KRÜGER VEOLIA

HOW TO MANAGE THERMAL REMEDIATION OF A CHEMICAL WASTE LANDFILL? CHEMISTRY IS KEY!

Søren Eriksen
Niels Ploug
Jesper Holm

A matter of clean soil

Chlorinated 2024

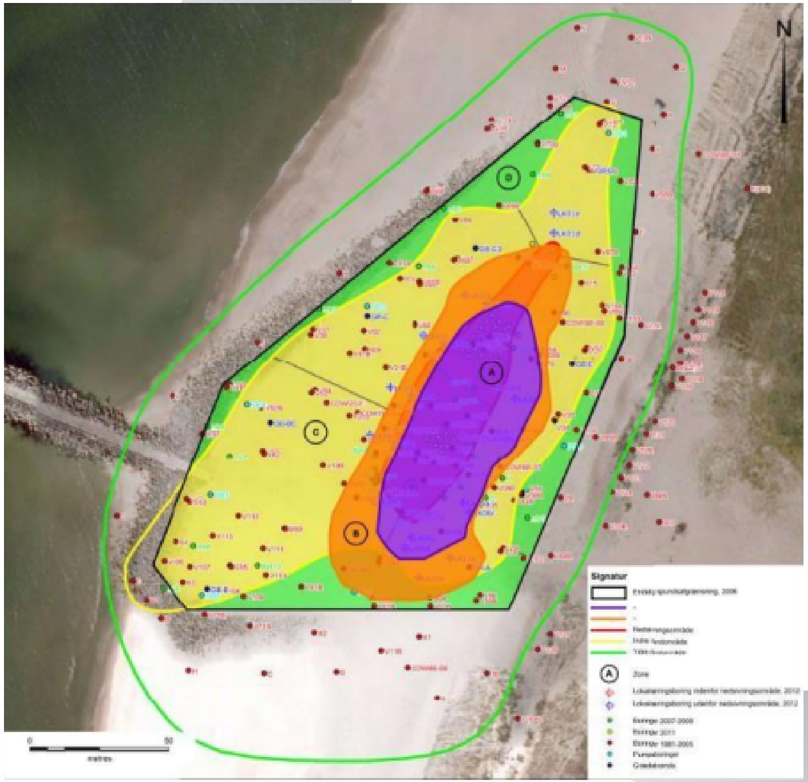
Agenda

Contaminants
- **Conseptual site model**
- **Remedial targets**

Lab study results

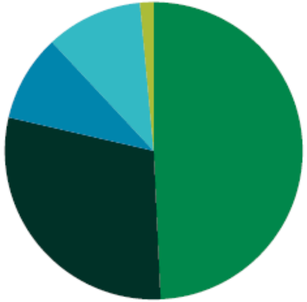
Pilot study
- **Design**
- **Operation**
- **Results**

Scale up
- **Modelling**
- **Thermal challenges**
- **Chemical challenges**



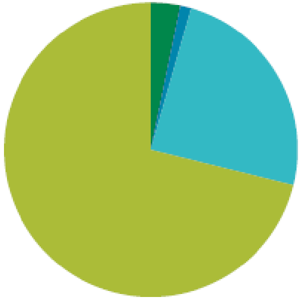
Contaminants

100 t organic



- Parathion
- Other pesticides
- Degradation products, intermedeates & byproducts
- Solvents
- Chlorophenols

