TREATMENT OF SOFT DRINK INDUSTRY WASTEWATER USING ANAEROBIC BAFFLE REACTOR

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ABSTRACT

The anaerobic baffled reactor (ABR) with six anaerobic compartments was conducted to investigate the treatment efficiency of wastewater from soft drink industry. The 15 litres working volume of ABR was acclimatized with granular sludge from upflow anaerobic sludge blanket (UASB) that operating for cassava wastewater treatment plant. The mixed liquor volatile suspended solid (MLVSS) concentration of seed sludge was 4,000 mg MLVSS/l. The ABR system was operated for 36 days under continuous flow rate of 5.21 ml/min, hydraulic retention time (HRT) of 48 hours. The loading of the influent chemical oxygen demand (COD) was maintained at 6.75 g COD/day (900 mg COD/l of ABR). The results indicated that organic removal efficiency of the wastewater treatment increased with the increase in the number of ABR compartment. The highest COD removal efficiency was 35.75% (2.41 g COD/day), which occurred in the first compartment: and also the efficiency for the effluent was 86.58%. This ABR system was achieved removal efficiency for color and suspended solids (SS) 77.63% and 73.41%, respectively. Average pH and temperature in the effluent remained 6.8 and 27.8°C, respectively. The result shows the volatile fatty acid (VFA) concentration of effluent was 384.57 mg/l and effluent alkalinity (Alk) was 2,715 mg/l, resulting in VFA/Alk ratio of approximately 0.14. The biogas production (17.67 ml/day) was presented fraction of 72.86% of methane. Observations from this study suggested that the ABR with 4 compartments was efficient technology appropriate for soft drink industry wastewater and was also capable of sustaining more organic loading.

KEYWORDS: Anaerobic baffled reactor; biogas production; soft drink; wastewater treatment

1. INTRODUCTION

Soft drink manufacturing process generates effluents that contain a moderate to high organic strength, most of which is easily biodegradable. (Namaghia and Mousavi, 2014; Vergine et al., 2015) The COD of soft drink wastewater (SDW) depends mainly on the specific production process and is usually in the range of 1-10 gO_2/l. In some cases, higher COD values (up to 30 gO_2/l or more) are observed (Kalyuzhnyi et al, 1997).

Several anaerobic technologies have been successfully used for SDW treatment (Kalyuzhnyi et al, 1997; Redzwan and Banks, 2010). The ABR performs well in treating medium and high COD strength of soluble wastewater at mesophilic temperatures (Nachaiyasit and Stuckey, 1997; Vinitnantharat et al., 2011), with COD removal efficiencies of more than 95% (Barber and Stuckey, 1999). The advantage of such a compartmentalized reactor is the partial separation of acidogenic and methanogenic processes, its stability to hydraulic shocks, and its ability to separate the liquid (hydraulic retention times, HRT) and solid retention times (SRT) (Grobicki and Stuckey, 1991). According to its high carbohydrate content (Peixoto et al, 2011; Isla et al, 2013), the use of SDW may as suitable substrate for acidogenic fermentation, i.e., the conversion of organic compounds into volatile fatty acids (VFA) through the hydrolytic and acidogenic stages of the anaerobic process. Therefore, the feasibility of the ABR system is needed to assess wastewater treatment from soft drink industry. Hence, the aim of this research was to evaluate the performance of anaerobic baffled reactors in treating soft drink industry wastewater at 6.75 g COD/day (900 mg COD/l of ABR) at different compartment (1, 2, 3, 4, 5, 6 and effluent), and to determine soft drink industry wastewater and biogas production.

2. MATERIAL AND METHODS

2.1 Microorganisms

The seed granulated anaerobic sludge from the UASB treatment plant of cassava starch wastewater was used in this study. The sludge was acclimatizing by using soft drink industry wastewater.

