Compound Specific Isotope Analysis of 2,3-Dichloroaniline Reveals Aerobic Biotransformation in Constructed Wetlands

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Background/Objectives. Compound specific isotope analysis (CSIA) is an established tool to identify and quantify the transformation of organic contaminants. To date, CSIA has never been applied to track the fate of 2,3-dichloroaniline (2,3-DCA) in situ. Although persistent in the environment, several microorganisms were identified as able to degrade 2,3-DCA, thus making this contaminant a potential candidate for bioremediation. The objective of this work was 1) to determine stable isotope enrichment factors and 2) apply them at a contaminated site.

Approach/Activities. In a controlled-laboratory experiment, we grew a mixed culture enriched to aerobically transform 2,3-DCA. The concentration and isotope signatures for carbon, hydrogen, and nitrogen of 2,3-DCA were measured over time. The data were modeled by the Rayleigh model to determine enrichment factors, i.e., ε values. Then, samples from a pilot constructed wetland systems treating 2,3-DCA contaminated water were analyzed for CSIA.

Results/Lessons Learned. We found negligible carbon and hydrogen isotope fractionation, and a significant inverse nitrogen isotope effect during aerobic 2,3-DCA biodegradation using the mixed enrichment culture. The corresponding Apparent Kinetic Isotope Effect for Nitrogen ($AKIE_N$) values ranged from 0.9938±0.0003 to 0.9922±0.0004. The $\varepsilon_{N,\_bulk}$ values, ranging from +6.2±0.3 to +7.9±0.4‰ were applied to investigate the potential in situ 2,3-DCA biotransformation at the contaminated site. The field-obtained carbon and nitrogen isotope signatures suggested aerobic biotransformation by native microorganisms between the inlet and outlet of the pilot constructed wetlands. This study proposes multi-element CSIA of 2,3-DCA as a novel tool enabling to track 2,3-DCA fate in groundwater and surface water.