Innovative HCH in-situ remediation using polymer as a reagent Carriers– Results at field scale

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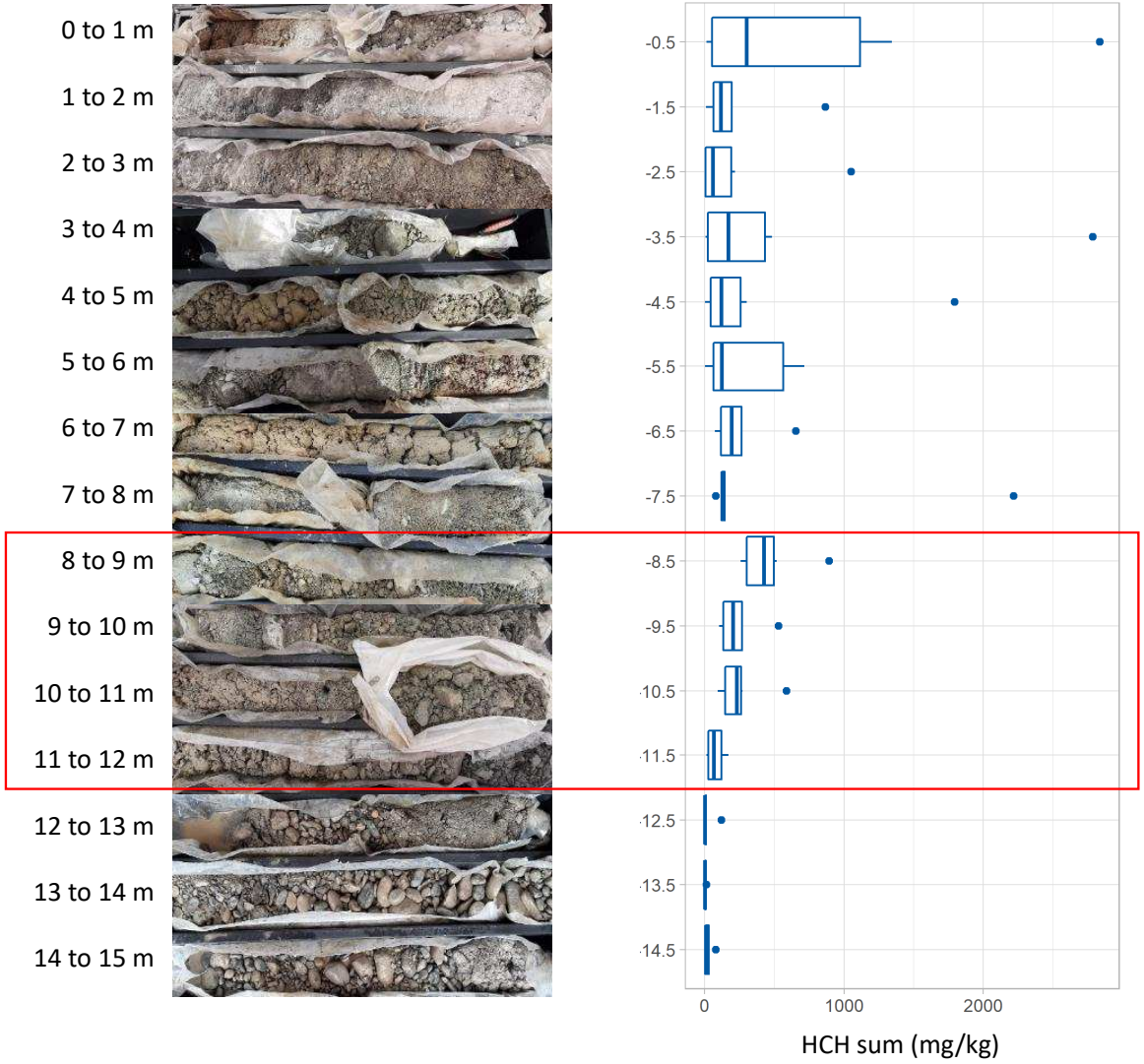
Improving treatment of HVOC adsorbed in high velocity aquifer

