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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Mine-water treatment

Towards passive treatment solutions for the oxidation of sulphide and subsequent sulphur removal from acid mine-water

Mine-water pollution remains one of South Africa's most critical water-pollution challenges. A WRC-funded study investigated passive treatment solutions for the oxidation of sulphide and subsequent sulphur removal from acid mine-water.

Sulphide removal from mine-water

Sulphide can be biologically oxidised under anaerobic conditions by photosynthetic bacteria and denitrifying organisms and in the presence of oxygen by colourless sulphur bacteria. These organisms have the potential to remove sulphide in passive acid rock drainage (ARD) treatment systems, such as the integrated managed passive (IMPI) treatment system, where sulphide oxidation is facilitated by a floating sulphur biofilm (FSB) in the linear flow channel reactor (LFCR).

Demonstration scale plant

A scaled-up version of the LFCR was included in a demonstration scale plant, based on the IMPI process, which has been constructed on the Middelburg mine site. However, the LFCR was not sufficiently robust and still required additional optimisation of design and operational parameters. The fundamental microbiology and chemistry of biological sulphide oxidation are relatively well understood, but the integration of this information with fundamental engineering principles in the context of a treatment system, particularly the LFCR required further work and underlies the rationale behind this project.

Laboratory scale

Laboratory-scale LFCR reactors were constructed at the University of Cape Town (UCT) and Golder Associates Research Laboratories (GARL). These reactors were used to characterise the hydrodynamics using tracer studies and assess the effect of sulphide loading and hydraulic residence time on sulphide oxidation performance. Analytical techniques to quantify intermediate reduced sulphur species were optimised and allowed the sulphur mass balance across the LFCR.

Refined conceptual model

Molecular biology techniques were used to characterise the microbial populations in the bulk phase and FSB. The data were used to inform a refined conceptual model to describe biological sulphide oxidation in the FSB. The information was used to suggest modifications to and improvements in the management of the demonstration plant.

Efficient operation of the LFCR

This depends on rapid biofilm development, is facilitated by heterotrophic organisms rapidly converting dissolved organic carbon to extracellular polymers, which support the sulphide oxidisers and the sulphur product. The biofilm bars oxygen mass transfer, which allows the creation of a reaction space within the FSB where the pH and redox conditions are conducive to partial oxidation of sulphide. Sulphide must be delivered to the reaction space consistently. This is dependent on the hydrodynamic flow and the relative density of the feed and bulk liquid. The density of the bulk must be lower than that of the sulphide in the feed.

Significant contributions

The research at GARL and UCT has helped in the fundamental understanding of the system, which has led to several recommendations to be implemented at the demonstration plant:

- Reconfiguration of the baffles in the LFCR to force the fluid flow over the top, rather than under the baffle.
- Raise the outlet point at the end of the channel to just below the liquid level.
- The effect of density on the hydraulic flow is difficult to manage as it is dependent of the DPBR performance, however, the relationship between feed and bulk solution density is now better understood.
- Review of the harvesting strategy and skimming the biofilm off the surface would prevent accumulated sulphur on the bottom of the reactor reacting with incoming sulphide to form polysulphides.
- The demonstration plant showed consistently low COD and the absence of residual VFAs, indicating that the system was carbon limited. If controlled molasses dosing does not stimulate carbon release it may be necessary to re-evaluate the materials and relative proportions.

Uncertainties and implications

This research has highlighted areas where further work could add significant value:

- The effect of temperature on the kinetics of sulphide oxidation in the FSB has not been quantified and would provide valuable information.
- The FSB harvesting strategy can be further improved.
- The relationship between biofilm structure and thickness and oxygen mass transfer limitation needs to be quantified as does the rate of sulphide diffusion through the biofilm.
- The relationship between dissolved organic carbon load and rate of biofilm generation needs to be better understood. The provision of sufficient organic carbon appears to be a particular challenge for the Middelburg demonstration plant, so information on the minimum organic carbon load required to ensure rapid FSB formation would be particularly valuable in this case.

Further reading:
To obtain the report, ***Towards passive treatment solutions for the oxidation of sulphide and subsequent sulphur removal from acid mine water*** (**Report No. 1834/1/12**)*)*, contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.