Applying Compound-Specific Isotope Analysis to Sites with Low Concentrations of 1,4-Dioxane

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Background/Objectives. The objective of this work is to develop a reliable method for performing compound-specific isotope analysis (CSIA) on low aqueous concentrations of 1,4-dioxane in groundwater in order to assess 1,4-dioxane biodegradation at field sites, specifically Department of Defense (DoD) sites. Phase 1 of this work focused on developing a new method for performing CSIA. That method was used to determine stable carbon and hydrogen isotope ratios in samples at concentrations in the 1 microgram per liter range. In addition to method development, findings from laboratory studies of aerobic cometabolic degradation reactions reported different stable carbon- and hydrogen-isotope enrichment factors for different organisms and/or growth substrates. One observation in common to all aerobic cometabolic degradation reactions is that enrichment in both carbon-13 and deuterium occurs in the remaining aqueous 1,4-dioxane as the reaction proceeds, but the enrichment in deuterium is much larger than for carbon-13. This finding highlights the need for determination of stable isotope ratios for both carbon and hydrogen for assessing biodegradation at field sites. Other conclusions of the Phase 1 research were that 1) the isotope ratio of 1,4-dioxane was variable at the limited number of field sites included in the study and 2) that a larger database on the isotopic composition of source 1,4-dioxane was needed to serve as a reference for comparing to the isotopic composition of 1,4-dioxane in groundwater samples.

Approach/Activities. Comprehensive case studies are being conducted to further document the value of CSIA for demonstrating 1,4-dioxane degradation at DoD sites. At least six case studies are targeted for CSIA of 1,4-dioxane (carbon and hydrogen) in groundwater samples. Phase 2 work also includes expanding the database on the isotopic composition of 1,4-dioxane sources by obtaining neat 1,4-dioxane samples from ten different manufacturers for characterization of stable carbon and hydrogen isotope ratios.

Results/Lessons Learned. A summary of the isotopic composition of 1,4-dioxane in groundwater at the field sites will be provided. Coupled with the expanded database on the isotopic composition of source 1,4-dioxane, the implications of using CSIA and conclusions from CSIA of 1,4-dioxane in field samples will be discussed. This research, funded by the Strategic Environmental Research and Development Program (SERDP), has greatly advanced the applicability of CSIA to 1,4-dioxane for demonstrating biodegradation and for forensic purposes.