

# BIOREMEDIATION of chlorinated phenols, using dilute INTEROX<sup>®</sup> Hydrogen Peroxide : demonstration trough mass balance



## CONCLUSIONS

The mass balance enabled the evaluation of the individual contribution of the flushing and the biodegradation processes to the global remediation.

Initially, flushing was the main process of remediation. After the development of in situ conditions favorable for the aerobic biodegradation, the main process of contamination removal is bioremediation contributing for 71% to the global contaminant removal.

The injection in the aquifer of a diluted solution of INTEROX<sup>®</sup> Hydrogen Peroxide proved to be efficient to control the dissolved oxygen concentration and consequently to stimulate the activity of the indigenous aerobic microbial population.

The remedial strategy developed during the pilot test has been scaled up to the entire contaminated area (1ha, 79000m<sup>3</sup>).

**Solvay**  
**Chemicals**



## Description

### Context

During ground work, a ground water contamination with chlorinated and non-chlorinated phenolic compounds (phenol, cresol, mono- and dichlorophenols) was discovered.

The retained remedial strategy was in-situ bioremediation. The indigenous microbial activity was stimulated by introducing oxygen as a diluted solution of INTEROX® Hydrogen Peroxide.

**Table 1 : Contaminants highest concentrations**

Phenol	30900	µg/l
o - Cresol	302000	µg/l
2 - Chlorophenol	29100	µg/l
4 - Chlorophenol	58300	µg/l
2,4 - Dichlorophenol	75900	µg/l
2,6 - Dichlorophenol	15900	µg/l
4 Chloro - 2 Methylphenol	39300	µg/l
6 Chloro - 2 Methylphenol	10800	µg/l

### Hydrogeology

Overall geological profile

0 – 4 m	made up ground and loam
4 – 14 m	sandy loam
Below	low permeability silts

Hydraulic conductivity :  $4 \cdot 10^{-5}$  -  $2 \cdot 10^{-4}$  m/s

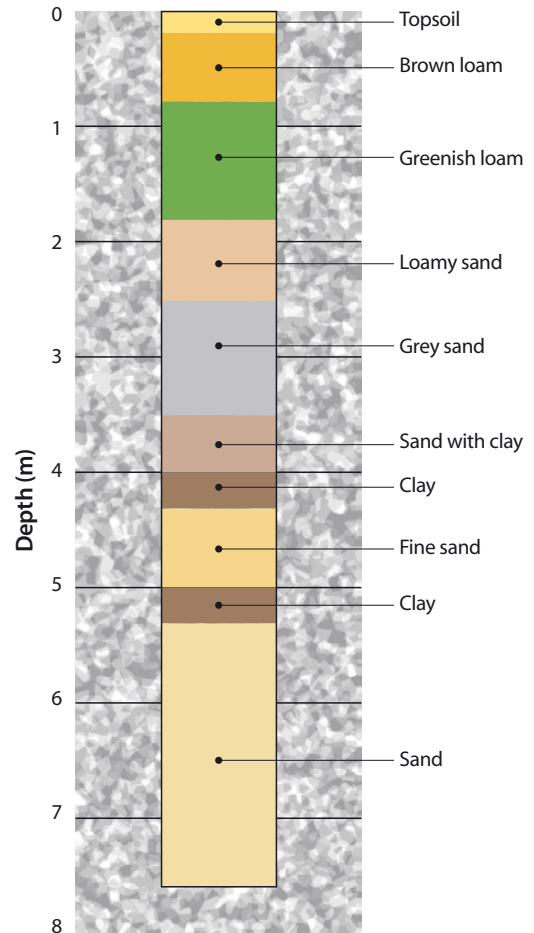
Piezometric level at the site is controlled by drainage ditches.

### Geochemistry

The ground water is naturally brackish with depth.

Strongly reducing condition prevails in the plume with methane present and sulfide up to 22 ppm.

**Figure 1 : Log profile well A1**



## Remedial Strategy

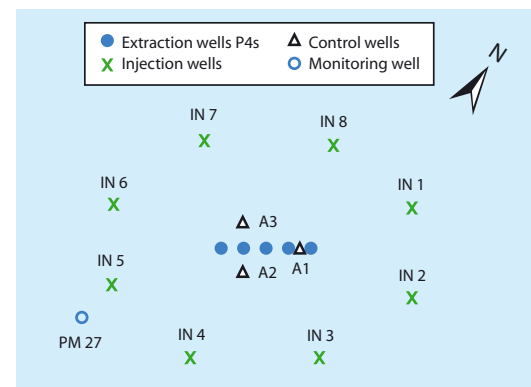
A combination of Pump & treat and in-situ bioremediation was selected based on lab and field test.

The extracted water was treated on site prior to discharge in the site waste water system.

