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Short Communication

Study on biomethonization of waste water from jam industries

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Abstract

Anaerobic digestion of wastewater from jam industries was studied in a continuous reactor with different organic loading rates (OLR) and the optimum organic loading rate was 6.5 kg COD/m^3/day when it was operated with three days HRT. The biodegradability of wastewater in batch experiments was about 90%. The removal efficiency of total COD and soluble COD were found to 82% and 85%, respectively. The specific methane production was 0.28 m^3/kg of COD removed/day.

Keywords: Biomethanization; Anaerobic digestion; Bio-conversion; Jam waste; Biogas; COD removal

1. Introduction

Biomethanization of fruit wastes is the best-suited treatment as the process not only adds energy in the form of methane, but also results in a highly stabilized and treated effluent. It is a clean alternative for the putrescent organic wastes. Some waste streams can be treated by conventional methods like aeration which are both energy intensive and expensive. Compared to the aerobic method, the use of anaerobic digesters in processing these waste streams provides greater economic and environmental benefits and advantages. Apart from treating the wastes, the methane produced from the anaerobic system can be recovered. Besides reducing the amount of green house gases by controlled use of methane from waste, the substitution of oil and coal with bio-energy will result in saving the global environment by reducing the use of fossil fuels (Kansal et al., 2004).

The wastewater from food-processing industries is very rich in organic contents and may be a potential source for production of methane gas. There are over 18,550 food-processing industries in India, emanating large quantities of wastes (Viswanath et al., 1992). These wastes are either uneconomically utilized or disposed off without treatment, thereby causing serious pollution problems. With the 50% of moisture content or above, it is found that bio-conversion processes are more suitable than thermo-conversion process (Baridiya, 1991).

Organic pollutants are converted into methane in the anaerobic treatment of solid wastes (Iglesias et al., 1998). Anaerobic digestion experiments were carried out on market wastes (Ranade et al., 1987), on food-market organic wastes (Alvarez et al., 1992), and on Korean food wastes (Cho et al., 1995). Bouallagui et al. (2004, 2005) carried out detailed studies on the anaerobic degradation of fruits and vegetable wastes. Alvarez et al. (1992) have shown that biomethanation of food-market waste resulted in a production of 0.64 m^3 biogas/kg total solids (TS) added.

The biogas yield from canteen wastes, which was a mixture of fruit and vegetable wastes (FVW), when subjected to anaerobic digestion varied from 0.82 to 0.9 m^3/kg of VS added (Nand et al., 1991). Viswanath et al. (1992) reported a production of 0.12 m^3 biogas/kg TS added with Hydraulic Retention Time (HRT) of 16 days and the biogas yield from varied between 0.6 and 1.0 m^3/kg VS/day from the same type of waste. Biomethanation of banana peel and pineapple wastes studied by Bardiya et al. (1996) at various HRTs showed a higher rate of gas production at lower retention time. Many studies have been carried out both in batch and continuous modes, to determine how co-digestion of different organic solid wastes including FVW with

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cattle slurry can improve the efficiency of degradation (Callaghan et al., 1999, 2002). The present study was intended to assess the biogas potential of wastewater from Jam industries in terms of waste stabilization efficiency and net energy recovery.

2. Methods

Batch experiments were carried out in four identical reactors of 2-l capacity each with liquid displacement system for biogas collection. Three equally spaced ports were designed along the height of the reaction zone. The bottle was made air tight with a rubber stopper through which a gas collection tube passed. The other end of the tube was connected to a bottle, which was filled with alkali solution (2 N KOH). The reactor was mounted on a magnetic stirrer (2 MLH) for mixing.

For the continuous study, the cylindrical shape reactor (two litre capacity) was used. Sludge zone and gas phase were designed to have 10% of the effective volume each. Feeding was done from the bottom with a peristaltic pump and withdrawal of sample was made from the top of the reactor. Mixing was carried out using magnetic stirrer. Feeding rate was adjusted based on the HRT and OLR, both in continuous mode and semi-continuous mode using the peristaltic pump. During the operation, each OLR was maintained until a steady state was attained.

