Production and *in-situ* use of biogas in a UASB reactor treating chocolate-industry wastewater under psychrophilic conditions

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Abstract
During 50 days, a 244 L pilot-scale UASB reactor was operated treating industrial wastewater with high soluble chemical oxygen demand (COD_S) that varied from 1,200 to 3,200 mg/L. The generated biogas was used in-situ through a combustion chamber in order to heat up the reactor influent. The COD_S removal efficiency was low (74 ± 10%) and the biogas production was in the range of 360 to 1,200 L/d. The heating value of the methane in the biogas, allowed increasing the influent temperature an average of 3.6 °C.

Keywords: UASB; psychrophilic temperature; biogas production

INTRODUCTION

Operating temperature has a great impact in the removal efficiency of upflow anaerobic sludge blanket (UASB) reactors treating wastewater. Psychrophilic anaerobic wastewater treatment is a suitable option for wastewaters discharged at low ambient temperatures (Lettinga et al. 2001). The generated biogas has an added value, since it can be used to heat up the reactor, increasing its temperature and, therefore, improving its efficiency.

MATERIALS AND METHODS

Industrial wastewater (WW) used in this research was from a chocolate-processing industry and had high COD_S concentration (1,200 - 3,200 mg/L) and low pH (4.4). The WW was stored at ambient temperature of Toluca Valley (18 ± 2 °C). A 244-L pilot-scale UASB reactor was operated at short hydraulic retention time (HRT) (6 h), treating 950 L-WW/d. The undiluted raw WW was fed into the reactor and alkalinity was added with sodium bicarbonate (2 g/L). Produced biogas was conducted to a combustion chamber, where it was burn with a Bunsen burner. Inside the combustion chamber, above the Bunsen burner, an 8-L boiler contained a copper coil through which the reactor influent was circulated.

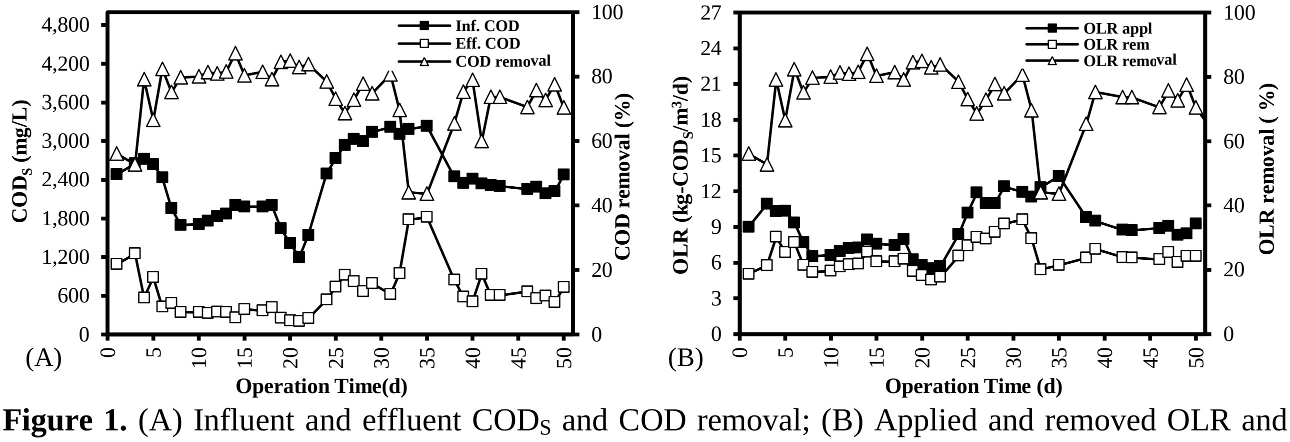

Figure 1. (A) Influent and effluent COD_S and COD removal; (B) Applied and removed OLR and OLR removal

Daily Produced Energy (D.P.E.) was calculated using Equation 1:

$$D.P.E. = C_W \times DT \times F \quad (1)$$

where C_W is the heat capacity for wastewater (4.2 kJ/L•°C) (Crites et al. 2014); DT is the differential of temperatures (°C) and F is the average working flow of WW in the reactor (L/d).

RESULTS AND DISCUSSION

Figure 1A shows the COD_S removal efficiency during the 50-day experiment. The average removal efficiency was 74%, which was lower than that obtained by other authors (Akila et al., 2006; Bandara et al., 2011) and similar to that obtained in the same reactor during other investigation (Esparza-Soto et al., 2013). However, the first authors worked with synthetic wastewater and low applied organic loading rates (OLR_{appl}). The OLR_{appl} were kept in the range of 6.4 ± 1.2 kg $COD_S/m^3/d$ (Figure 1B).

The measured biogas production varied from 360 to 1,200 L/d (Figure 2). The differential of temperatures (DT) of the influent before and after the boiler, varied from 0 to 7 °C, with an average of 3.6 ºC.

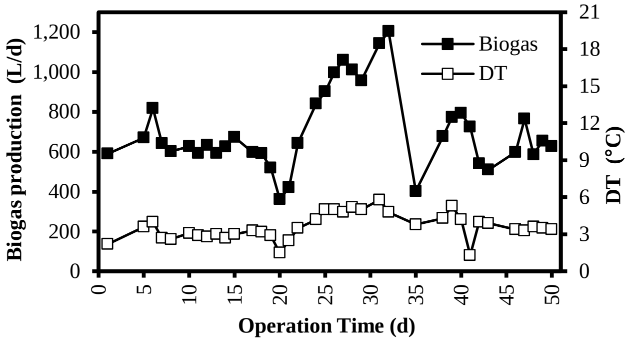

Figure 2. Biogas production and differential of temperatures (DT)

The calculated D.P.E. (using equation 1) was estimated in a total of 2.0 kW-h/d, which is enough energy to maintain twenty 100 W lightbulbs, working 24 h a day, uninterrupted.

CONCLUSIONS

The 244 L pilot-scale UASB reactor operated under psychrophilic conditions and at short HRT, removed from 64 to 84% of the influent COD_S, and produced 360 to 1,200 L/d of biogas. The combustion energy of biogas, allowed increasing the reactor influent temperature an average of 3.6 ºC and a maximum up to 7 °C. The produced energy from biogas could lead to major savings in electrical energy resources, especially for low temperature regions, such as Toluca Valley.

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