Stabilization of PFAS contaminated soil
Two full scale projects in Sweden
Helena Hinrichsen, GM EnvyTech
Sweden

NOT Switzerland!!
Guideline Values on PFAS in soil and groundwater Sweden

SGI:s Publication 21, Preliminary Guidelines for PFAS in soil and ground water (Pettersson m.fl. 2015)
SGI- Swedish Geotechnical Institute

- Soil, domestic use, PFOS: 0.003 mg/kg (Groundwater protection)
- Soil, industrial use: 0.02 mg/kg (Surface water)

- Ground water, PFOS: 0.045 ng/l
- Surface water, PFOS: 230 ng/l

Svenska Livsmedelsverket SLV
SLV – Swedish food department
- Drinking water Sum PFAS1 190 ng/l
Guideline Values on PFAS, Sweden

Naturvårdsverket rapport 6871, Guidens for risk evaluation and remediation of PFAS contamination within contaminated areas, 2019

NV - Swedish National EPA

“The preliminary guideline value of PFOS regarding protection of surface water shall not be interpreted as it is accepted to release water with concentrations of PFOS of 230 ng/l to halt på 230 ng/l to the stormwater system or to a recipient. The value shall therefore NOT be used as a criteria for lechate water or urban discharge”
The daily routines of remediation….

- **LOTS** of talking about the risks, fate and transport on consultant level
- **LOTS** of talking on EPA level both, national and council - *Kommun*
- **GREAT** awareness of the creation of source areas at landfills
- **GREAT** interest in new techniques on all levels
- **BUT**
  - **NO** guidelines or prohibiting laws in sight for depositing PFAS soil in Landfill
  - **NO** Guidelines in sight for Landfill leachate

➡️ The daily routine of dig and dump continues
Lotsplatsen Firestation, Vellinge

- Firestation in use to be upgraded
- Local PFAS contamination in GW

- One very limited "hot spot" in soil located
Lotsplatsen 1, Fire station Vellinge

Remediation proposal plan submitted to EPA:
- Pump and treat for GW
- Excavation and deposit for soil, approx. 5 m³
  - Soil sampling in pit after soil removal
  - All excavated soil to be sampled

EPA Answer:

GW – ”Yes, Good idea!”

Soil – ”Only aloud to move and deposit the soil if we could show that the landfill have a clear concept and plan for handling PFAS contaminated soil and leachate water. We are not to spread this contaminant elsewhere”
Rembind Plus, Ziltek

A powdered product, designed to bind irreversibly to both organic and unorganic contaminants such as TPH, PAH chromium, arsenic and PFAS, to prevent leaching.

- 200 – 400 µm
- Black, dusty powder
- Comes in big bags

How does it work?

- Aluminium Hydroxide (Amorphous)
- Electrostatic Interactions
- Hydrophobic Interactions
- Physical Binding
- Van der Waals
- Activated Carbon

[Image of the product application]
Lab trial by Eurofins

- Procedure as recommended by Ziltek:
  - 1 sample split in two – 1A and 1R
  - Sample 1R mixed with 2% Remind, add 15% of water
  - Sample 1A left untreated (control)

- Preparation
  - Recomended by Ziltek: leave for 24 hours
  - We did: Swedish standard – didnt want any questions the method used

- Analyzing procedure
  - 1A: 2 step leachability test, EN 12457-3
  - 1R: step leachability test, EN 12457-3
    ➔ Standard procedure for all soils with contamintion levels > FA
      (Hazardous Waste taget Levels in Sweden)
Lotsplatsen 1, Firestation Vellinge

Lab trial Results

- Results showed minimization of leachate by:
  - > 96%, L/S 2
  - >99%, L/S 8
  - Since no criteria or guidelines, didn't really know what this meant, but low enough numbers + good % = Yes!