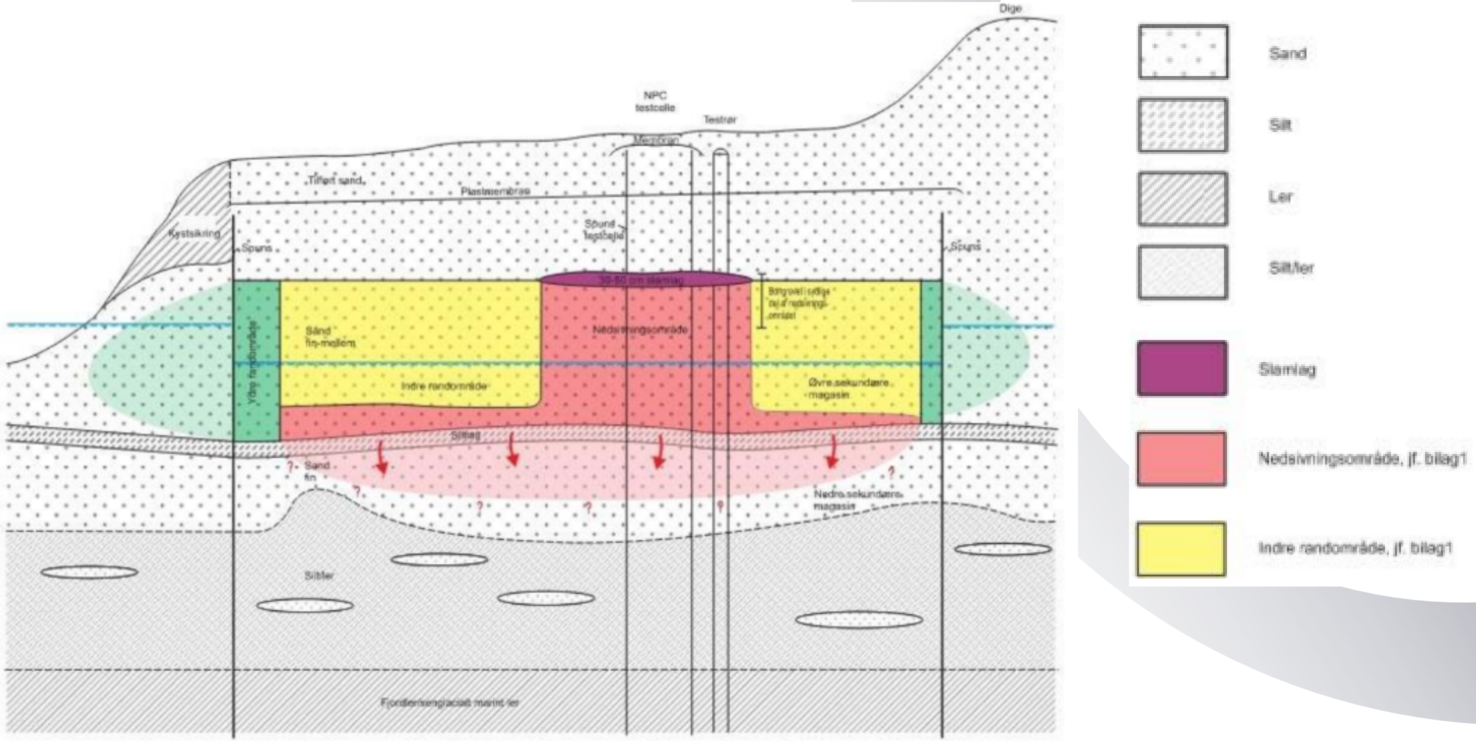
7 t mercury



- Soluble salts
- Acid soluble salts
- Organically bound
- Elemental
- Sulphide

50-200 t sulphur

Conseptual site model



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Remedial targets

Target volume 99 000 m³ – 19 400 m² - 6-8 m bgs.

Compounds and soil concentration in mg/kg dw	Above -1.5 m	Below -1.5 m
Organophosphate pesticides	0.1	0.4
Σ Chlorophenols	3	12
Σ Phenol	70	280
Σ BTEX	25	100
Mercury	3	25

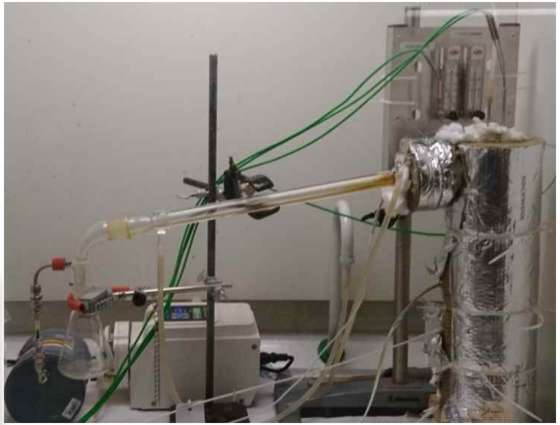
<u>Key questions:</u>

Are 1000 - 4000 mg pesticides per kg soil manageable?

