Geophysical Research Abstracts, Vol. 9, 06744, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-06744

Reactive transport and transformation in soils: Simultaneous investigation of the interplay and interdependencies of hydraulic, chemical and biological processes

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Transport and fate of solutes and colloids are controlled by the mutual impact of soil hydraulic, soil (micro)biological and soil chemical processes. As a matter of fact, in most studies employing soil only effects are studied which relate to one, sometimes two soil science disciplines. Soil column experiments offer the unique opportunity to elucidate the interplay and interdependence of hydraulic, chemical and biological processes in natural porous media. However, to relate the response of a given soil to a certain constellation of biogeochemical and hydraulic factors, the column experiment has to be run employing a sufficiently complex experimental design. This design will then provide the information required to identify and quantify the non-linear and frequently rate-limited interactions and transformations. In contrast, a simple column outflow experiment with steady state inflow boundary condition will only provide ambiguous results inappropriate for process identification and quantification. To overcome this equifinality in the experimental results is thus the fundamental challenge when studying interdependent hydraulic, biological and chemical processes in soils. Employing optimized column experiments with soil materials originating from different sites, utilizations, solutes and colloidal particles, experimental designs will be presented which may help to discern the share of hydraulic, physical and chemical processes in the response behaviour. It will be shown, however, that column response analysis and design optimization along with a sophisticated experimental design requires a process-based, integrative, biogeochemical and hydraulic simulation and identification tool.