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Case Study

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ANAEROBIC SULFATE REDUCTION AND METAL PRECIPITATION IN UPFLOW HYBRID REACTOR: COMPARISON OF SINGLE AND TWO STAGE PROCESSES

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1 Introduction

Biological anaerobic sulfate reduction to sulfide by sulfate reducing bacteria (SRB) is an effective and economically attractive option in removing heavy metals from acid mine drainage (AMD), an acidic and sulfate-rich waste stream produced by the mining industry. The metal removal process can be accomplished either in a single-stage reactor in which the biological sulfate reduction to sulfide and metal precipitation as metal sulfide occur simultaneously, or in a two-stage reactor where it happens sequentially. The single stage process may be expected to be more cost-effective and simpler to operate. However, studies conducted with suspended growth cultures by this group and others suggest that above a certain level of metal loading, the process of sulfate reduction and the corresponding metal precipitation is adversely affected (Shahsavari et al., 2015, Kieu et al., 2011 & Utgikar et al., 2002). Therefore, to make the single stage process more efficient and viable, strategies would need to be developed and tested so that the accumulated precipitates could not affect the process of sulfate reduction by SRB. In this study, a modified up-flow anaerobic hybrid reactor (UAHR) was studied as a single stage process and the results were then compared to those of a two stage process to examine the effectiveness of the UAHR configuration.

2 Materials and Methods

Two identical UAHRs (configuration shown in Figure 1) were inoculated with anenriched culture of SRB developed from a mixture of anaerobic sludges from industrial (ethanol) and municipal wastewater treatment plants in Chatham, Ontario. In the start-up phase, the reactors were operated semi-continuously on a synthetic wastewater (Sodium Sulfate (Na_2SO_4): 4500 mg/L, Dextrose ($C_6H_{12}O_6$):2850 mg/L, Ammonium chloride (NH_4Cl): 1000 mg/l, Potassium phosphate monobasic (KH_2PO_4): 100 mg/L and Potassium phosphate dibasic (K_2HPO_4): 400 mg/L) at an hydraulic retention time (HRT) of 40 days. After establishing a steady state condition, one UAHR was used to represent the single-stage process for which the synthetic wastewater feed was modified to include metal (copper). The other UAHR represented the first stage of the two-stage process and the feed. Batch precipitation experiments were conducted with a synthetic copper solution with the effluent from this reactor to represent the second-stage of the two-stage process. The performance of the two processes was compared over different hydraulic, organic, and sulfate loading rates by varying the HRT between 40 and 2.5 days at a temperature of 33±3°C. The parameters such as pH, Oxidation Reduction Potential (ORP), total organic carbon (TOC), sulfate and sulfide concentration were measured according to standard methods (APHA, 2005). The volatile fatty acids (VFA) and alkalinity were determined following the methods suggested by

Dilallo et al.(1961). The solids inventory in both reactors were also carried out at the end of the reactor operation.

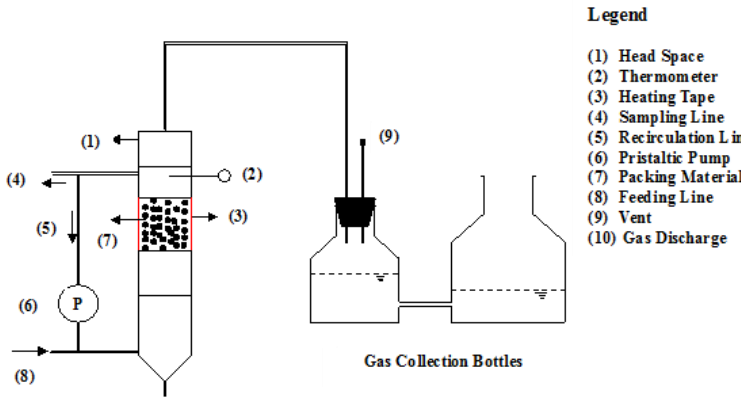

Figure 1: Schematic of UAHR Configuration

3 Results

Close to complete sulfate removal was achieved in both reactors at HRT level as low as 10 days. The sulfate removal efficiencies decreased with decrease in HRT to 5 and 2.5 days but were stil similar at around 79% in both reactors However, the rate of copper removal were different. The rate of copper removal in the single stage process was found to reach upto 625 mg/L/d, which is approximately two times of that of the two stage process. In previous studies with single-stage suspended growth systems, sulfate reduction was shown to be inihibited by metal precipitates formed (Shahsavari et al., 2015, Kieu et al., 2011 & Utgikar et al., 2002). The results from the current study show that the proposed UAHR configuration was successful in overcoming the inhibition of SRB by the metal precipitates. The solids inventory inside single stage reactor showed > 99% of precipitated copper in the bottom third of the reactor. It is postulated that the improved performance of the single-stage process in the current study is due to the SRB present in the upper section of the UAHR reactor that did not suffer from the inhibitory effects of metal precipitates.

4 Conclusion

The results show that both sulfate reduction and copper precipitation in the single stage process were similar to or better than the two-stage process over the entire duration of the study.

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