



## Advances in Biological In-Situ Remediation: Full Scale Applications in the Netherlands

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## Experts in environmental and sustainable biotechnology

- Groningen, The Netherlands
- Established 1988
- Technology, Innovation, Implementation
- 25 experts

*environmental technology, process technology,  
microbiology, biotechnology, ecology, chemistry,  
civil engineering, geohydrology*

**Specialized in in-situ bioremediation  
and ecological risk assessment**

Consultancy and Engineering



## Leading international consultancy and engineering group

- Providing sustainable solutions for the markets: Transportation & Infrastructure, Buildings, Manufacturing & Telecommunications, Water, Aviation, Spatial Planning and Environmental.
- 3.800 professionals all over the world;
- Headoffice in the Netherlands, in Amersfoort;
- Broad international (practical) experience in Risk Assessment, environmental policy, soil remediation and other environmental issues;
- Sites in Taiwan, Ireland, Sweden, Portugal, Romania, Spain etc.

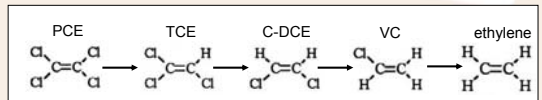
Gateway to solutions



## Natural or Enhanced Reductive Dechlorination of chlorinated ethylenes

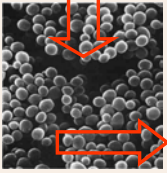
- organic carbon
- redox conditions
- presence of the right organisms
- pH

### Reductive Dechlorination route:





Bacterial strain	Degradation to
<i>Dehalobacter restrictus</i>	C-DCE
<i>Dehalospirillum multivorans</i>	C-DCE
<i>Desulfuromonas chloroethenica</i>	C-DCE
<i>Desulfotobacterium sp</i>	C-DCE
<b><i>Dehalococcoides ethenogenes (D.E.)</i></b>	<b>Ethene</b>



Specific DNA

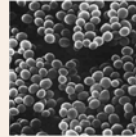


- Pre-investigation of sites
- Monitoring of processes in the soil and water



## Case 1: Total Concept Evenblij at Hoogeveen site and Almelo site

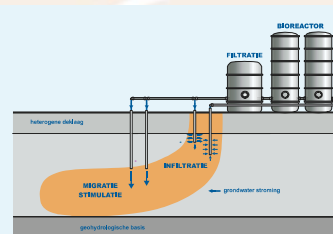
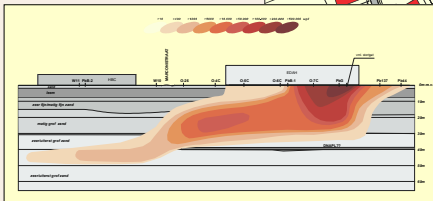
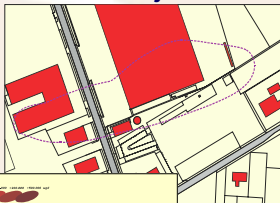
Description of sites:  
lack of dechlorinating bacteria, therefore  
bioaugmentation of soil and groundwater



