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Biodenitrification potential in a karst aquifer: experiments and modeling

I. Ghergut (1), U. Naumann (2), K.-P. Seiler (2), P. Maloszewski (2), W. Stichler (2)

(1) Applied Geology Group, Geosciences Centre, University of Goettingen, D-37077 Goettingen, Germany (ighergu@gwdg.de), (2) GSF Institute of Groundwater Ecology, D-85764 Munich-Neuherberg, Germany

The vulnerability of a karst aquifer to contamination by diffuse-input agrochemicals depends mainly on its hydrodynamic/hydraulic characteristics (Seiler and Behrens 1992, Sauter 1993), and especially on its associated (variable) epikarst-zone extent and processes (Sauter 1993, Einsiedl 2003, Geyer 2003). The karstified rock's intrinsic ability to support biodegradation processes (Seiler and Hartmann 1997) is the 'step factor' in vulnerability assessment. Its contribution to the final extent of what is perceived as natural attenuation strongly depends on the flow regime, which makes it difficult to quantify in absolute terms. It often appears as 'negligible', yet sometimes as 'considerable', for reasons which still require investigation in field and laboratory, in conjunction with an adequate modeling approach (Seiler et al. 2004).

To interpret the results of microbial denitrification experiments carried out under groundwater conditions with rock samples of the Southern Franconian Alb (a karstic area in Germany, with high exposure to nitrate input), a nutrient transport-consumption model is formulated and its predictions compared to observed denitrification levels, measured enzyme activities and short- or mid-term changes in bacterial numbers as recorded in five bioreactors operating in situ.

This approach relies on a number of simplifying assumptions, of which the most important is that of a meagre biofilm development, for a single (bulk) bacterial population in up to three phases, free of predation/competition and feeding on a two-component substrate. Nonlinear kinetics is assumed for nutrient consumption and biomass growth, first-order exchange is assumed between similar species in different phases, coupled with a dual-porosity model for nutrient and biomass flow and transport.

Interpretation difficulties persisting even with controlled-flow experiments are discussed.