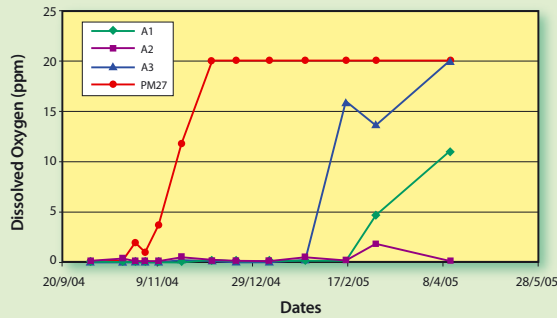
The aerobic indigenous bacterial population is stimulated by the injection of diluted INTEROX® Hydrogen Peroxide (50 to 1000 ppm) as oxygen source and nitrate (50 ppm) as nitrogen source.

Central extraction wells at  $1 \text{ m}^3/\text{h}$   
Peripheral injection wells at  $0,8 \text{ m}^3/\text{h}$

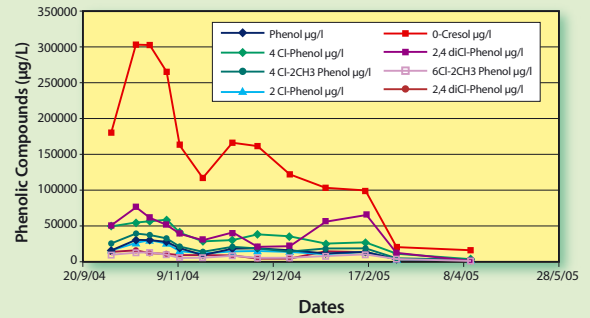
**Figure 2 : in situ pilot plan**



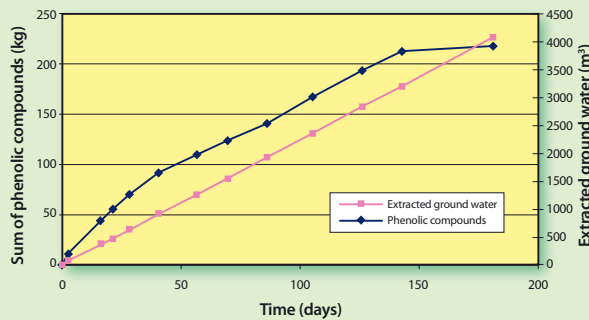
**Figure 3 : Dissolved oxygen concentration evolution in control wells**



**Figure 4 : Contaminant concentrations evolution in Control well A1**



**Figure 5 : Mass balance of the extracted quantities**

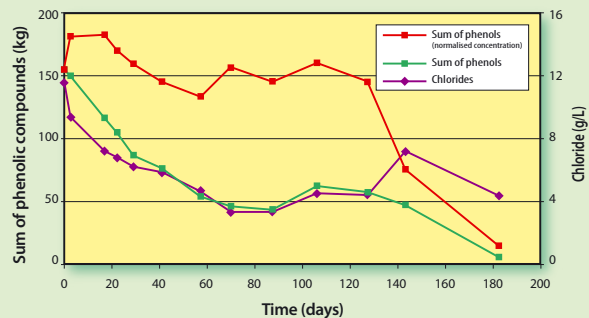


**Interpretation of the results:**

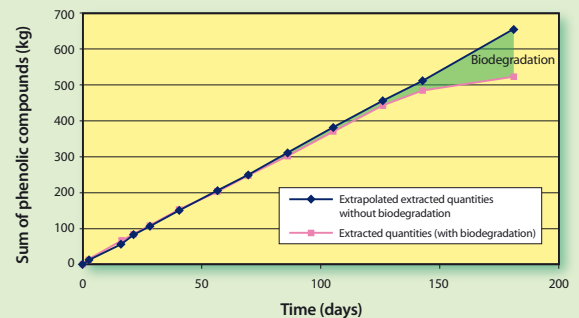
Hypothesis for the evaluation of the contribution of the bioremediation

- 1) Chlorides behave as a perfect tracer chemically and biologically inert,
  - 2) The concentrations of chloride and contaminants in the inflow (0,2m<sup>3</sup>/h) into the pilot area is considered to be constant for the duration of the pilot trial.
- In order to differentiate the dilution effect from the bioremediation on the contaminants, the phenolic compounds concentrations have been normalized against the chloride concentrations.

**Figure 6 : Chloride, sum of phenolic compounds in extracted ground water and normalized concentration of the latter**



**Figure 7 : Biodegradation estimation based on data normalised against the chloride concentration**



**Global mass balance on the phenolic compounds**

Extracted contaminant mass through flushing (measured)	219 kg
Biodegraded contaminant mass (estimated)	50 kg
Total mass remediated	269 kg

Stoichiometric mass of contaminant potentially degraded based on the available oxygen of the INTEROX® Hydrogen Peroxide supplied	500 kg
Estimated yield of the hydrogen peroxide based on contaminant destruction only	10 %

**Mass balance on the period (day 143 to 182) after the onset of the biological activity**

Rate of extraction without biodegradation (extrapolation)	1.41 kg/d
Real rate of extraction (with biodegradation)	0.41 kg/d
Contribution of the biodegradation	71 %

## **SOLVAY CHEMICALS**

Solution Unit Soil Remediation  
Rue de Ransbeek, 310 - B- 1120 Brussels - Belgium  
Tel. +32 (0)2 264.17.34 - Fax +32 (0)2 264.18.05  
[www.remediation-soil.com](http://www.remediation-soil.com)



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