

Development of the floating sulphur biofilm reactor for sulphide oxidation in biological water treatment systems

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Abstract

The formation of floating sulphur biofilm was observed in the microbial ecology studies of tannery ponds undertaken by the Environmental Biotechnology Group at Rhodes University. This was related to the steep Redox gradients established at the air/water interface of anaerobic, organically loaded and actively sulphate reducing systems. This study investigated the potential for applying these observations in developing a floating sulphur biofilm reactor for the removal of sulphide from sulphide-rich effluents produced in wastewater treatment systems. This was carried out in five sequential experimental phases. Where original studies had been undertaken using sulphide-rich water derived from sewage sludge as the carbon source, the successful establishment of a floating sulphur biofilm from effluent of lignocellulose-derived wastewaters had been shown.

The effect of influent sulphide concentrations, flow rate and reactor dimensions on the sulphur biofilm formation were investigated for the optimisation of elemental sulphur recovery and sulphide removal efficiency. Polysulphide formation was enhanced by inserting a silicone tube rack and resulted in increased elemental sulphur recovery. Sulphide removal efficiency of 65% and a sulphur recovery of 85% were obtained at the end of the investigation while inter-harvest recovery period of the biofilm was reduced from an initial 4-5 days to 6-12 hours.

Introduction

Biological sulphur cycle in the treatment of high sulphate wastewaters relies on the activity of sulphate reducing bacteria (SRB), which, in the presence of organic compounds such as carbon and an electron donor source, will reduce the sulphate to sulphide (Jorgensen, 1982; Gilfillan, 2000; Bowker, 2002; Rein, 2002; Pulles Howard and de Lange Inc., 2002; Molwantwa et al., 2003; Dunn, 1998; Rose, 2002). However, sulphide is a toxic by-product, which can be removed from the treated wastewater either as a metal sulphide or in its oxidised form as elemental sulphur removed as a suspended solid.

Biological oxidation of sulphide in natural environments has been noted without the chemical parameters and bacterial populations present in these natural systems being well documented (Jorgensen, 1982; Gilfillan, 2000; Bowker, 2002). Although the formation of elemental sulphur in floating sulphur biofilm which form under various conditions in nature has been noted, little work has been carried out on the potential biotechnological applications of such systems (Gilfillan, 2000; Bowker, 2002; Rein, 2002). The development of a reliable technology for sulphur recovery under heterotrophic conditions would increase the choice of possible carbon sources and especially waste carbon sources for biotechnological sulphate reduction (Rein, 2002; Rose, 2002). A process that can produce large amounts of elemental sulphur from sulphide under heterotrophic conditions would contribute significantly to the development of an integrated biological sulphate removal process to treat the large volumes of AMD that

are predicted to occur in South Africa (Pulles Howard and de Lange Inc., 2002; Molwantwa et al., 2003; Rose, 2002).

In an attempt to develop a biotechnological sulphide oxidising process, the Environmental Biotechnology Group (EBG) studied the chemical parameters of abiotic and biotic sulphide classical flask experiments (Bowker, 2002; Rein, 2002). The results of these studies suggested that the presence of an organic carbon source and a heterotrophic bacterial population were able to decrease oxygen concentrations thereby favouring biological sulphide oxidation and the subsequent formation of elemental sulphur a product (Bowker, 2002; Rein, 2002). Results of these studies also suggested that the overall oxygen supply rate was a key parameter in determining the major product of microbial sulphide oxidation under heterotrophic conditions (Rein, 2002). After the observation of a sulphur biofilm forming on the surface of tannery ponds in Wellington (Dunn, 1998), further research was done on the fundamental microbiology and structure of the sulphur biofilm (Gilfillan, 2000; Bowker, 2002).

A major fundamental research effort on biological sulphide oxidation mechanisms and processes has been undertaken by the EBG with input from Pulles Howard and de Lange Inc. (PHD). This project was funded by the Department of Arts Culture Science and Technology (DACST), and has resulted in the development of a basic sulphide oxidation technology that would serve to remove sulphides formed during the biological reduction of sulphate from wastewater (Rein, 2002; Pulles Howard and de Lange Inc., 2002). A sulphide oxidising bioreactor (SOBR) was developed for the operation of the process.

Objectives

The objectives of the project were:

- Evaluate and refine a previously developed sulphide oxidation process that can be incorporated into both passive and active sulphate removal technologies.

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