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Umweltmonitoring GmbH

14th International HCH and Pesticides Forum

SOURCE ALLOCATION AND DEGRADATION EVALUATION OF HCHS WITHIN A CONTAMINATED AQUIFER USING COMPOUND-SPECIFIC STABLE CARBON ISOTOPE ANALYSIS (CSIA)

Kuntze, K., Richnow, H., Fischer, A.

How to assess HCH-contaminated sites

Who was this and how many?

Is degradation taking place?

Can degradation be stimulated?

Compound-specific Stable Isotope Analysis (CSIA)

What are isotopes ?

Number of Neutrons

p	1	2	3	4	5	6	7	8
	H	He	Li	Be	B	C	N	O
n	Number of Protons							
0	^{1}H							
1	D	^{3}He						
2	T	^{4}He	^{5}Li	^{6}Be		^{8}C		
3		^{5}He	^{6}Li	^{7}Be	^{8}B	^{9}C		
4		^{6}He	^{7}Li	^{8}Be	^{9}B	^{10}C	^{11}N	
5			^{8}Li	^{9}Be	^{10}B	^{11}C	^{12}N	^{13}O
6		^{8}He	^{9}Li	^{10}Be	^{11}B	^{12}C	^{13}N	^{14}O
7				^{11}Be	^{12}B	^{13}C	^{14}N	^{15}O
8			^{11}Li	^{12}Be	^{13}B	^{14}C	^{15}N	^{16}O
9					^{14}B	^{15}C	^{16}N	^{17}O
10				^{14}Be	^{15}B	^{16}C	^{17}N	^{18}O
11						^{17}C	^{18}N	^{19}O
12					^{17}B	^{18}C	^{19}N	^{20}O
13						^{19}C	^{20}N	^{21}O
14							^{21}N	^{22}O
15								^{23}O
16								^{24}O

stable isotopes

radioactive isotope

synthetic

...atoms of an element with the same number of protons but **different numbers of neutrons**

For example Carbon:

^{13}C = 0.96% to 1.16%

^{12}C = 98.84% to 99.04%

^{13}C / ^{12}C **Isotope ratio**

$^{2}H/^{1}H$

$^{37}Cl/^{35}Cl$

$^{15}N/^{14}N$

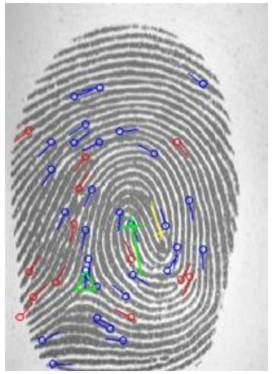
measured via isotope ratio mass spectrometry (IRMS)

$$\delta^{13}C\ [‰] = \left(\frac{\left(^{13}C/^{12}C\right)_{\text{sample}}}{\left(^{13}C/^{12}C\right)_{\text{standard}}} - 1 \right)$$

Why do I need to analyze them

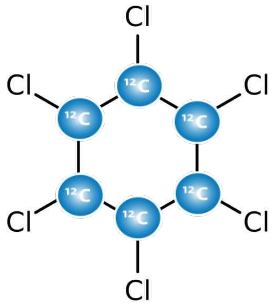
Isotope signature of the primary compound

$\delta^{13}C$ = -26 ‰ VPDB
$\delta^{37}Cl$ = +4 ‰ SMOC
$\delta\ ^{2}H$ = -50 ‰ SMOW
$\delta^{18}O$ = +2 ‰ SMOW
$\delta^{15}N$ = +7 ‰ AIR

