

Treatment of brewery wastewater using anaerobic sequencing batch reactor (ASBR)

Shao Xiangwen^{*}, Peng Dangcong, Teng Zhaohua, Ju Xinghua

School of Environmental and Municipal Engineering, Xi'an University of Architecture and Technology, Xi'an 710055, China

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Abstract

Brewery wastewater was treated in a pilot-scale anaerobic sequencing batch reactor (ASBR) in which a floating cover[@] was employed. Long time experiments showed that the reactor worked stably and effectively for COD removal and gas production. When the organic loading rate was controlled between 1.5 kg COD/m³ d and 5.0 kg COD/m³ d, and hydraulic retention time one day, COD removal efficiency could reach more than 90%. Sludge granulation was achieved in the reactor in approximately 60 days, which is much less than the granulation time ever reported. In addition, high specific methanogenic activity (SMA) for formate was observed. The study suggests that the ASBR technology is a potential alternative for brewery wastewater treatment.

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Keywords: Brewery wastewater; ASBR; Granular sludge; SMA; Formate

1. Introduction

In China, there are more than 100 big breweries in which a great volume of wastewater is produced. For each cubic meter of beer produced, the water consumed in general is 10–20 m³, of which more than 90% will be discharged into sewer system. Moreover, there exists a great amount of beer losses (8.01–14.96%) in production line, which is also entering wastewater collecting system finally (Xu, 2000). Because of the high biodegradability of brewery wastewater (BOD₅/COD > 0.5), biological treatment is widely used. Traditionally, wastewaters from different processes are mixed together and treated with aerobic processes, such as conventional activated sludge, oxidation ditch, sequencing batch reactor and biofilter (Liu, 2003). However, brewery wastewater is characterized by high strength soluble organic pollutants and suspended solids (SS). Aerobic treatment requires an intensive amount of energy for aeration. In addition, a large amount of wasted sludge is

produced, which costs large capital to disposal. Therefore, Brewery companies are reluctant to employ wastewater treatment facilities. Source separation is an alternative for sustainable solution. For the part of wastewaters discharged from boiling and fermentation processes in which high strength organic carbon is contained, anaerobic treatment is believed to be the best choice. High rate anaerobic reactors, such as up-flow anaerobic blanket reactor (UASB), anaerobic granular bed baffled reactor (GRABBR) and anaerobic fluidized bed (AFB), have been reported to treat brewery wastewater and a satisfactory COD reduction obtained (Baloch et al., 2007; Ochieng et al., 2002; Parawira et al., 2005).

Anaerobic sequencing batch reactor (ASBR) is a newly developed technology and has been extensively studied due to its advantages: (1) no short circuit, as in the case of fixed-bed continuous systems; (2) high efficiency for both COD removal and gas production; (3) no primary and secondary settles; (4) flexible control, etc. This new technology has been successfully applied in laboratory and pilot scales for treatment of high strength wastewaters, such as landfill leachate (Bodík et al., 2002; Holloper and Dague, 1994;

^{*} Corresponding author. Tel.: +86 29 82202506; fax: +86 29 82202729.
E-mail address: shao_xiangwen@yahoo.com.cn (X. Shao).

Kennedy and Lentz, 2000; Timur and Öztürk, 1999), slaughterhouse wastewater, municipal sludge (Zhang et al., 1996) and dairy wastewater (Dugba and Zhang, 1999). However, no study has been reported for brewery wastewater treatment.

In this study, brewery wastewater was treated using a pilot-scale ASBR reactor with floating cover[®] (patent no: ZL 2004 2 0042282.3). The performance of the reactor, such as COD removal, gas production, sludge granulation and specific methanogenic activities (SMA), is investigated.

2. Methods

2.1. ASBR reactor

The pilot-scale ASBR used in this work was made of PVC (33 cm in diameter and 120 cm in height) with a working volume of 45 L. A stirrer with 150 RPM was restored to provide the mixing of substrate and biomass in the reactor. Gas production was recorded with a wet gas meter continuously. The temperature in the reactor was controlled at 33 ± 1 °C.

