Geophysical Research Abstracts,
Vol. 10, EGU2008-A-11853, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-11853
EGU General Assembly 2008

Assessment of the relative contribution of the biodegradation and the sources for chlorinated ethenes in groundwater using stable carbon isotopes.

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Chlorinated ethenes: tetrachloroethene (PCE), trichloroethene (TCE) extensively used as degreasing agents in many industries, and their daughter products: dichloroethene (DCE) and vinyl chloride (VC) are among the most common groundwater contaminants due to spills and wastewater discharges. Different EU policies such as the IPPC Directive of 1996 (controlling installations of industries responsible for wastewater emissions) and the Directive 2006/12/EC (on waste) are contributing to protect the environment by minimising the considerable input of these contaminants into the subsurface in Europe.

Contamination of groundwater by these mobile and harmful chemicals leads to degradation of water quality and causes major environmental problems for hazard, remediation and liabilities points of view. Identifying the sources of such contaminants, assessing of their relative contribution and determining their transport and fate in groundwater represent major issues to improve remediation efficiency and liabilities evaluation.

This study combines the characterisation of the contamination of an aquifer located in an industrial site close to Antwerp (Belgium) with an experimental study for evalua-

tion of the extent of biodegradation in conditions similar those observed in the site.

The concentrations and carbon isotopic compositions of PCE, TCE, *cis*-DCE and VC were measured on twenty-six water samples from the field using headspace GC-MS and GC-C-IRMS, respectively.

Within the contaminated plume of the studied aquifer, the four selected compounds show high concentrations up to 9600, 3500, 2000 and 82μg/L, respectively. Two potential sources responsible for the contamination could be identified. For these sources the two carbon isotopic compositions of dissolved PCE were discriminated by a 4 permil difference. The ^{13}C enrichment observed in deeper groundwater for PCE provides evidence for its biodegradation in this aquifer. The ^{13}C enrichment of *cis*-DCE and VC associated with the increase of their concentrations confirms this assumption.

An experimental enrichment factor of -7.8 ± 0.8 permil was calculated for PCE using Rayleigh equation applied to the data measured on five samples collected within the 78 days batch laboratory experiment. This value, higher than the previous reported for biotic PCE dechlorination provides evidence for the contribution of abiotic dechlorination in the field, which produces higher enrichment factors. The resulting extent of PCE degradation in the studied field is ranging from 28 to 89%. One of the two sources, which is located upstream, could contribute to the major part of this contamination.