2.2 Wastewater

The soft drink industry wastewater was obtained from ThaiNamthip Co., Ltd., Nakhon Ratchasima province. The loading of the influent chemical oxygen demand (COD) was maintained at 6.75 g COD/day (900 mg COD/l of ABR). The pH was adjusted to 7.00 ± 0.02. by NaOH and H_2SO_4

2.3 Reactor Start-up and Operation

The ABR laboratory-scale reactor consists of six compartments was set up at room temperature. The schematic of the ABR setup is shown in Figure 1. The seed sludge, containing MLVSS 4,000 mg/L, was inoculated into the ABR reactor with effective volume of 15 L. The pH of soft drink industry wastewater was adjusted to 7.00 ± 0.02 by NaOH and H_2SO_4. The COD loading to the reactor was maintained at 6.75 g COD/day (900 mg COD/l of ABR). Starting up of the system was fed continuously into the reactors with soft drink industry wastewater at the flow rate of 5.21 ml/min (7.5 L/day), and operated at hydraulic retention time (HRT) of 48 hours for 36 days.

2.4 Analytical Procedure

The soluble chemical oxygen demand (COD) and suspended solids (SS) concentrations were analyzed as described in the standard methods (APHA, AWWA and WPCF, 1998), while the pH was measured using pH meter type Sension 378. Color was determined absorbance by the UV-VIS spectrophotometer (Genesys 10 series) at wavelengths at 400 nm. The alkalinity (Alk) and volatile fatty acid (VFA) were measured simultaneously according to direct titrimetric method. The amounts of the composition of the biogas including CH_4, CO_2 and N_2 were determined by a gas chromatograph (GC- 2014) and biogas production was measured by the rise of the floating gas holders out of the water.

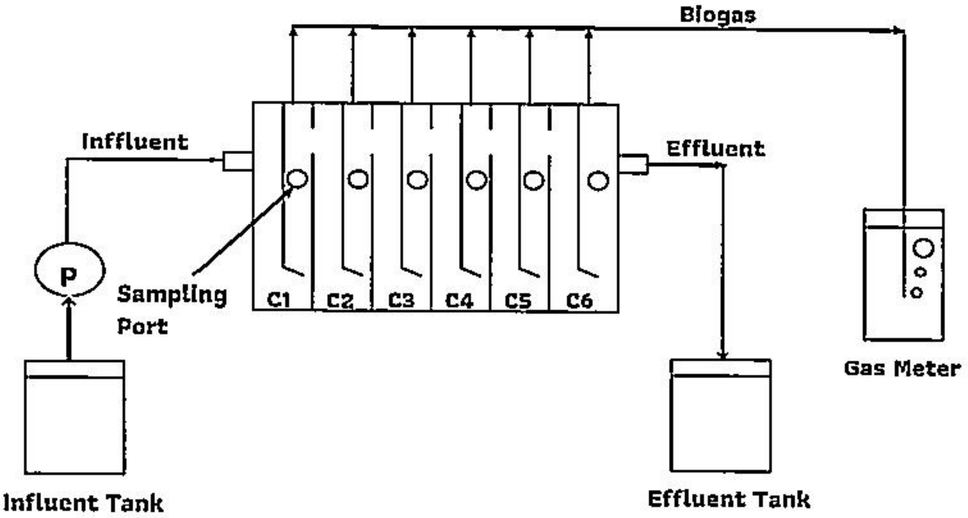

Figure 1. Schematic diagram of the ABR.

2.4 Statistical analysis

All results in this research were subjected to variance analysis of Varian (ANOVA) and compared with the average by Least Significance Difference (LSD) at different level of 0.05 ($P < 0.05$).

3. RESULTS AND DISCUSSION

3.1 Organic Removal Performance

Figure 2 presents the steady state COD removal efficiencies of ABR for 36 days. The accumulated COD removal of ABR increased from first compartment through to sixth compartment and effluent. Effluent accumulated COD removal of ABR at steady state was 86.58% (5.85 g COD/day). 35.75% COD reduction (2.41 g COD/day) was observed in first compartment of ABR that similar result was obtained by Vinitnantharat et al. (2011). More and more COD removal took place in later compartment and gradually up to 80.74% (5.45 g COD/day) in sixth compartment.