## Contaminated site Evenblij

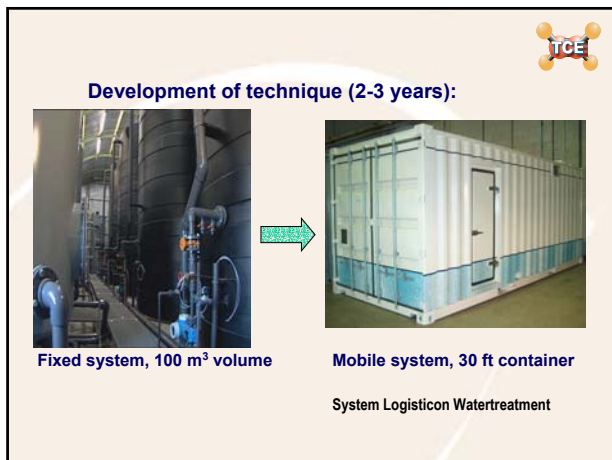
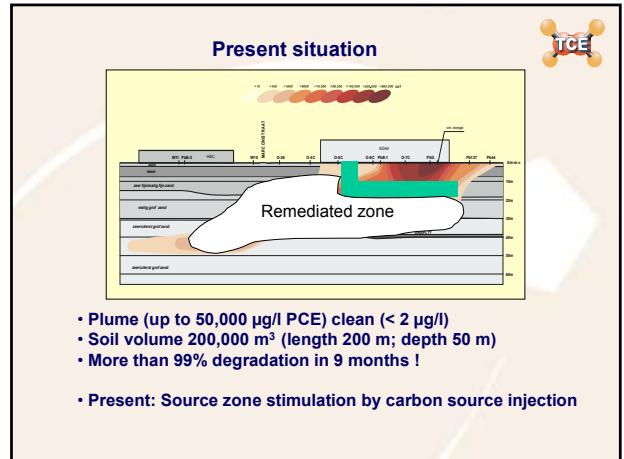
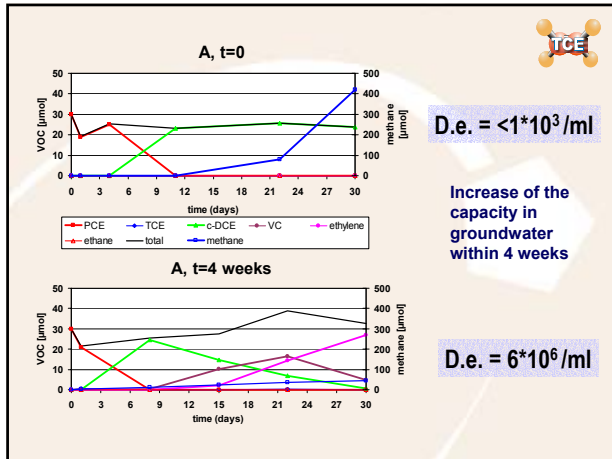


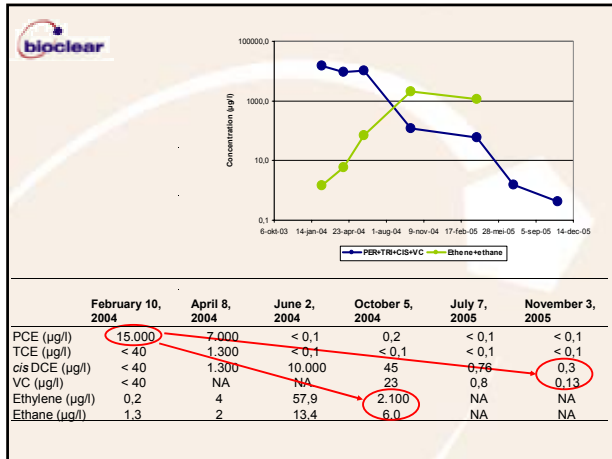
- pure product in upper layer
- plume > 200.000 m<sup>3</sup>
- no Natural Attenuation and no complete dechlorination after carbon source addition



Transfer of degradation capacity from  
bioreactor to the soil:  
Infiltration of organisms

