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Identification of Abiotic Degradation Pathways of Chlorinated Ethenes: Novel Lines of Evidence from Compound-Specific Stable Isotope Analysis

Tomasz Kuder (tkuder@ou.edu), Ann Sullivan Ojeda and R. Paul Philp (University of Oklahoma, Norman, OK, USA)
Brady D. Lee (Pacific Northwest National Laboratory, Richland, WA, USA)

Background/Objectives. At certain sites, abiotic degradation of chlorinated ethenes may be an important attenuation mechanism. Unequivocal demonstration of abiotic degradation is difficult, due to the absence of pathway-specific degradation products or due to poor mass balance of such products. Therefore, means to identify the dominant degradation pathway(s) that do not rely on product mass balance and not involving complicated and time consuming experimental work (such as “abiotic microcosms”) would be very welcome. The compound-specific stable isotope analysis (CSIA) approach was proven to be very useful in the assessment of CEs biodegradation. Similar scope of CSIA applications can be envisioned for the assessment of abiotic degradation of CEs. However, most CSIA work to date on abiotic degradation utilized C CSIA only and the information potential of dual-element CSIA (combinations of C, Cl and H data) for differentiation of biotic and abiotic degradation mechanisms remains largely unexplored. In this presentation, we will discuss the results from an ongoing study of novel lines of dual-element CSIA evidence based on stable isotope ratios (C, Cl, H) of parent CEs and their degradations products, for differentiation between the effects of biotic and abiotic degradation pathways that may conceivably occur at contaminated field sites.

Approach/Activities. The data are being collected from laboratory degradation experiments (batch degradation experiments). The experiments address two potential application areas: i) Identification of reaction mechanisms in the absence of pathway-specific degradation products (at certain locations, apparent attenuation of CEs occurs in aerobic or sub-aerobic environments conducive to aerobic biodegradation and to abiotic degradation on Fe(II)/Fe(III) mineral surfaces, where the alternative degradation mechanisms generate little or none pathway-specific products); and ii) Identification of reaction mechanisms at sites with permeable reactive barrier (PRB) activities or with related in-situ treatments (in at sites with PRBs, different abiotic and biological may contribute to overall attenuation).Abiotic degradation with ZVI serves as the model for abiotic reactions. For comparison, biotic degradation data are obtained for an anaerobic *Dehalococcoides* culture and for several aerobic organisms.

Results/Lessons Learned. The anticipated results of the study will provide a set of reference data (in the form of enrichment factors and parent-daughter compound isotope ratio differences) for the assessment of utility of dual-element CSIA in differentiation of biotic and abiotic degradation, for the two application areas defined in the preceding section. In particular, the Cl and H isotope ratios will be most informative, given the scarcity of published data. The results will be used to identify any lines of CSIA evidence that bear good potential for successful implementation in future field site assessment.