2017 - 2021

3 technologies developed and tested at lab scale

One was selected (reactive gel) to be assessed on the field

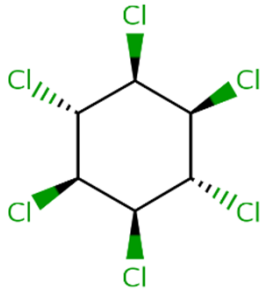
→ Objective: Increase contact between reactive and pollutant in a high velocity aquifer (homogeneous delivery and increased contact time)



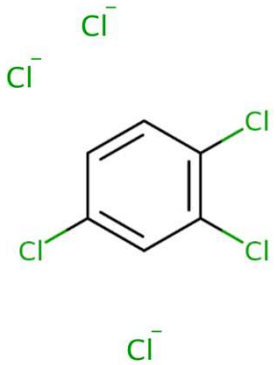
- Alluvial materials
- GW table : 8-10 m depth
- GW flow: 10 m/day

- High concentrations in lindane and isomers : Q_{25} – Q_{75} : 11 – 265 mg/kg between 0-15m

=> Main objective : treating the capillary fringe and the first meters of aquifer



+ alcaline agent



LINDANE and isomeres

Persistant organic pollutant (POP)

Low mobility
(Low vapor pressure and solubility)

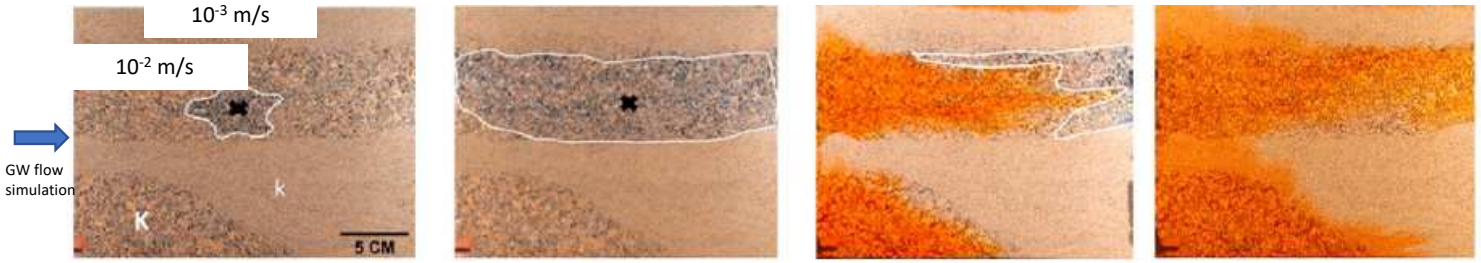
NON-TREATABLE
within sites conditions

1,2,4-Trichlorobenzene

Non-listed as a POP

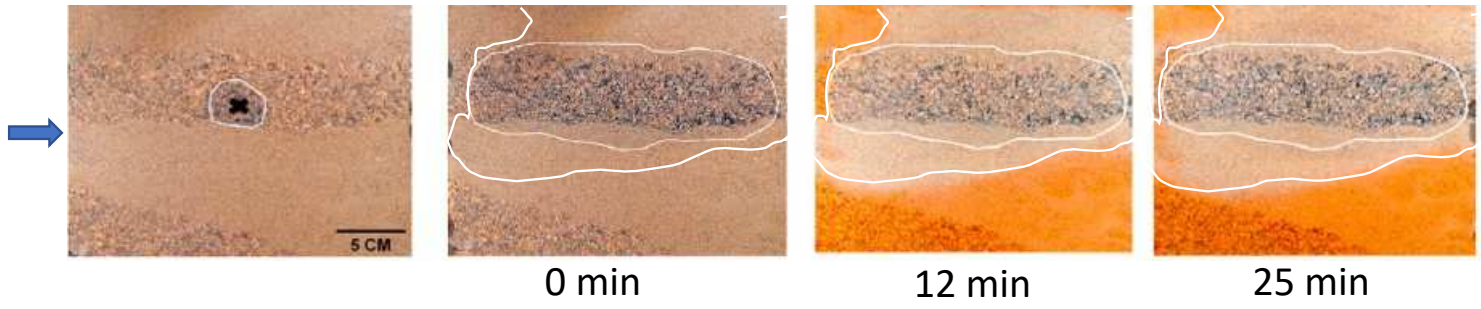
More mobile
Henry constant x400

TREATABLE
with conventional treatment (sparging/venting)



