

Comparison of treatment options for remediation of soil from a wood impregnation site

Steffen Hertle, Monika Liugé, Josef Bjuhr,
Sebastian Nilsson, Johnny Sjödin, Jurate Kumpiene
Nordrocs 2026 – Helsinki, FI



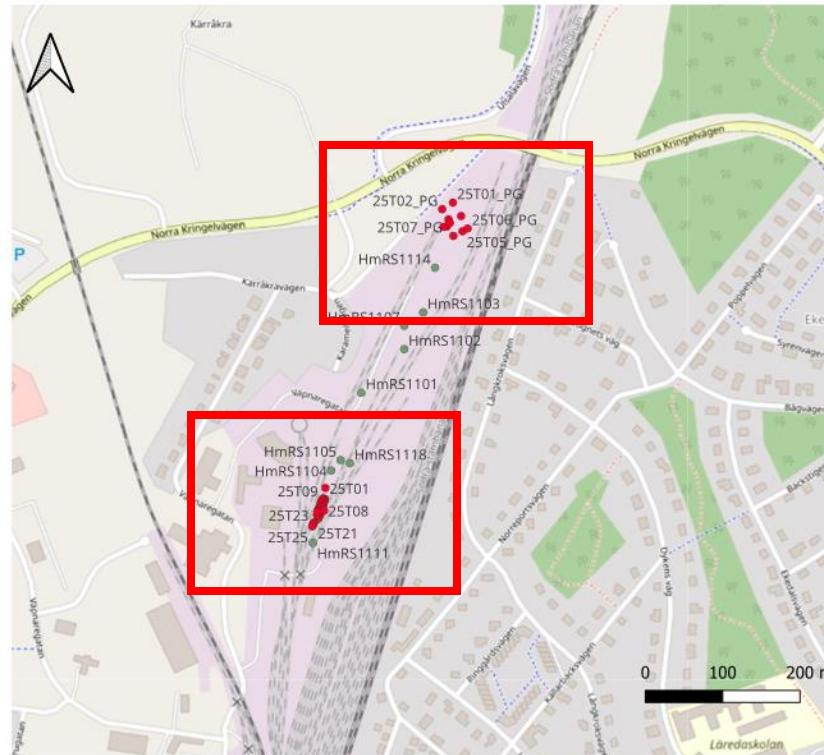
Wood impregnation - background

- Creosote oil (PAH) and Boliden salt (As, Cr, Cu, Zn) have been widely used in Sweden. In the 1980s, there were 243 wood impregnation plants in the country
- Creosote and As have been banned for quite some time due to their carcinogenic properties
- Contaminants remain in soil at former treatment sites and can leach into the groundwater





Hässleholm site



- Site is still actively used
 - Infrastructure cannot be removed → excavating/landfilling the soil is not an option
- Northern area is mainly contaminated with As
 - Lab experiments for arsenic immobilization
- Southern area with PAH
 - Lab experiments for PAH removal
 - Field pilot site

Treatment options for remediation of a former wood impregnation site



Thermal treatment
(PAH)



In situ chemical
oxidation
(PAH)



Soil washing
(PAH, As)



Electrostimulated
degradation (PAH) /
stabilization (As)

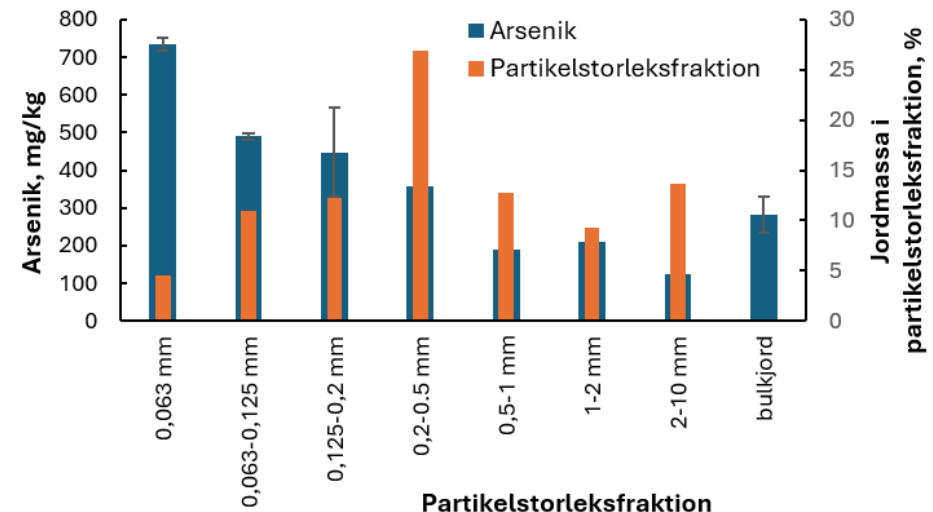


Immobilization (As)

PAH composition of soil used in lab experiments:

35 %	L-PAH	
60 %	M-PAH	~1,400 mg/kg _{DW}
5 %	H-PAH	

As concentrations

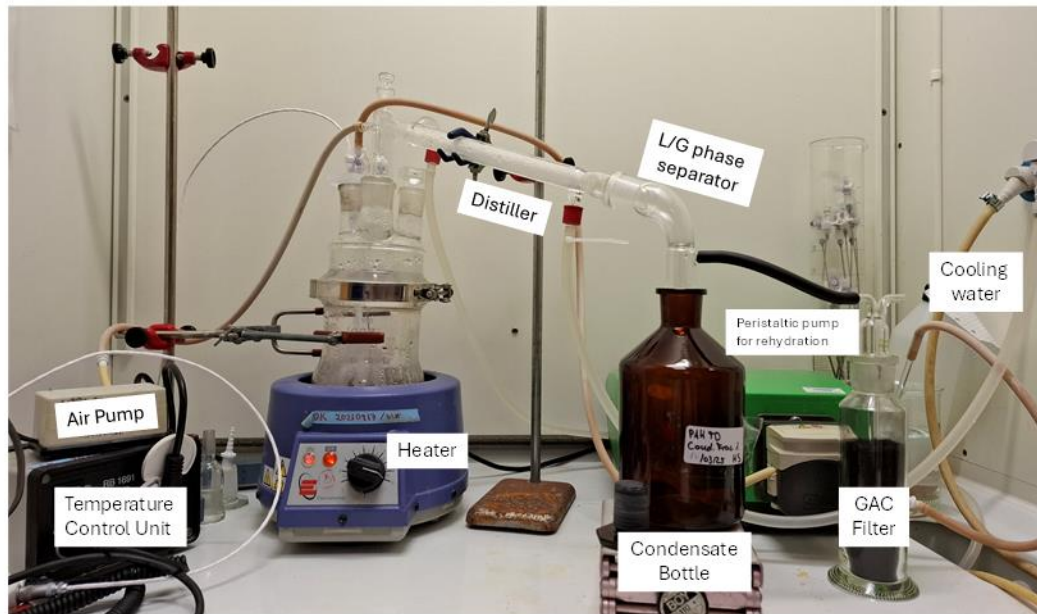


Thermal soil treatment



■ Thermal desorption and vaporization

- Can only target organic contaminants, but some effects possible for As
- Condensate collected in 2-hour fractions
- Evaluation through PAH removal from soil and PAH recovery in condensate fraction



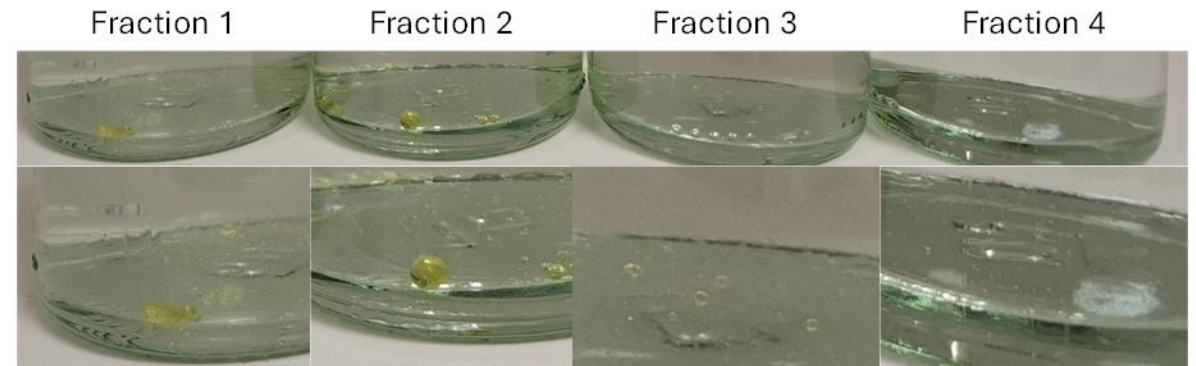
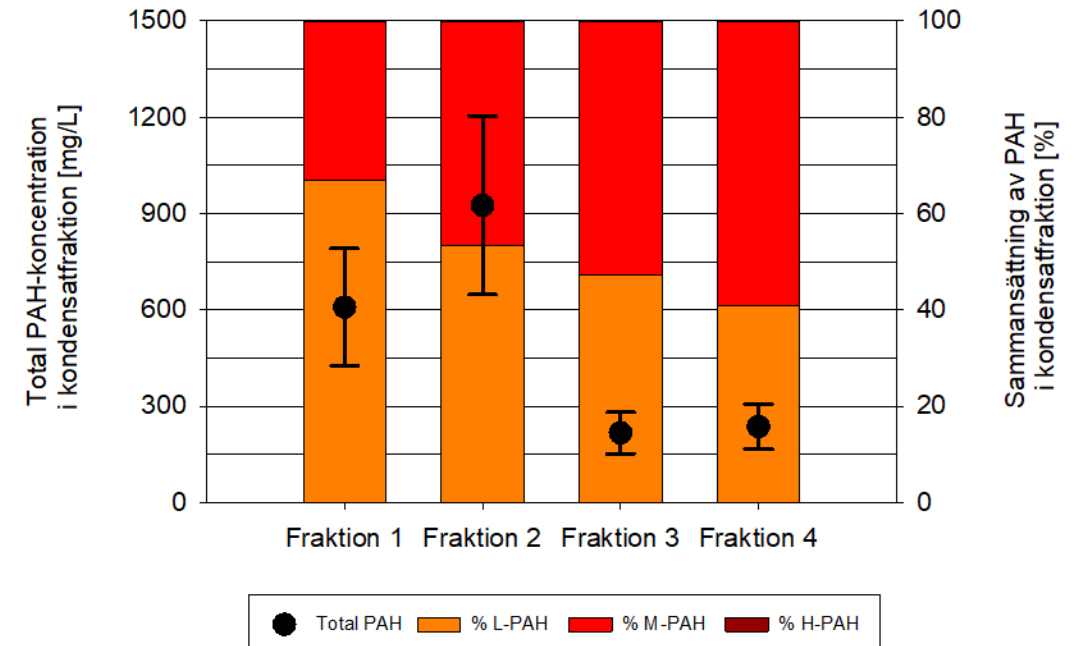
Thermal soil treatment