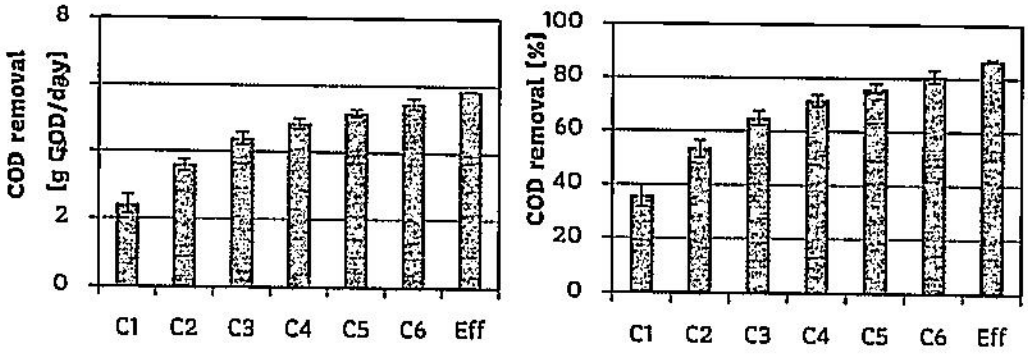

Figure 2. The COD removal of ABR compartments at 36 days.

The color removal of ABR compartments at 36 days are shown in Figure 3. It is seen that the color removal of ABR increased from first compartment through to sixth compartment and effluent. The accumulated color removal at 36 days in compartment 1, 2, 3, 4, 5, 6 and effluent were 36.84, 43.42, 49.34, 69.08, 69.08, 69.73 and 77.63 %, respectively. The reduction of color has been also reported that this preference may be explained by anaerobic degradation [Carliell et al., 1995; Laowansiri et al, 2008]. This result indicated that the color removal was 35.75% in first compartment [Vinitnantharat et al., 2011], and gradually up to 69.73% color removal was achieved in sixth compartment. Meanwhile, no significant statistical differences ($P<0.05$) in the accumulated color removal were observed between the values for compartment 4, 5 and 6.

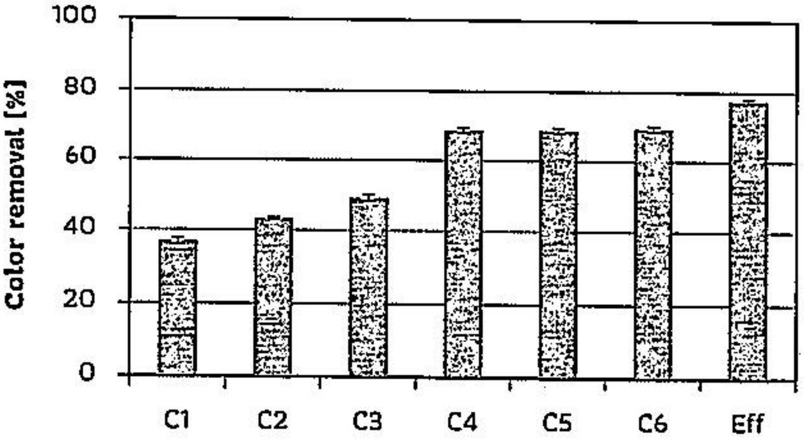

Figure 3. The color removal of ABR compartments at 36 days.

Figure 4 shows the accumulated suspended solids removal efficiencies and temperature of ABR compartments at 36 days. The trendy suspended solids removal of ABR increased from first compartment through to sixth compartment and effluent. The results obtained show a gradual increase of accumulated suspended solids removal from 42.89 to 73.41% in compartment 1, 2, 3, 4, 5, 6 and effluent. The results in Fig. 4 show that the suspended solids removal efficiencies at temperatures between 27- 29 °C were 42.89% in first compartment, and gradually up to 65.32%

in sixth compartment. However, the accumulated suspended solids removal efficiencies were not significant different ($P<0.05$) in compartment 3, 4, 5 and 6. As a result, ABR performed well at HRT of 48 hr and 27.8-29.0 °C that suitable for mesophilic bacteria growth (Langenhoff and and Stuckey, 2000).

