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title: **Combining tracer hydrology and isotopic analysis to assess in situ natural transformation of chlorinated ethenes in groundwater**

author(s): **Helena I. Ferreira Amaral**
Laboratório Nacional de Energia e Geologia, Portugal, helena.amaral@ineti.pt

Christoph Aeppli
Stockholm University, Sweden, christoph.aeppli@gmail.com

Michael Berg
Eawag, Switzerland, michael.berg@eawag.ch

René P. Schwarzenbach
ETH Zurich, Switzerland, schwarzenbach@env.ethz.ch

Rolf Kipfer
Eawag, Switzerland, rolf.kipfer@eawag.ch

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Tracer hydrology (mainly groundwater dating methods) and compound-specific stable (^{13}C) isotope analysis (CSIA) were combined to assess the natural transformation of chlorinated ethenes (CEs) in groundwater at the field scale. Two field sites representing different natural hydrogeological settings were selected to verify the usefulness of the suggested approach in the determination of timescales of *in situ* degradation processes. The selected study sites differed mainly in the groundwater residence times, groundwater redox conditions and on the level of contamination and were chosen to represent situations of favorable and unfavorable conditions for the CE natural transformation. Site I was a confined two-aquifer system, where CE transformation is taking place under the highly anoxic conditions and groundwater residence times of up to 40 years of the upper aquifer. This aquifer overlays an oxic aquifer only slightly contaminated and with water ages of up to 17 years, where no CE transformation occurs. Site II, an aerobic aquifer with short water residence time of about 2 years showed no evidence of CEs transformation, before and after remediation measures. Moreover, evidences based on the environmental tracers suggest the presence of bedrock fractures to act as a long lasting CEs "reservoir", implying that will take many decades, or even centuries, for the contamination to reach acceptable levels.

It is shown that even under unfavorable conditions for transformation, our methodological approach adds valuable information to the understanding of the evolution of the organic contamination, to the location of contaminant source zones and to the estimation of time-scales for the decrease of contamination levels to acceptable levels.

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