Will we achieve the required reduction of mercury with the particular speciation ?

How to manage health and safety?

Lab study results



350°C for 2 - 4 days acheives target

< 1mg/kg total mercury

< 0.01 mg/kg pesticides (< D.L.)

50 - 85% destruction of parathion

Solid condensates

- **Sulphur**
- **Partially decomposed organic contaminants**

Soil color dependent on aeration and heating rates

No risk of thermal runaway

Pilot scale design

350°C target temperature

Aeration via perforated pipes

Heated extraction line

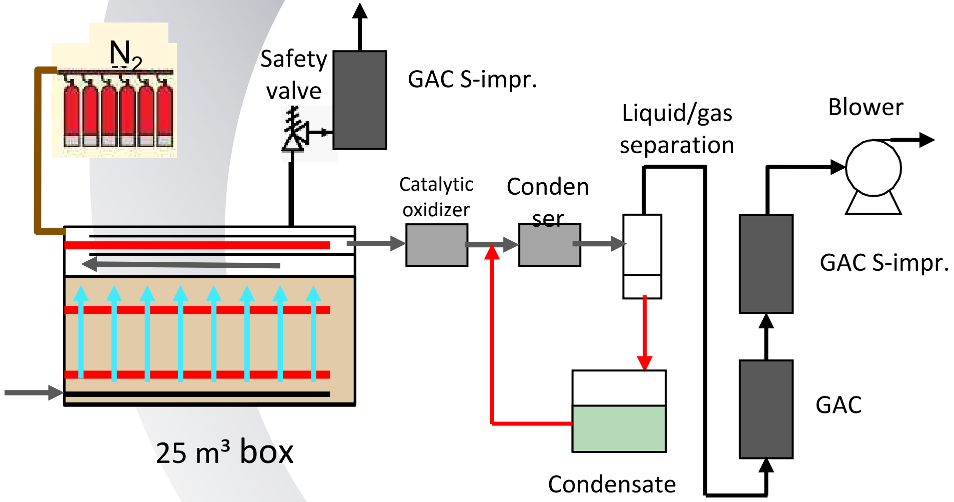
LEL monitoring

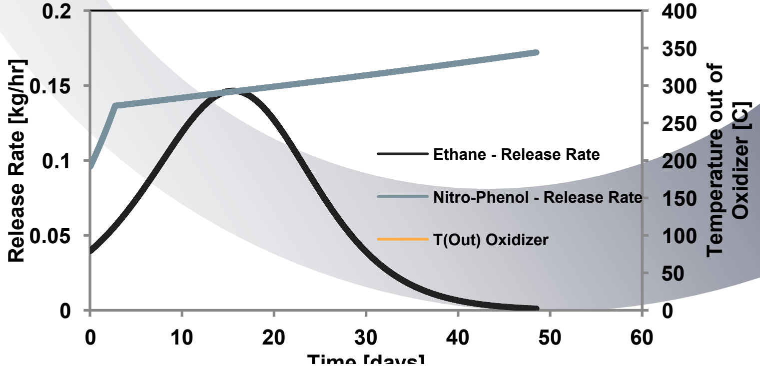
Closed box

- **Inert gas blanket**
- **Relief valve vent through sand and GAC**

Decomposition rate modelling

Extensive safety precautions when filling the box





Pilot scale operation

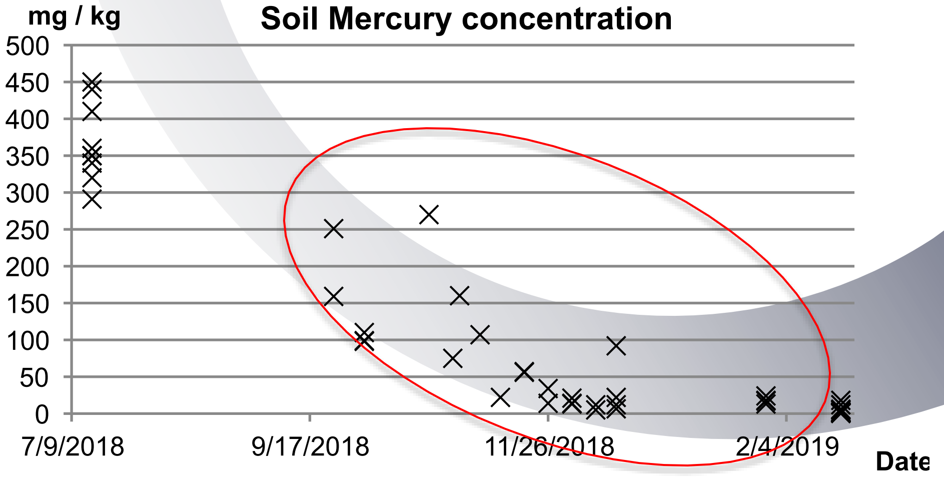
Initial heating challenging:

