion can be developed to different temperature ranges including mesophilic temperatures of approximately 35°C and thermophilic temperatures ranging from 35°c to 60°c. the conventional anaerobic digestion is carried out at mesophilic temperature that is 35-37 °C[7]. The thermophilic temperature is worth considering because it will lead to give faster reaction rates and higher gas production.

The present study was carried in Jalgaon; a city in the north of Maharashtra state, which is in western India. Jalgaon is located at 21.01 °N 75.56 °E. It has an average elevation of 209 meters. The climate of Jalgaon is tropical and the maximum and minimum temperature range for the summer is 45 °C-29°C and the maximum and minimum temperature is 26°C – 6°C. The study was undertaken to investigate the effect of seasonal variation on biogas yield from food waste. As mentioned above the temperature is considered to be an important variable to affect the gas production rate. Hence it becomes utmost important to know the climate and temperature of a particular region before installation of a biogas plant to make the successful working of the plant.

MATERIAL AND METHODS

The study was conducted to detect the biogas production from food waste using various substrates; and to analyze the effect of seasonal variation on the rate of biogas production. The amount of substrates used for the analysis is same in both seasons for all the substrates.

The samples used for the study are; food processing industry waste of candy preparation (IW,) cooked food waste (CW), banana waste (BW), raw vegetable waste (RW), it includes the cut outs of vegetable and tomato waste (TW). The IW was obtained from the candy preparation plant, from papaya in, Jalgaon. CW was collected at house hold level and it includes the leftover food and dish wash waste. The other substrates used as wastes were obtained from the local sources available in Jalgaon City. The substrates were collected between the months of March, April and May for summer analysis and November, December, and January for winter analysis. After the collection the samples were stored at a 0°C in refrigerator before carrying the experimental study. Before starting the process of gas production all the substrates were kept separately for fermentation for 5 days in conical flasks.

All apparatus were properly washed with soap solution and allowed to dry. A set of 2 glass bottle (750 ml) with air tight crock were used as digester , that is one bottle was used as digester and other to collect the gas produced the bottle was filled with 1 N NaOH . Both the bottles were connected to each other by a rubber tube. The biogas produced in the digester passed through rubber tube in the gas collection bottle. The pressure caused displacement of NaOH solution. Carbon dioxide gets dissolved in NaOH, thus the gas collected was pure biogas. The research was conducted in summer and winter seasons, at room temperature. The retention time for the study was of 16 days.

The parameters analyzed were pH, Alkalinity, Chemical Oxygen Demand. All the parameters were analyzed by the procedure mentioned in[8]. Protein and Carbohydrate contents were analyzed according to[9] . Methane gas was analyzed by G.C Perkin Elener (Auto XL), column (10 F Packed) Carbowork 20 M, FID Nitrogen as a carrier gas 14 ml, Cal temperature 50°C, Injection 200°C and Detector 210 °C.

RESULT AND DISCUSSION

The values of pH, Alkalinity and chemical oxygen demand for both the seasons are depicted in tables 1 to 5. The pH varied through the process, which indicated the stability of the process. Along with change in the pH the alkalinity also varied accordingly. The highest chemical oxygen demand removal was obtained from IW in summer season. This also indicated maximum biogas production.

Biogas production from all substrates commenced within 24 hours. The gas production was measured in terms of chemical oxygen demand (COD) removal. In this reference the maximum COD removal was in IW and in summer season, thus the maximum gas generation was in IW in summer. A study carried by

[10]indicated that thermophilic temperature is more effective for biogas production than mesophilic temperature. The study of [11] also reported higher biogas production using thermophilic digesters as compared to psycrophilic and mesophilic digesters. The research of[12&13] mentioned that the

Table 1. Industrial Waste

S. No	Days	Summer			Winter		
		pH	Alkalinity	COD	pH	Alkalinity	COD
1	0	5.9±0.01	600±1	740±1	5.6±0.02	550±1.1	700±1.12
2	2	5.8±0.01	590±1.2	658±1	5.5±0.01	540±1	605±1
3	4	5.7±0.01	580±1	569±0.5	5.4±0.01	530±1.1	517±1.35
4	6	5.7±0.01	570±1.1	476±1.1	5.4±0.01	520±0.5	437±1.1
5	8	5.1±0.5	620±1.5	381±1	5.7±0.1	560±1.2	360±1
6	10	6.6±0.01	680±1.5	295±1.2	6.2±0.1	620±1.06	291±1.2
7	12	7.0±0.5	720±1.5	200±1	6.8±0.01	670±1.24	214±1
8	14	7.6±0.05	770±1	110±1.3	7.1±0.01	720±1.33	136±0.75
9	16	8.1±0.1	810±2	37±0.5	7.9±0.01	780±1.5	65±0.5

All values are the average standard deviation of three months.

