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Biogeochemial modeling of biodegradation and stable isotope fractionation of DCE in a small-scale wetland

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In recent years, the use of (constructed) wetlands has gained significant attention for the in situ remediation of groundwater contaminated with (chlorinated) organic hydrocarbons. Although many sophisticated experimental methods exist for the assessment of contaminant removal in such wetlands the understanding how changes in wetland hydrochemistry affect the removal processes is still limited. This knowledge gap might be reduced by the use of biogeochemical reactive transport models.

This study presents the reactive transport simulation of a small-scale constructed wetland treated with groundwater containing cis-1,2-dichloroethene (cDCE). Simulated processes consider different cDCE biodegradation pathways and the associated carbon isotope fractionation, a set of further (bio)geochemical processes as well as the activity of the plant roots. Spatio-temporal hydrochemical and isotope data from a long-term constructed wetland experiment [1] are used to constrain the model. Simulation results for the initial oxic phase of the wetland experiment indicate carbon isotope enrichment factors typical for cometabolic DCE oxidation, which suggests that aerobic treatment of cDCE is not an optimal remediation strategy. For the later anoxic phase of the experiment model derived enrichment factors indicate reductive dechlorination pathways. This degradation is promoted at all wetland depths by a sufficient availability of electron donor and carbon sources from root exudates, which makes the anoxic treatment of groundwater in such wetlands an effective remediation strategy.

In combination with the previous experimental data results from this study suggest that constructed wetlands are viable remediation means for the treatment of cDCE contaminated groundwater. Reactive transport models can improve the understanding of the factors controlling chlorinated ethenes removal, and the used model approach would also allow for an optimization of the wetland operation needed for a complete degradation of these contaminants.

[1] Imfeld, G., Aragonés, C., Zeiger, S., von Eckstädt, C., Paschke, H., Trabitzsch, R., Weiss, H., and Richnow, H. (2008). Tracking in situ biodegradation of 1,2-dicholoroethenes in a model wetland. Environ. Sci. Technol., 42: 7924-7930.