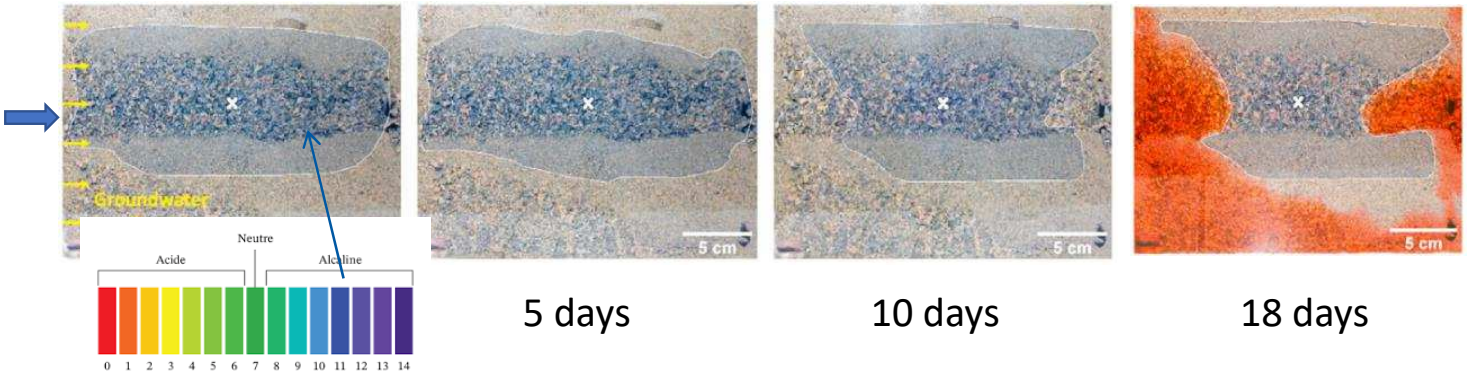
1) Injection of alcaline reagent alone

- Flows only in high permeability
- Leached by GW flow



2) Injection of reactive gel

- Propagates more homogeneously (shear-thinning behaviour)
- Not leached by GW flow (bypass)



- Very slow dissolution by GW flow
- Lifetime > 3 weeks
- Alcaline reagent remains stored in the gel

FIELD PILOTE

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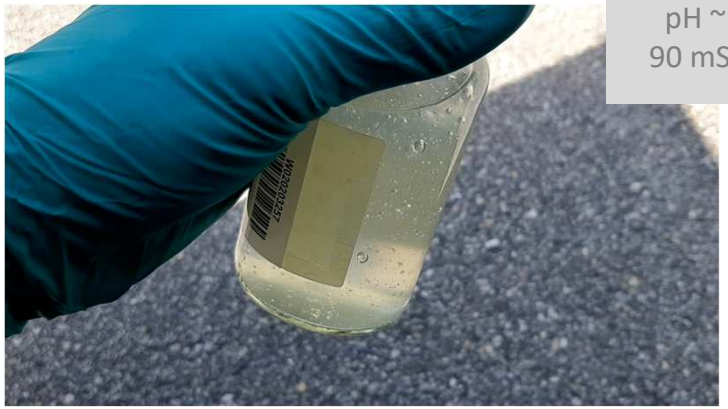
FIELD PILOT > SET UP

FIELD PILOT > GEL PREPARATION

Biodegradable gelling agent

Alcaline reagent

Water



pH ~ 13
90 mS/cm

Gel ready for injection !

