Assessment of chloroethene biodegradation in the subsurface by microbiological, molecular and isotopic tools

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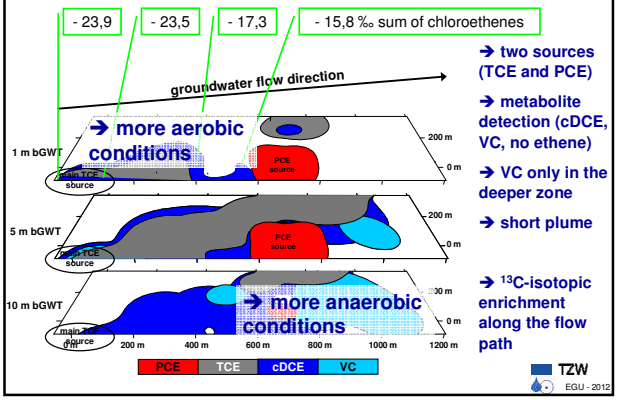
SITE CONDITIONS



→ two sources (TCE and PCE)

→ metabolite detection (cDCE, VC, no ethene)

→ VC only in the deeper zone

→ short plume

→ ^{13}C-isotopic enrichment along the flow path

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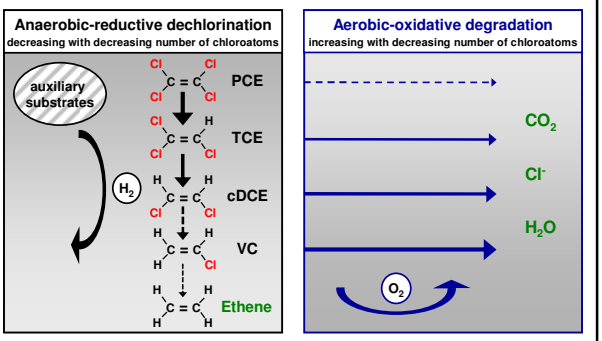
MICROBIAL DECHLORINATION OF CHLOROETHENES



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PCR (POLYMERASE CHAIN REACTION) MPN (MOST PROBABLE NUMBER)

PCR: detection of bacterial DNA
- → + quick test
- → - no proof of activity

MPN: quantification of growth
- → + proof of activity in the laboratory
- → - slow test

Reductive dechlorination

Desulfomonile
Desulfuromonas
Dehalobacter
detected in all wells

Dehalococcoides
detected in 1 well

PCE → TCE → cDCE → VC → Ethene

total heterotrophes
rich and poor medium
nitrifying and denitrifying bacteria
iron-reducing bacteria
sulfate-reducing bacteria

Aerobic oxidation

CO_2
Cl^-
H_2O

VC degrading bacteria detected in all wells

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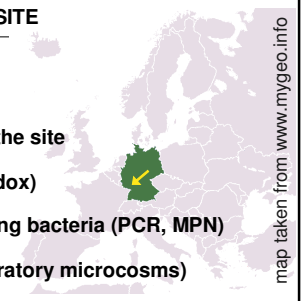
MULTIPLE LINES OF EVIDENCE APPROACH AT THE FRANKENTHAL SITE

assessment of

- pollutant distribution at the site
- site hydrochemistry (Redox)
- presence of dechlorinating bacteria (PCR, MPN)
- degradation ability (laboratory microcosms)
- ^{13}C-isotope fractionation

in order to obtain a site specific degradation scheme



map taken from www.mygeo.info

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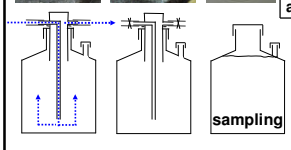
DEGRADATION STUDY IN MICROCOSMS

Degradation pathway	Anaerobic – reductive	Aerobic – oxidative
Pollutants	PCE / TCE	cDCE / VC
Electron-donors	Acetate + Hydrogen	Chloroethenes
Electron-acceptors	Chloroethenes	Oxygen