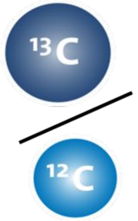


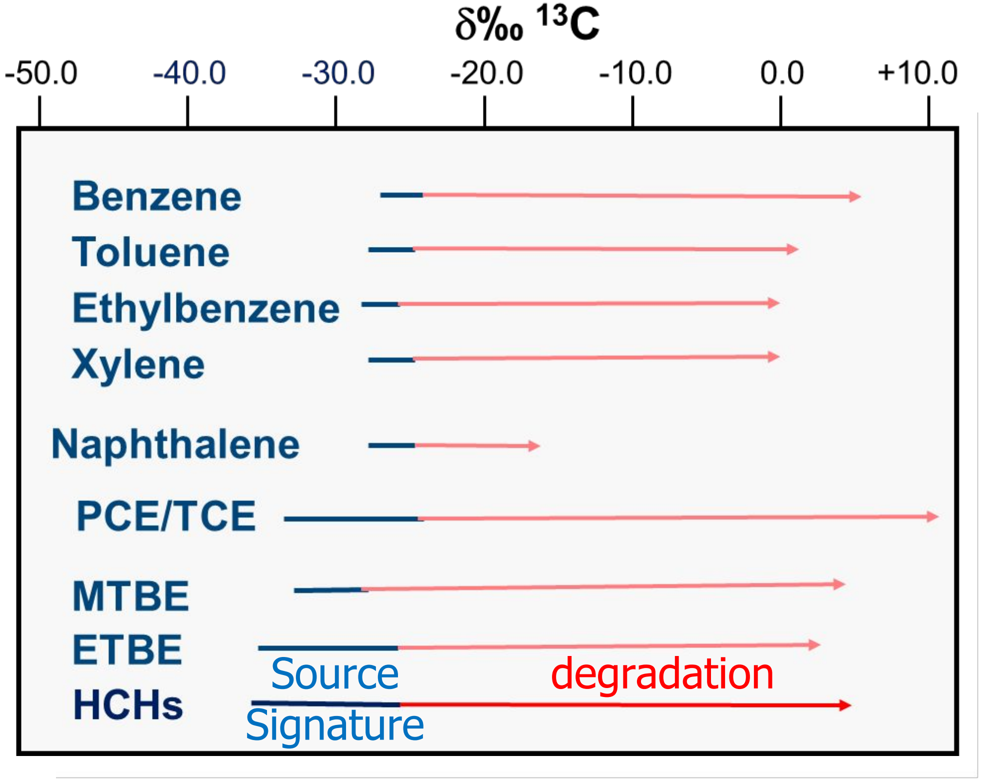
FINGERPRINT – Source Identification

^{12}C-HCH



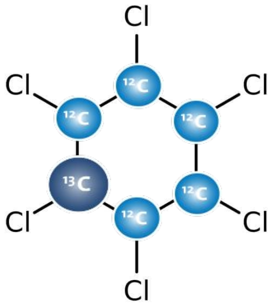
DEGRADATION





Pollutant molecules with **heavy isotopes** (^{13}C) are **degraded more slowly**.

