



EU-Life: Demonstration of the Use of Monitored Natural Attenuation (MNA) as a Remediation Technology - DEMO-MNA (2003-2006)

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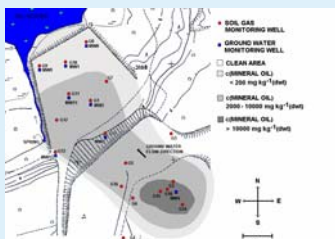


Three lines of evidence

- Site history
 - Geochemical evidence on biodegradation
 - Microbiological experiments, contaminant degradation
- > Efficiency of natural attenuation in risk management



Site



Salminen et al. 2004, Biodegradation 15: 29-39

- Mineral oil up to 68 600 mg/kg (dwt)
- Closed landfill site
- Fine sand - gravel



Activities

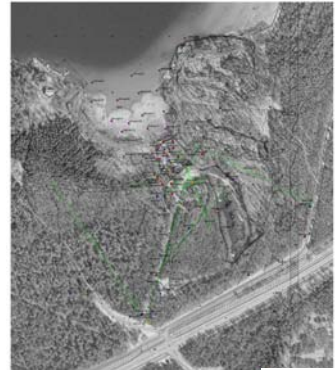
- Field studies: ground penetration radar survey, electrical resistivity sounding, soil sampling, ground water monitoring, sediment sampling, soil gas monitoring
- Laboratory analyses: contaminant concentrations, biological activity, ecotoxicology, soil structure



Activites cont.



- Modelling: geology, ground water flow, contaminant transportation
- Evaluation of efficiency of natural attenuation
- Risk assessment and risk management during the remediation



DEMOMNALIFE
Location of investigation points 1 : 1000

- Drilling point
- Sediment Sample
- Test pit
- Groundwater well GTK
- Groundwater well SYKE
- End of resistivity line
- Resistivity line
- Infiltration test
- Reference point



Soil sampling by drilling



Soil sampling by digging



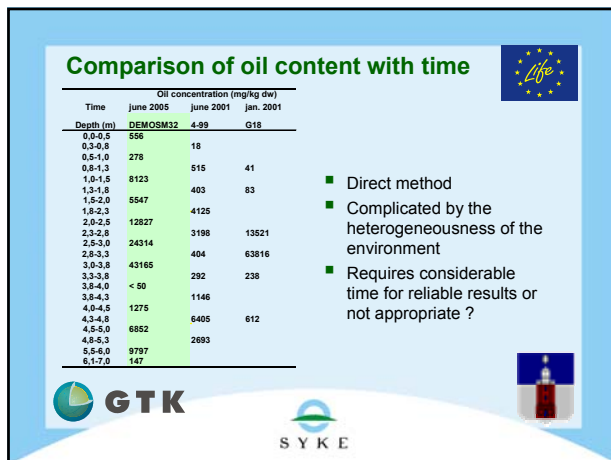
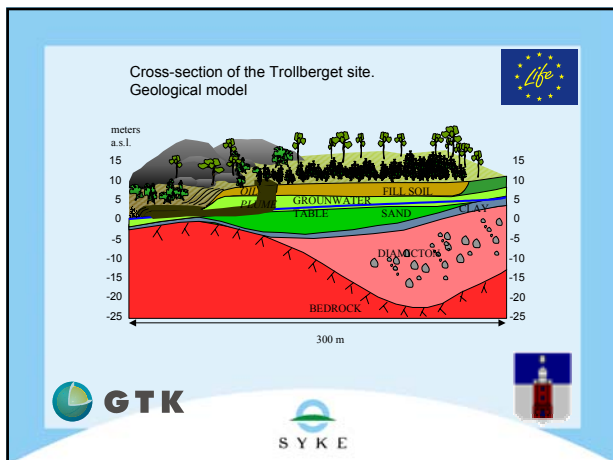


Table 1. Selected groundwater data from the Trollberget site October 2004.

Parameters	Upstreams DEMOGW05	Near hot spot MW4	Midgradient DEMOGW20	Downgradient MW8
Hydrocarbons µg/l	< 100	830 000	63 000	<100
Orthoxylene µg/l	<0.1	50	15	0.49
Meta+paraxylene µg/l	<0.1	130	27	0.32
Naphthalene µg/l	<0.1	<1	7 ^a	<0.1
Ethylbenzene µg/l	<0.1	19	11	0.31
Benzene µg/l	<0.1	1.6	2.0	0.5
Oxygen ^b mg/l	4.6	nd ^c	2.4	3.5
Fe (II) mg/l	1	77	31	0
Nitrate mg/l	<0.2	nd	<0.2	1.4
Sulfate mg/l	9.8	nd	5.6	2.9
Methane mg/l	0.02	5.3	2.7	0.5
HCO ₃ ⁻ mg/l	18	nd	566	596
Elec. conduct. mS/m	7	nd	94	98
pH	7.0	nd	6.6	7.8
Temperature °C	9.2	nd	11.5	10.8

