REMTECH EXPO

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# STUDY OF CONTAINMENT SYSTEMS TO REDUCE METHANE PRODUCTION AS PART OF GROUNDWATER REMEDIATION

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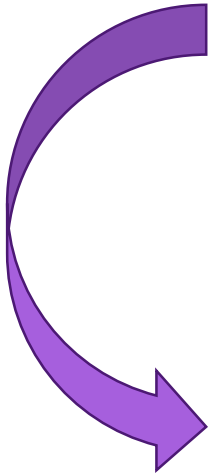
# Index

- Introduction on groundwater (GW) remediation technologies related with methane production;
- Preliminary evaluation on methane production;
- Presentation of a Case study: Use of methane containment systems, and
- Conclusion.

# Remediation technologies for groundwater related with methane production

The most representative remediation approches are listed below:

- In Situ Bioremediation (ISB);
- Enhanced Reductive Dehalogenation (ERD);
- In Situ Chemical Reduction (ISCR);



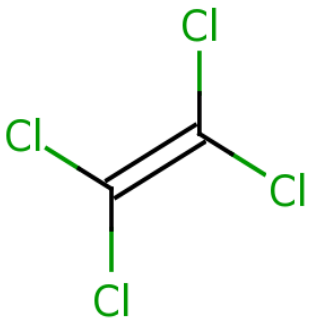
These technologies could lead to the formation of **by-products**

- VC accumulation in subsoil atmosphere;
- ***Methane accumulation in subsoil atmosphere;***
- Changes in groundwater pH and reduction-oxidation (redox);
- Solubilization of metals in groundwater.