^{13}C-HCH



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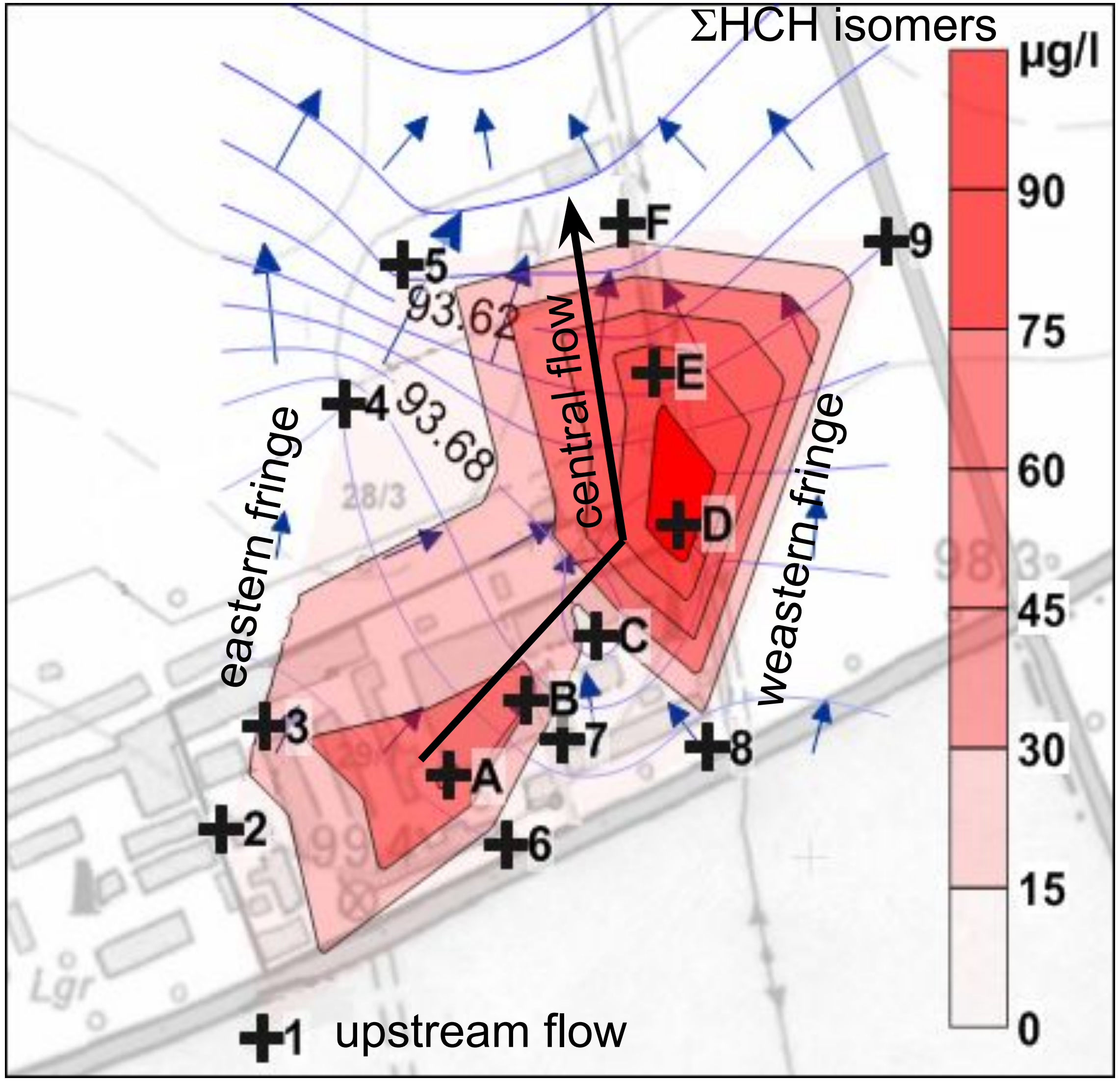
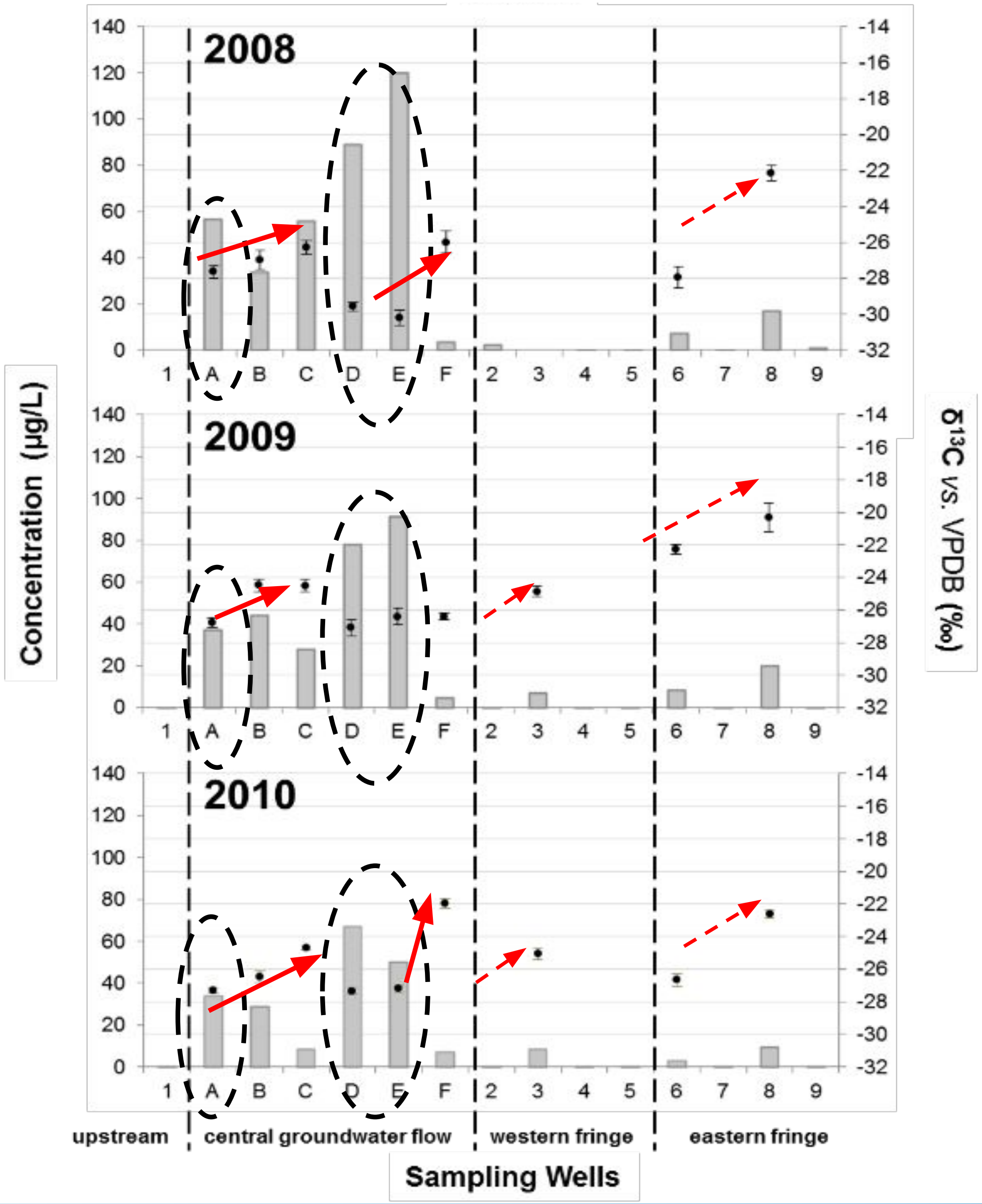
Field site: HCH-contaminated aquifer