Full scale dechlorinating  
bioreactors

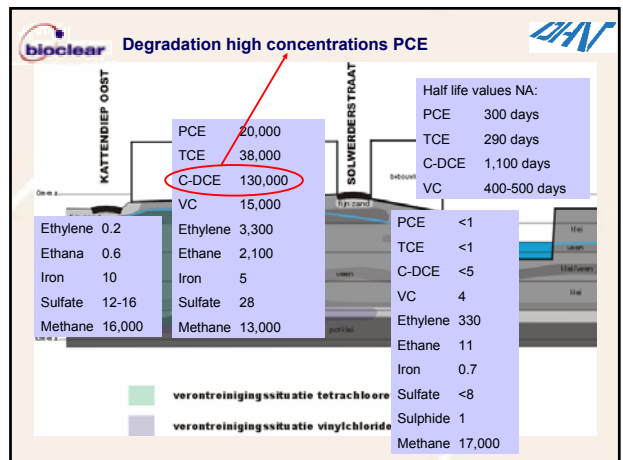
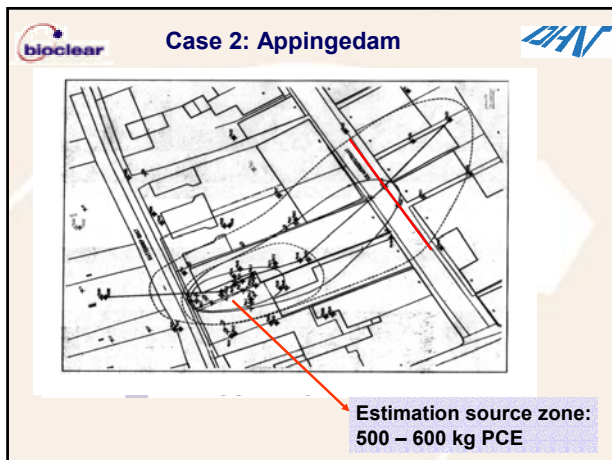


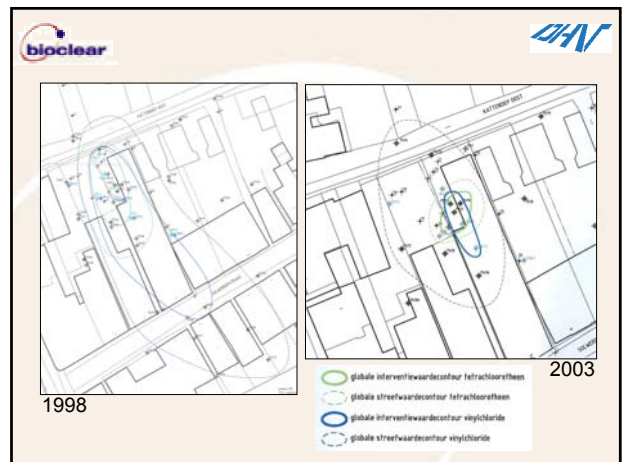
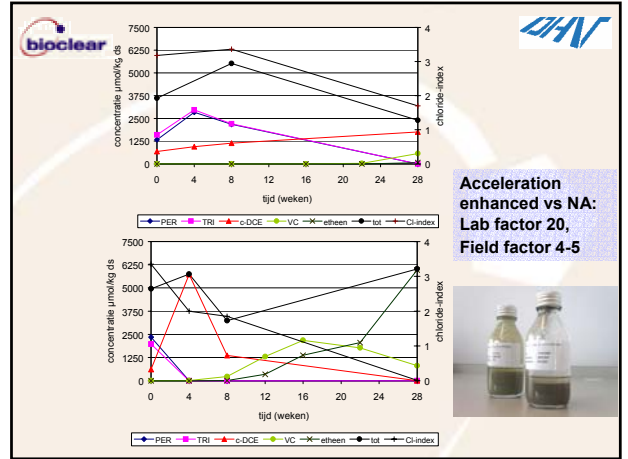
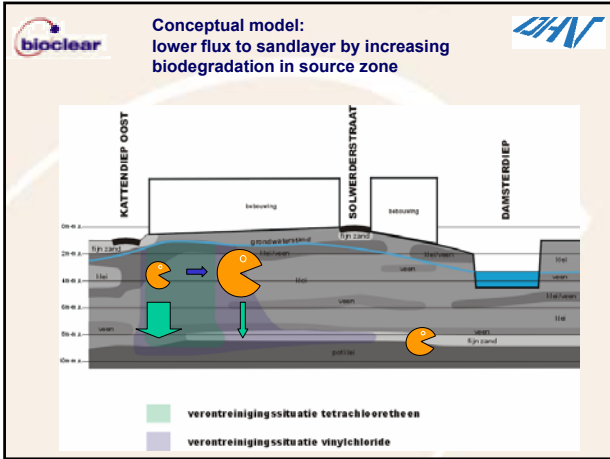