- **Sulphur condensation blocking piping**
- **Rapid pesticide decomposition → high LEL**

Sulphur oxidation made operation easier

Catalytic oxidizer is vulnerable

Mercury is released slowly



Pilot test results

Pesticides are remediated at 200 °C

99.9% of parathion is destroyed in-situ

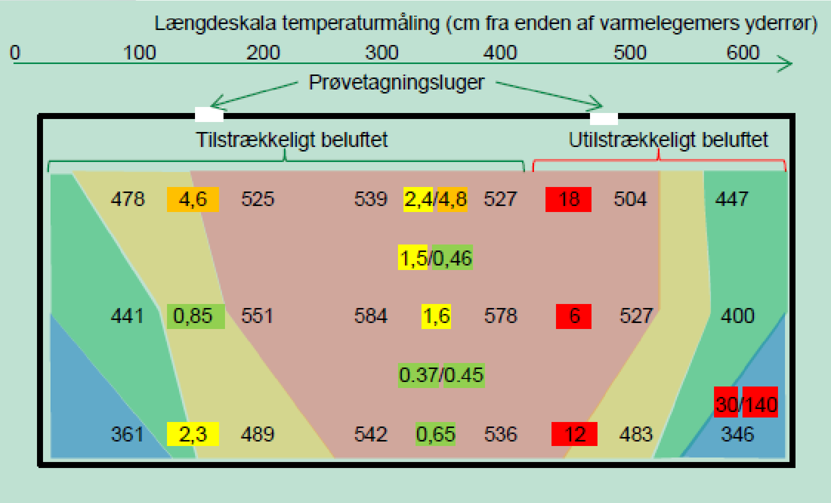
99.5% of mercury is remediated at 350-500 °C
– even though mainly present as mercury sulfide
– if sufficiently aerated

Catalytic oxidation not suited

LEL managed by controlling heating rate

Sulfur is a challenge:
Elemental sulfur condensate as a solid –SO_2/SO_3 is corrosive

Heater cans are severely oxidized



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Pilot test conclusions

Remediation targets can be met:

- **Temperature > 350°C to remediate mercury sulphide**
- **Sufficient aeration to oxidize mercury sulphide**