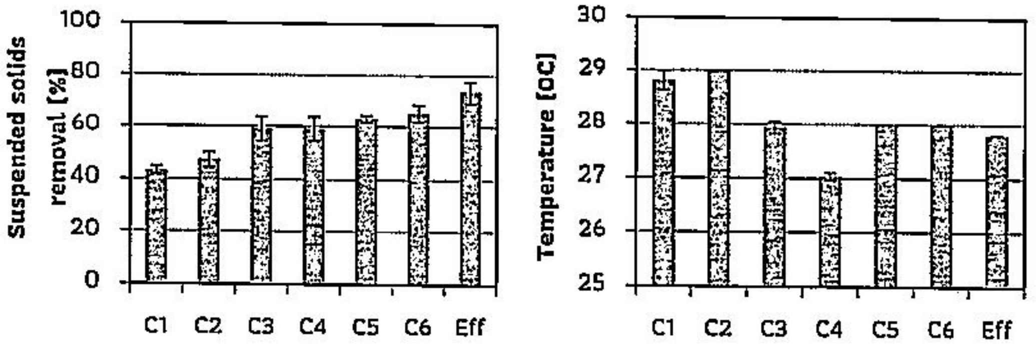

Figure 4. The suspended solids removal and temperature of ABR compartments at 36 days.

3.2 Performance of Anaerobic Baffled Reactor System

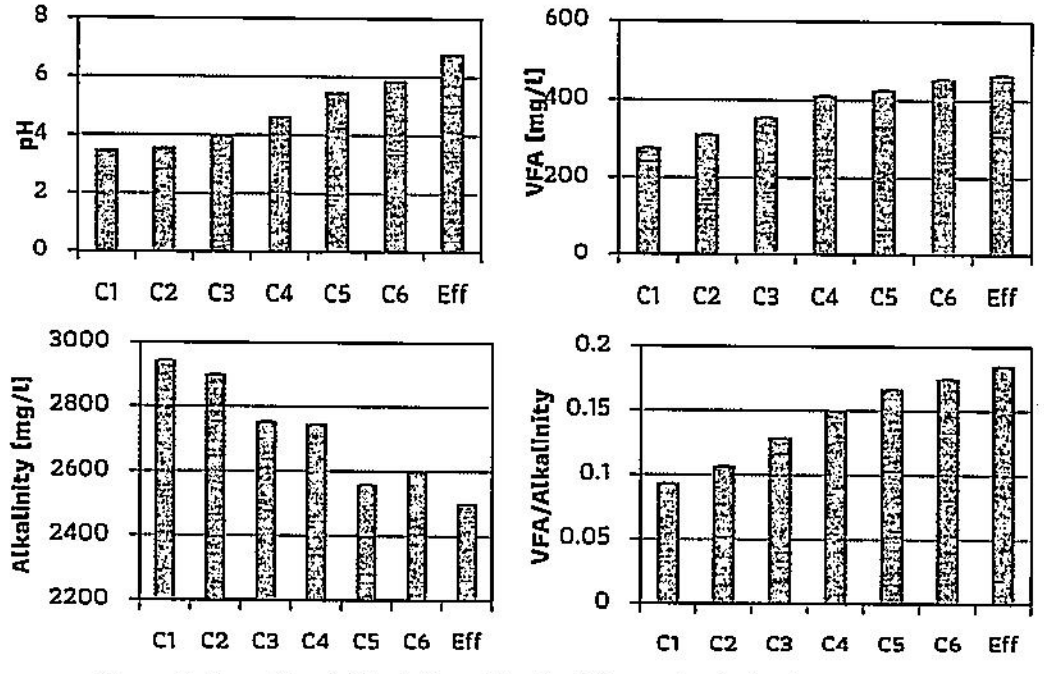

Figure 5. The pH, volatile fatty acid, alkalinity and volatile fatty acid/alkalinity of ABR compartments at 36 days.

