Passive treatment of mine drainage using sulphate-reducing bacteria: a field experiment

Nicolette Stanley
Department of Geology, University of New Brunswick, Fredericton, New Brunswick, E3B 5A3, Canada

The research was based at the Mount Pleasant Mine site in southern New Brunswick where Fe, Zn and As-contaminated water drains from the mine portal. The project involves the use of bacterial sulphate reduction to precipitate metals from the water as insoluble metal-sulphide minerals in anaerobic columns. The columns were filled with a permeable reactive mixture that would promote the growth of sulphate-reducing bacteria (SRB). Water samples were collected at six points along the 16 m column flow path, and analyzed for the concentrations of major cations, anions, and trace metals, as well as, pH, Eh and alkalinity.

The data suggest that sulphate-reducing conditions have been attained intermittently within the columns. During these time periods the SO_4 concentration decreased by between 30 and 70 %. With the onset of sulphate reduction, a decrease in Fe, Zn, and As was not immediately achieved as might be expected. Instead, during the first few intervals of sulphate-reduction, the concentration of Fe increased from approximately 10 mg/L up to a maximum of 20 mg/L, and the As concentration increased also from 4 mg/L up to a maximum of 70 mg/L. The increases can be attributed to the coexistence of Fe(III)-reducing bacteria and sulphate-reducing bacteria. Prior to the onset of sulphate-reducing conditions, Fe(III) oxy-hydroxides from the mine water accumulated in the columns. As sulphate-reducing conditions were attained in the columns, conditions were also favourable for the reductive dissolution of Fe(III) oxyhydroxides. These reactions reduce iron to the soluble Fe(II) form, and also mobilize As which is associated with the Fe(III) oxy-hydroxides through adsorption and co-precipitation. After 200 days of running the experiment, the iron concentration started to decrease across the columns from 12 mg/L to 8 mg/L. This is an indication that the SRB became the predominant microbial colony in the columns and that the excess iron hydroxides hade been depleted.

During time periods when sulphate reduction was occurring, the concentration of Zn decreased significantly versus distance along the flow path, with initial concentrations of 4.5 mg/L declining to less than 1 mg/L. Sulphate reduction generally results in an increase in pH from 6 to 6.5 across the columns; however, during the last period of sulphate reduction the pH increased to 8.

Currently the columns are not achieving sulphate reduction continuously. The sulphate-reducing bacteria need an optimal anaerobic environment with a continuous source of organic substrate to remain active. The temperature and flow rate are also variables that can change the activity of the SRB. The minimum temperature and maximum flow rate for the survival of the bacteria have not been determined. If sulphate reduction is to be used for passive treatment of the mine water then changes in these conditions would have to be studied. The data could be used to determine the minimum residence time in the reactive material required to treat the water and whether the organic substrate used will be a limiting ingredient.