Flammable gasses must be release at a controllable rate

- **Slow heating**
- **Sufficient ventilation**
- **Monitor LEL**

Sulphur oxidation is preferred

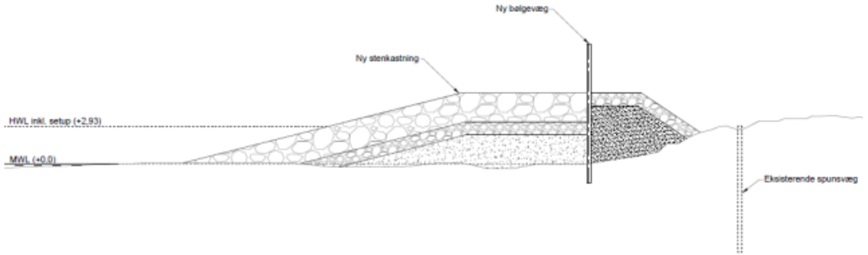
In situ remediation is preferred

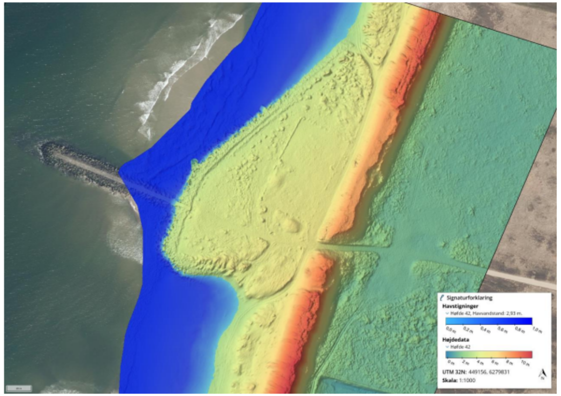
Challenges for full scale

Site and location:
- Close to the sea
- Part of treatment volume is below sea level
- Protected natural reserve

Thermal treatment in situ
- Heat loss at the sheet pile
- Leakage through the sheet pile
- How to assure target temperature at silt layer

Treatment plant
- Low discharge concentration permitted to the sea
- Biological wastewater treatment challenging





Figur 7: Illustration af designvandstand inkl. bølgestuvning (2,93 mDVR90). Blå farve indikerer vand. (SCALGO, 2022)

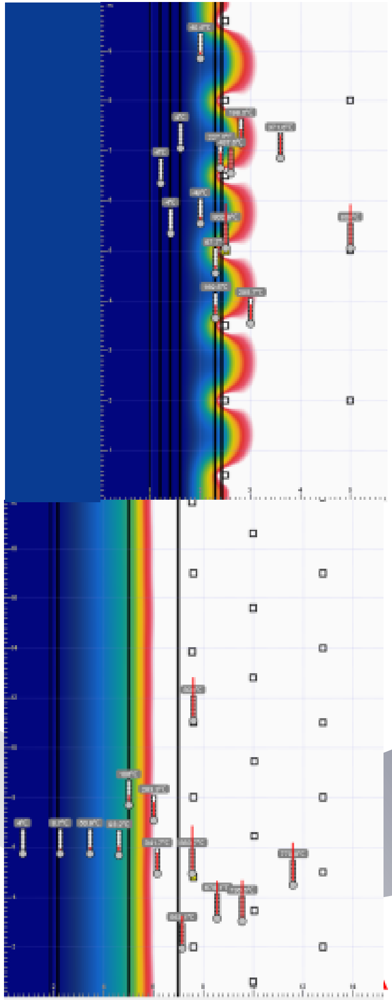
Full scale ISTD design

Additional sheet pile extended to clay layer
- **Much more predictable heating at existing sheet pile**
- **Longer sheet pile is easier to reuse**