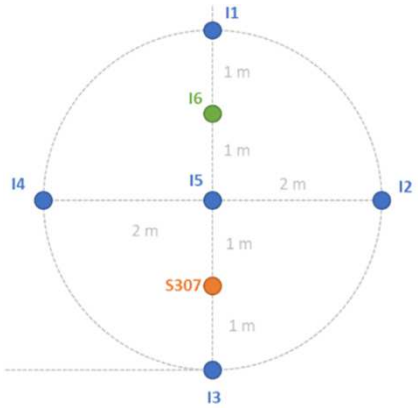
Containerized setup for gel preparation and injection

Injection well

FIELD PILOT > GEL INJECTION AND MONITORING

25 m^3 of gel injected into wells I1 to I6

→ 150 m^3 of reactive gel injected



Monitoring (automated)

- GW table levels (6 probes)
- Conductivity (Multi-depth, 25 probes)
- Temperature

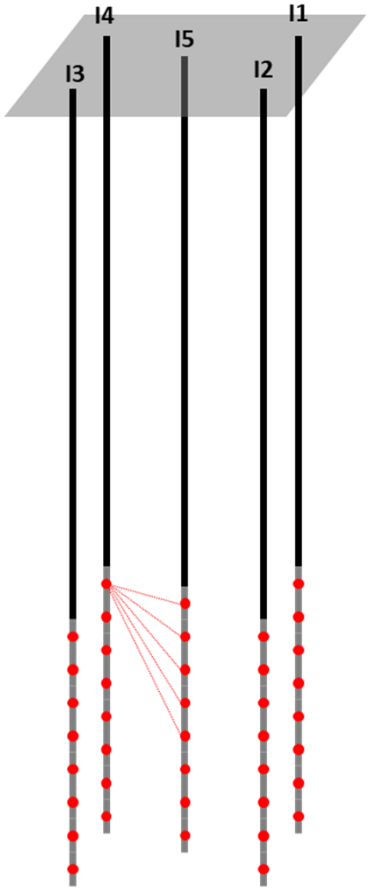
Monitoring (manual)

- Diagraphy (pH, ORP, conductivity, dissolved O_2 and temperature)
- Hydrogeological assays (GW flow velocity,…)

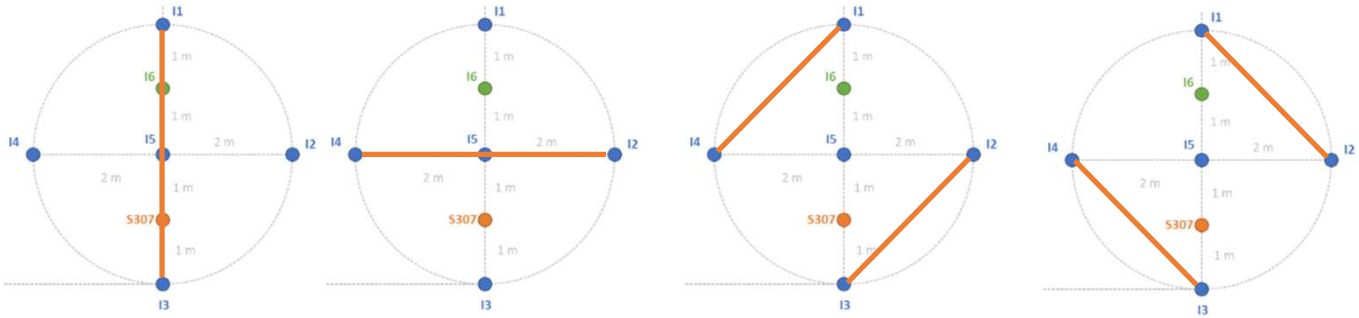
Analytic monitoring

- Weekly GW samples
- Multi-depth samples (before/after injections)
- Monitoring of lindane and isomers, chlorobenzene (mono- to hexa-), benzene, HC, TOC