- Primarily removal of L-PAH and M-PAH from soil
 - Fraction composition indicates that PAH removal from soil is primarily in first 2 fractions
- Additional removal of
 - Aliphatics C_{10} - C_{16} (81 mg/kg $\rightarrow$ 46 mg/kg)
 - Aromatics C_{10} - C_{16} (350 mg/kg $\rightarrow$ 220 mg/kg)

→ Longer time did not improve removal

→ Treatment limited by physicochemical PAH properties

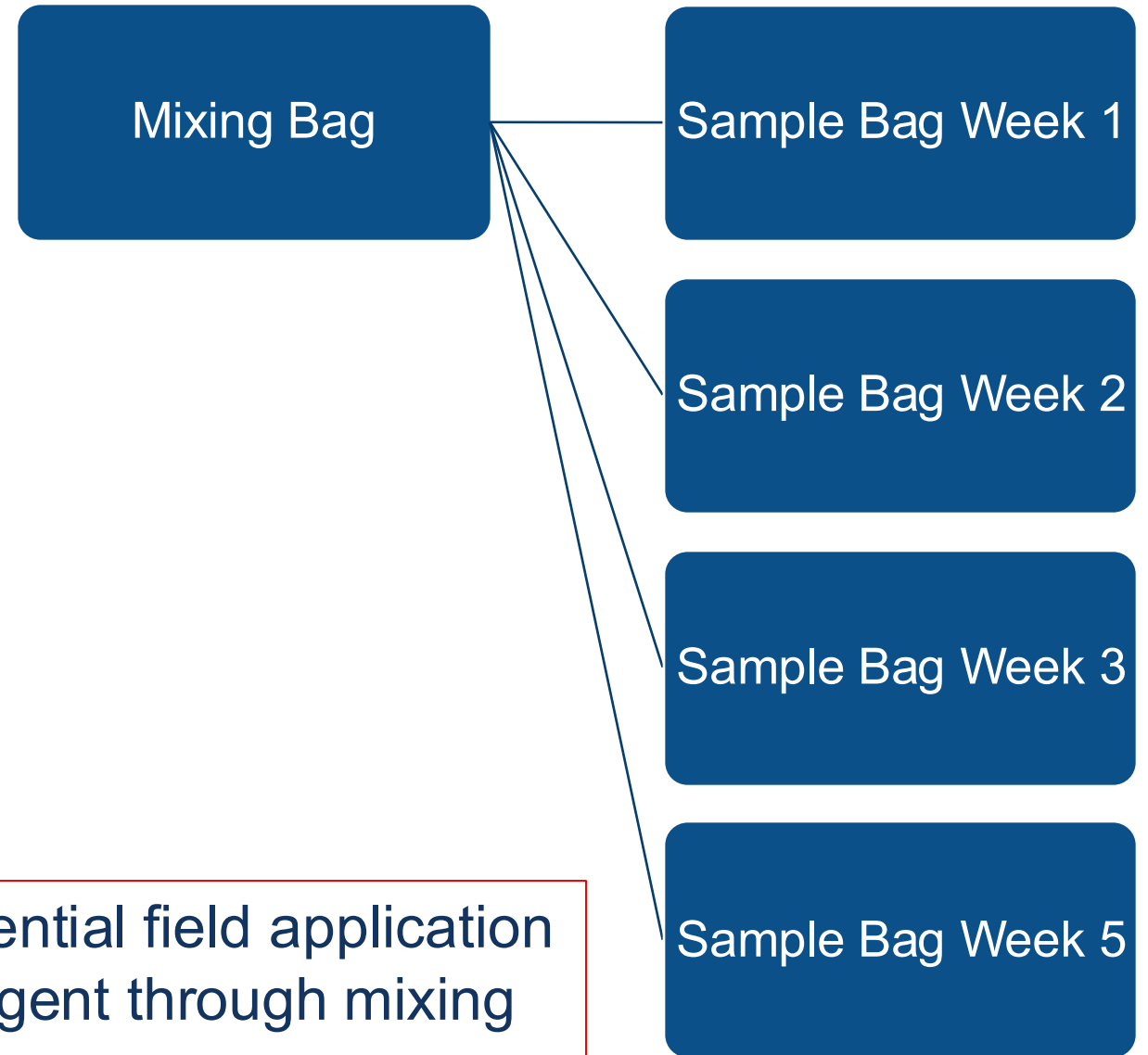


ISCO treatment



- Evaluation of two commercial ISCO products
 - Sulfate radical based product
 - Hydroxyl radical based product
- Can mineralize organic contaminants and oxidize As
- Production of slurry and application amount according to manufacturers instructions

