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Grass-cellulose as energy source for biological sulphate removal from acid mine effluents

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INTRODUCTION

The biological sulphate removal technology requires carbon and energy sources to reduce sulphate to sulphide. Plant biomass, e.g. grass, is a sustainable source of energy when cellulose is utilised during anaerobic degradation, producing volatile fatty acid (VFA) and hydrogen (H_2). This process involves cellulose utilising microorganisms, present in the guts of ruminants (**Figure 1**).

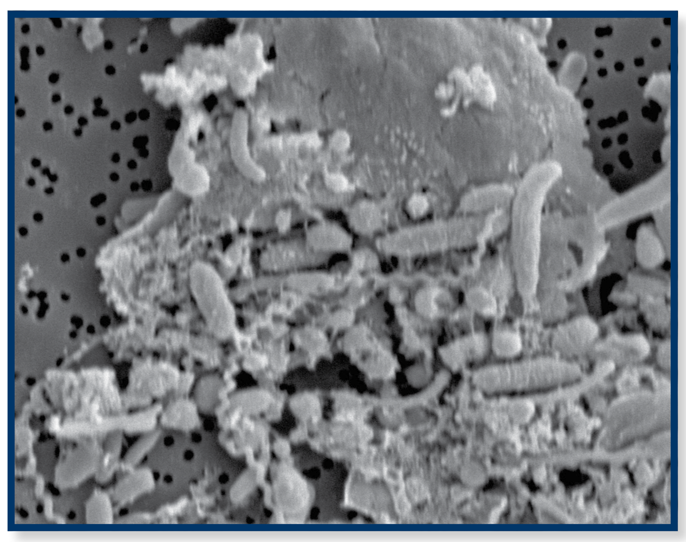


Figure 1: The rumen fluid of ruminants contain many microorganisms that can degrade grass-cellulose to VFA and H_2

Objective

To investigate whether sustained biological sulphate removal can be achieved, operating a continuously fed hybrid reactor at 25°C, treating sulphate-rich synthetic and pre-treated mine water, using the degradation products of grass-cellulose as the carbon and energy sources.

MATERIALS AND METHODS

Feed water

Initially, synthetic sulphate-rich feed water was used (2.5 g/l, Na_2SO_4), which later changed to pre-treated, sulphate-rich mine water, consisting of one part acid mine drainage (AMD) and one part reactor effluent after biological sulphate reduction. Due to the acidic and metal-rich character of the mine water, it was pre-treated with the alkalinity- and sulphide-rich effluent of the biological reactor in a 1:1 ratio, to increase the pH and to precipitate the metals as metal-sulphides. The feed water entered the fermentation reactor (FR) at the top to get into contact with the grass cuttings. A recycle stream (60 l/d) was installed from the fermentation part of the reactor to the top of the reactor for mixing purposes. The effluent left FR at the bottom (**Figure 2**).