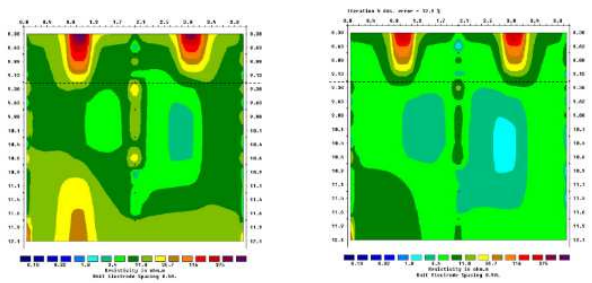
FIELD PILOT > TOMOGRAPHY AND ELECTRICAL RESISTIVITY MONITORING



Allows resistivity measurements between wells



→ Then 2D images are created



GEL PROPAGATION

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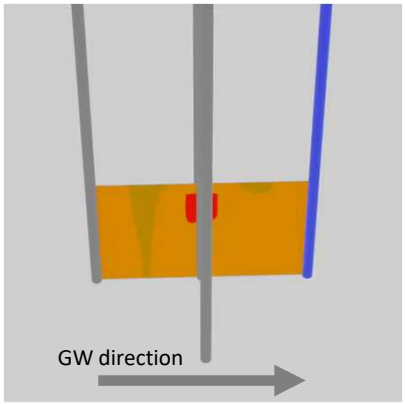
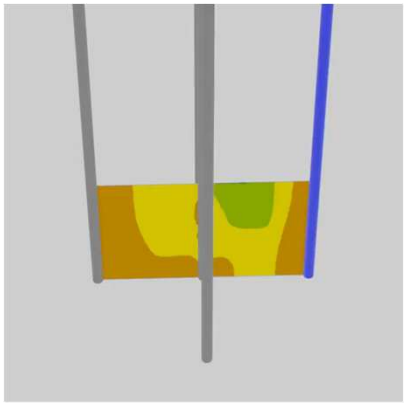
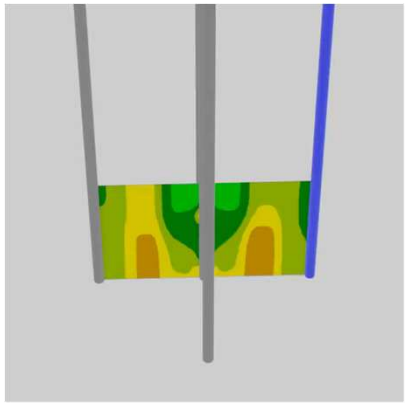
GEL PROPAGATION > CENTRAL INJECTION (I5) MONITORING



