Stabilization or mobilisation of PFAS at firefighting sites in Norway – feasibility for remediation

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16TH INTERNATIONAL CONFERENCE ON CHEMISTRY AND THE ENVIRONMENT
Poly- and Perfluoroalkyl Substances (PFASs)
Outline:

- Background
- Site location: AFFF at OSL airport
- Groundwater remediation
  - Pump and treat
- Unsaturated zone remediation
  - Stabilisation?
  - Soil washing?
  - Landfilling?
- Discussion
Background:

- AFFF used historically at Norwegian civil and military airports
- PFAS in soil, groundwater, rivers, lakes, fjords and in biota
- Investigating fate and transport PFAS in the environment
- Investigating cost-effective remediation for PFAS in soil and water
Site location: Oslo Airport, Gardermoen

- Military airport since 1912
- Norway’s largest groundwater reservoir
- Groundwater level at 2 to 30 m depth
- Historic use of AFFF without barriers
- PFAS in soil leach to groundwater and are transported to nearby waterbodies (rivers)
- New Oslo Airport opened in 1998
Oslo Airport fire fighting training site

- 6 training platforms
- Surface cover/Barriers
- Runoff collection systems
- Runoff to WWTP 1998-2015
- Runoff treatment since 2015
- AC-filter
PFOS source determination at the site

- The use of AFFF at the site
- Estimated PFAS in the soil
PFOS in the unsaturated zone (0-3m)
Co-contaminants at the site (hydrocarbons)
Groundwater remediation: Pump and treat

- Groundwater pumping wells downgradient
- Cleaned water re-infiltrated into wells
- Maintain groundwater level in area
- AC filters in series remove PFAS
- Spent AC filters are incinerated
- How long is pump and treat needed?
PFAS treatment efficiency in AC-filter at OSL

PFOS-concentration in groundwater and the amount PFOS removed in the AC filters since oktober 2015

[Graph showing PFOS concentration and removal efficiency over time from 2015 to 2017]
Laboratory testing of sorbent amendment to sandy PFAS contaminated soil

- Soil classified as sandy
- PFOS dominates with concentrations from 9 to 2600 μg/kg
- Leaching quantified with one step aqueous batch leaching test
- Sorbent amendment
  - activated carbon (AC)
  - compost soil (C)
  - montmorillonite (MM)
### Measured $K_D$-values for PFOS in sand

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sampling depth</th>
<th>Total PFOS concentration</th>
<th>Leaching-concentration PFOS</th>
<th>$K_D$</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>$C_{PFOS, soil}$ µg/kg</td>
<td>$C_{PFOS, porewater}$ µg/L</td>
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<td>Fines between gravel</td>
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</table>

Average $K_D$ for PFOS in sandy soil 10 L/kg
Reduction in PFOS leachate concentration after sorbent amendment and $K_D$ soil+sorbent

$K_D$ soil+sorbent (L/kg)

- 18.81 ± 1.47
- 16 960 ± 0
- 18.25 ± 1.40
- 6.04 ± 0.41
- 7 287 ± 6 292
- 5.52 ± 0.08
- 7.80 ± 0.28
- 1 906 ± 1 132
- 9.20 ± 0.19

C – compost soil; AC – activated carbon; MM - montmorillonite
Enhanced remediation based on contaminant properties and site specific conditions

- Stabilization or mobilization?
- Pump and treat barrier for PFAS transport by groundwater
- Soil washing at the training areas
  - Above the membran barrier sites
  - Collection of runoff water
  - Treatment in AC filter
- Soil washing at hotspots outside training areas
  - Pumping groundwater
  - Treatment in local AC filter and downstream AC filter
  - Enhancing the groundwater concentration to be extracted by downstream remediation pumps and treated with AC filter
Discussion

- Quantify the PFAS source
- Hydrogeological site investigation
- Identify the leaching paths from the source
- Transport mechanisms in the unsaturated zone
  - adsorption and desorption in the porewater
  - degree of soil saturation
- Transport mechanisms in the groundwater
  - advective transport
  - adsorption and desorption
  - dispersion and diffusion
- Contribution to recipient: concentration (ng/l) and flux (g/year)
- Risk assessment (EQS-values for water, sediment and biota)
- Determine remediation action
Thank you for your attention 😊
Questions?