Table 2. Cooked Food Waste

S. No	Days	Summer			Winter		
		pH	Alkalinity	COD	pH	Alkalinity	COD
1	0	5.5±0.25	540±1.5	705±2	5.3±0.25	520±1.34	650±2.1
2	2	5.2±0.01	530±1.25	610±2	5.2±0.34	510±1.05	573±2
3	4	5.1±0.01	520±1.33	515±1.5	5.1±0.02	510±1.75	487±1.7
4	6	5.1±0.36	520±1.05	426±1.2	5.1±0.02	500±0.75	402±1.5
5	8	5.3±0.01	570±1.5	339±1	5.3±0.05	520±1.5	320±1
6	10	5.7±0.1	610±1.75	246±1	5.7±0.045	550±1.25	250±1.2
7	12	6.1±0.05	640±1.5	169±1.5	6.1±0.75	610±1.5	191±1.5
8	14	6.7±0.1	690±1	93±0.75	6.7±0.5	670±1	130±1
9	16	7.2±0.5	730±2.1	39±0.5	7.2±0.1	710±1	70±0.5

All values are the average standard deviation of three months.

Table 3. Banana Waste

S. No	Days	Summer			Winter		
		pH	Alkalinity	COD	pH	Alkalinity	COD
1	0	5.5±0.05	550±1.2	640±2	5.2±0.2	510±1.5	600±2
2	2	5.4±0.25	540±1.05	567±2	5.1±0.01	500±1.3	512±1.5
3	4	5.4±0.01	530±1	482±1.5	5.1±0.01	490±1.5	452±1
4	6	5.3±0.01	520±1	402±1.5	5±0.05	510±1	388±0.75
5	8	5.6±0.75	570±1.5	321±1	5.2±0.75	530±1.5	336±1
6	10	5.9±0.5	590±1	275±0.75	5.6±0.25	550±2	286±1.5
7	12	6.2±0.05	630±1	206±1	5.8±0.35	570±2.5	242±1
8	14	6.6±0.01	660±2	162±1.5	6.1±0.66	590±2	198±1.5
9	16	6.9±0.5	690±	100±0.5	6.3±0.5	620±2	150±0.5

All values are the average standard deviation of three months.

thermophilic digestion of cattle waste is more stable than the mesophilic digestion at different hydraulic retention times. Thermophilic anaerobic digestion shows several advantages over mesophilic anaerobic digestion; such as an increased degradation rate for organic solids a high gas production rate, improved solid-liquid separation and increased disinfection of pathogenic organisms[13&14]. A similar study was carried out by[15] for biohydrogen production the study indicated that the temperature has a considerable effect on the cumulative hydrogen production; it was observed that the cumulative hydrogen production increased at thermophilic temperatures and 45 OC was found the most favorable for maximum cumulative hydrogen production.

Among the volatile fatty acids acetic acid, butyric acid and propionic acids were identified. A study carried by[16] stated that acetic acid and butyric acids were the main intermediates which occurred in mesophilic and thermophilic temperatures where as propionic acid was found in mesophilic but not in thermophilic temperatures.

For food waste, the major constituents are carbohydrates, proteins, fat and cellulose which are more feasible for biological degradation. The protein content reduced till 16th day in all the substrates. It was observed that the maximum reduction of protein content was in IW in summer season and the least reduction of protein was in TW in the winter season (data not mentioned here). Similar results were observed for the carbohydrates. According to[1] a lot of microorganisms can utilize carbohydrate in the digestion culture.

Table 4. Raw Vegetable Waste

S.	Days	Summer			Winter		
No		pH	Alkalinity	COD	pH	Alkalinity	COD
1	0	5.3±0.05	540±1.75	625±2.5	5.1±0.01	510±1	570± 1.5
2	2	5.2±0.05	530±1.35	569±1.5	5.0±0.01	500±1	502±2
3	4	5.2±0.01	520±1.05	532±1	4.9±0.05	490±1	451±2.5
4	6	5.1±0.05	510±1.25	476±1.75	4.8±0.02	480±1	389±1.5
5	8	5.2±0.01	530±1.5	408±2.25	4.9±0.01	500±1.5	347±1
6	10	5.5±0.75	560±1	343±1	5.2±0.1	520±0.5	308±1.5
7	12	5.8±0.5	590±1.2	269±0.75	5.6±0.1	560±1	268±2.1
8	14	6.2±0.1	630±1.25	214±1.5	5.8±0.75	580±1.7	229±1.5
9	16	6.5±0.5	660±2	145±0.5	6.0±0.1	610±1.5	190±1

All values are the average standard deviation of three months.

