Impact of HRT and temperature on an anaerobic moving bed biofilm reactor treating brewery wastewater

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Abstract
Three anaerobic moving bed-biofilm reactors (AMBBR) with working volumes of 4 L and filled with 40% by volume of plastic media (specific surface area 680 m^2/m^3) by volume were examined for brewery wastewater treatment. The hydraulic retention time was decreased in steps from 24 to 6 h throughout the study. Results showed that an 18 h retention time was optimal, with more than 85 % removal of total COD at an organic loading rate of 5.4 kg $tCOD/m^3d$. This corresponded to specific surface area removal rate of approximately 18 g $tCOD/m^2d$. Gas yields were from 0.31 to 0.35 m^3 CH_{4prod}/kg $tCOD_{rem}$ (at 35 °C).

Keywords
Hydraulic retention time, anaerobic moving bed-biofilm reactor, brewery wastewater

INTRODUCTION

Several technologies are used to treat brewery wastewater which are either aerobic, anaerobic, or a combination of both. Anaerobic processes applied to industrial wastewater require small volumes and high removal capacities while maintaining a typical solids retention time (SRT) of 25-30 d (Stronach et al., 1986). The minimum SRT required to support the slow growing microorganisms and therefore maintain the methanogenic bacteria in an optimum environment has been estimated as 4d at 35°C without safety factors applied (Lee et al., 2011). For this reason, several reactor configurations are used to enhance biomass retention (e.g., fluidized bed, upflow sludge blanket and moving bed biofilm reactors) and therefore promote the anaerobic digestion pathways. The goal of this study was to develop design parameters for an anaerobic moving bed biofilm (AMBBR) reactor treating brewery wastewater. The main objectives of the study were: 1) determine process performance at different hydraulic retention times (HRT; 24, 18, 12, 8, and 6 h); and 2) evaluate performance at different temperatures (35, 30, 25, and 20 °C).

MATERIAL AND METHODS

Three reactors with working volumes of 4 L in a 35 °C chamber were constructed. Plastic media with specific surface area of 680 m^2/m^3 (AC920 manufactured by Headworks Bio) was used at 40% working volume. Under these conditions two months were required for the start-up and maturation of an anaerobic biofilm (di Biase et al., 2015). Total suspended solids (TSS) and volatile suspended solids (VSS) as well as total and soluble chemical oxygen demand (tCOD; sCOD) in the influent and effluent were analysed. Gas quantification was carried out using leak-proof tubes (Nalgene 180 PVC 0.635 cm ID, 1.5 OD) and mass flowmeters (FMA 4000 digital mass flow meter). Tedlar gasbags were installed to collect and consequently analyse gas composition by gas chromatography. A syphon was used for the effluent discharge and 24, 18, 12, 10, 8, and 6 h as HRT were provided. Before each change in HRT a kinetic test on suspended biomass was performed in 0.5 L flasks. Soluble COD was added as glucose to concentrations in excess of 5 g to ensure half-saturation coefficients were not limiting. During the study the concentration in the influent was kept at an average of 3.8 g sCOD/L and 5.1 g tCOD/L by diluting the brewery's fermenter underflow (150 ± 10 g COD/L). Alkalinity of 1.5-2.0 g $CaCO_3$/L was provided as calcium bicarbonate.

RESULTS AND DISCUSSION

The pH in the feed was between 6.4 and 7.1 while pH and alkalinity in the effluent ranged from 6.6 to 7.3 and 1.3 to 1.6 g $CaCO_3$/L, respectively. The neutrality of the pH along with the alkalinity values in the effluent suggested that the system was stable over the study and provided a suitable environment for methanogens without the risk of acidic conditions due to a greater acidogenic activity.

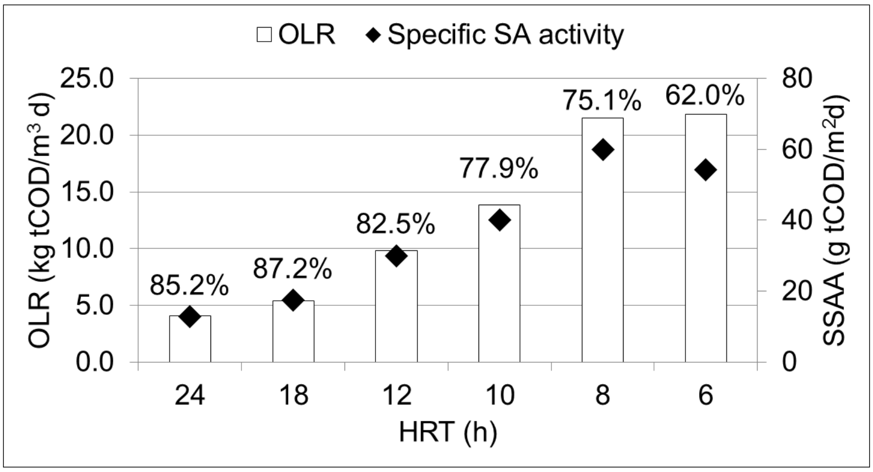

Figure 1 – Averaged organic loading rate (OLR), specific surface area activity (SSAA), and of total COD at each interval of applied HRT.

The average organic loading rate (OLR) was 4.1 kg tCOD/m^3 d at 24 h and 21.8 kg tCOD/m^3 d at 6 h. The removal efficiency was more than 80% when the HRT was greater than or equal to 12 h, while lower levels of HRT resulted in decreased COD removal. The specific surface area activity increased with OLR, however effluent tCOD started to increase when the HRT was less than 18 h. Furthermore, at the lowest HRT of 6 h, a significant loss in performance was observed even though the OLR did not increase significantly. The OLR did not increase as expected since the brewery's fermenter underflow contained less tCOD at that time. Suspended biomass kinetic tests showed an increasing contribution to sCOD removal as the HRT was decreased. In particular, kinetic tests at the 24 h HRT resulted in undistinguishable removal while the suspended biomass was observed to remove 1.70 g $sCOD_{rem}$/d at an HRT of 8 h. This observation was likely due to increased biomass growth and consequently more sloughing off of the anaerobic biofilm at lower levels of HRT.

CONCLUSION

The AMBBR technology was found to be capable of treating brewery wastewater at high removal rates at different hydraulic residence times (HRT) in the reactor. The best performance achieved was at an HRT of 18 h, with removal rates greater than 85 % of total COD. At this HRT the specific surface area removal rate was 18 g tCOD/m^2 d. Total unit methane generation was 0.31 to 0.35 L CH_{4prod}/g $tCOD_{rem}$ with 66 % methane in biogas .

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