! Lab experiment will outperform any potential field application through the better contact of soil and reagent through mixing in the bags

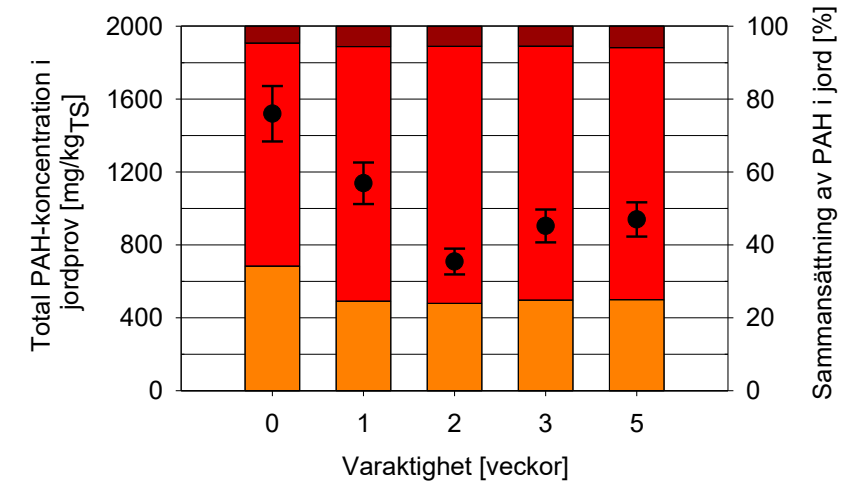


ISCO treatment

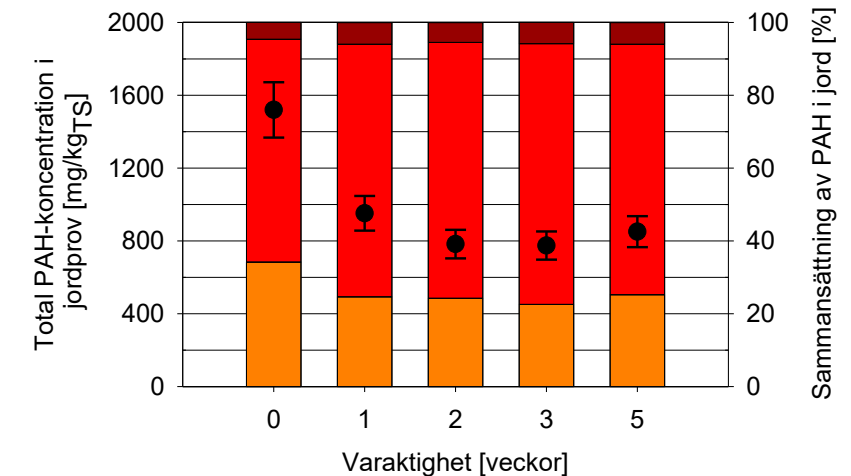


- Primarily removal of L- and M-PAH
 - H-PAH largely unaffected
- Potential site treatment will require multiple ISCO injections over time
- Expected pH shift is seen in samples
 - Sulfate radical based → soil goes acidic
 - Hydroxyl radical based → soil goes alkaline→ pH shift can cause issues when ISCO application is used as part of a treatment train in case other processes are pH sensitive