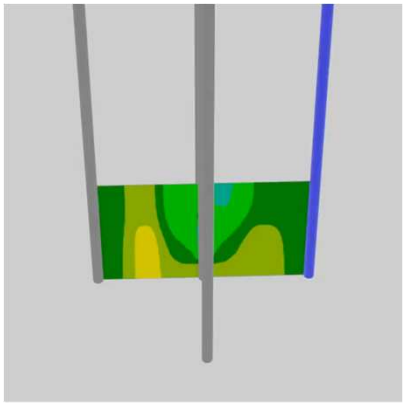
0 m³



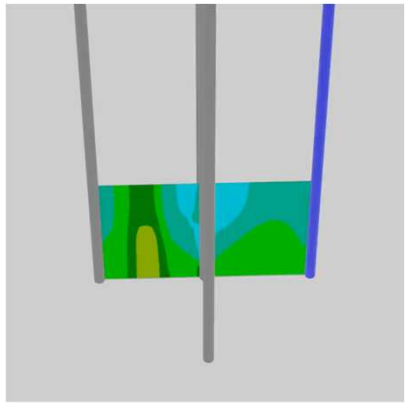
1 m³



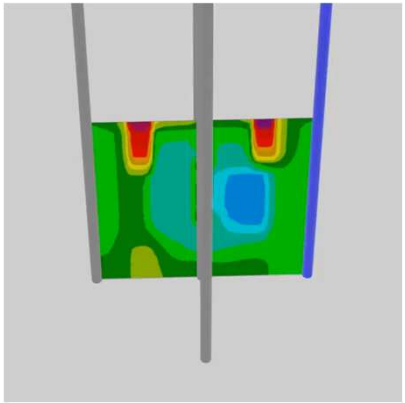
2 m³



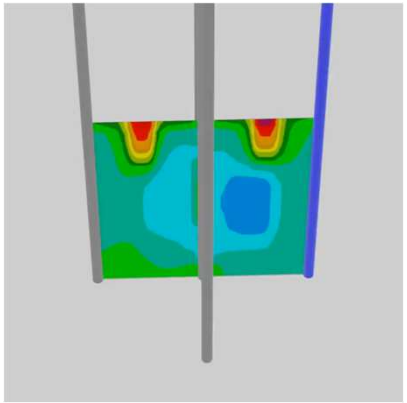
5 m³



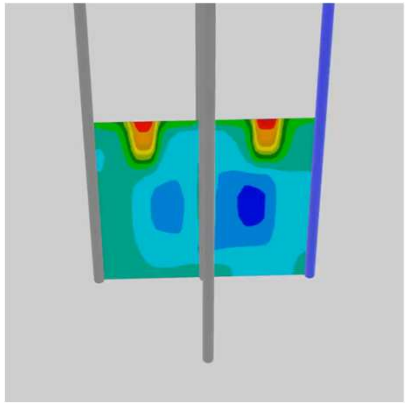
10 m³



12 m³

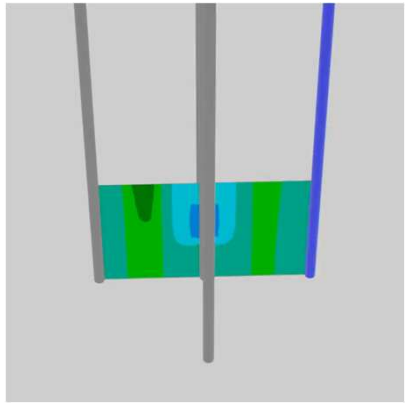


17 m³

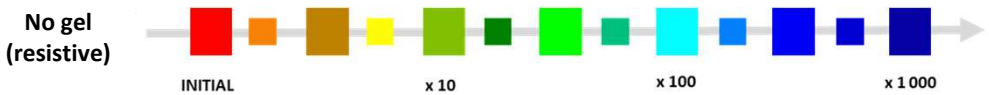


25 m³

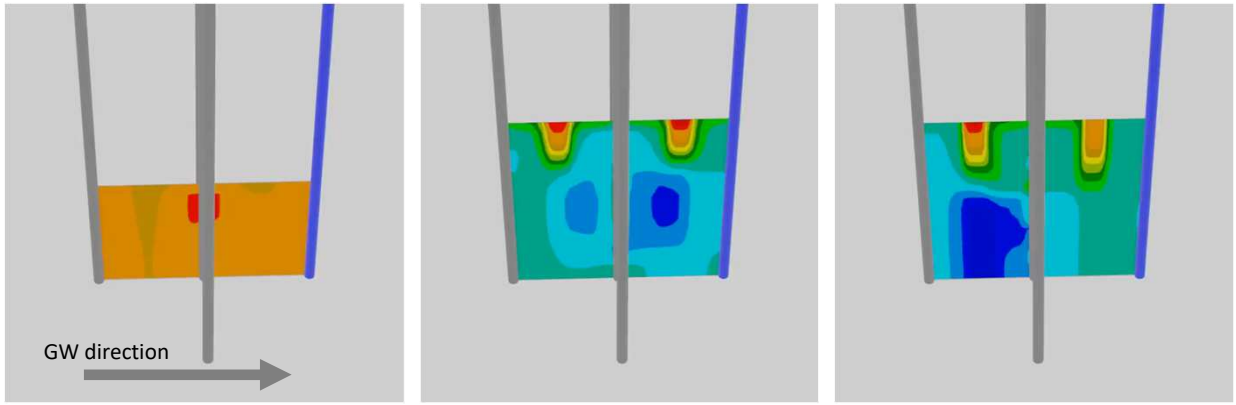
+ 4 days
(rest)



25 m³

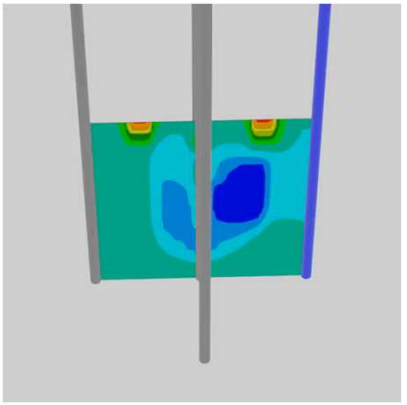


GEL PROPAGATION > CENTRAL INJECTION (I5) MONITORING



0 m^3 | 25 m^3 | 150 m^3

+ 3 weeks
(rest)



150 m^3

No visible difference after 25 m^3 injected, since gel propagation continued beyond ERT-imaging zone.
Gel arrived 10 m upstream (Pz47) after 120 m^3 injected.

