

452 - USE OF DUAL CARBON-CHLORINE ISOTOPE ANALYSIS TO IDENTIFY DEGRADATION PATHWAYS OF 1,1,1-TRICHLOROETHANE IN GROUNDWATER

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The high susceptibility of chlorinated aliphatic hydrocarbons (CAHs) like 1,1,1-trichloroethane (1,1,1-TCA) to be transformed via different competing pathways (biotic and abiotic) complicates the assessment of their fate in groundwater. This knowledge is necessary to evaluate contaminant degradation and potential formation of toxic intermediates. Identifying pathways is further complicated in sites contaminated by mixed CAHs because some degradation products of 1,1,1-TCA can be formed from different precursors. Here, identification of pathways based solely on substrate-product concentration relationships may lead to ambiguous interpretations.

This study investigates, for the first time, dual C-Cl isotope fractionation as a means of identifying and assessing degradation pathways of 1,1,1-TCA in groundwater. Distinctly different dual isotope trends ($L = \Delta\delta^{13}\text{C}/\Delta\delta^{37}\text{Cl}$) were observed for 1,1,1-TCA transformation via oxidation with heat-activated persulfate ($L = \infty$), reduction with zero-valent iron ($L = 1.5 \pm 0.1$), hydrolysis and dehydrohalogenation (HY/DH, $L = 0.33 \pm 0.04$) in laboratory experiments, illustrating the potential of a dual isotope approach. This approach was evaluated in an aerobic aquifer impacted by 1,1,1-TCA and trichloroethylene (TCE) with concentrations of up to 20 mg/L and 3.4 mg/L, respectively. For 1,1,1-TCA, the dual isotope slope determined from field samples ($L = 0.6 \pm 0.2$, $r^2 = 0.75$) was close to the slope observed for HY/DH in the laboratory ($L = 0.33 \pm 0.04$), indicating that HY/DH was the predominant degradation pathway of 1,1,1-TCA in the aquifer. The observed deviation could be explained by a minor contribution of additional degradation processes. This result, along with the little degradation of TCE determined from isotope measurements, confirmed that 1,1,1-TCA was the main source of the 1,1-dichloroethylene (1,1-DCE) detected in the aquifer with concentrations of up to 10 mg/L. This study demonstrates that a dual C-Cl isotope approach can strongly improve the qualitative and quantitative assessment of 1,1,1-TCA degradation processes in the field.