Hydroxyl radical based



Sulfate radical based

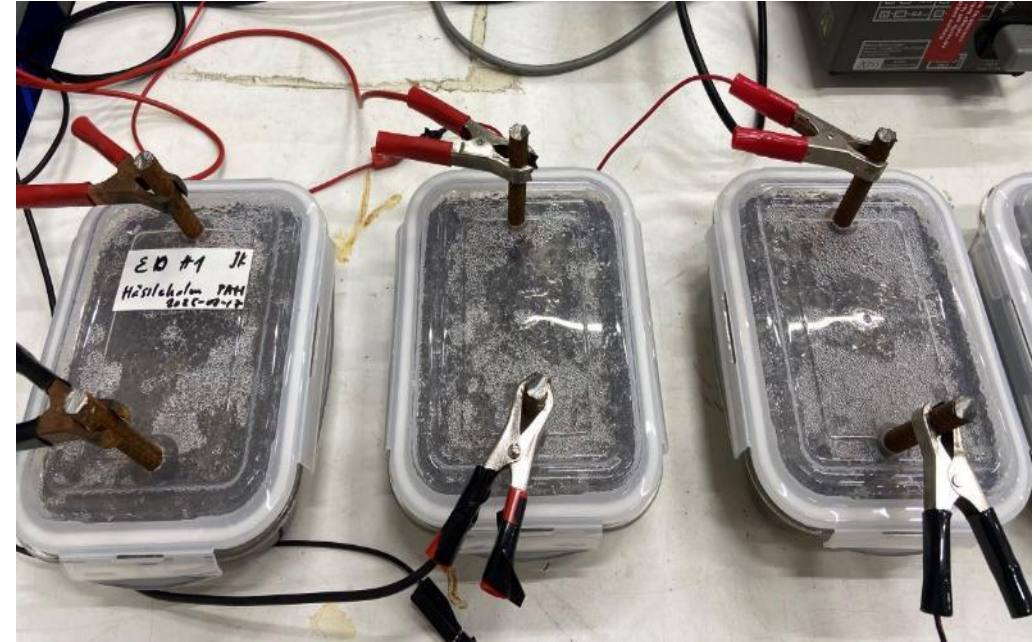


● Total PAH % L-PAH % M-PAH % H-PAH

Electro-remediation



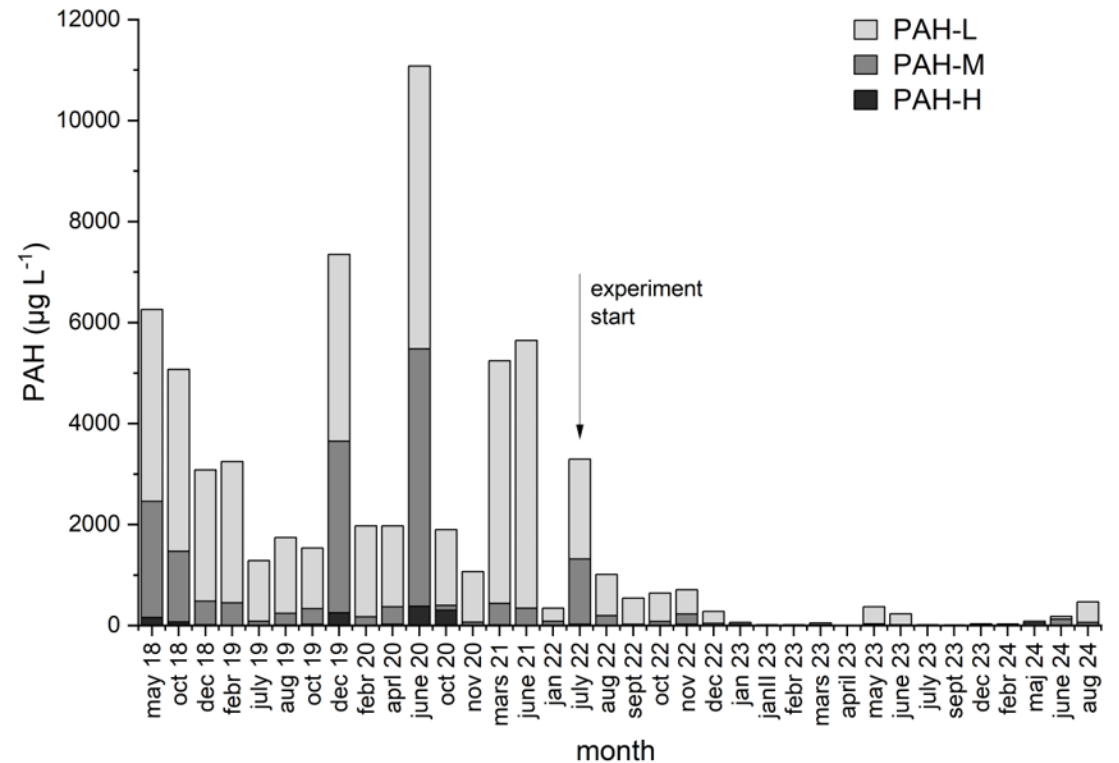
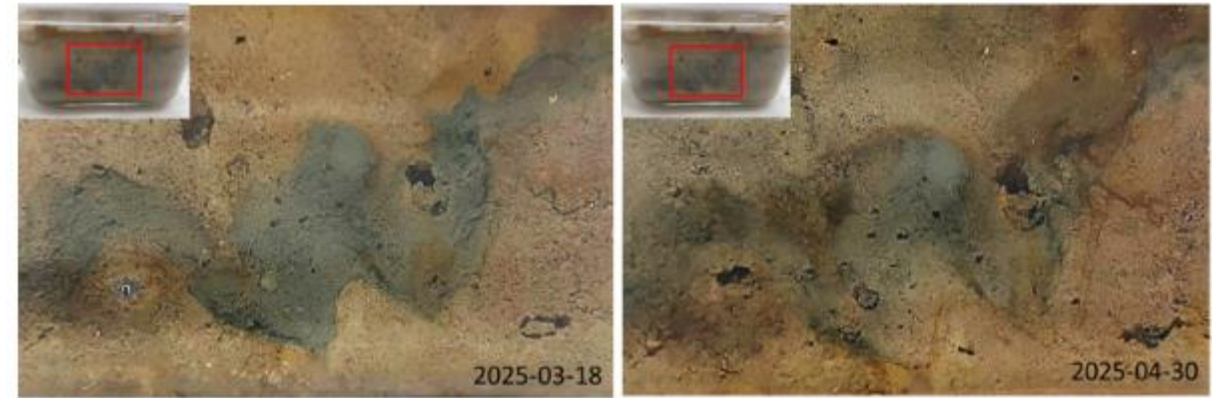
- Usage of iron electrodes with alternating polarization
 - Voltage potential of 3.3 V/cm
 - 10-week treatment duration
- Possible processes
 - Direct oxidation at electrode surface
 - Indirect oxidation through creation of reactive oxygen species and Fenton Reaction
 - Biostimulation through electrochemical oxygen production



Electro-remediation



- Visual changes in oil distribution in soil
- Limited decrease in PAH concentrations
- Slight decrease in aliphatics C_{12} - C_{16} and aromatics C_{10} - C_{16} ,
- Possible issues:
 - Voltage gradient was too high
 - Oversaturation of soil with electrons
 - Too short time



