Assessment of in situ degradation of chlorinated ethenes and bacterial community structure in a complex contaminated groundwater system

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Introduction

The occurrence of in situ degradation of chlorinated ethenes was investigated in several geological units of a complex groundwater system in Bitterfeld, Germany. The hydrogeochemistry and the distribution of chlorinated ethenes was assessed using multivariate analysis. The in situ biodegradation was evaluated by stable isotope analysis, and biomarkers (16S rRNA) were applied to detect specific dehalorespiring genera. In parallel, the changes of the microbial community composition in the aquifers were evaluated using variation partitioning analysis. The concentration and isotope fractionation analysis revealed that chlorinated ethenes were subjected to substantial biodegradation. Taxon-specific investigation indicated the simultaneous presence of various potential dehalorespiring populations (Dehalococcoides, Desulfuromonas, Dehalobacter) in several wells. Variation partitioning analysis of the bacterial community structure in the contaminated groundwater system indicated a predominant effect of the chlorinated ethenes concentrations (56.3% of the variance, P=0.005).

Biodegradation and reductive dechlorination

Experimental set-up

Study area

Chemical and hydrogeological characterization

1) Quaternary aquifer

2) Isotope fractionation of vinyl chloride in the lower quaternary aquifer⁵

3) Isotope fractionation of ethene in the upper tertiary aquifer⁵

Molecular analysis

1) Taxon specific 16S rRNA-based PCR amplification to detect dehalogenators

2) Influence of contaminant concentrations on the bacterial community structure

Conclusion

Potential complex dehalogenating bacterial community: several taxa per well

Systematic detection of Dehalococcoides sp. in all geological layers

Principal component analysis can be employed for analysing spatially and temporally the major trends of variation of the geochemistry and the contaminant patterns of geologically complex contaminated groundwater systems

Evidence for natural attenuation of PCE and TCE to ethene was provided in several geological units of the groundwater system using multiple distinct but converging lines of evidence

Isotope signatures were used as a spatial and temporal indicator for biodegradation: in the initial phase, the product is lighter than the educt, and as the biodegradation proceeds, the product becomes heavier

Molecular investigations showed a complex bacterial community potentially associated with in situ biodegradation of chlorinated ethenes in several geological units

Variation partitioning analysis of the bacterial community structure in the contaminated groundwater system indicated a predominant effect of the chlorinated ethenes concentrations (56.3% of the variance, P=0.005)

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