Gel showed high persistency despite high permeability and high GW flow

10 months after the end of injection, significant amount of gel is still present in the soil !

HCH DEGRADATION IN SOIL AND GROUNDWATER

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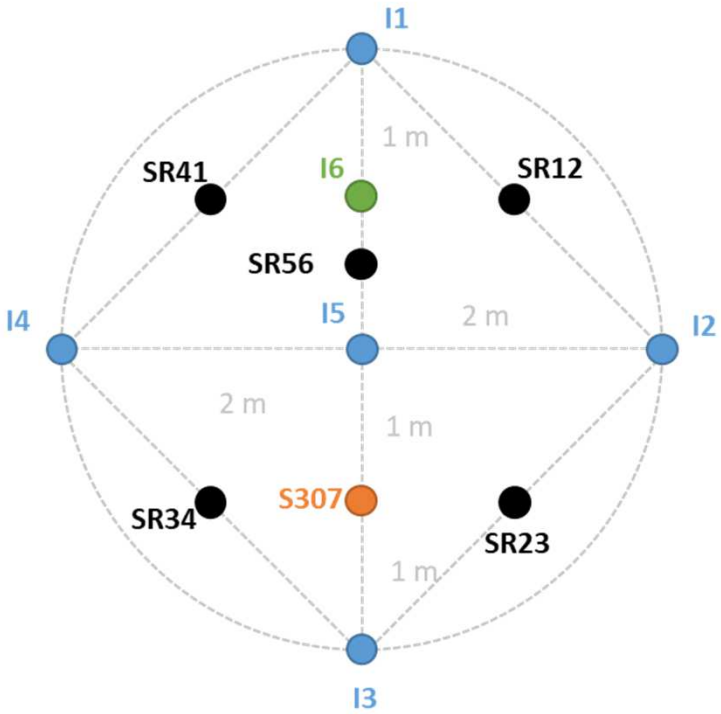


Initial characterisation :

- 6 soil drillings 0-15 m
- 90 samples

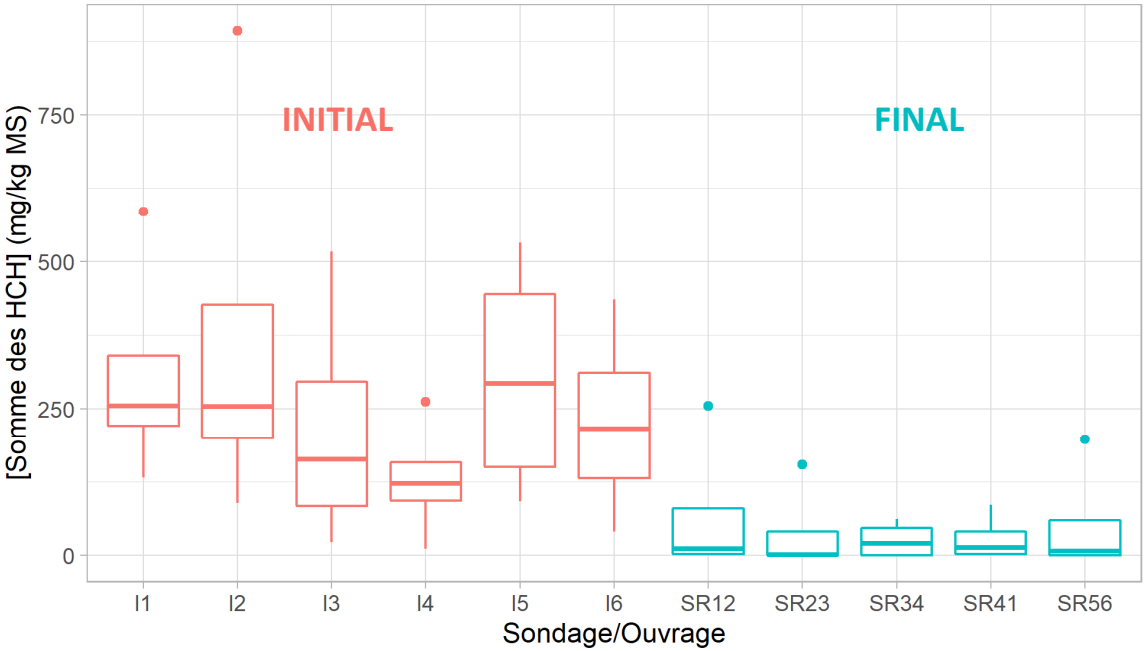
Final characterisation (1 month after injections) :