Process comparison

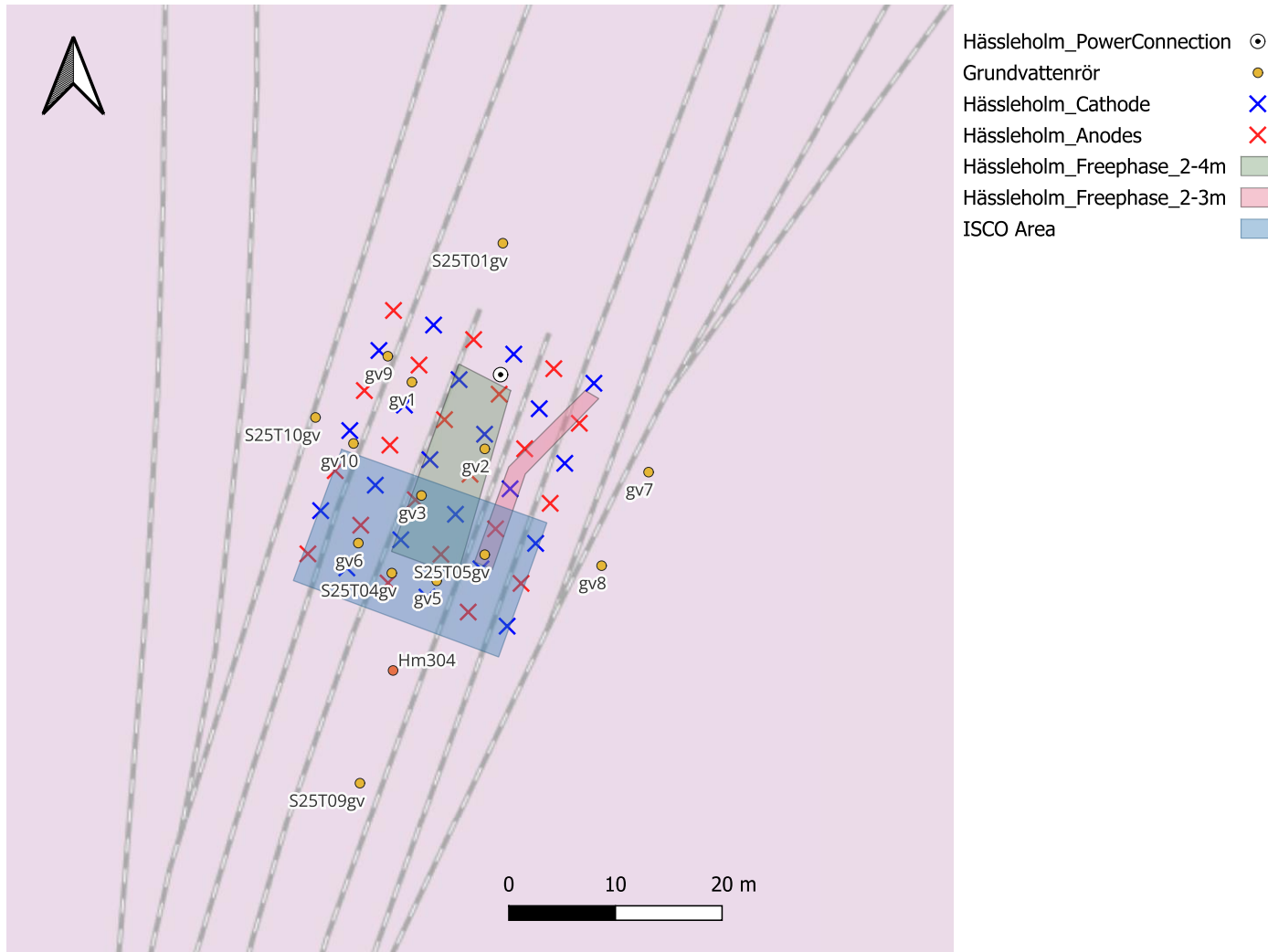
- Thermal treatment strongly limited by physicochemical properties of PAH
 - Effectivity of treatment will fall off rapidly
 - Immense energy input required for in-situ soil heating (excavation is not an option)
- ISCO treatment showed highest PAH removal
 - Fast degradation results
 - Will affect soil and groundwater due to pH shift
- Electro-remediation showed the least efficiency in the lab experiments
 - Advantageous as minimal intervention is needed
 - Feasible low input method if time is not a decisive factor

Hässleholm bangård – field pilot – southern area

- Site is still in active use → Excavation is not an option
- Copper and arsenic primarily between 0-2 m b.s.l.
 - Highest concentration of **As 450 mg/kg**
- Creosote / PAH from 1-4 m b.s.l.
 - Highest concentration **PAH 10,700 mg/kg**
- Combined treatment approach
 - ISCO as more aggressive approach for highly contaminated groundwater volume (mg/L-range)
 - Electroremediation for less contaminated groundwater volume