# ISCR & ERD

**ISCR:**

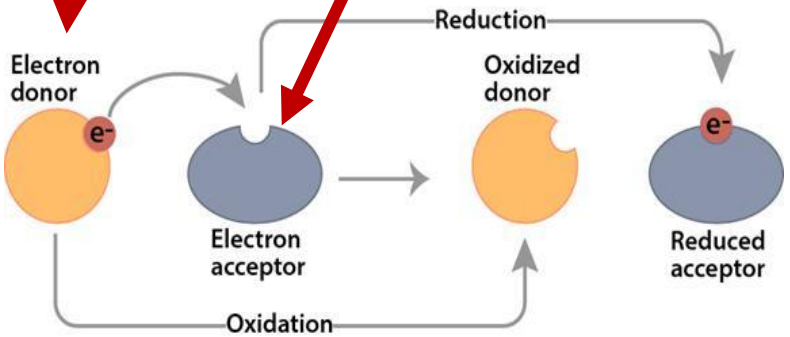
$Fe^0$

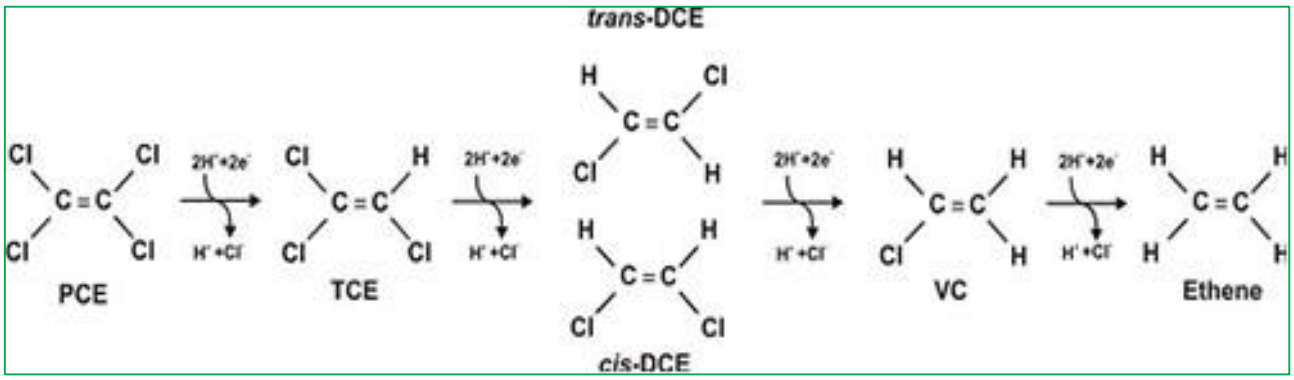



**PCE**
**(Tetrachloroethylene)**

**Methane production**

**Organic materials + Nutrients → CH4**




**ERD:**

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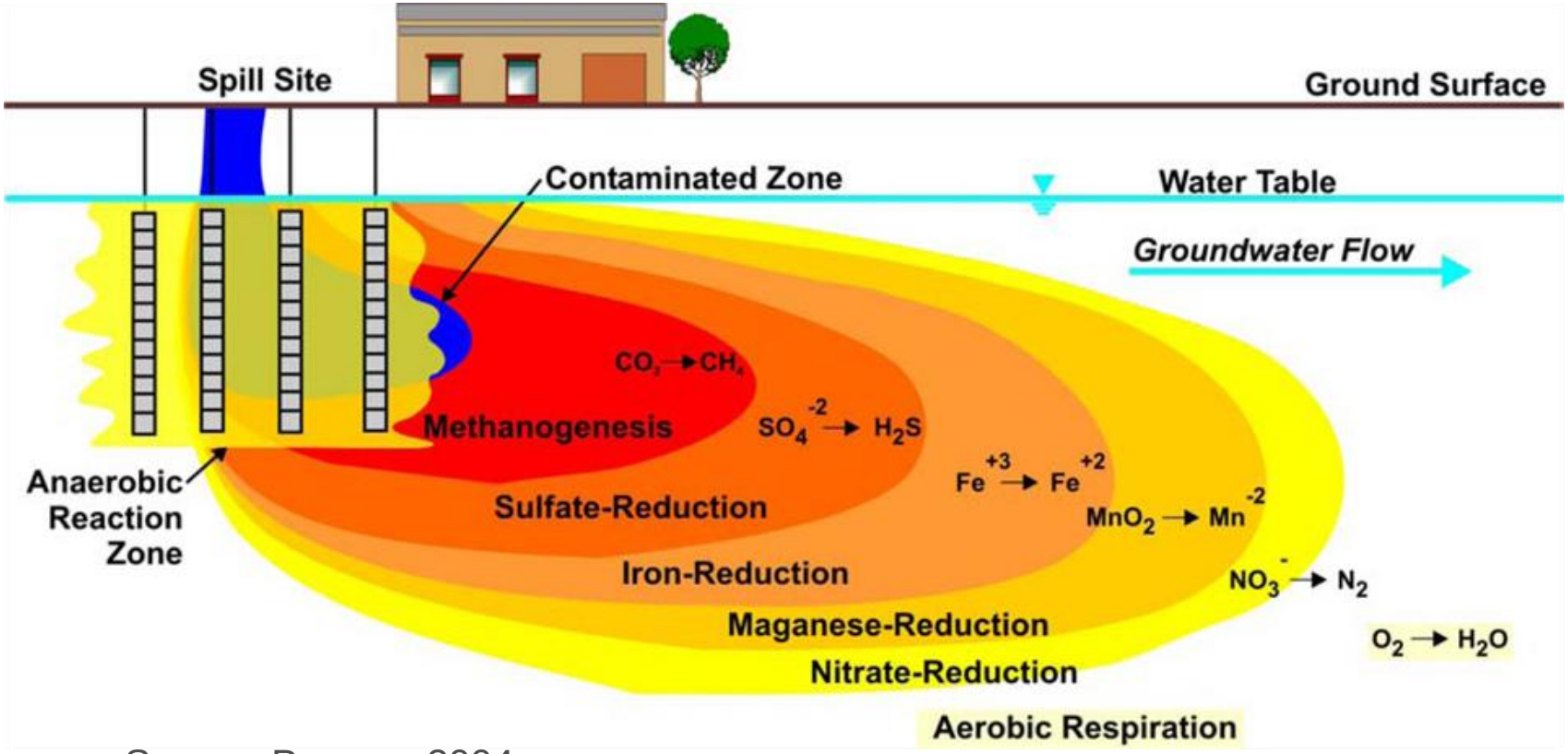
# Methane production as a by-product of ERD

Anaerobic microbes use electron acceptors in preferential order:

*Nitrate, manganese, ferric iron oxyhydroxides, sulfate, and carbon dioxide.*




Source: Parsons 2004.



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# Methane production (Archea)

Biological methane formation is a microbial process catalyzed by methanogens (Archaea)

Methane inhibitor limits the growth and productivity of Archaea during in situ remediation processes by disrupting enzyme and coenzyme systems unique to methanogens.

