INNOVATIVE REMEDIATION OF GROUNDWATER CONTAMINATED BY CHLORINATED HYDROCARBONS

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ABSTRACT

High concentration of chlorinated aliphatic hydrocarbons (mainly trichloroethylene, TCE) was detected in groundwater at the site of a former metalworking plant in Hungary. Lab- and pilot-scale experiments were set up to compare the potential technology-alternatives. Based on the results *In situ Chemical Oxidation* (ISCO) with hydrogen peroxide by using push & pull technique was implemented in full scale. Complex evaluation of the results has confirmed the laboratory findings: ISCO using hydrogen peroxid with iron and phosphoric acid can be a cost effective viable method of achieving risk-based remediation goals at this site.

LAB-SCALE FEASIBILITY STUDIES

Enhanced biodegradation using additives (toluene, cyclodextrin)

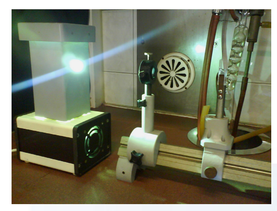
Reactors GW – groundwater	TCE-degrading cell conc. [cell/ml] *10^2	TCE-degradation [%]	[mg]
GW (without additives)	15	10	0.5
GW + 500 µg/ml toluene	110	48	2.5
GW + 292 µg/ml TCE	46	14	20.4
GW + 292 µg/ml TCE + 0,5 % RAMEB	460	30	43.8
GW + 292 µg/ml TCE + 1,0 % RAMEB	1100	30	43.8
GW + 292 µg/ml TCE + 500 µg/ml toluene	210	32	46.7
GW + 292 µg/ml TCE + 1000 µg/ml toluene	1100	41	59.8

TCE was cometabolised by microorganisms in the presence of toluene as a growth substrate. Even though positive results the efficiency of the TCE-removal should be improved.

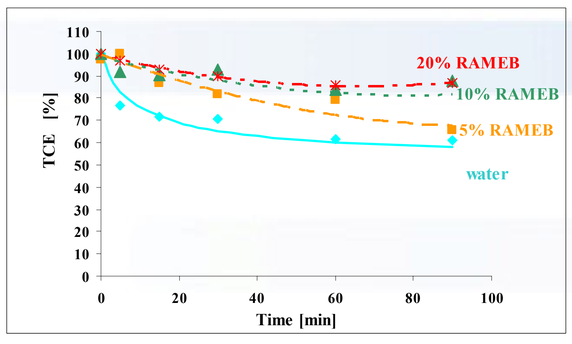
Photodegradation by UV irradiation in the presence of cyclodextrin (RAMEB)

Extraction experiments were performed prior to UV irradiation: 0, 5, 10 and 20 % aqueous solutions of RAMEB was applied. 10 ml TCE and 200 ml of cyclodextrin solutions was periodically shaken for 3 days and the concentration of TCE was measured by gas chromatography.

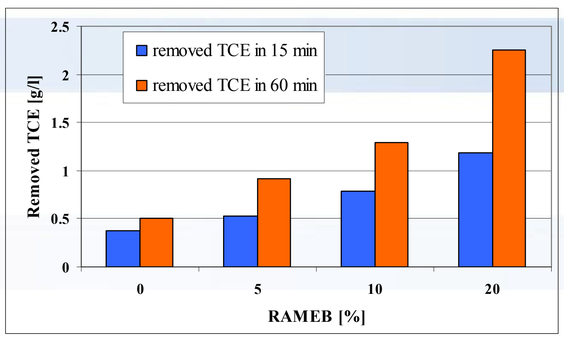
UV irradiation: 3 ml of supernatant from the extraction experiments was irradiated with high pressure mercury lamp and sampled in every 5 min.



