



On the Upscaling of the reaction-advection-diffusion equation in porous media with monod-like kinetics.

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The contamination of groundwater is a severe problem in many industrial and developing countries as it imposes a severe threat to water resources. Therefore the biodegradation of these groundwater contaminants has been extensively investigated in the laboratory and in the field. However, a direct quantification of in situ biodegradation is often impossible. The extrapolation of laboratory results on microbial degradation processes to in situ biodegradation processes in the field is challenged by finding an adequate description of the bioavailability of chemical species. In porous media, microorganisms are primarily residing on the surface of the solid matrix. Thus, their activity is controlled by species concentrations in their immediate vicinity, only. Controlled by transport processes at the pore or sub-pore scale these bioavailable concentrations differ from average concentration measured at the macro-scale. We investigate (bio)reactive transport processes within individual pores or pore assemblies. By explicitly resolving pore geometries, advective-diffusive transport and microbial degradation are simulated by making use of the software toolbox UG allowing for a quantitative analysis of bioavailability limitations on microbial contaminant degradation. These numerical simulation results are accompanied by analytical upscaling leading to the formulation of effective equations with effective degradation and effective dispersion coefficients for biodegradation processes at the pore scale. We will demonstrate that, in addition to the classical result of a reaction- and a diffusion-limited regime in case of first order degradation processes, a new transition regime appears for Monod kinetics. The new regime indicates a concentration limitation (this phenomenon is known from lab experiments). The three regimes and their implica-

tions for practical applications are discussed.