THERMAL DESORPTION PILOT TESTING BIOCHIM MACHELEN

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Introduction

- Client: OVAM (Flemish Waste Agency)
- 2 separate pilot projects in 2013
- Contractor: Jan De Nul – Envisan with 2 subcontractors for the heating techniques
- under supervision of OVAM, VITO and TEC
-Testing of several techniques on 1 of the most polluted sites in Flanders

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History

Fire in 1993

Chemical company Biochim totally destroyed

all of the stored solvents ended up in soil and groundwater

LNAPL (pure product) spread over more than 1 ha

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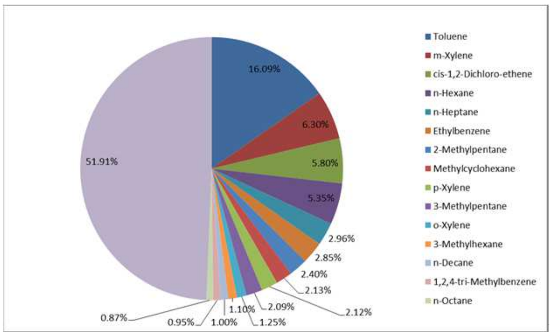
Contaminants in soil vapour

- Cocktail of 132 measured, volatile and semi-volatile compounds
- Traces of PCB's and heavy metals
- PFOS is currently being investigated (no data known)



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Identified contaminants in LNAPL

- C9-C12 Aromatic Compounds
- C7-C40 Aliphatic Compounds
- Diethyl-Hexylphtalate
- Indane
- Di-isodecylphtalate isomers
- Biphenyl
- Biphenyl Oxide

PS: DNAPL will be investigated/remediated separately as part of a large scale remediation (multiple sources)

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4 Pilots in 2011

- Soil vapour extraction + air treatment
- Multiphase-extraction (water / vapour / product) + treatment
- Confined space excavation
- LNAPL-recovery using different types of skimmers

⇒ Conditions and limitations known

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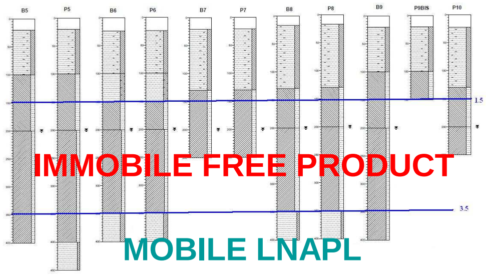
4 Pilots in 2011

- Soil Conditions:

Permeable sands (explosive vapours!) →

Loam with unconfined aquifer →

Permeable sands with confined aquifer →



- Contamination: highly toxic and explosive mixture

⇨ safety limitations for extraction, treatment and employees

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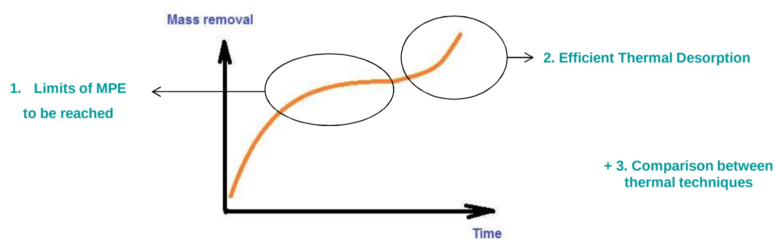
<u>Thermally Enhanced Soil Vapour Extraction</u>

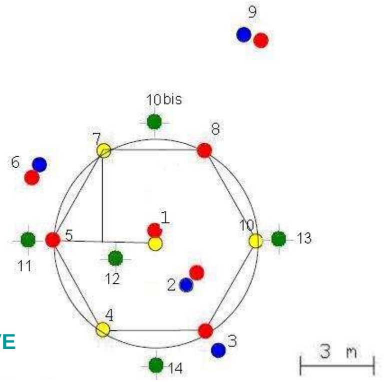
1. Multiphase extraction + radio-frequency heating
2. Soil vapour extraction + hot air conduction

Goals:



+ 3. Comparison between thermal techniques

1.1 MPE

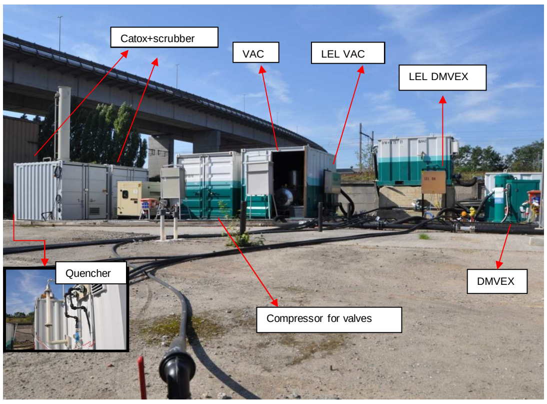


Yellow: shallow sand SVE

Red: deep sand MPE

Green: loam MPE

1.1 MPE



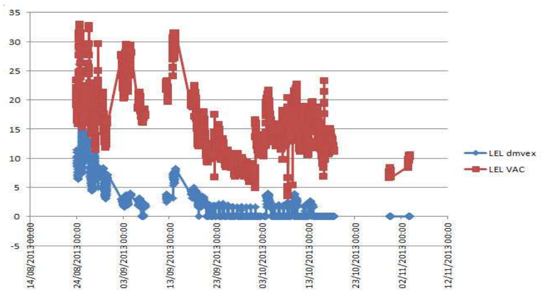
Air extraction: 80 m³/h (DMVEX) + 260 m³/h (VAC) = 340 m³/h

Air treatment: 500 m³/h (water treatment: 5 m³/h)

1.1 MPE

%LEL

(undiluted)



Time

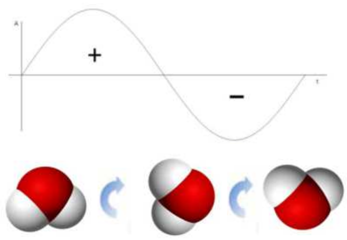
Goal 1 achieved and area was far less contaminated than in 2011

252 kg mass removal in air phase during 3 months pilot (+ 4.63 kg water phase + LNAPL)

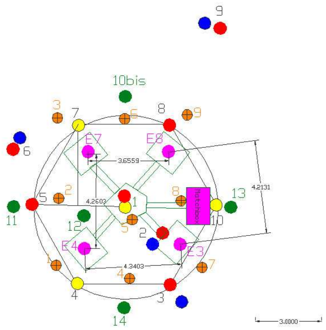
1.2 MPE + ISRFH

In-situ radio-frequency heating:

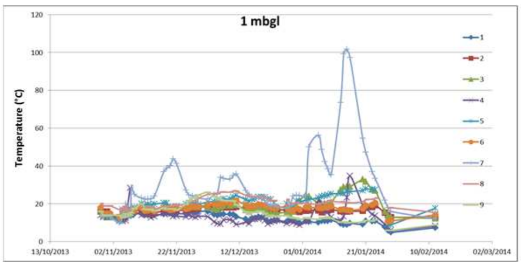
- waves in the MHz range cause an oscillating, electromagnetic field in the soil
- dielectric molecules rotate in this oscillating field
- the rotation causes friction which in turn heats the soil
- temperatures up to 300°C are theoretically possible

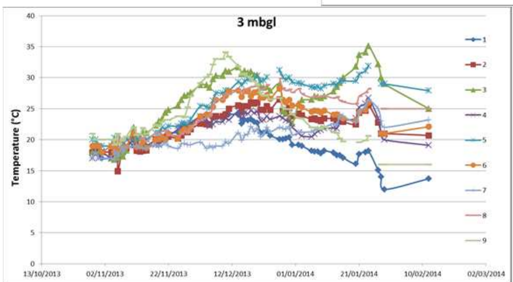


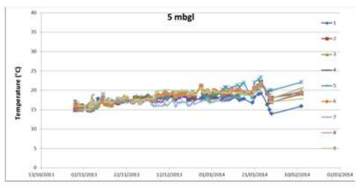
1.2 MPE + ISRFH



1.2 MPE + ISRFH







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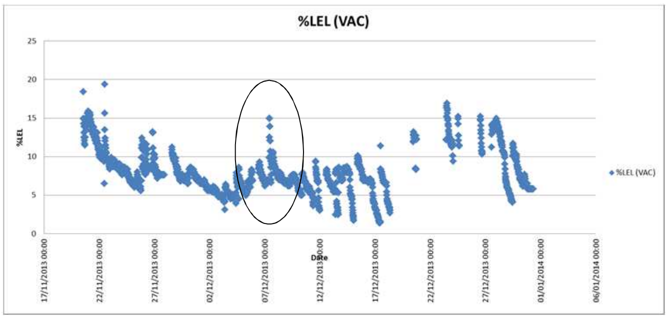
1.2 MPE + ISRFH

- only limited 'evidence' of increasing %LEL
(all other peaks due to shut-down and restart)



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1.2 MPE + ISRFH

- Insufficient heating: 25°C on average at 3 mbgl
- A lot of problems due to:
  - Fluctuating groundwater level
  - Electrodes at water interface, impedance correction for both unsaturated and saturated area was required
  - Coax cable got damaged (corrosion + arcing)
  - Matchbox got seriously damaged (overheated due to impedance problem)

- 28.143 kWh used for the heating over 49 days
- 54.687 kWh + 3,959.4 L propane used for extraction and treatment (4.5 months)