RAMEB improved the efficiency of the whole technology (extraction & UV irradiation)



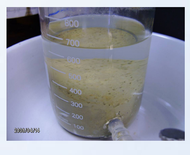
TCE concentration in the solutions of various RAMEB concentrations during UV irradiation

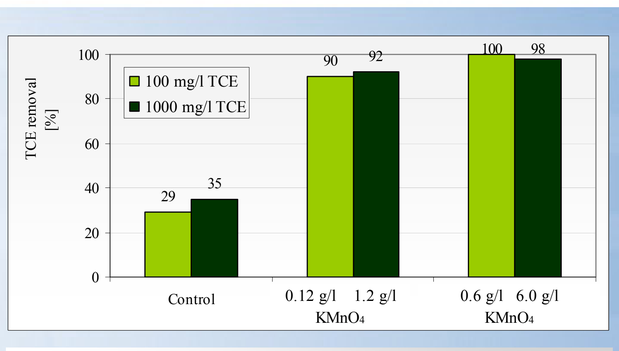


Efficiency of the technology characterized by the amount of TCE removed

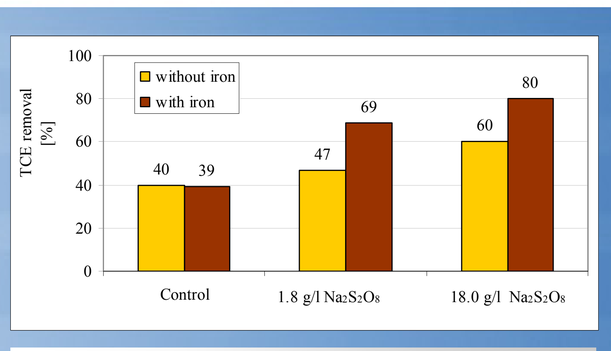
ISCO applying potassium permanganate, sodium persulfate and hydrogen peroxide

In situ **chemical oxidation of contaminated groundwater (and soil) using potassium permanganate, sodium persulfate and hydrogen-peroxide was modelled in batch reactors 250 ml of volume.**

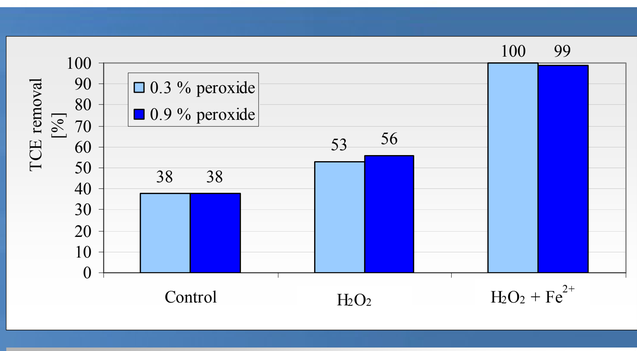




Efficacy of permanganate treatment on groundwater contaminated by TCE



Efficacy of persulfate treatment on groundwater contaminated by 100 mg/l TCE



Efficacy of hydrogen peroxide treatment on groundwater contaminated by 100 mg/l TCE

The combination of ISCO using hydrogen peroxide with ferrous iron and phosphoric acid was the most effective and can be a feasible option for remediation of the site.

FIELD DEMONSTRATION – ISCO USING H_2O_2

High concentration of trichloroethylene was identified in the concentration of 150–35,000 µg/l in groundwater at the site of a former metalworking plant in Hungary.