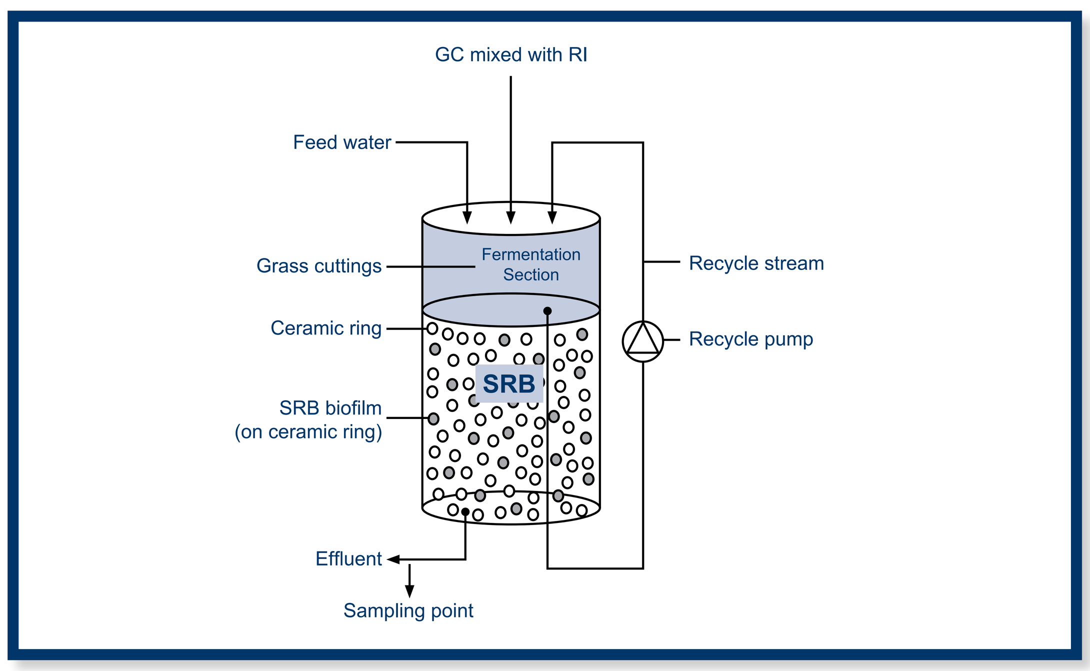


Figure 2: Schematic overview of FR

Figure 3: Laboratory scale hybrid reactor system FR

Reactor system and biomass

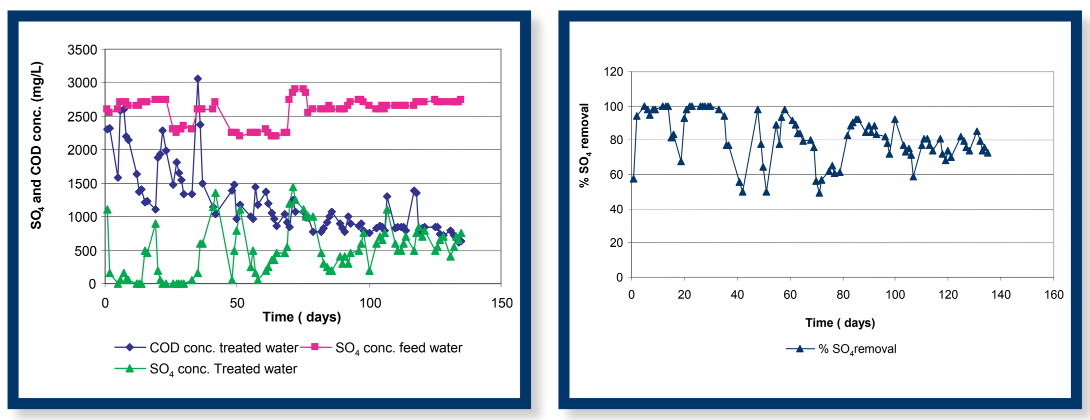
A 20 l perspex one stage anaerobic hybrid reactor system operating at 25°C, consisting of a fermentation (FR) and a sulphate removal section (SR) was used (**Figures 2** and **3**). The bottom part contained ceramic rings as packing material. A mixture of sulphate removing bacteria (250 ml) formed a biofilm on the ceramic rings. The top part of the reactor contained grass cuttings, to which rumen fluid, containing a cellulose degrading microbial population, was added. The pH of the reactor was maintained at 6.6-6.9.

Experimental

The study consisted of three experimental periods, both when feeding synthetic and pre-treated feed water, determined by the addition of GC and microorganisms. Weekly grass-cuttings were added (150 g) to maintain a high chemical oxygen demand (COD) concentration in the reactor.

RESULTS

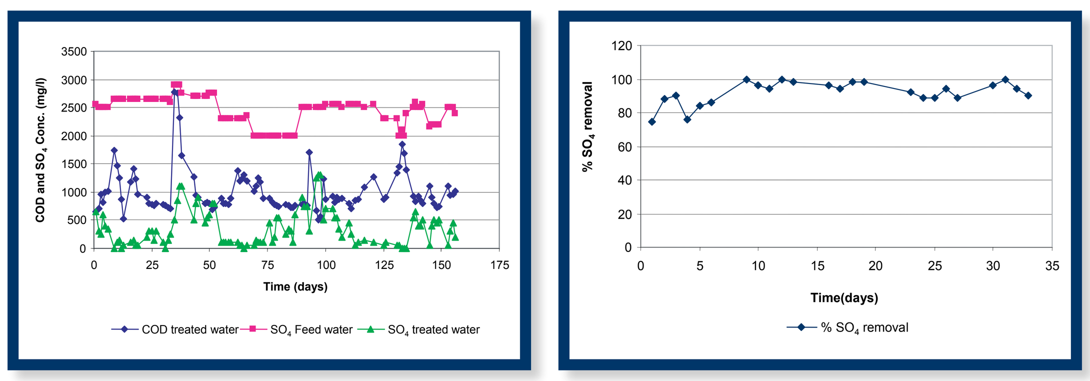
Operation of fermentation reactor in continuous mode at 25°C feeding synthetic feed water



Figures 4 and 5: SO_4 and COD concentrations in the feed and in the treated water of FR, feeding synthetic feed water and the % SO_4 removal (82%)

The relationship between the COD and SO_4 concentrations in the reactor can be observed from **Figure 4**: When the COD concentration was high, the sulphate concentration was low. Thus it is important to maintain a high reactor COD concentration, achieved by adding cut grass and by a healthy cellulose degrading microbe population.

Operation of HFS in continuous mode at 25°C feeding pre-treated mine water



Figures 6 and 7: SO_4 and COD concentrations in the feed and in the treated water of FR, feeding pre-treated mine water and the % SO_4 removal (86%)

Table 1: shows a comparison between the two feed protocols

Reactor parameters	Synthetic feed water	Pre-treated AMD
SO_4 removed g/d	12.1	10.4
SO_4 removed (%)	82	86
Acetate (mg/L)	108	70
Propionate (mg/L)	21	14
Butyrate (mg/L)	11	11
g SO_4 removed/1 g grass	0.41	0.49
Redox potential (mV)	-165	-168
Iron (mg/L)		0.3
Zn		<0.04

CONCLUSIONS

- SO_4 removal obtained at 25°C: achieving 82% and 86% removal efficiency when treating synthetic water and AMD, respectively
- Noticeable relationship between high reactor COD concentration and efficient sulphate removal
- High reactor COD concentration maintained by weekly addition grass cuttings and healthy fermentation microbial population
- Degradation products of grass cuttings (propionate and butyrate) function as the carbon and energy source for continuous biological sulphate removal, producing acetate
- Feeding synthetic feed and pre-treated AMD, 1 gram grass removed 0.41 and 0.49 gram SO_4, respectively
- Metal removal, e.g. Fe and Zn observed in treated AMD
- Technology ready to be demonstrated.

Researchers at the CSIR successfully treated acid mine drainage, using the degradation products of grass-cellulose as ammunition for the sulphate removing bacteria, which then could reduce sulphate, often a major pollutant in mine effluents.

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