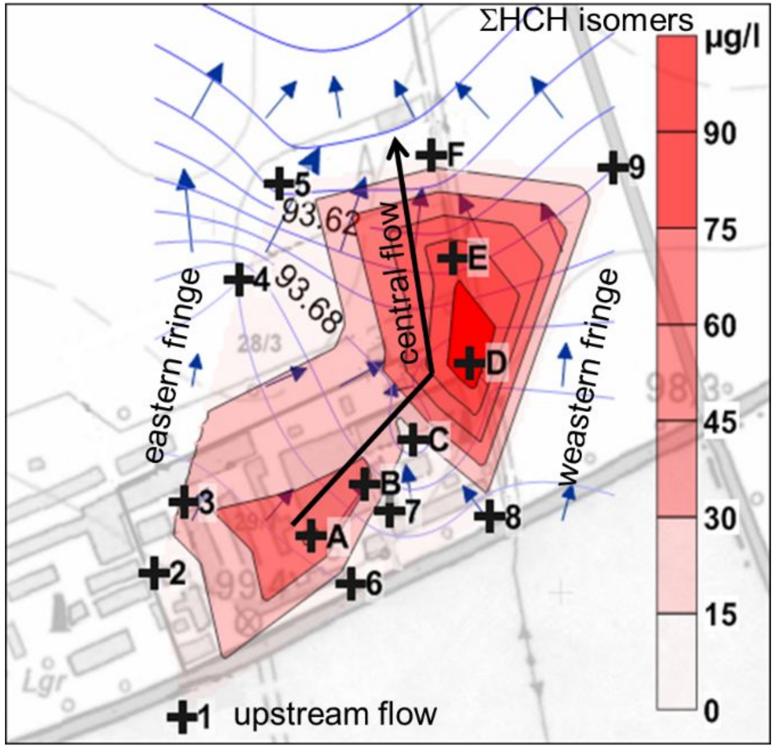


1. Can source zones of HCHs be confirmed by CSIA?

2. Does *in situ* degradation of HCHs take place and to which extend?

δ-HCH





Source

Former production facilities at well A