2.2. Seed sludge

The seed sludge was taken from a UASB reactor in Xi'an Hans Breweryhouse. The sludge is typically flocculent with MLSS of 22.510 g/L, MLVSS of 8.398 g/L and VSS/SS of 0.37. Thirty liters of the sludge was pumped into the reactor.

2.3. Brewery wastewater

The wastewater discharged from the boiling and fermentation process is approximately 5000 mg COD/L, which is composed of concentrated water from the boiling vessel and washing water. The concentrated wastewater was obtained from Xi'an Hansi Breweryhouse with a chemical oxygen demand (COD) of 22 500–32 500 mg/L, TKN of 320–450 mg/L, TP of 144–216 mg/L, volatile suspended solids (VSS) of 1400–4800 mg/L, and pH of 3.2–3.9, and was diluted to required strength with potable water as that discharged before feeding. NaHCO_3 was added to adjust the influent pH in the range of 6–7.

2.4. ASBR operation

The ASBR was started with an organic loading rate (OLR) of 1.0 kg COD/m³ d, then the organic loading rate increased step by step to guarantee a low COD effluent. The batch cycle was controlled in 8 h during which 1 h was used for feeding, 6.35 h for reacting, 0.5 h for settling and 0.15 h for decanting. Fifteen liters of supernatant water was decanted per cycle, which provided a hydraulic retention time (HRT) of 24 h. When COD in the effluent was kept in stable, samples were obtained to evaluate the reactor performance.

2.5. Analytical methods

COD, pH, suspended solids (SS), alkalinity, mixed liquor suspended solids (MLSS) and mixed liquor volatile suspended solids (MLVSS) were analyzed according to the standard methods. The volatile fatty acids (VFA) were measured using a gas chromatograph (THERMO-FINNGAN GC2000) equipped with a capillary column (DB-FFAP, 0.32 mm × 30 m) and flame ionization detector (FID). Injector and detector temperatures were 230 and 250 °C, respectively. The temperature of the oven was programmed to rise from 100 to 200 °C during the analysis with an elevation of 10 °C/min. Nitrogen gas (flow rate: 1.0 mL/min) was used as a carrier. The sludge specific methanogenic activities (SMAs) for formate, acetate, propionate and butyrate were determined at 35 °C using serum bottles test (280 mL) with 250 mL basal medium supplemented with 2–4 gVSS/L sludge taken from the reactor and 1.2 g COD/L of formate, acetate, propionate and butyrate respectively.

3. Results and discussion

3.1. Chemical oxygen demand removal

The experiment lasted for 250 days. The time courses of COD in influent and effluent and organic loading rate (OLR) are shown in Fig. 1. It can be seen that the reactor worked very well. During start-up period, COD concentration in the effluent was kept in less than 300 mg/L even OLR was increased quickly to 3.0 kg COD/m³ d. Correspondingly, COD removal efficiency was more than 90%, and significant gas production was observed. On the 53rd day, OLR in the reactor reached to 5.0 kg COD/m³ d and COD removal efficiency maintained in the same level. Although there was significant fluctuation on organic loading rate in the following experiment, the COD removal efficiency stabilized and a very low effluent COD was obtained.

Compared with other reactors treating the same type of wastewater, OLR in ASBR was relatively low. Baloch et al. (2007) obtained an OLR of 2.16–13.38 kg COD/m³ d and a COD removal of 93–96% in a GRABBR reactor. Parawira

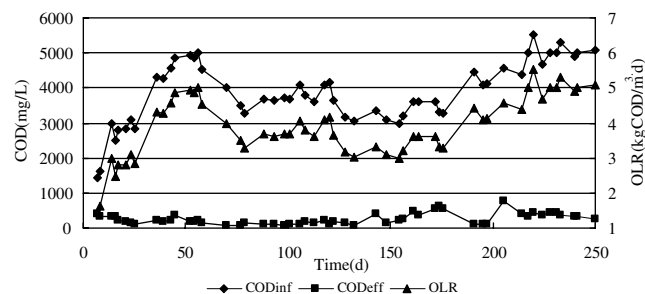


Fig. 1. Variation of COD_{inf} , COD_{eff} and volume loading rate (OLR) during the experiment.

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