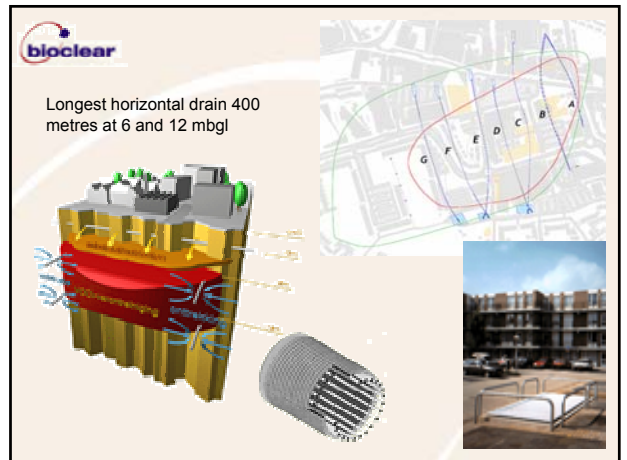
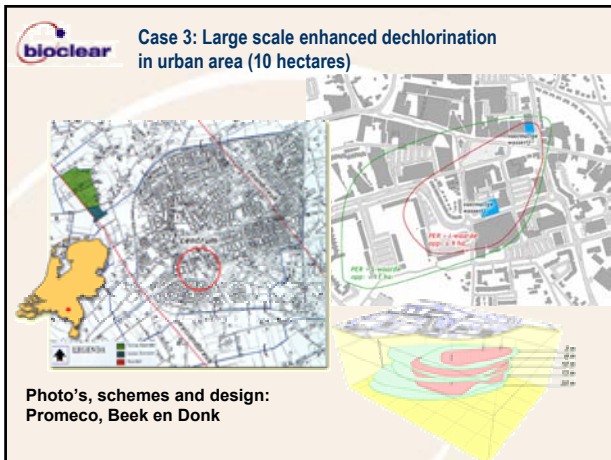
	February 10, 2004	April 8, 2004	June 2, 2004	October 5, 2004	July 7, 2005	November 3, 2005
PCE (µg/l)	15,000	7,000	< 0.1	0.2	< 0.1	< 0.1
TCE (µg/l)	< 40	1,300	< 0.1	< 0.1	< 0.1	< 0.1
cisDCE (µg/l)	< 40	1,300	10,000	45	0.76	0.3
VC (µg/l)	< 40	NA	NA	23	0.8	0.13
Ethylene (µg/l)	0.2	4	57.9	2,100	NA	NA
Ethane (µg/l)	1.3	2	13.4	6.0	NA	NA

## NIRAS

### Site Kongevej, Copenhagen



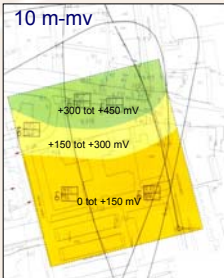






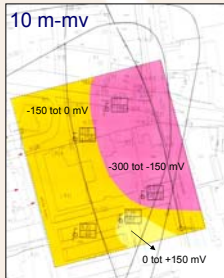
Change in redox conditions,  
necessary for dechlorination

10 m-mv



T=0 situation

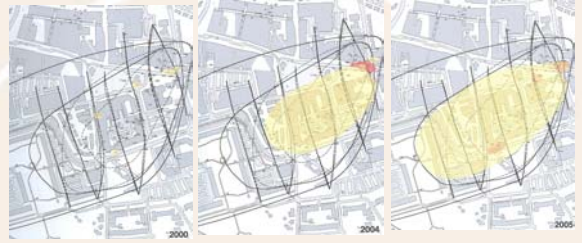
10 m-mv



6 months after start up



Vinyl chloride



Ethylene



Site Mälarstranden, Västerås



City of Västerås, JM, PEAB



## Remarks and conclusions



- **Good pre-investigation necessary:**
  - show capacity
  - use for design
  - prevent problems in full scale application phase
- **Bioremediation can be very powerful and fast**

Use the strength of nature!

Thanks for your attention