# Guidance for the evaluation of Methane production

- The *2016 ASTM standard guide for Evaluating Potential Hazard as a Results of Methane in the Vadose Zone (Publication ASTM E2993-16)*, highlight that methane in soil gas may only pose a hazard to buildings under a very limited number of situations; e.g.: potential for pressurized flow, like a gas pipeline rupture, large landfill or natural gas deposit causing pressure.

- According to ASTM no methane incidents have ever been found to be caused by methane diffusion alone, which is typical of migration conditions for in-situ bioremediation sites.

# Guidance for the evaluation of Methane production

*The GL suggests a screening approach to plan the most proper in-situ mitigation actions in case of significant methane production*

**Table 1 Suggested Screening Levels and Actions for Soil Gas Methane at Anaerobic Bioremediation Sites**

| Sampled Medium | Concentration | Action |
|---|---|---|
| Ground water | >10 mg/L | Monitor Soil Gas |
| Soil Gas External | >10% of LEL | Check for receptors/ consider mitigation |
| Soil Gas Sub Slab | >10% of LEL | Mitigate |
| | <10% of LEL | Monitor |
| Indoor Air | >10% of LEL | Evacuate/ Mitigate |

*2016 ASTM standard guide for Evaluating Potential Hazard as a Results of Methane in the Vadose Zone (Publication ASTM E2993-16).*

# Evaluation of Methane production

- The presence of significant concentration of methane in groundwater leads to carefully monitor the possible formation or accumulation of methane in the subsoil in neighboring confined areas;

- This aspect is particularly sensitive on operating site or in the presence of commercial buildings near the intervention areas.

# Evaluation of Methane production

**Before choosing ISCR / ERD as remediation technology for the site it is important to verify/evaluate:**

- The presence of buildings (residential or commercial) within the Site or nearby the intervention area
- The presence of methanogens microorganisms in the aquifer
- Evaluate the monitoring plan to identify possible methane production and possible systems to prevent methane accumulation.

# Case Study: Remediation approach

**PILOT TEST – 2015**

ISCR/ ERD – Calibration phase

Preliminary verification of methane formation: Methane were detected in GW and Subsoil atmosphere

Definition of a monitoring protocol to identify and monitor the possible formation and accumulation of methane

**PHASE 1 - 2016**

Source zone treatment: ISCR/ ERD application

Methane inhibitor injection added to the substrates to inhibit methane formation

**PHASE 2 - 2017**

ISCR/ ERD injection for Plume area treatment

Start-up of biofiltration plant for the aspiration of soil vapors, to reduce or eliminate the possible production and accumulation of methane

**PHASE 3 – 2018**

ISCR/ ERD injection to finalize the plume area treatment

Methane inhibitor added to the substrates near-by building area in addition to the biofiltration plant working continuously after Phase 2

# Mitigating actions: Methane inhibitor added to ISCR/ ERD

1. Pilot test evidenced methane production in GW up to 10 mg/l
2. Presence of methane in soil gas, particularly beneth the paved areas, while, in grassy area, the accumulation was much less evident

Full scale was designed with Methane inhibitor injection together with substrates to reduce the methane formation





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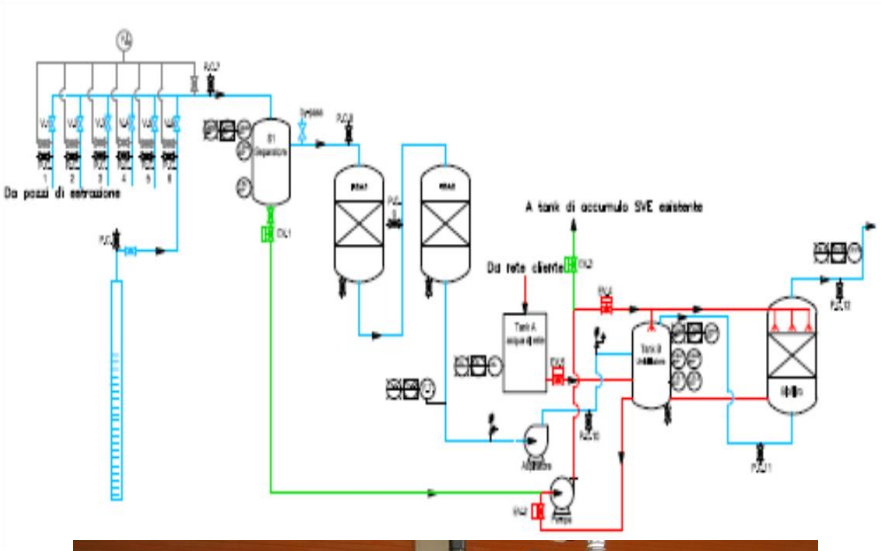
# Containment System: Biofiltration Plant

