Focus on CSIR Research in Pollution and Waste

CSIR Natural Resources and the Environment
2007

High sulphide concentrations tolerated by sulphate reducing bacteria

Background

Acid mine drainage (AMD) is a common result of mining activities caused by bacterial oxidation of sulphide minerals (pyrite) that results in sulphate rich waste water.

AMD can be treated biologically in the presence of sulphate reducing bacteria (SRB) and organic matter such as ethanol. During this process hydrogen sulphide (H_2S) is formed, which can have toxic effects on the methanogenic activity (Koster *et al.*, 1986) as well as on the sulphidogenic bacteria (Okabe *et al.*, 1995). Lens & Hulshoff Pol (2000) showed that at neutral pH values, free H_2S (which is more toxic than HS^-), accounts for 50% of total dissolved sulphide, whereas at pH 8 it is only around 10%.

$$C_2H_5OH + SO_4^{2-} \longrightarrow HS^- + 2CH_3COO^- + H^+ + H_2O$$

Aim of study

The CSIR conducted a study to demonstrate that high sulphide concentrations (>500 mg/ℓ) can maintain the biological SO_4 reduction process.

Materials and methods

Feed Water

The feed water to the reactor consisted of AMD which was supplemented with macronutrients (25 mg/ℓ ammonia-N and 5 mg/ℓ PO4-P and 3 mg/ℓ Fe). Initially, Sodium bicarbonate was added to maintain a pH of higher than 7.0. This procedure was terminated once sufficient alkalinity was generated from sulphate reduction.

Reactor System

The CSIR-o-sure demo plant (Vol.: 100 m³) consisted of a fibreglass cylindrical reactor with a cone shaped clarifier build inside (Fig 1 and 2) was operated at Navigation Mine, Witbank, SA at ambient temperature.

Biomass

The reactor was seeded with anaerobic digester sludge, obtained from the Sewage Works, Pretoria

Carbon and Energy source

The carbon and energy source added to the feed water was a mixture of ethanol (1.5 mℓ ethanol/ℓ feed) and sugar (0.25 g sugar/ℓ feed).

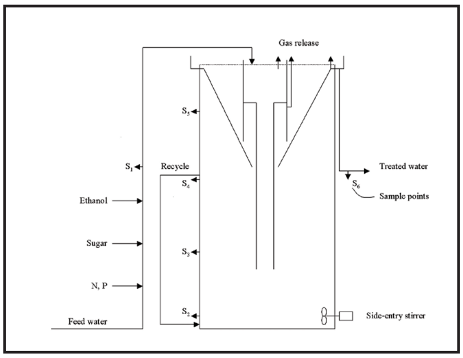

Figure 1 and 2: Completely mixed single stage reactor

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Results and discussion

Continuous operation

When sulphate reduction was efficient, high levels of sulphide (>600 mg/ℓ) were produced (Figure 3). At these high sulphide concentrations, SO_4 removal continued, indicating that the SRB were not inhibited by the high sulphide levels. This result is contrary to findings of other investigators who found that sulphate reduction is inhibited by sulphide concentrations higher than 500 mg/ℓ. However, most of those studies were operated at a reactor pH of 6.5-7.0 whereas the reactor pH in this study was maintained at an average pH of 7.5 (Figure 4). Sulphide toxicity is strongly dependent on pH. Molecular H_2S has been found to be the major toxic form of sulphide because H_2S can pass through the lipid cell membrane into the cytoplasm (Speece 1996). At pH 8 most of the total sulphide is in the HS^- form.

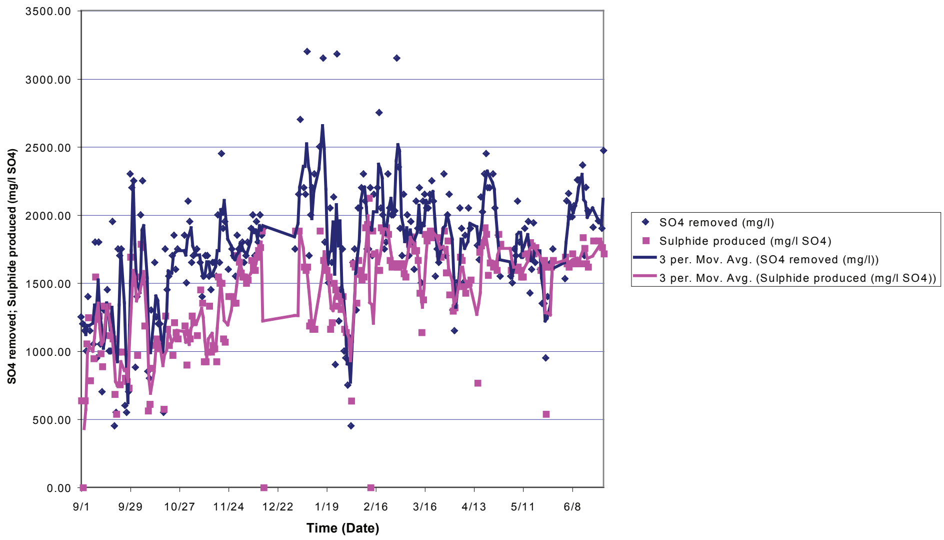

Figure 3: The process stability of reactor system

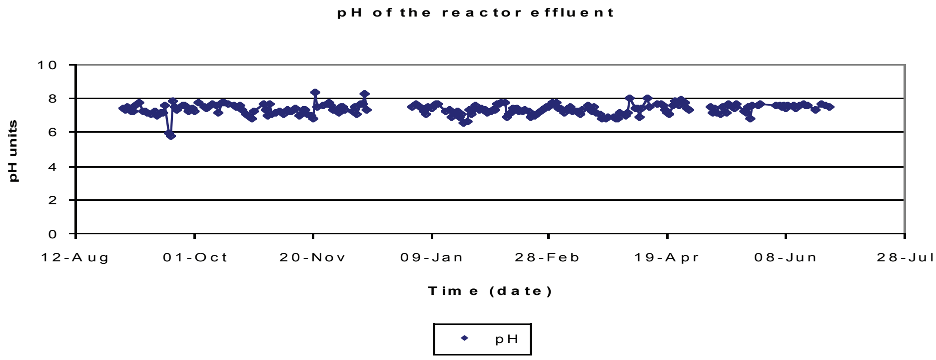

Figure 4: The pH in the reactor effluent

Batch studies

The results of the batch studies showed that the specific SO_4 reduction rate increased from 2.3 to 3.4 and to 4.9 g SO_4 (L/d) when the sulphide concentration increased from 132 to 644 and to 1424 mg/L. These results showed that a high sulphide concentration in the reactor was actually beneficial for the biological SO_4 reduction. This finding can be ascribed to the low reduction/oxidation potential and the higher pH values in the reactor. It was observed however that under these conditions the volatile suspended solids (VSS) values decreased, which is in accordance with the study of Okabe *et al.*, (1992) and Weijma (2000), which showed that when the sulphide concentration increased the cell size decreased (*Desulfovibrio desulfuricans*).

Conclusions

- Stable reactor performance: removal of 12 g SO_4/(ℓ.d) at HRT of 5.1 h;
- Good sulphate reduction and a high sulphide production;
- Low redox potential and high pH values, conditions conducive for improved sulphate reduction;
- Reactor biomass (VSS) decreased when only ethanol as C+E source;
- Therefore mixture of sugar and ethanol as C+E source advisable.

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