Steady-state modelling of biogeochemical processes in an aquifer

G. Furrer

Note: The text is not fully transcribed due to the limitations of the image. The content details biogeochemical processes occurring in groundwater, the use of a laboratory column filled with aquifer sand as a carbon source for microbial processes, and the modelling of the quasi-steady-state conditions. It discusses the turnover of carbon and sulphur, the consumption of electrons by oxygen, nitrate, and sulphate, and the formation of carbon dioxide and hydrogen sulphide. The column was treated as a series of boxes according to sampling points, and a sensitivity analysis was conducted. A graph illustrates the long-term behaviour of FeOOH(s) and FeS(s) in the time span of 301 days and in the flow distance of 94 cm, showing the increase in FeS(s) fraction and the movement of its front towards the end of the column.

Fig. 1. Long-term behaviour of the solids FeOOH(s) and FeS(s) in the time span of 301 days and in the flow distance of 94 cm. As a function of operation time, the FeS(s) fraction of the total iron gradually increases and the front of FeS(s) moves towards the end of the column, reflecting the extent of the overall sulphide-immobilisation capacity of the aquifer sand.

483
calculations, the pH is most sensitive with respect to 'disproportionation' of lactate into propionate, acetate and bicarbonate as well as to the processes 'aerobic respiration' and 'denitrification'.

In the second part, time-dependent serial data from the column experiments were used to develop a dynamic model to describe the evolution of concentration profiles of the redox-sensitive chemical components iron(II), sulphate/sulphide, FeOOH(s), and FeS(s). The turnover rates of the slow processes 'reduction of sulphate', 'reduction of FeOOH(s)', 'formation of FeS(s)' and 'precipitation of FeS(s)' were determined by using an extended version of the program STEADYQL in combination with the parameter optimisation program SUFI. The major sink for sulphide appeared to be FeOOH(s) that is gradually transformed into FeS(s). Under the prevailing experimental conditions with a flow velocity of approximately 1 meter per day and a dissolved sulphate concentration in the inflow of 200 \( \mu \text{M} \), the calculated sulphide front migrates in the order of 1 meter per year (Fig. 1).

In conclusion, it is possible to carry out prognostic modelling on the propagation of a sulphide plume in an anaerobic aquifer if the average surface characteristics of the aquifer matrix are known. A possible environmental problem may be derived from such information for aquifers that exhibit reducing conditions. Sulphide immobilisation may lead to a sulphide-free groundwater even if strongly reducible conditions are predominant. However, as soon as the binding capacity for sulphide is used up, a sudden increase in the sulphide concentration may result and affect the quality of a nearby water supply.

References