Former HCH-dump at wells D/E

Degradation

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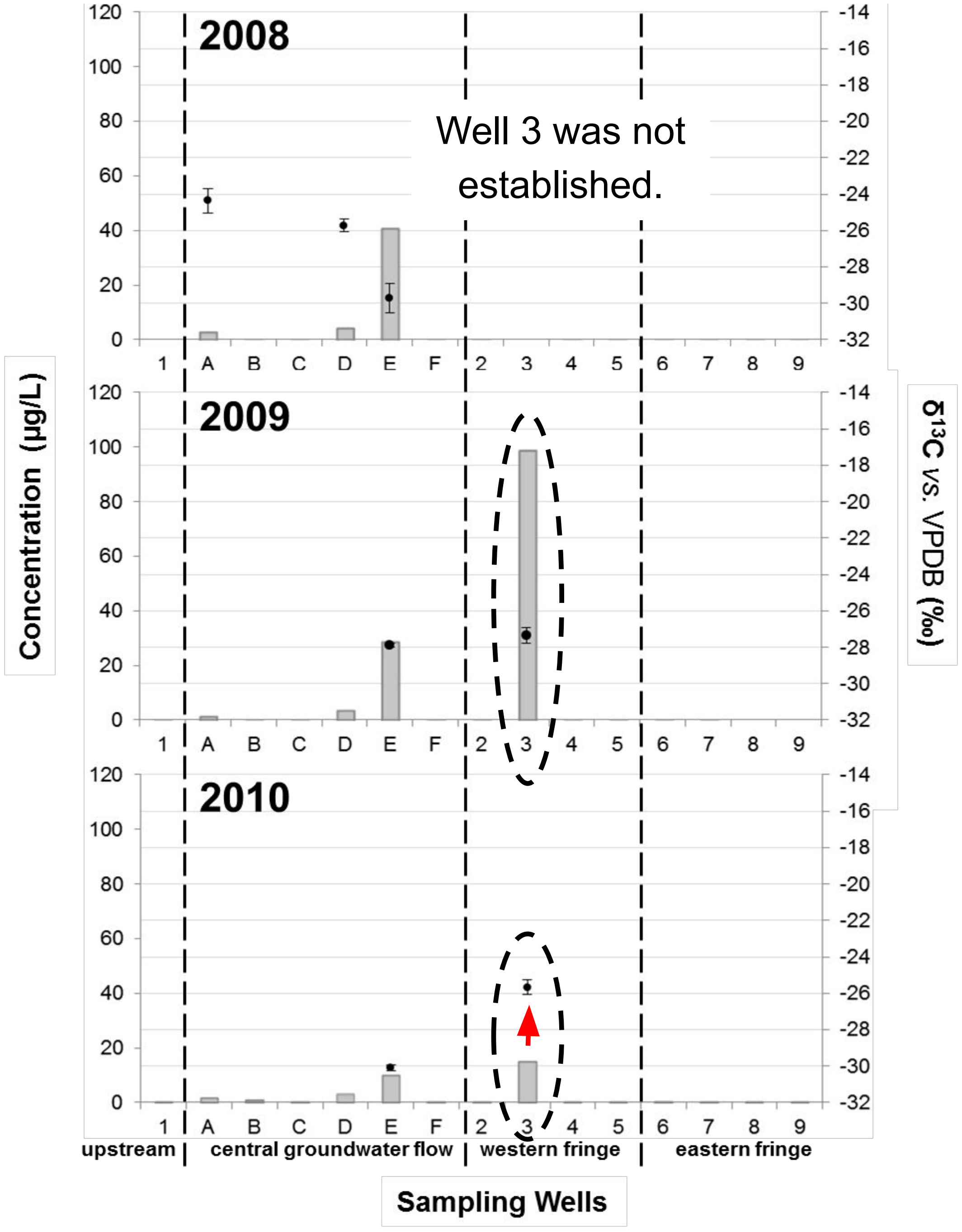
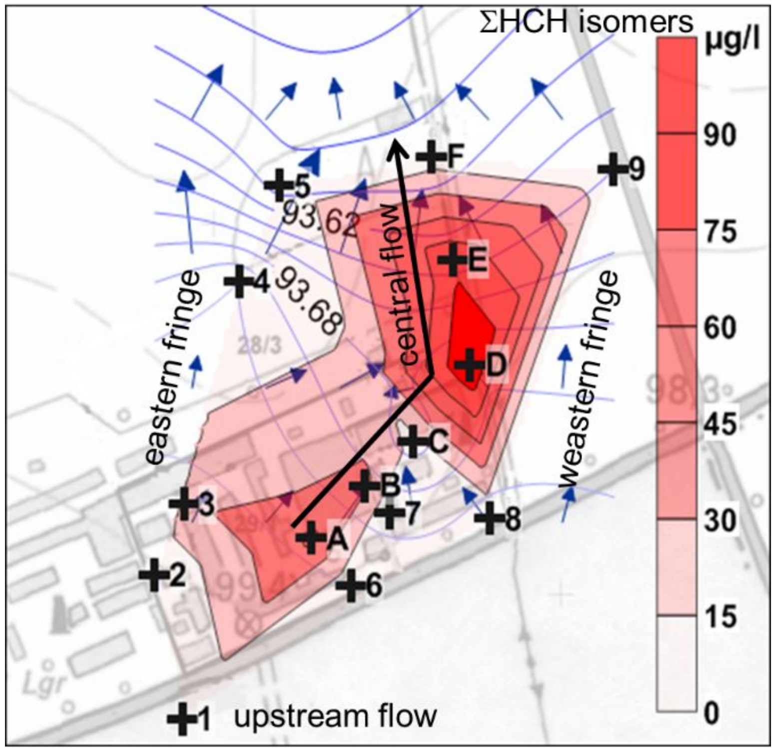
γ-HCH