Results from Phase 1 showed a delay of about 7 months in methane production AND a reduced amount of methane in both GW and subsoil.

Due to the presence of closed building in a radius of less than 30 m from the area of injection, Phase 2 design foresaw the installation of a biofiltration plant to extracts soil vapors and avoiding methane accumulation

# Containment System: Biofiltration Plant



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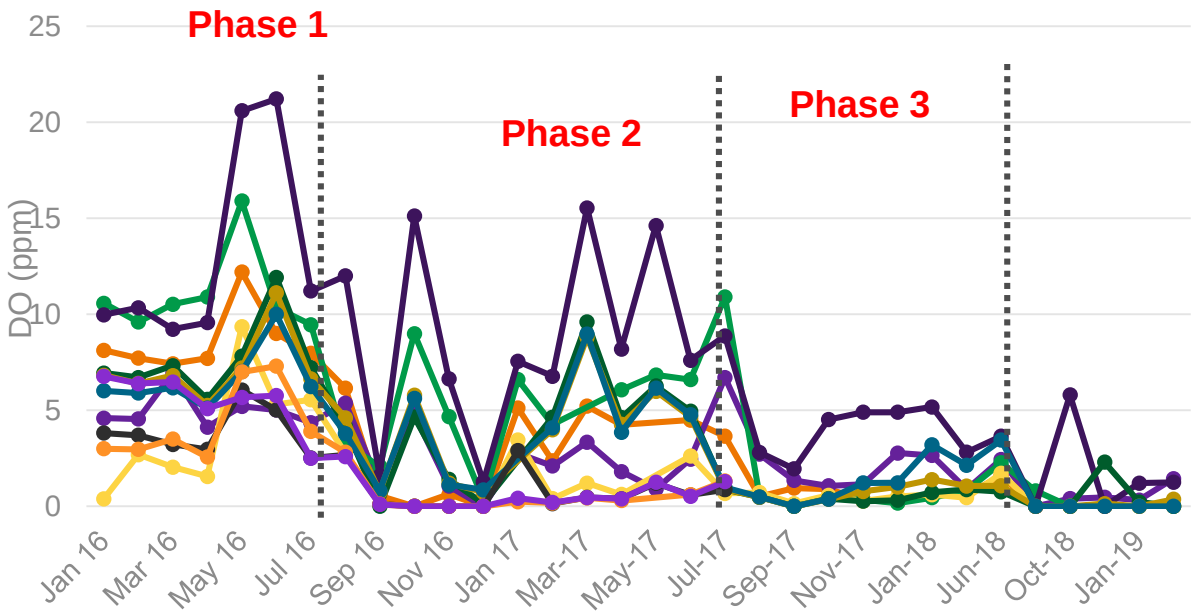
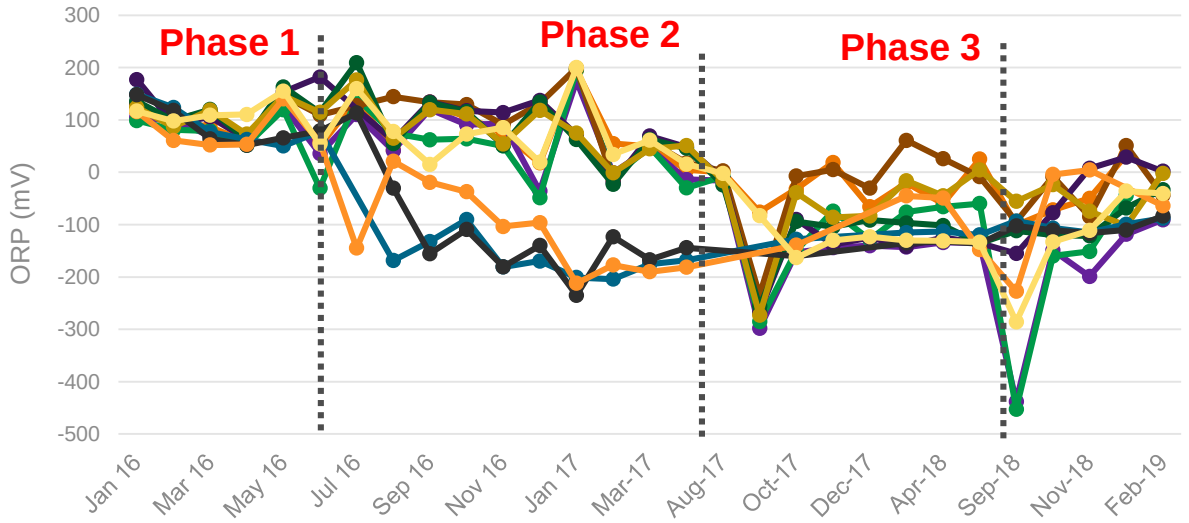
# Groundwater (GW) monitoring - Dissolved Oxygen (DO) & Oxidation Reduction Potential (ORP)