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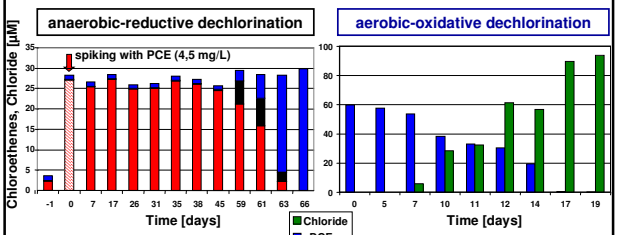
DEGRADATION STUDY IN MICROCOSMS



➔ reductive dechlorination of PCE/ TCE to cDCE in groundwater from several wells

➔ formation of VC only in groundwater from few wells

➔ aerobic mineralization of cDCE and VC in groundwater from several wells

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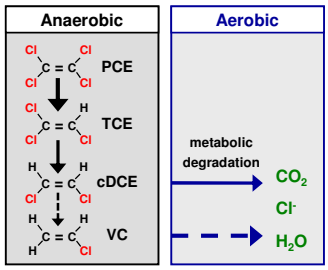
SITE SPECIFIC DEGRADATION SCHEME



➔ 1) anaerobic-reductive dechlorination of PCE/ TCE to cDCE (VC)

➔ 2) aerobic-oxidative mineralisation of cDCE (VC)

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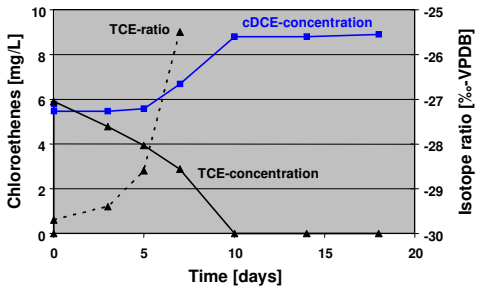
STABLE CARBON ISOTOPE FRACTIONATION DURING ANAEROBIC TCE DEGRADATION



➔ remaining TCE is enriched in ^{13}C

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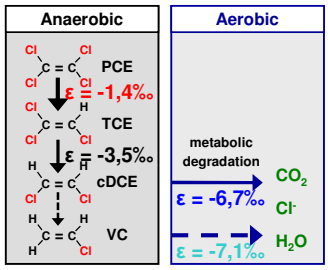
BIODEGRADATION AND ISOTOPE FRACTIONATION



➔ each biodegradation step causes ^{13}C-isotopic enrichment

➔ ^{13}C-enrichment factors enable quantification of degradation processes in the field

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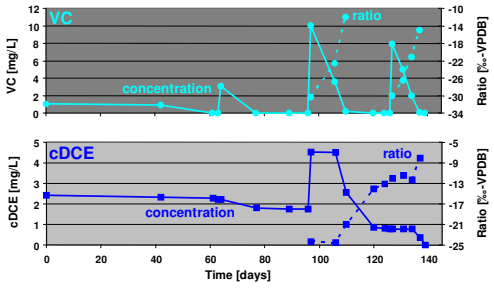
STABLE CARBON ISOTOPE FRACTIONATION DURING AEROBIC cDCE AND VC DEGRADATION



➔ remaining cDCE and VC are enriched in ^{13}C

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SUMMARY

Identification of the site-specific biodegradation processes	✓ setup of an site-specific degradation scheme
by a multiple lines of evidence approach	✓ corresponding results
and determination of site-specific ^{13}C-enrichment factors in microcosm studies.	✓ significant fractionation enables quantification

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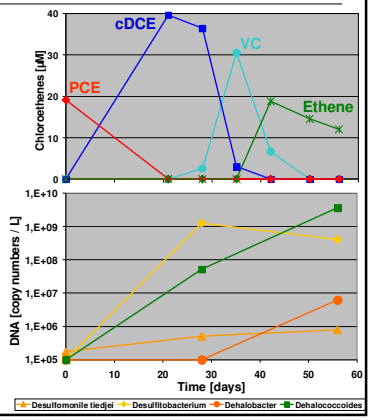
OUTLOOK: INCREASED APPLICATION OF PCR

detection of enzymes with different degradation specificities

development of PCR-methods for aerobic degradation processes

demonstration of bacterial growth during pollutant degradation with quantitative PCR



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SELECTED PUBLICATIONS AND CONTACT

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