Degradation of Perchloroethene by zero-valent iron evaluated by carbon isotope fractionation

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Perchloroethene (PCE) is a widely spread groundwater contaminant in formally used industrial sites. Zero valent iron (ZVI) is used for in situ chemical reduction (ISCR) of PCE contaminants in the groundwater. A key factor in the application of in situ remediation technologies is a proper monitoring of contaminant reduction. The measurement of the stable isotope ratio is a promising method that is already used for quantifying microbial degradation of chlorinated contaminants. The carbon isotope ratio of PCE, measured by – isotope ratio mass spectrometry coupled to a gas chromatograph via a combustion interface (GC-C-IRMS), increases during degradation of PCE and can be directly related to the degree of degradation. It can be used to directly quantify chemical degradation and thus serves as a useful monitoring tool for groundwater remediation.

An experiment to determine the carbon isotopic fractionation factor was performed as a lab experiment using Nanofer Star (NANOIRON). Two different PCE concentrations (c_1: 220mgL^{-1}, c_2: 110mgL^{-1}) mixed with 0.5 g of ZVI were sealed under deoxygenated conditions in 250 ml glas bottles locked with mininert caps. The bottles were incubated on a shaker for 865 h. Samples were taken weekly to measure the change in the carbon isotopic ratio of PCE as well as its concentration.

Results showed a strong increase in the carbon isotope ratio (δ-value) of PCE (start: -27 ‰ end: -4 ‰), which indicates a significant dechlorination process of PCE. Beside PCE also one degradation product (Trichloroethylene – TCE) was measured. TCE was further dechlorinated as indicated by the δ-value change of TCE from -26 ‰ to -4 ‰ An unexpected intermediate value of -45 ‰ for TCE was observed in the experiment. This fluctuation could be induced by the time depending concentration due to degradation and conversation processes. Furthermore, it seems that the progress of the δ-value is affected by the starting concentration of PCE (δ-value of $c_1 < c_2$) as there is a higher ratio of PCE to ZVI.