These graphs show the anaerobic area created after each injection phase. Anaerobic condition needed for a successful in situ biodegradation of chlorinated solvents into ethane and consequently Methane production.



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# GW monitoring: Methane distribution

Methane concentration in GW after each injection increases:

- In Phase1, methane inhibitor were injected and methane were produced (with concentrations up to 20 mg/l) after almost 7 months from injection;

- In Phase 2 methane inhibitor were not injected but the biofiltration plant were installed and the methane was produced immediately after injection (with concentrations up to 35 mg/l) but due to soil vapor exctraction we avoid methane accumulation on the Subsoil;

- In Phase 3, the methane inhibitor injected with the substrate, with biofiltration plant working, confirmed methane production in Groundwater without accumulation of the subsoil.

# Soil gas (SG) monitoring

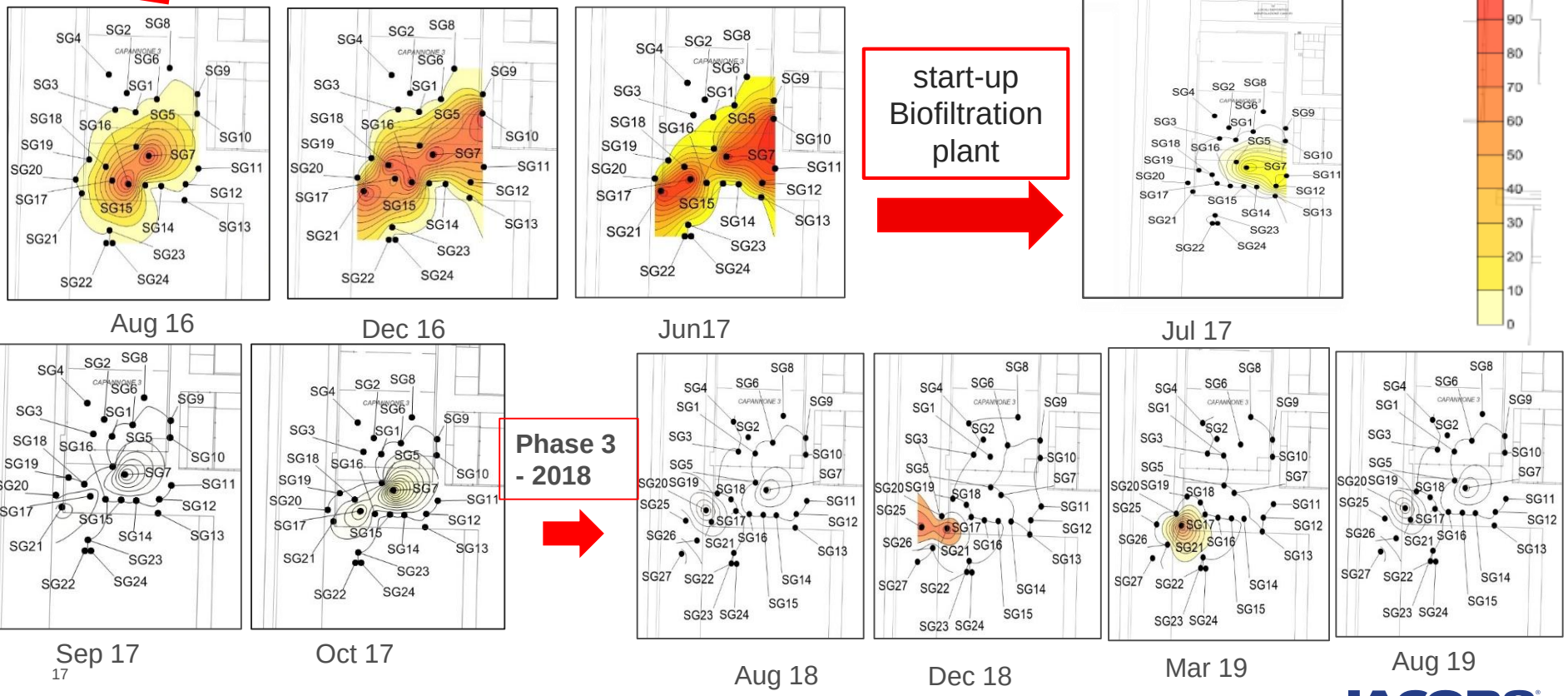
- ✓ During the injection activities, soil gas was monitored to measure Lower Explosivity Level (LEL) and Methane in Soil Gas (SG);
- ✓ Biofiltration plant was installed after P2S2 (July 2017) to treat produced methane and prevent methane accumulation in subsoil.