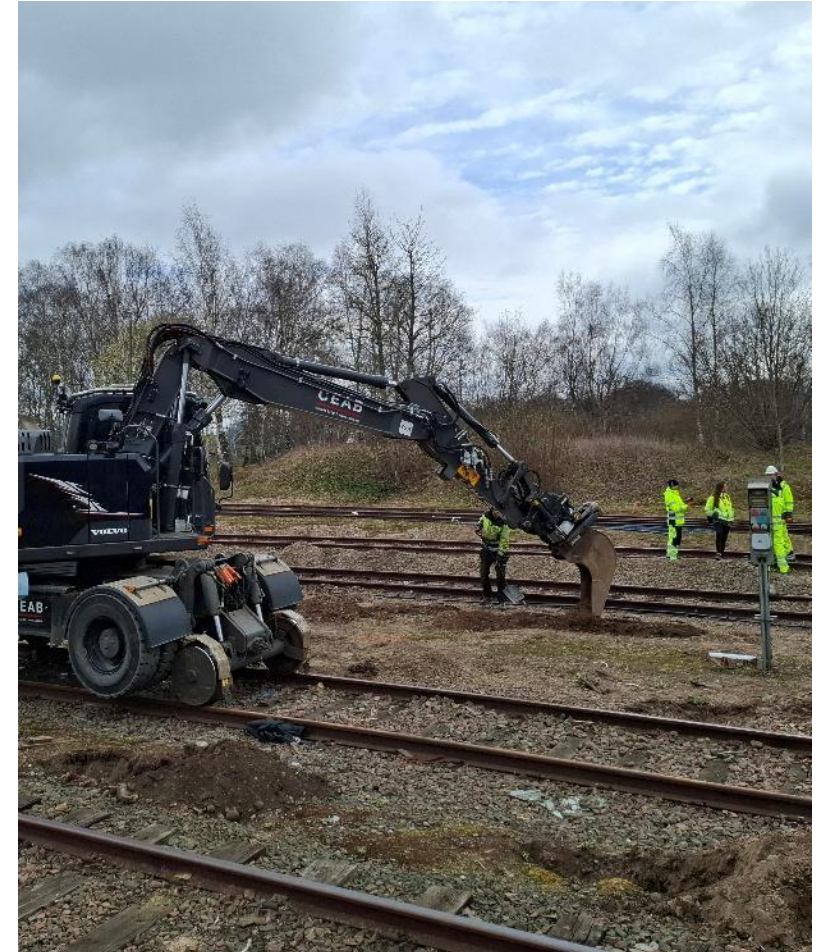
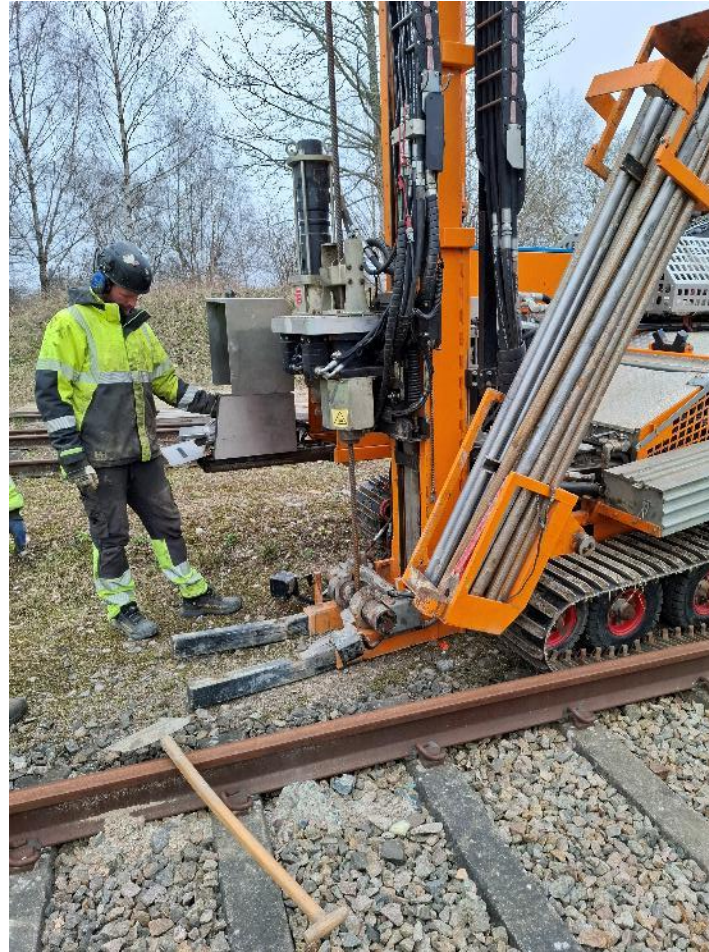
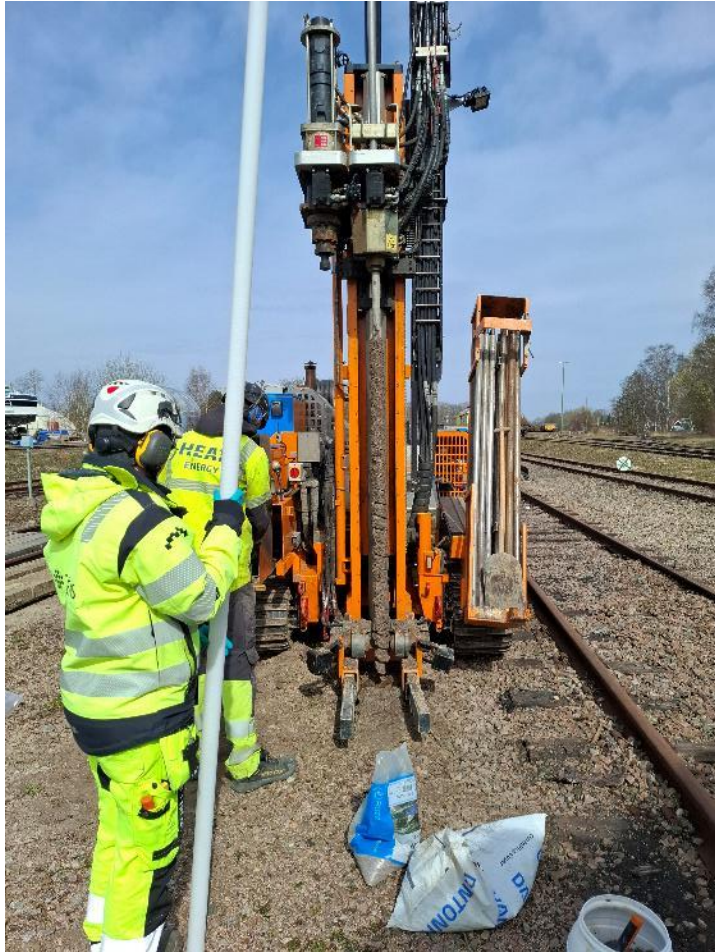