- Conclusions:
  not suited for loamy layer with water interface
  2 matchboxes required (saturated and unsaturated areas separated)

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2. SVE and conductive heating

- hot air conduction : a strong temperature gradient is installed in the soil by using a tight network of closed pipes, transporting burning gases
- the hot air in het pipes has a temperature above 250°C
- transfer of heat by conduction

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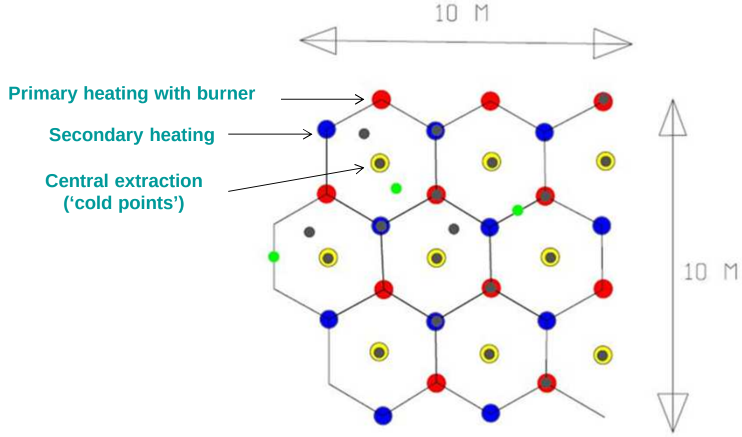
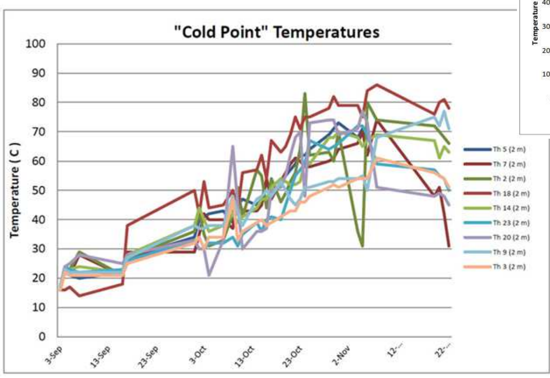
2. SVE and conductive heating

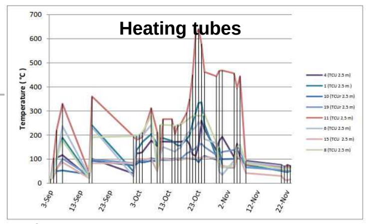


2. SVE and conductive heating

- SVE : 150 m³/h and treatment of 500 m³/h (catox + scrubber)
- 350 m³/h fresh air dilution as a function of measured LEL !!

2. SVE and conductive heating

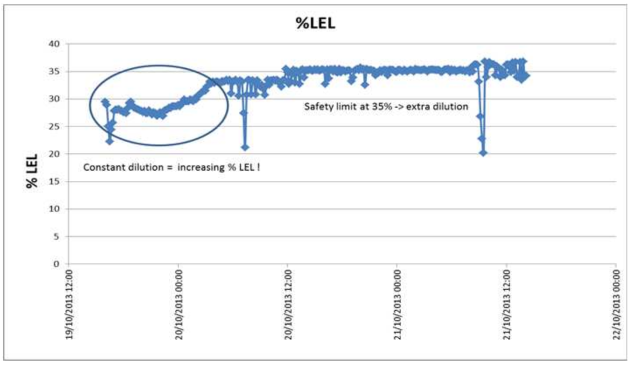




- 25,716 L of Propane used
- 5,498 kWh used for burners
- August 30 – November 6

Heating achieved

2. SVE and conductive heating



Goal 2 achieved and area was far more contaminated than the ISRFH area

877.5 g/u mass removal without heating and 966.4 g/u with heating but with higher dilution and hence lower extraction rate

2. SVE and conductive heating

- Smear zone heating until 6 mbgl was required: heating tubes were put in permeable sands
- Very efficient heating
- Extraction had to deal with vaporized LNAPL and steam, resulting in 100% LEL

- High vapour pressure in the soil

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2. SVE and conductive heating

- tubes = iron = expansion during heating

- very hard to seal -> vapours escaping

- ambient air monitoring

- biomonitoring

- eventually shut down due to neigbouring houses

- proposal for limited heating area was not accepted

- proposal for C3 treatment (cooling, compression and condensation) was not accepted

- proposal for ERH was not accepted

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CONCLUSIONS

▪ thermal desorption works

▪ MPE works

▪ MPE and/or SVE is required prior to heating in order to lower contaminant release (zone MPE versus zone SVE)

▪ heating should be saved for local hot spots

▪ heating either too slow or too fast

▪ hard to heat both saturated and unsaturated zone

▪ ERH (6- or 3-phase) is an alternative but humidification of the unsaturated zone is then required

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Questions?