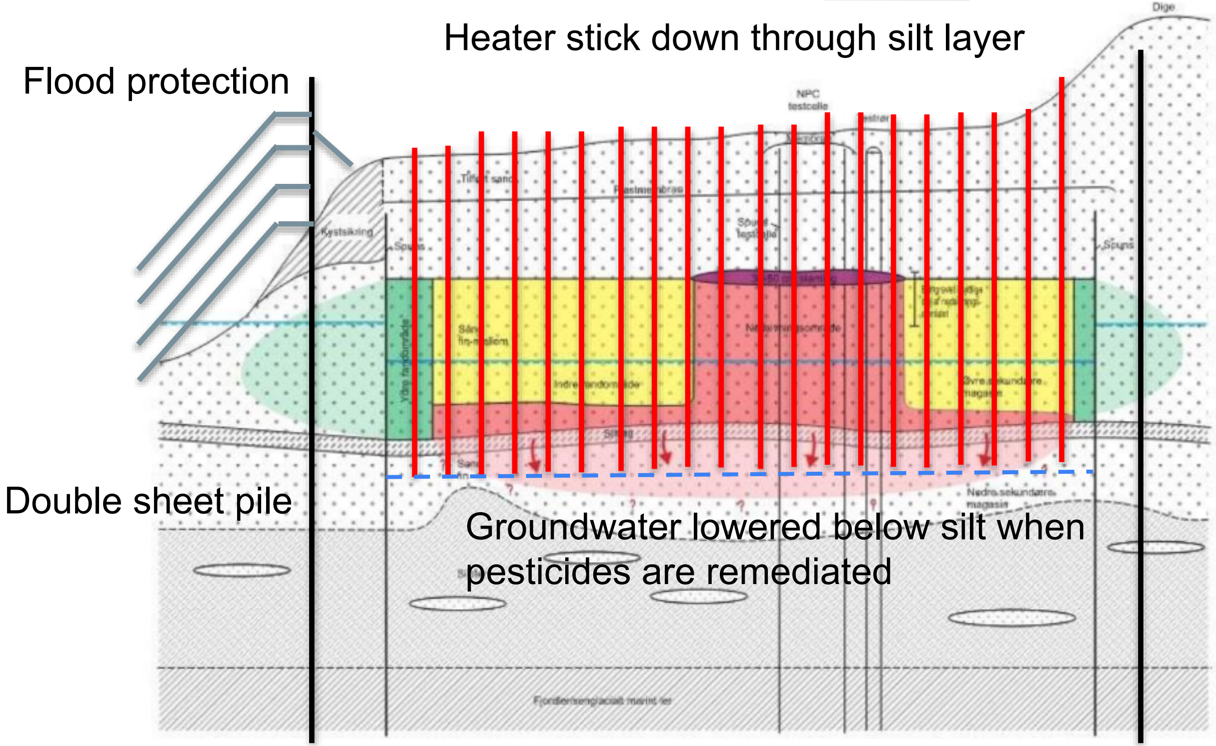
Pumping water below silt layer after remediation of pesticides.

Two partial volumes treated at different heating rate to optimize treatment plant and utilities