<table>
<thead>
<tr>
<th>Sample markning</th>
<th>Sample treated L/S=2</th>
<th>Sample not treated L/S=2</th>
<th>Sample treated L/S=8</th>
<th>Sample not treated L/S=8</th>
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</thead>
<tbody>
<tr>
<td>Units ng/l</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6:2 FTS</td>
<td>&lt;10</td>
<td>12</td>
<td>&lt;0,30</td>
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<td>PFBA</td>
<td>&lt;20</td>
<td>24</td>
<td>&lt;0,60</td>
<td>&lt;20</td>
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<tr>
<td>PFBS</td>
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<td>&lt;0,30</td>
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<td>&lt;10</td>
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<tr>
<td>PFDA</td>
<td>&lt;10</td>
<td>220</td>
<td>&lt;0,30</td>
<td>57</td>
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<tr>
<td>PFHpA</td>
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<td>21</td>
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<td>&lt;10</td>
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<td>PFHxA</td>
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<td>PFHxS</td>
<td>&lt;10</td>
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<td>&lt;0,20</td>
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<tr>
<td>PFNA</td>
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<td>PFOA</td>
<td>&lt;10</td>
<td>20</td>
<td>&lt;0,30</td>
<td>&lt;10</td>
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<tr>
<td>PFOS</td>
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<td>830</td>
<td>0,77</td>
<td>220</td>
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<tr>
<td>PFPeA</td>
<td>&lt;10</td>
<td>150</td>
<td>&lt;0,30</td>
<td>12</td>
</tr>
<tr>
<td>Sum PFAS SLV 11 (ng/l)</td>
<td>&lt;50</td>
<td>1400</td>
<td>0,77</td>
<td>290</td>
</tr>
</tbody>
</table>
The "Unfortunate golden rule": The Contamination must come from somewhere …

New results from pit edges and excavated soil: 22 µg/kg
Approx mass: 60 tonnes
➔ New lab trial
   From discussion with Ziltek: add 3% Rembind

➔ Sample mixed with 3%,
   2 step leachability test, EN 12457-3

Lab trial Results, round 2

<table>
<thead>
<tr>
<th>Conclusion - or confusion !!??</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contamination level in sample</td>
</tr>
<tr>
<td>L/S 2</td>
</tr>
<tr>
<td>L/S 8</td>
</tr>
<tr>
<td>Suggested target value for protection of surfacewater</td>
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</table>
Lotsplatsen 1, Firestation Vellinge

Results PFAS in leachate from HMAB Landfill, Hässleholm

<table>
<thead>
<tr>
<th>Delström</th>
<th>Februari</th>
<th>April</th>
<th>Juni*</th>
<th>Augusti</th>
<th>Oktober</th>
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<tbody>
<tr>
<td>FA</td>
<td>2 800</td>
<td>2 000</td>
<td>1 820</td>
<td>2 000</td>
<td>3 500</td>
</tr>
<tr>
<td>IFA</td>
<td>9 800</td>
<td>11 000</td>
<td>10 300</td>
<td>11 000</td>
<td>13 000</td>
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<tr>
<td>Gamla IFA</td>
<td>10 000</td>
<td>9 700</td>
<td>9 380</td>
<td>8 600</td>
<td>8 400</td>
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<tr>
<td>TBA</td>
<td>300</td>
<td>310</td>
<td>138</td>
<td>390</td>
<td>1 000</td>
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<tr>
<td>SBR UTG</td>
<td><strong>5 600</strong></td>
<td><strong>5 900</strong></td>
<td><strong>4 600</strong></td>
<td><strong>6 800</strong></td>
<td><strong>4 900</strong></td>
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</table>
Full scale project - 60 tonnes of PFAS contaminated soil stabilized with Rembind
Surface treatment plant
Markaryd


Client very clear with the fact that this was to be done the RIGHT way. No shortcuts. Asked landfills to take on these soils in a correct manner, present SOPs → NO
Surface treatment plant
Markaryd

Lab trial

Different PFAS concentrations were tested:
- Control sample ≤ 50 µg/kg PFAS
- Control sample 710 - 1100 µg/kg PFAS
- PFAS soil ≤ 50 µg/kg ➔ 3% Rembind
- PFAS soil 710 - 1200 µg/kg ➔ 3% AND 5% Rembind