The pH, volatile fatty acid (VFA), alkalinity (Alk) and volatile fatty acid/alkalinity of ABR compartments at 36 days are illustrated in Figure 5. The pH levels in the ABR dropped to 3.5 during in first compartment (Vinitnantharat et al., 2011). The pH increased from first compartment through to a maximum pH in last compartment. The pH of the effluent was 6.8. The VFA concentration in the ABR dropped to 275 mg CH_3COOH/l during in first compartment. The VFA concentration increased from first compartment through to a maximum VFA concentration in last compartment. The VFA concentration of the effluent was 463 mg CH_3COOH /l. The alkalinity as calcium carbonate equivalent was also monitored and required about 1000-3000 mg/l for anaerobic digestion[Wilcox et al., 1995]. This was observed that ABR alkalinity was in the range of 2500-2900 mg$CaCO_3$/l of treatment. The present results showed that the trend of alkalinity concentration decreased from first compartment through to a minimum alkalinity concentration in last compartment. The alkalinity concentration of the effluent was 2,500 mg $CaCO_3$/l. Both VFA and alkalinity data supported that the reactor was operating properly [Vergine et al., 2015]. In particular, methanogenesis is become unstable when the ratio value of VFA/Alkalinity was above 0.3 [Lefebvre et al., 2006; Mosquera-Corral et al., 2001]. The VFA/Alkalinity ratio in first compartment through to sixth compartment and effluent of ABR at 36 days ranged between 0.09 and 0.18.

3.3 Methane Production

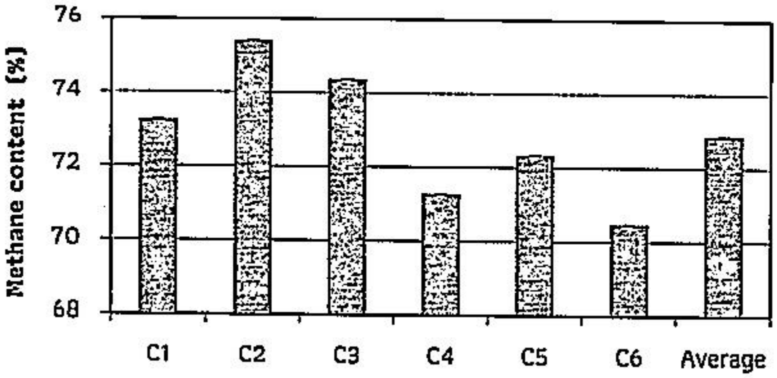

Figure 6. The methane production of ABR compartments at 36 days.

Biogas production of ABR compartments was 17.67 ml/day. The methane productions of ABR compartments at 36 days were investigated as shown Figure 6. The highest methane yield (75.41%) was obtained in second compartment. The average methane content and the average methane production along with these treatments by ABR were 72.86% and 12.87 ml CH_4/day, respectively.

4. CONCLUSIONS

This work presents the investigation of ABR with six anaerobic compartments for soft drink industry wastewater treatment. Organic removal of ABR increased from first compartment through to sixth compartment and effluent. The high removals of 35.75% COD, 36.84% decolorization and 42.89% SS were observed in the first compartment of ABR. The performance of the ABR system was effective in the organic removal and could take place in more organic loading. In addition, the ABR could achieve 17.67 ml/day for biogas production, 72.86% methane content and 12.87 ml CH_4/day, respectively. The results revealed that the ABR with four anaerobic compartments was a potential reactor for treating the soft drink industry wastewater. Furthermore, the good performance of ABR can be employed for operating with more loading of soft drink industry wastewater.

5. ACKNOWLEDGEMENT

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