2.1. Analysis

Samples were withdrawn when the steady state was reached. Parameters like pH, moisture content, solid contents in terms of total solids (TS), volatile solids (VS), total suspended solids (TSS) and volatile suspended solids (VSS), Chemical Oxygen Demand (COD), Volatile Fatty Acid (VFA), and Alkalinity were analyzed following the methods prescribed by using APHA (1998). Total Kjeldahl Nitrogen (TKN) was measured by macro Kjeldahl method (APHA, 1998).

3. Results and discussion

Anaerobic sludge seed for the digestion study was collected from an existing Up-flow Anaerobic Sludge Blanket (UASB) reactor. The sludge was taken from the bottom portion of the UASB reactor of 12.5 m^3 capacity. The pH of the sludge was in the range of 6.63–6.61, while the moisture content, TS, VS, TSS, VSS and alkalinity were 83.8%, 162, 106, 110.5, 53 and 4.5 g/l, respectively. The average moisture content of the waste was about 96.5%. The pH, TS, VS, COD and BOD concentrations varied from 3.2–4.3, 2.5–3.5%, 2.3–2.4%, 19.2–26.8 g/l, and 13.89–21.7 g/l, respectively.

3.1. Batch reactor

In the biodegradability study, COD is one of the critical parameters to determine the treatment efficiency of reactors. During the initial period, the reduction of soluble COD (COD_s) was high (nearly 51% removal in three days). It was stabilized nearly at 90% for the COD_s as well as for the total COD (COD_t) removed. The variation of removal efficiency of COD_s and COD_t are shown in Fig. 1.

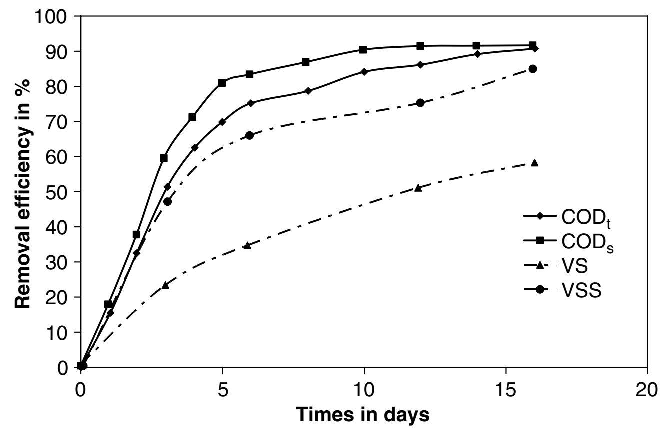

Fig. 1. Variation of removal efficiency with time.

pH and VFA are the main controlling parameters in anaerobic digestion. Though the initial pH was set as 7.4, due to the increased rate of VFA production, pH decreased to 6.7 on 4th day; thereafter it increased and reached to 7.2 without adding any external buffering agent. The variation in removal efficiency of VS and VSS are shown in Fig. 1. Evidently on 6th day, the removal efficiency of VS was 65.7% but the corresponding removal for VSS was only 33.3%. The VS and VSS removal efficiency observed on 16th day were 84% and 58%, respectively.

3.2. Continuous system with different OLR

On continuous mode, a three days of HRT was optimal as the maximum methane production was on 3rd day, and thereafter the production of biogas was decreased significantly. Once the system attained a steady state in terms of COD removal and methane production, the experiments were repeated with different OLR in the range of 5.5–7.5 kg COD/m^3/day.

Initially, the continuous reactor was started with an OLR of 5.5 kg COD/m^3/day and a HRT of three days, which ensured that the F/M ratio of 0.5 was maintained (Mark et al., 2002). After the initial imbalances over the two days to acclimatize with the substrate, the COD reduction reached a steady value of 79.5% in 10 days. Removal efficiency of COD is shown in Fig. 2. It could be observed that VS was reduced considerably resulting in a high removal efficiency of 80% after 10 days. The corresponding VSS removal efficiency was only 56.5% (Fig. 2). Since it was difficult to distinguish between the VSS of the substrate and that of biomass, the VSS reduction accounted was inclusive of the biomass growth. Although the pH of the feed slurry was adjusted to 7.2 with a VFA concentration around 700 mg/l, it lowered to a value of 6.65 within four days after