Optimisation of a floating sulphur biofilm reactor in a passive acid mine drainage treatment system

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Abstract

Acid Mine Drainage (AMD) is a significant problem associated with the commercial exploitation of sulphidic minerals. Passive remediation systems are an attractive alternative, particularly for AMD from dispersed sources such as waste rock dumps and coal spoils. The Integrated managed passive treatment (IMPI) system consists of a Degrading packed bed sulphate reduction Reactor (DPBR) and a Linear flow channel reactor (LFCR), where hydrogen sulphide is converted to sulphur via a floating sulphur biofilm (FSB). A full sulphur species material balance was conducted in order to characterize the rate of sulphate reduction (DPBR) and sulphide oxidation within the LFCR. Furthermore, a carbon balance was performed across the integrated system. The performance of the DPBR was monitored from start-up to steady state for 6 months. The chemical oxygen demand of each organic packing component was analysed as well as the rate of dissolved organic carbon release. The initial release of volatile fatty acids (VFAs) was high. However, there was a subsequent rapid decrease in the rate of VFA production. The release of organic carbon in the form of VFAs was identified as a key parameter in the performance of the subsequent LFCR unit. Sufficient dissolved organic carbon in the LFCR feed is a prerequisite for a robust FSB. The reactor was able to achieve an 80%, 84% and 85% conversion of hydrogen sulphide, resulting in a removal rate of 130 mg/L/day. The LFCR was run at a hydraulic residence time of 0.5, 1 and 2 days respectively. Of the sulphur generated, 85% and 88% reported to the biofilm for the 1 and 2 day residence times respectively. It was identified that the rate of acetate utilization was approximately 0.25 g/L/day with a greater proportion being consumed at reactor startup. The elemental composition of the biofilm was analysed, revealing that the film was composed of sulphur (84%), carbon (10.3%), inorganics and heavy metals (5.7%). Scanning electron microscopy was used to observe biofilm structure and assess how this was affected by changes in operating conditions. The biofilm acts as a barrier to oxygen mass transfer, preventing excess oxygen from reaching the reactive zone, thus ensuring only partial oxidation of sulphide to sulphur. The mass transport within the biofilm was characterised using microprobe analysis and a mass transfer profiling system. The mixed microbial population was also characterized within the system, in order to better understand the dynamics between the sulphate reducing and sulphide oxidizing bacterial populations.

Keywords: acid mine drainage, passive, biofilm, volatile fatty acids