**Phase1 - 2016**

**Phase 2 - 2017**

start-up Biofiltration plant

**Phase 3 - 2018**




Aug 16 | Dec 16 | Jun17 | Jul 17

Sep 17 | Oct 17 | Aug 18 | Dec 18 | Mar 19 | Aug 19



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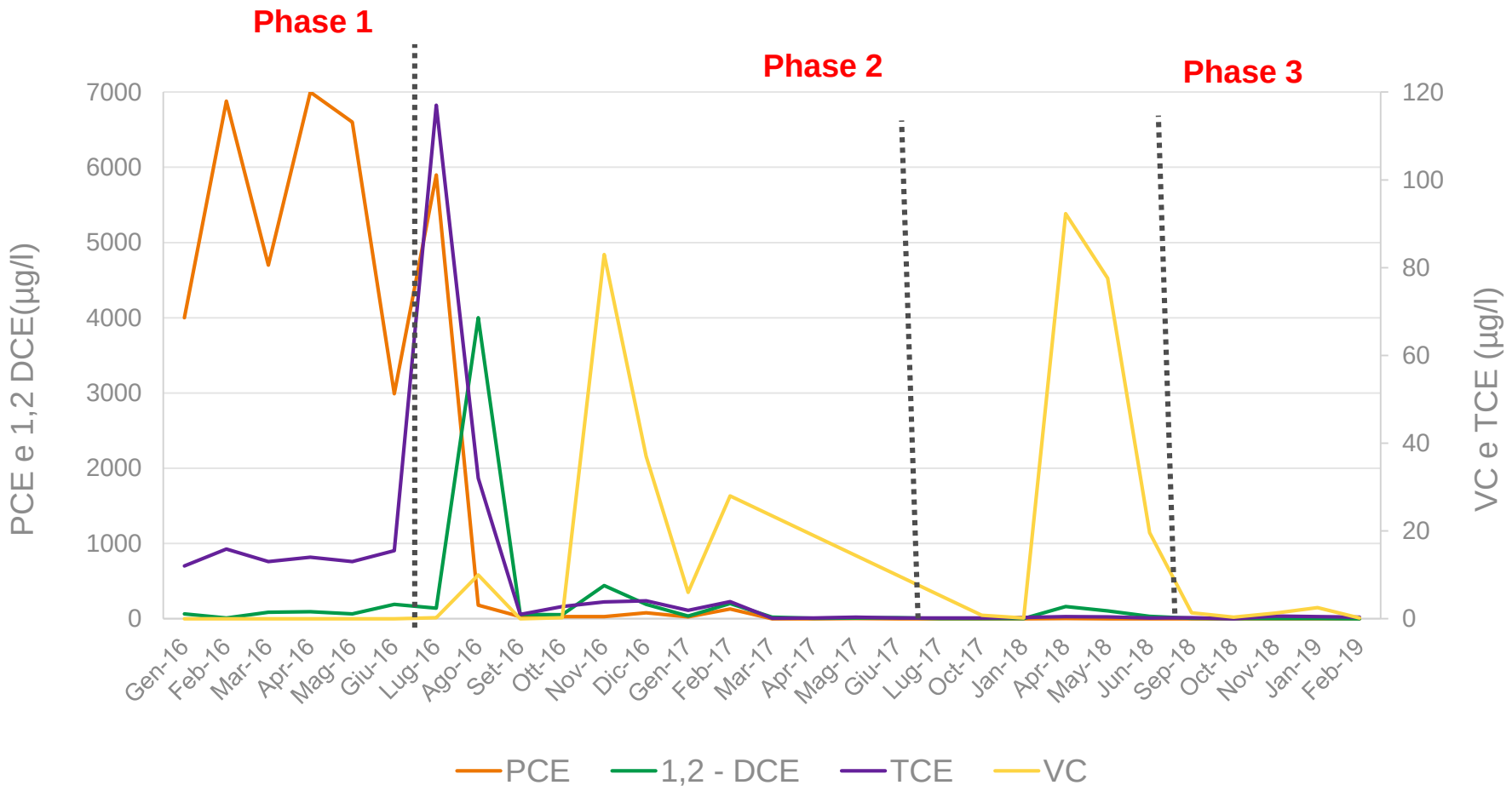
# GW monitoring : Tetrachloroethylene (PCE) in Source Zone