Source

Former storage depot

Degradation

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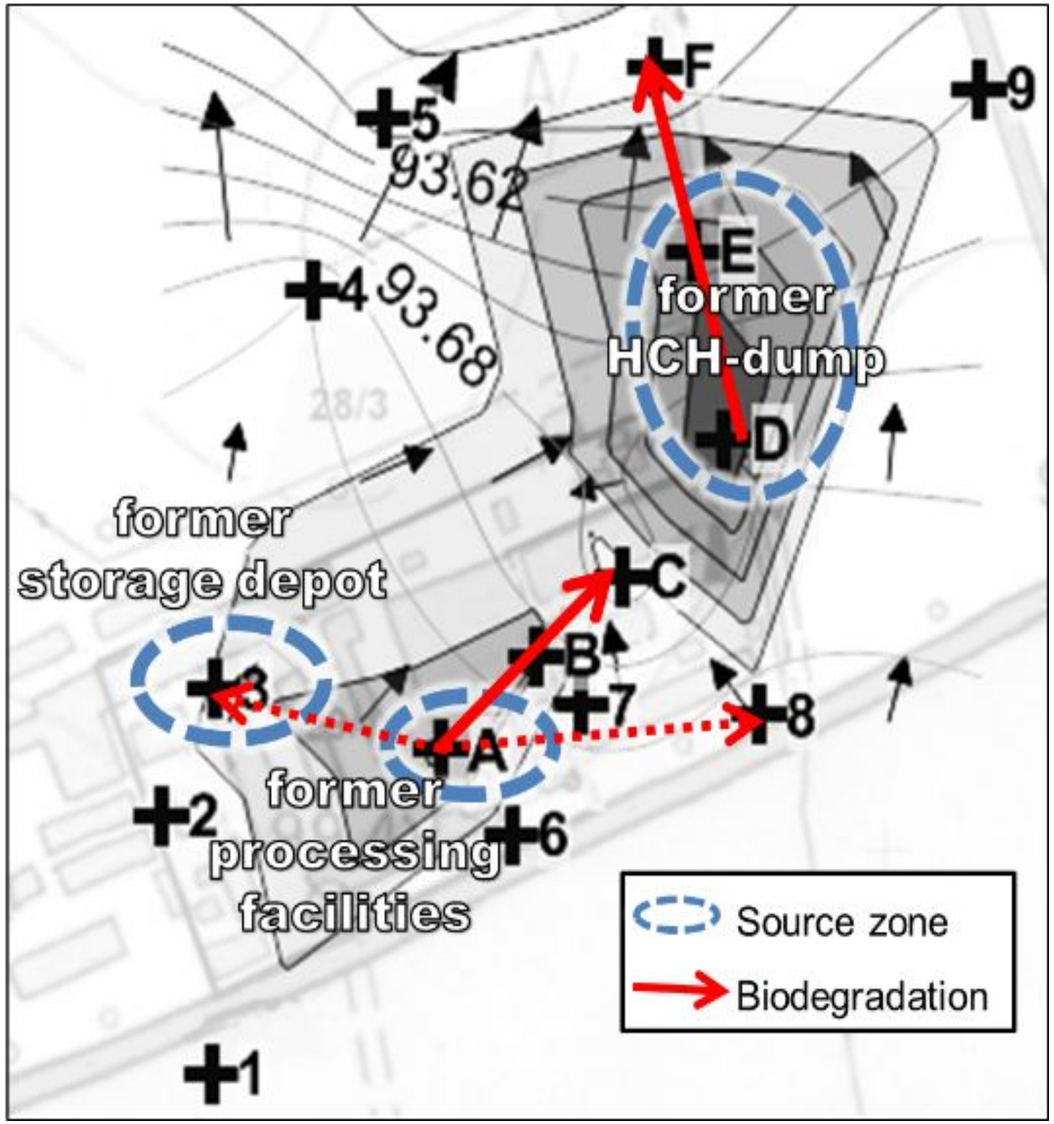
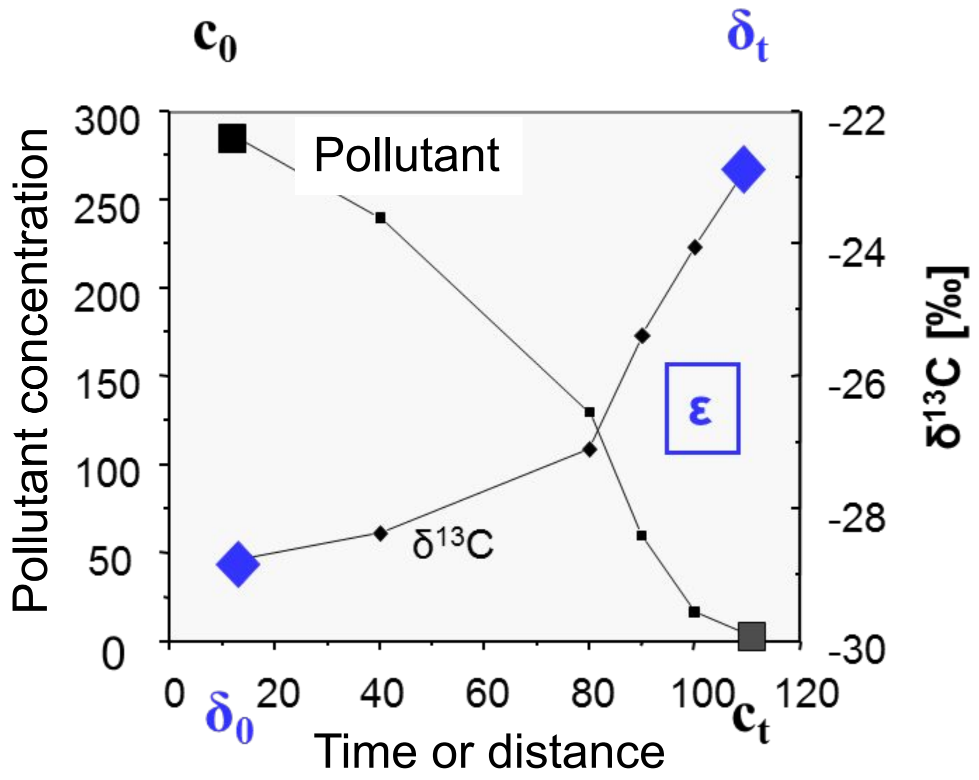
Improved conceptual site model due to CSIA