Thermal oxidizer to meet water discharge requirements

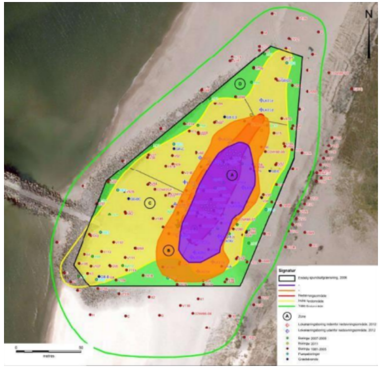


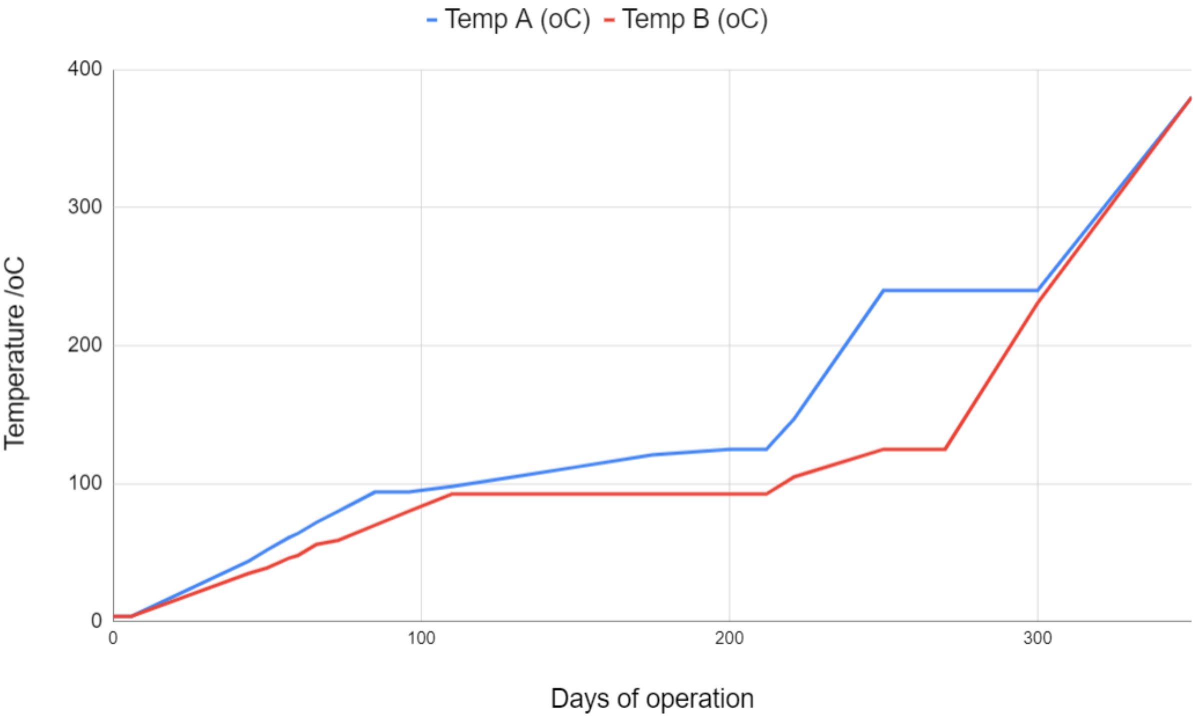
Full scale ISTD design



Split volume thermal design

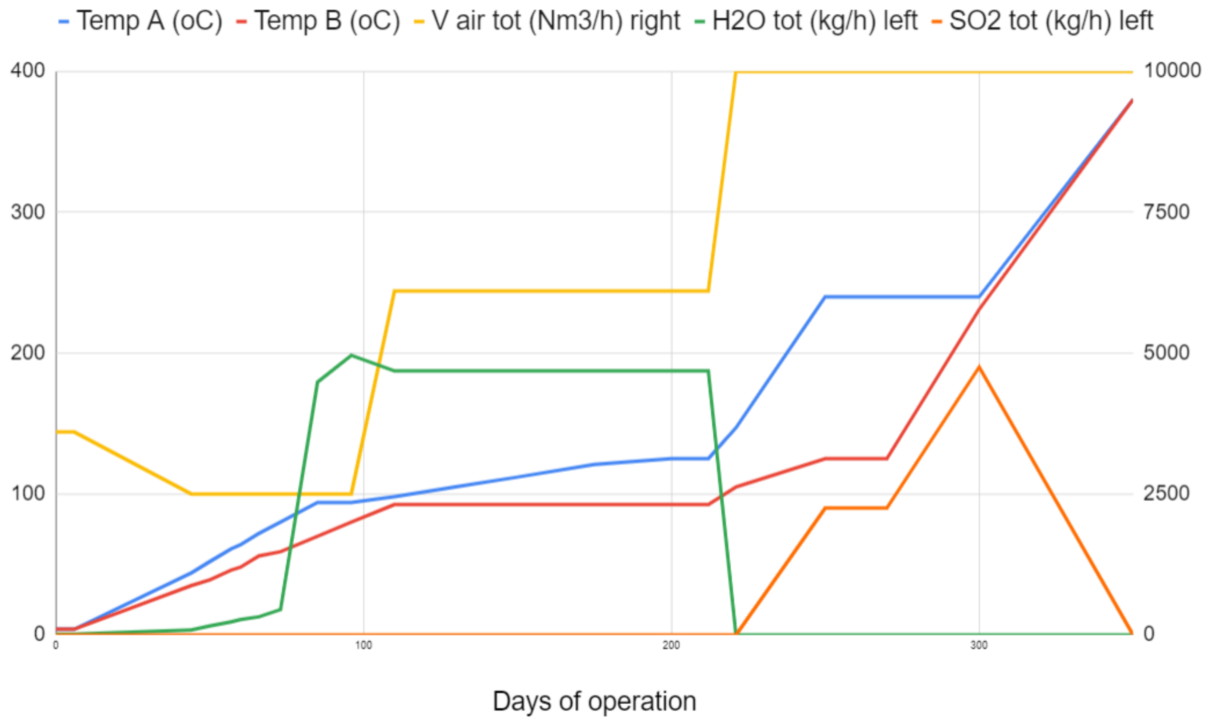
Differentiated heating rate for high (A) and low (B) concentration zones