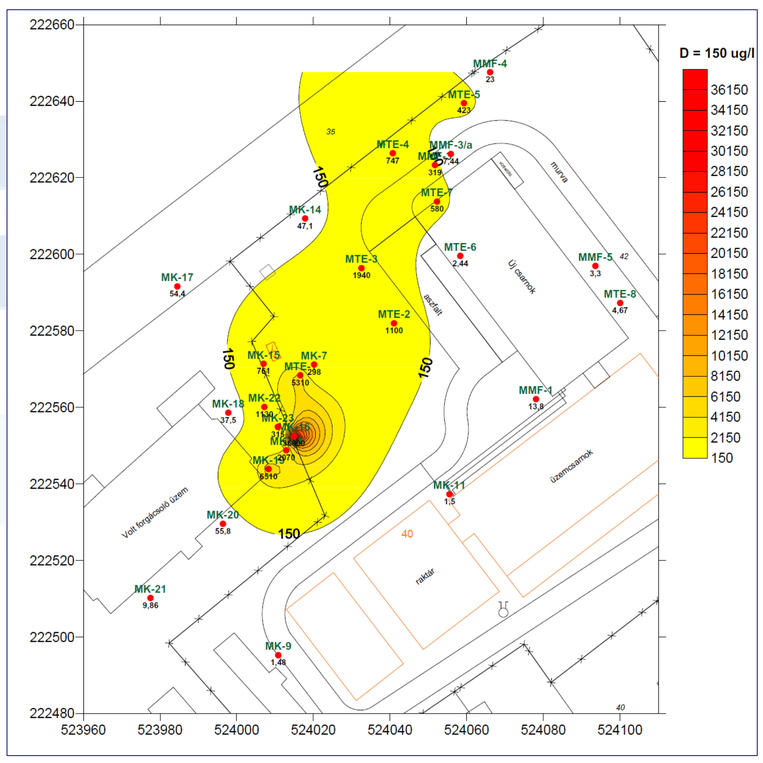
Hungarian Limit Value (D): 150 µg/L

- MK, MMF – Groundwater monitoring wells

  MK16, MK19, MK22, MK23, MK24, M3 - Injection wells on the highly contaminated site

  MTE1 – Extraction well on the highly contaminated site

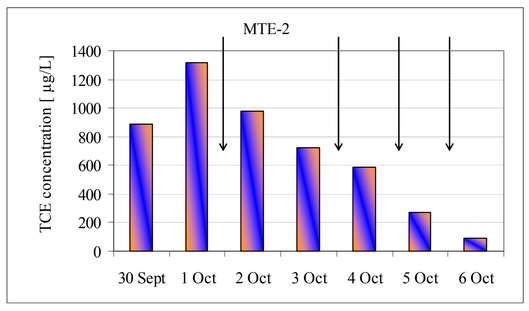
TCE distribution in the groundwater on the site

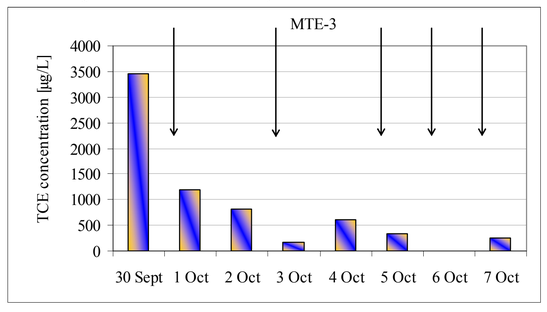


The ISCO method with hydrogen peroxide (0.15-0.6%) by using push & pull technique was implemented in full scale. Wells pumped in turns were involved in the remediation at the polluted site. The effectiveness of the chemical oxidation was promoted by addition of phosphoric acid.

The field-scale technology-monitoring included the gas chromatographic measurement of chlorinated hydrocarbons, measurement of pH, conductivity and analysis of inorganic anions such as such as chloride, nitrate, sulphate, carbonate and phosphate.

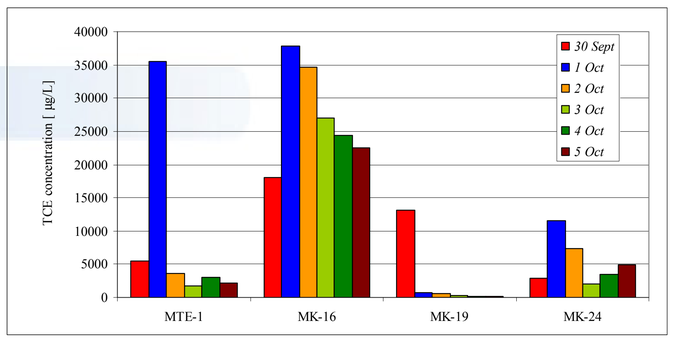
Results of the push&pull technique on the slightly contaminated site (MTE-2 and MTE-3 wells: extraction and injection in turn)





On the effects of the applied innovative technology TCE-concentration of the groundwater was reduced in all cases. The initial 13,000 µg/l TCE-concentration in one of the wells on the treated site has already been decreased to ~1000 µg/l after the first injection. In the most polluted well on the site the TCE concentration was reduced to the half from the original 35,000 µg/l following one week of operation.

Results of the push&pull technique on the highly contaminated site (daily treatment)



SWOT

Strengths: H_2O_2 can rapidly and effectively degrade chlorinated aliphatic hydrocarbons. Microorganisms are not negatively affected by H_2O_2 application (< 2%).

Weaknesses: Costs of chemical agents.

Opportunities: *In situ* treatment may reduce costs. Applicable for hot spots and highly contaminated zones.

Threats: Handling large quantities of hazardous oxidizing chemicals.

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