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# Conclusion

- With the present study useful information was obtained regarding the application of containment systems to reduce/ eliminate the production and the accumulation of methane as part of groundwater remediation.
- It is important to note that in the Case history particular attention was paid to the aspect of methane from the initial phases of the project (Pilot Test – 2015).
- The results show that throughout the expected injection cycle, methane production was observed in both groundwater and interstitial subsoil vapours.
- The monitoring protocol allowed us to acquire useful information for the design of the containment systems and to keep this phenomenon under control.
- As the result of this interventions we could mention the correct design of a remediation intervention both for safety and environmental aspects, with over 99.9% reduction in PCE concentration.

# *Thank you!*

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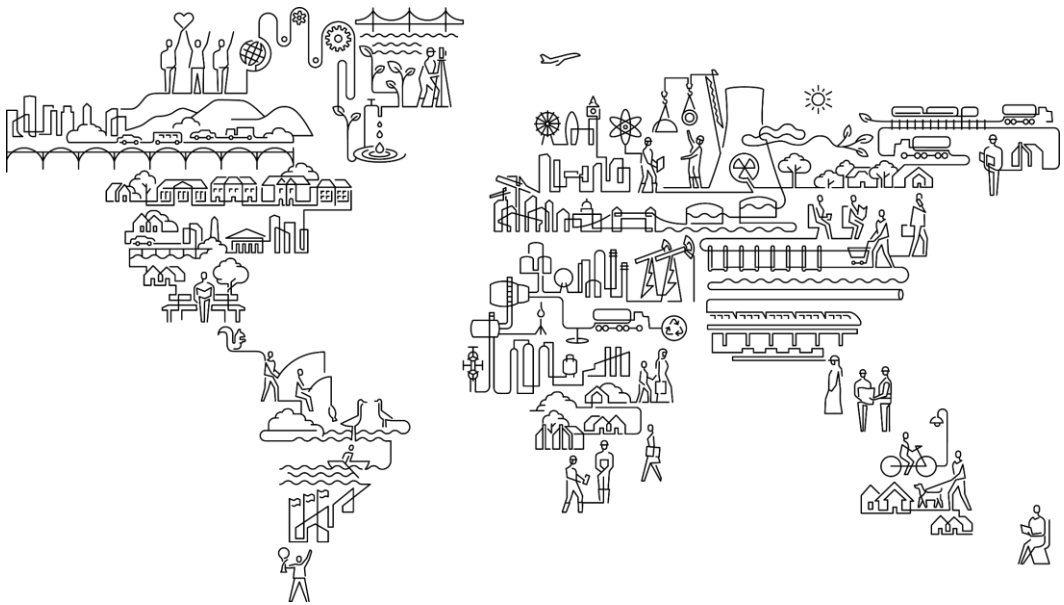



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