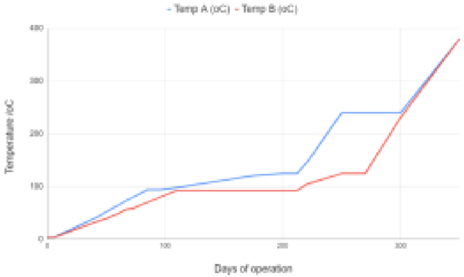
Split volume thermal design

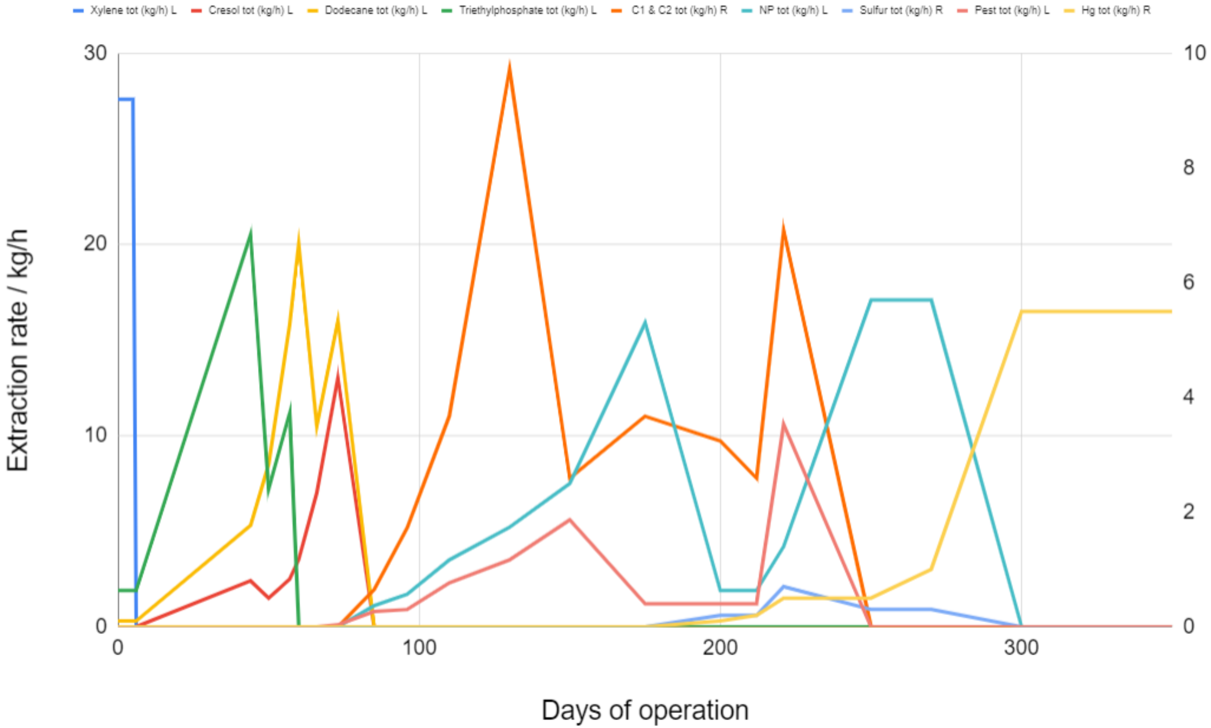
Total ventilation flow and extraction rates og water vapor and sulphurdioxide



Treatment plant load

Extraction rates of main contaminants.





Conclusions

A conservative design is required

- **Pilot testing show that process is sensitive to temperature and aeration**
  - **Allow for enough heater power to reach at least 350°C**
  - **Make sure ventilation is sufficient**
- **Remediating the pesticides give off 15 t of flamable gasses besides the 10 t of solvents**
  - **Make sure the ventilation will handle the load at safe concentrations**
  - **Allow sufficient time for slow controlled release of flammables**
  - **Consider oxidizing to avoid releasing the 15 t of methane, ethene and ethane**
- **Flooding during storm conditions is a risk**
  - **In situ remediation minimizes the consequences of a flood exceeding preparations**

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Questions?