- 5 soil drillings 0-15 m
- 75 samples

Gel still present (observed) in soil samples at sampling time

HCH DEGRADATION > CONCENTRATIONS IN SOIL

Targeted depth
(between 8 and 12 m)



Initial median (mg/kg)
146

Final median (mg/kg)
2,05

Degradation yield
99%

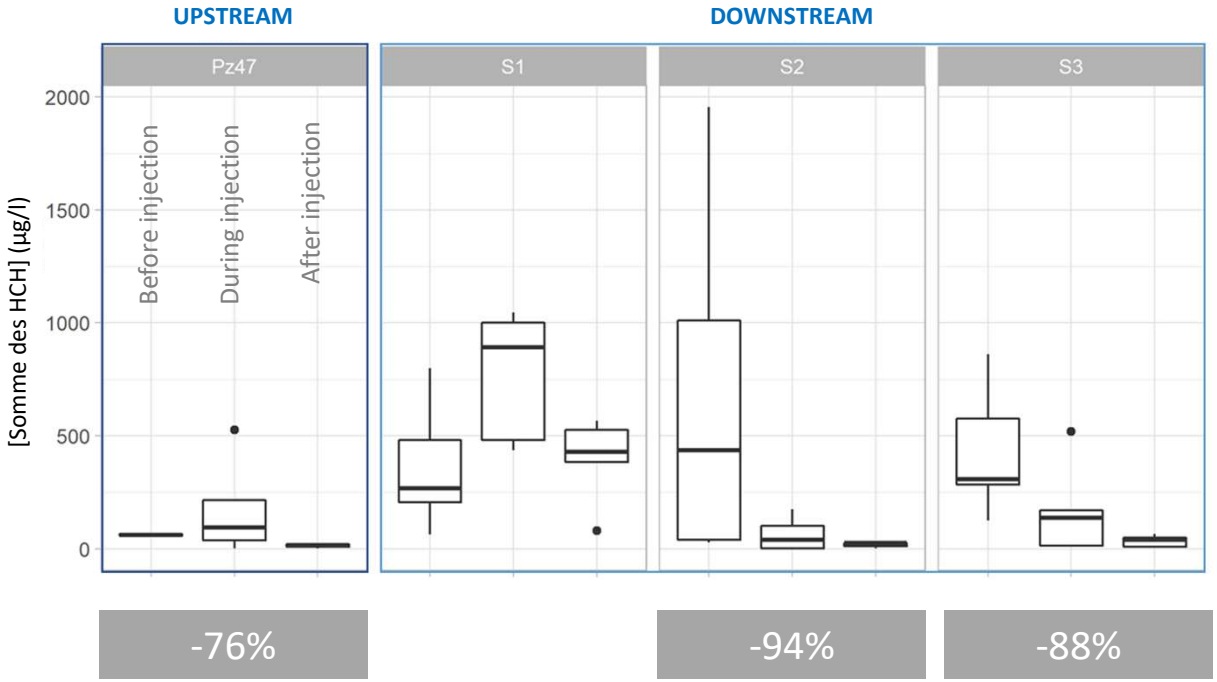
Whole depth
(between 0 and 15 m)

Initial median (mg/kg)
119

Final median (mg/kg)
17,2

Degradation yield
86%

HCH DEGRADATION > CONCENTRATIONS IN GROUNDWATER



Conclusions

Gel is a very interesting vector to disperse reagents in soils: it improves spatial distribution and time contact with adsorbed contaminants, even in the context of high velocity aquifer!

Alkaline gel is very efficient for in-situ lindane and isomers degradation.

Gel is able to strongly reduce local groundwater flow during several month.

Tomography can be used to monitor 3D gel propagation in real-time.

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