Quantification of pollutant biodegradation



Laboratory experiment

Field data

<u>Rayleigh equation</u>

$$\lambda = -\frac{1000}{\varepsilon \times t} \ln\left(\frac{\delta_t + 1000}{\delta_0 + 1000}\right)$$

1. Order degradation rate constant

Distance-related

Time-related

	λ_s [1/m]	λ_t [1/d]
δ-HCH:	19×10^{-3}	6×10^{-3}
α-HCH :	10×10^{-3}	3×10^{-3}
β-HCH :	37×10^{-3}	11×10^{-3}

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Conclusions

- CSIA confirmed different source zones at the investigated field site

- CSIA provided evidence of HCH degradation in the investigated aquifer

- CSIA allowed quantification of HCH degradation for expected flow paths

For detailed information see Bashir et al. 2015, Water Research 71: 187-196.

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Environmental Monitoring Tools
Compound-specific stable isotope analysis (CSIA)
In situ Microcosms (BACTRAP®)
Laboratory Microcosms / Treatability Studies
PLFA Analysis
Molecular Genetic Analysis (qPCR)
GC-MS Analysis (GC-Fingerprints)
Metabolite Analysis
Enantiomer Analysis (Pesticides!)

Evaluating drinking water resources
(e.g., Tritium, $\delta^{2}H$, $\delta^{18}O$, FCKW/SF_6, ^{3}He, ^{85}Kr, ^{14}C)

Investigating renewable and fossil energies
(e.g., Evaluating microbial processes in hydrogen underground storage)