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(Proceedings ModelCARE2011 held at Leipzig, Germany, in September 2011) (IAHS Publ. 355, 2012), 169-174.

Reactive transport simulation of volatile organic compound removal in vertical flow soil filters

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Abstract Vertical flow soil filters are an emerging technology for the treatment of groundwater contaminated with volatile organic carbon compounds. These filters are characterized by unsaturated flow conditions and high contaminant removal rates, but for the assessment of their remediation efficiency a sound distinction between biodegradation and volatilization is crucial. In this study, a vertical flow soil filter system exposed to intermittent feeding of contaminated groundwater leading to a highly transient flow pattern was simulated using the numerical model MIN3P. Simulated processes include (besides other reactions) the microbial degradation of aqueous species as well as their volatilization and advective-diffusive transport in the water phase and the soil air phase. Flow and transport processes were calibrated using measured field data and the model subsequently used to describe the removal of ammonium and two volatile organic contaminants – benzene and MTBE. Model results confirm experimentally observed high removal rates and show that both removal processes – biodegradation and volatilization – have the potential to significantly contribute to such removal. The contribution of each process depends on the design and operation of the filter system, the hydraulic properties of the filter material, and the degradation capacity of the microbial population. If these factors are sufficiently well combined volatile emissions can be avoided and observed contaminant removal can be nearly all attributed to biodegradation.

Key words reactive transport modelling; volatile organic compounds; unsaturated zone; groundwater remediation; biodegradation