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Anaerobic Digestion of Vegetable Wastes for Biogas Production in Single Chamber and Double Chamber Reactors

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Abstract

The compositions of solid wastes of a rural market of Bangladesh and the results of two sets of laboratory experiments on biogas generation from the easily biodegradable wastes under daily feed condition are presented in this paper. Cow dung, cauliflower stick, papaya and potato were the major biodegradable wastes. Daily average composition of the biodegradable wastes was used in the experiments. The average Total Solids (TS) and Volatile Solids (VS) concentrations of the raw substrate were determined as 18.90% and 15.10% respectively. The experimental setups were placed in a large closed chamber containing two room heaters. The room heaters were operated alternatively at 35°C to maintain a favorable condition for anaerobic digestion of the substrate. In the first setup, a single chamber reactor and a double chamber reactor were used. In the single chamber reactor, 750 g wastes and required amount of inoculum were added initially to make the effective volume of 2 L. For the double chamber reactor, each chamber was initially fed with 350 g wastes and inoculum was added to make the effective volume of 1 L. The single chamber reactor was operated for 58 days and the double chamber reactor was run for 23 days. From the 2nd day of operation, each reactor was fed daily with a mixture of 18.75 g wastes and the required volume of tap water to make the total volume of 50 mL after taking out equal volume of slurry from the reactor. The second set of experiment was similar to the double chamber reactor of the first setup, but it was operated for 54 days including the last 16 days operation at room temperature as the heaters became out of order. In case of the first setup, the temperature varied from 31°C to 36°C and the rate of biogas generation was not affected due to this variation. The results of the experiments revealed that for the Organic Loading Rate (OLR) of 1.42 g VS/L/d, the daily stable biogas generation rate was 0.22 m3 /kg of VS added for the single chamber reactor, and apparently the daily stable average rate of biogas production was 0.37 m3 /kg of VS added for the double chamber reactor. During the second set of experiment, the temperature varied in between 32°C and 36°C when the chamber-heater was on and the rate of biogas generation was not affected, and the stable rate of biogas generation was 0.26 m3 /kg of VS added for the OLR of 1.42 g VS/L/d. The temperature of the chamber varied from 22°C to 25°C when the heater became out of order and the sudden drop of the temperature by about 10°C affected the rate of biogas production greatly. Atthe ambient temperature, the stable rate of biogas generation was only 0.08 m3 /kg of VS added.

Cities and rural growth centers are places of rapid economic growth, trade, education and employment resulting in increasing the consumption of resources and generation of wastes. The world is facing the burning problems of management of large quantities of solid wastes produced in these places and meeting the energy requirements due to rapid growth of urban population. The vegetable markets of these areas produce large quantities of biodegradable wastes which are very poorly managed in developing countries producing malodorous gases, greenhouse gases, and leachate during on-site degradation and pollute the water when the wastes are thrown into local water bodies. Hence, the wastes should be properly managed to have clean environment and reduction of greenhouse gas emission to slow down the climate change. The high moisture and Volatile Solids (VS) contents in vegetable wastes make these more suitable for anaerobic digestion than incineration and composting. Anaerobic digestion of solid wastes is becoming popular day by day as a method of solid waste management as it produces biogas which can be used for steam heating, cooking and generation of electricity . The residual slurry can be used as a bio-fertilizer and soil conditioner. Huge amount of biodegradable solid wastes are generated in the markets of Bangladesh and these are the potential sources of biogas generation. An investigation on the type and quantity of solid wastes produced in a rural vegetable market of Bangladesh was carried out, and the biogas generation from the wastes was quantified through laboratory scale single chamber and double chamber reactors under daily feed condition at controlled temperature and sharp decrease in ambient temperature. The investigation was done to compare the results with those found in the available literature and to see the effect of the change in the ambient temperature on the gas generation. In addition, finding the difference in biogas production between single chamber and double chamber reactors were the objective as short circuiting of the added wastes is likely to happen in case of single chamber reactor. This paper presents the results of the investigation.

Based on the results of the present study, the following conclusions can be made:

1. About 48% of the wastes generated in the market were easily biodegradable. Cow dung, cauliflower stick, dry paddy

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straw, banana leaves, papaya, and potato were the major easily biodegradable wastes.

2. The TS and SS contents of the easily biodegradable portion of the market wastes were 18.90% and 15.10% respectively.

3. Under daily feed condition at favorable temperature, the stable biogas generation rate was 0.22 m3 /kg of VS added and 0.26 m3 / kg of VS added for single chamber reactor and double chamber reactor respectively for OLR of 1.42 g VS/L/d and 40 days HRT.

4. Sudden and sustained change of ambient temperature changed the biogas production rate drastically.

Keywords: Anaerobic digestion; Biodegradable waste; Biogas; Hydraulic retention time; Single chamber reactor; Double chamber reactor; Organic loading rate.

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