ABSTRACT

Acid wastewater from a titanium dioxide plant is disposed by land application at Australind, Western Australia. The wastewater is discharged into a series of unlined lagoons on the coastal sand dunes which consist primarily of limestone-bearing beach sand down to the water table. It is the carbonate component of the sand which neutralises and subsequently removes the acid from the wastewater. The present research was aimed at developing a simulation model which could adequately describe the basic phenomena of the neutralisation process occurring within the sand dune beneath the lagoon and above the water table, that could aid in the management of disposal of the wastewater.

The model developed essentially simulated the one-dimensional solute transport beneath a lagoon and the transformation accompanying flow in the porous medium. Changes in $H^+$ concentration in the liquid were established to be due to advection, dispersion and the neutralisation reaction. For modelling purposes, hydrodynamic dispersion in a finite column was considered. Neutralisation kinetics was investigated by using a shrinking-sphere model combined with a first-order hydrogen diffusion-controlled reaction. Ionic equilibria were also considered and were found to contribute significantly to the concentration of $H^+$ in the liquid.

A computer simulation programme, NALS, was written to predict the effluent quality of sulphuric acid solution passing through a finite column of limestone-
bearing sand. The programme was based on both the explicit and implicit finite difference schemes, with and without the inclusion of dispersion. The schemes were studied for their stability, and for their convergence to known analytical solutions in simpler cases.

Experiments were conducted to test the validity of the model. Model parameters were evaluated separately in simple and isolated batch experiments. Finite columns were built to test the once-through reacting system. The sand used in the experiment was of 0.250 and 0.355 mm size with a carbonate content of 9.4 and 14.4% respectively. Acid normalities were 0.02 N, 0.06 N, 0.12 N, and 0.24 N, with flow rates of 20 cm$^3$/min, 40 cm$^3$/min, and 60 cm$^3$/min. In addition, the effect of dissolved iron was also considered by using acid solutions with 100 ppm and 1000 ppm Fe in the last stages of the experimental programme.

Although both explicit and implicit numerical schemes gave similar results, the computation time required in the former scheme was too high to be of any practical application. Sensitivity analysis on the model parameters revealed that the model was more sensitive toward changes in rate constant than in dispersion coefficient. The model could predict successfully the performance of the sand column at low acid concentrations. At high concentrations with abundant deposition of gypsum, it was found that the model was not adequate to describe the reduction in reaction rate. In general, however, the model could be used to predict the start of break-through where effluent quality began
to deteriorate, and the end of neutralisation, so that the minimum and maximum capacities of the natural treatment system could then be estimated for management purposes.