<table>
<thead>
<tr>
<th>Ämne</th>
<th>Halt Summa PFAS SLV 11</th>
<th>Lakning</th>
<th>PFHxS ng/l</th>
<th>PFOS ng/l</th>
<th>Rembind %</th>
<th>pH</th>
<th>ng/kg</th>
<th>Summa PFAS SLV 11 ng/l</th>
<th>Reduktion lakning %</th>
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<tbody>
<tr>
<td>Samlingsprov 1</td>
<td>1100 + 710</td>
<td>L/S 2</td>
<td>2 800</td>
<td>230 000</td>
<td>0</td>
<td>7,5</td>
<td>230000</td>
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<td>0,0</td>
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<tr>
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<td>1100 + 710</td>
<td>L/S 8</td>
<td>150</td>
<td>27 000</td>
<td>0</td>
<td>7,6</td>
<td>27000</td>
<td></td>
<td>0</td>
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<tr>
<td>Samlingsprov 1</td>
<td>1100 + 710</td>
<td>L/S 2</td>
<td>77</td>
<td>8400</td>
<td>3</td>
<td>7,8</td>
<td>8500</td>
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<td>96,3</td>
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<td>L/S 8</td>
<td>11</td>
<td>1500</td>
<td>3</td>
<td>7,7</td>
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<td>94,4</td>
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<td>98,0</td>
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<td>L/S 8</td>
<td>10</td>
<td>1100</td>
<td>5</td>
<td>7,7</td>
<td>1100</td>
<td></td>
<td>99,5</td>
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<tr>
<td>Samlingsprov 2</td>
<td>22+31+23+13+21+59</td>
<td>L/S 2</td>
<td>270</td>
<td>3800</td>
<td>0</td>
<td>7,6</td>
<td>4300</td>
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<td>0</td>
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<td>Samlingsprov 2</td>
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<td>L/S 8</td>
<td>12</td>
<td>960</td>
<td>0</td>
<td>7,7</td>
<td>970</td>
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<td>0</td>
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<tr>
<td>Samlingsprov 2</td>
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<td>L/S 2</td>
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<td>7,6</td>
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<td>86,3</td>
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<tr>
<td>Samlingsprov 2</td>
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<td>L/S 8</td>
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<td>77</td>
<td>3</td>
<td>7,7</td>
<td>77</td>
<td></td>
<td>92</td>
</tr>
</tbody>
</table>
Full scale project - 3000 tonnes of PFAS contaminated soil stabilized with Rembind

**Remediation**

- Tearing down 2500 m² of building
- ”Digg and dump” app 3000 m³
- Pre classification of soils in 20 x 20 m, 0.5 m depth intervals
- Soil noted to contain lots of gravel and rocks
- Concrete with PFAS levels above target levels
- Foundations found under groundwater level ➔ water treatment
Full scale project - 3000 tonnes of PFAS contaminated soil stabilized with Rembind

Speaking of the gravel, stones and rocks...
Remember the ”clean” gravel from the Vellinge project

What if:
Pre tumbling treatment before adding Rembind ➔
Less mass, less rembind, an extra tumbling cost ➔ - $$$
EPA gives OK if sample shows contamination levels below project specific target levels
**Full scale project - 3000 tonnes of PFAS contaminated soil stabilized with Rembind**

<table>
<thead>
<tr>
<th>Soil to landfill</th>
<th>PFAS &lt; KM</th>
<th>948,1 tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>FA metals</td>
<td>20,56</td>
<td>tonnes</td>
</tr>
<tr>
<td>PFAS 3%</td>
<td>2 585,90</td>
<td>tonnes</td>
</tr>
<tr>
<td>PFAS 5%</td>
<td>432,64</td>
<td>tonnes</td>
</tr>
<tr>
<td>concrete</td>
<td>964</td>
<td>tonnes</td>
</tr>
<tr>
<td><strong>Sum to landfill</strong></td>
<td><strong>4951,2 tonnes</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Reused gravel</strong></td>
<td><strong>584,76 tonnes</strong></td>
<td></td>
</tr>
</tbody>
</table>

...But we are doing it all again with lab trials starting in end september 2019.
Project of ca 60 000 tonnes of PFAS soil.
And for that we have some new toys 😊😊