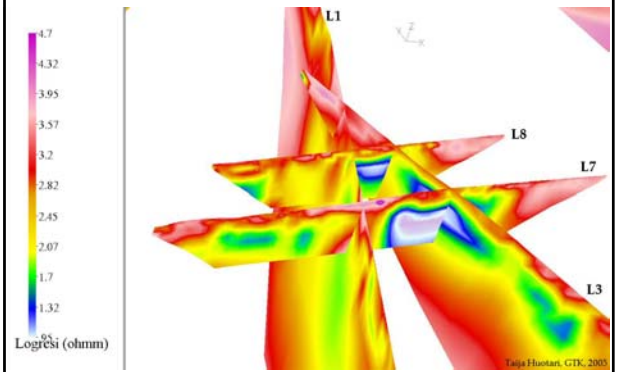
^a Hydrocarbons disturb integration
^b Low oxygen concentrations may be overestimated due to the sampling technique.
^c Not determined

Logos: GTK, SYKE

Electrical resistivity measurements



Transects of resistivity measurements

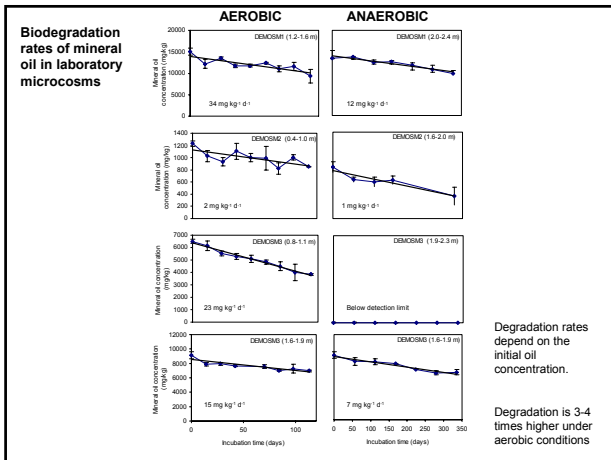
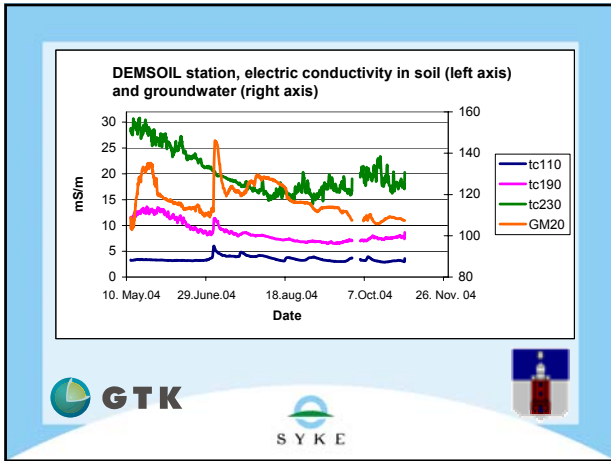


Installation of soil on-line monitoring sensors



DEMSOIL monitoring station





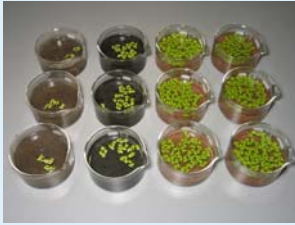
Bottles compared to soil cores

Microbial respiration activities in intact soil cores were at least 10 times lower than soil samples that were transferred to closed bottles with a gas space.

Logos: **GTK**, **SYKE**

Ecotoxicological tests

- Plant tests: salad, rye grass, red-clover, cress, duckweed
- Animal tests: pot worm, earthworm
- Soil animal community structure at the site



Critical contaminants



- Soil
 - Metals: Pb (major) (As, Ba, Cd, Cr, Cu)
 - Dioxins (PCDD/PCDF)
- Sediment
 - Cu, As, Cd, Pb, Zn
- Groundwater
 - Naphthalene, xylenes



Conclusions 1 (2)



- Maximum oil concentrations in the unsaturated zone
- Efficient aerobic and anaerobic biodegradation
- Elevated CO_2 and HCO_3^- concentrations in soil gas and groundwater cause elevated electrical conductivity
- Elevated Fe II, and presence of CH_4 indicates iron reduction, fermentation and methanogenesis



Conclusions 2 (2)



- On-line monitoring and electrical resistivity measurements are promising tools
- Soil from the deeper contaminated layers were toxic to soil animals, but a normal forest floor invertebrate community was detected in the surface layers of the site.
- Laboratory test may overestimate the degradation rates
- Heterogeneity of the site makes it difficult to obtain reliable time series of the contaminant concentrations





Ongoing work

- Risk assessment
- Modelling of the changes in the plume (transport, biodegradation)



Outcome of the project

- Is natural attenuation efficient at this site (as well as other oil-contaminated sites in Finland) and can MNA be used as remediation technique?
- Are risks controlled during the remediation by MNA?
- Technical guidance for site characterization