Hässleholm bangård – field pilot – southern area



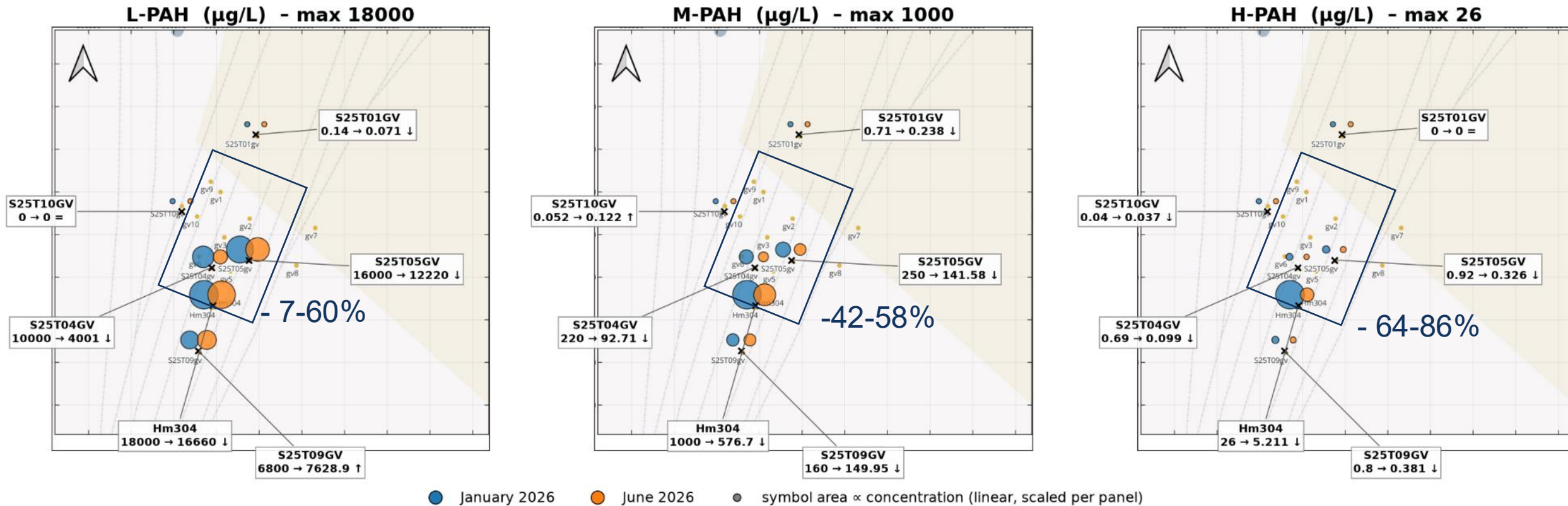
- 20x24 m electrode grid
 - 4 m distance between electrodes
 - Iron rod electrodes
 - Anodes and cathodes alternating
 - 0.1 V/cm field potential
 - Automatic polarity reversal
 - Remote control of power supply
- In summary
 - 168 m of iron rod electrodes
 - 320 m of wiring
 - 4 days of field works to set wells, electrodes and wiring

Hässleholm bangård – field pilot – setup



Recent development – before and shortly after installations

Hässleholm Bangård - change in PAH concentrations in groundwater, January vs June 2026



Field tests show better results than the laboratory pre-study

Acknowledgements

- Jonny Johanson, Johan Borg (LTU)
- Jenny Halling, Lina Glad (Tyréns)
- Zara Isaksson (Trafikverket)

FORMAS



TRAFIKVERKET



Kempestiftelserna

Project team during site installation; left to right:
Steffen Hertle, Johnny Sjödin, Jurate Kumpiene, Johan Borg, Josef Bjuhr



Contact:

Jurate Kumpiene

✉ jurate.kumpiene@ltu.se