Table 5. Tomato waste

S.	Days	Summer			Winter		
No		pH	Alkalinity	COD	pH	Alkalinity	COD
1	0	4.9±0.02	500±1.5	600±2.1	4.7±0.01	470±1	550±2.1
2	2	4.8±0.01	490±1.2	544±2	4.6±0.01	460±1	497±2
3	4	4.8±0.01	480±1	483±1.5	4.5±0.01	450±1	450±1.5
4	6	4.7±0.01	470±1	422±1	4.5±0.25	430±1.25	398±1
5	8	5.0±0.02	500±1.5	381±0.5	4.8±0.5	460±1.25	360±1
6	10	5.4±0.01	540±1	310±1	5.1±0.34	490±1.5	325±1
7	12	5.4±0.5	560±1.5	270±1.5	5.3±0.75	530±1.5	290±0.75
8	14	5.9±0.5	590±2	230±1	5.6±0.1	570±1.5	255±1.25
9	16	6.3±0.75	600±2.1	190±0.75	5.9±0.1	600±2	220±1

All values are the average standard deviation of three months.

CONCLUSION

Food waste could be utilized for energy generation. The food waste has satisfactory content of the organic matter, which could be useful in energy generation by anaerobic digestion. The outcome of the study indicated that the gas production was maximum in the summer season due to favorable temperature. Thus temperature is one of the important factors which affect the rate of biogas generation. Therefore before installation of any biogas plant the operational conditions should be taken in to consideration.

REFERENCES

1. Chen, W.C., Chen, W.C., Geng, D.S. The strategy and Bioenergy potential for kitchen waste recycling in Taiwan. *J. Environ. Eng. Manage.* 2008; **18**(4): 281-287.
2. Ofoefule, A.U., Uzodinma, E.O., Onukwuli, O.D. Comparative study of the effect of different pretreatment methods on biogas yield from water hyacinth (Eichhornia crassipes). *International Journal of Physical Sciences*. 2009; **4**(8): 535-539.
3. Karakashev, D., Batstone, D.J., Angelidako, I. Influence of environmental conditions on methanogenic compositions in anaerobic biogas reactors. *Applied and environmental microbiology*. 2005; **71**(1):331-338.
4. Angelidaki, I., Peterson, S.P., Ahring, B.K. Effects of lipids on thermophilic anaerobic digestion and reduction of lipid inhibition upon addition of bentonite. *Applied microbiology and biotechnology*, 1990; **33**: 469-472.
5. Wolin, E.A., Wolin, M.J., Walfe, R.S. Formation of methane by bacterial extracts. *Journal of biological chemistry.* 1963; 238: 2882-2886.
6. Ahring, B.K., Sandberg, M., Angelidaki, I. Volatile fatty acids as indicators of process imbalance in anaerobic digesters. *Applied microbial biotechonology*.1995; **41**: 559-565.
7. Sanchez, E., Borja, R., Weiland, P., Travieso, L., Martin, A. Effect of substrate concentration and temperature on the anaerobic digestion of piggery waste in tropical climate. *Process Biochemistry*. 2001; **37**: 483-489.
8. APHA, AWWAWPFC(ed): Standard methods for the examination of water and wastewater. 17th ed, Washington, DC. 1989.
9. J. Jayaraman: Laboratory Manual In Biochemistry, Madurai: New Age International Publishers 2000.
10. Kim, J.K., Oh, B.R., Chun, Y.N., Kim, S.W. Effects of temperature and hydraulic retention time on anaerobic digestion of food waste. *Journal of bioscience and bioengineering*, 2006; **12**(4): 328-332.
11. Bouallagui, H., Haouari, O., Touhami, Y., Cheikh, B., Marouani,R., Hamdi,M. Effect of temperature on the performance of an anaerobic tubular reactor treating fruit and vegetable waste. *Process Biochemistry.* 2004; **39**: 2143-2148.
12. Mackie, R.I., Bryant, M.P. Anaerobic digestion of cattle waste at mesophilic and thermophilic temperature. *Applied microbial biotechnology.* 1993; 38: 560-564.
13. Krugal, S., Nemeth, L., Peddle, C. Extended thermophilic anaerobic digestion for producing class A biosolids at the Great Vancouver Regional District's Annacis Island waste water treatment plant. *Water science technology*. 1998; **38**: 409-416.
14. Yang,K., Yu,Y., Hwang, S. Selective optimization in thermophilic acidogenesis of cheese-whey waste water to acetic and butyric acids partial acidification and methanation. Water resource. 2003; **37**: 2467-2477.
15. Tang, G.L., Huang, J., Sun, Z.J., Tang, Q.Q., Yan, C.H., Liu, G.Q. Biohydrogen production from cattle waste water by enriched anaerobic mixed consotoria: influence of fermentation, temperature and pH. *Journal of bioscience and bioengineering*. 2008; **106**(1): 80-87.
16. Chaiprasert, P., Bhumiratana, S., Tanticharoen, M. Mesophilic and thermophilic anaerobic digestion of pineapple cannery wastes. *Thammaset International journal of science and technology.* 2001; 6(2).