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# Quantification of Natural Attenuation processes based on stable carbon isotope fractionation during chloroethene degradation

**H. Martin** (1), S. Ertl (1), M. Heidinger (1), L. Eichinger (1), K. R. Schmidt (2), A. Tiehm (2)

(1) Hydroisotop GmbH, Woelkestr. 9, 85301 Schweitenkirchen, Germany (hm@hydroisotop.de / Phone: +49-8444-92890), (2) Technologiezentrum Wasser Karlsruhe, Karlsruher Str. 84, 76139 Karlsruhe, Germany

Assessing changes in the $^{13}$C-isotopic signature of contaminants is a reliable tool to monitor and to quantify microbial degradation processes in the field. Natural Attenuation (NA) is defined as the sum of processes which cause a decrease in contamination without human intervention. Using these natural processes for site remediation is increasingly considered as a sound alternative to active technical measures. Contrary to abiotic attenuation processes such as dispersion and sorption, biodegradation results in a net loss of contaminant mass within a plume.

The objective of this study at a field site in Frankenthal, Germany contaminated with mainly trichloroethene (TCE) and tetrachloroethene (PCE) was to provide evidence for microbial chloroethene degradation in the field and to quantify biodegradation based on $^{13}$C-isotopic signatures determined in field samples.

In various groundwater microcosms, both anaerobic reductive transformation (halorespiration) of tetrachloroethene and trichloroethene to cis-1,2-dichloroethene (cDCE) and aerobic oxidative mineralization of cDCE and vinyl chloride (VC) were accompanied by a significant isotopic fractionation effect.

The specific isotopic enrichment factors determined in the microcosm studies were used to quantify the extent of biodegradation based on the $^{13}$C-isotopic signatures of the contaminants in the field. The $^{13}$C-isotopic signatures were determined over several years (2000-2004-2005-2006) in numerous groundwater samples. The calculated

amount of biodegraded chloroethenes increased along the centre line of the plume with increasing distance from the source zone and remained stable over the years.

In conclusion, our study demonstrates that stable carbon isotope fractionation is suitable for assessing and quantifying chloroethene degradation in the field.

The modus operandi shown in this study can be applied for other contaminated field sites as well.

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