

Application of Compound-Specific ^{13}C Isotope Investigations of Chlorinated Hydrocarbons at Polluted Groundwater Sites

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Highly volatile chlorinated hydrocarbons are one of the most common pollutants found in groundwater. Due to complex contamination situations with overlapping contamination plumes the assessment of the organic contaminants requires the installation of expensive observation wells and high analytical effort. Here the determination of the stable isotope ratio $^{13}\text{C}/^{12}\text{C}$ of the organic compounds offers a promising and efficient tool to investigate the origin and the biodegradation characteristics of the chlorinated hydrocarbons in groundwater. The application of this method is based on characteristic isotope fingerprints, that differ in chlorinated solvents produced by different production pathways. This isotopic fingerprint is influenced neither by transport in the groundwater nor by retardation processes. Due to the fact, that two different contaminations can easily be distinguished by isotope ratios, an improved distinction of spatially and temporally different contamination plumes might be possible.

In course of biologically mediated degradation processes a shift of the isotope ratio between the precursor and the product can frequently be observed, such as with denitrification or sulfate reduction processes. The isotope fractionation is due to a preferential reaction of the bonds formed by the lighter isotopes and leads to a progressive enrichment of the heavy isotopes in the precursor while the product becomes depleted in the heavy isotopes. Biological degradation of the highly

chlorinated hydrocarbons is due to a co-metabolic dechlorination. Tetrachloroethene (PCE) for example degrades under anoxic conditions via trichloroethene (TCE) to cis-1,2-dichloroethene (cDCE). Subsequent degradation to vinyl chloride (VC) and ethene may appear under aerobic as well as reducing environments depending on the site specific conditions. In several laboratory studies it has been shown, that biodegradation of the chlorinated hydrocarbons is accompanied by an isotope fractionation of the stable carbon isotopes. The isotope ratios may be used to assess and quantify the dechlorination of the organic compounds at the field sites. This application is of great interest for remediation strategies including monitored natural attenuation of contaminations with chlorinated hydrocarbons.

However, the occurrence and the degree of isotope fractionation processes of chlorinated hydrocarbons at pollution sites is still an open question. In contrast to the laboratory studies, many of the field investigations show no evidence for isotope fractionation although biodegradation of the chlorinated hydrocarbons in the groundwater is significant. Only in some cases an isotope enrichment due to biodegradation has been observed. In this paper we will present three case studies, where compound specific ^{13}C isotope ratios have been applied resulting in different results according to isotope fractionation at the different pollution sites.