Presentation of Sustainable PFAS treatment technologies
SAFF – Surface Active Foam Fractionation

Helena Hinrichsen, Founder och Head of R&D
Envytech Solutions AB
Talk Layout

• What is PFAS, and why it is a FAST !! growing issue in Leachates

• Short summary of available PFAS water treatment technologies and their challenges

• Presentation SAFF- Surface Active Foam Fractionation – The first sustainable and suitable treatment method for complex waters and leachates
  
  • SHORT History

  • Results from full scale projects and Pilots

  • How it works and why

  • Summary of abilities and cost – Yes it is true! We will tell you the operational costs!
PFAS – Per- and Polyfluoroalkyl Substances - Forever chemicals
PFAS in leachates and waste

- As many products, plastic, metal, textile and (what else) contain PFAS, it leaches into our environment from landfills and waste storages.
- A mix of substances from short chains to long chains.
- Landfills and waste storage facilities become point sources.
  - Leads to the creation of complimentary contamination source zones.
  - Leachate pass treatment systems not designes for PFAS.
  - Contaminates groundwater and surface waters, and many more environmental impacts.

Leachate treatment soon a must in Sweden, Denmark and US.
PFAS Treatment technologies - Water

Adsorption
- Activated Carbon
- Ion exchange mass

Concentration
- SAFF – Surface Active Foam Fractionation

Destruction
- Electrochemical Oxidation
- SCWO – super critical water oxidation
- Thermal destruction
- Sub-critical destruction
Envytech Solutions – Adsorption tech
pre-treatments

Filter medias are sensitive for:
particles, pH, conductivity
cross-contaminants, other water chemistry, ex
BOD, DOC, COD TOC

YES! 99,9% removal etc.
But To what cost – All and all

• Cost for rental / buy of pre treatment tech, vessels
• Cost of running plants
• Chemicals for flocculation/precipitation
• Pre-filter medias
• Filter medias
• Service for pre treatment, backflushing etc
• Service for filtermedias exchange
• Cost for sludge handling system
• Cost of transport and deposition of sludge, WHERE?
• Cost of waste from used pre filter, incl Transport and deposition, WHERE?
• Cost of waste used filters, incl. Transport and deposition, WHERE?
SAFF – Surface Active Foam Fractionation
The Heavy Lifter in PFAS water treatment
SAFF – Surface Active Foam Fractionation

Developed by OPEC systems Australia as a result of a grant from Australian Defence

First full scale plant commissioned in May 2019 in Oakey, Australia

Envytech <3 OPEC September 2019

First full scale mobile unit commissioned in Sweden February 2021

Chosen technology for EU grants Horizon2020 as well as EU LIFE
To evaluate leachate treatment and other complex waters

SAFF™
Surface Active Foam Fractionation
‘AIR IN – PFAS OUT’
Sustainable Lead Treatment – in a Multi-stage WTP (PFAS)
SAFF – Surface Active Foam Fractionation

Exclusive Distributor Scandinavia / Europe
UK – in partnership with Cornelsen
It started in Australia – Oakey Military Base

- Military Base
- Fire fighting Foam usage
- First SAFF for PFAS in the world
- 3 year since start
- > 80 000 m3 treated
- Now becoming head treatment option for Australian Defence
- For PFAS water treatment
Some results over a 16 month period

>150 000 m³ treated

Flow rate: 20 m³/h

Waste: ca 1-2 m³/ 40 000 m³ treated

<table>
<thead>
<tr>
<th>Ämne</th>
<th>Removal rate % Telge SAFF40 18 min</th>
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<tbody>
<tr>
<td>PFHxS (Perfluorhexansulfonsyra)</td>
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<td>PFOA (Perfluoroktansyra)</td>
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<td>6:2 FTS (Fluortelomer sulfonat)</td>
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<td>PFDA (Perfluordekansyra)</td>
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<td>PFHxA (Perfluorhexansyra)</td>
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<td>91%</td>
<td>39%</td>
<td>44%</td>
<td>19%</td>
<td>38%</td>
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<td>PFBS (Perfluorbutansulfonsyra)</td>
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<td>87%</td>
<td>6%</td>
<td>18%</td>
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<td>PFPeA (Perfluorpentansyra)</td>
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<td>0%</td>
<td>16%</td>
<td>0%</td>
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<td>PFBA (Perfluorbutansyra)</td>
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<td>0%</td>
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</tbody>
</table>
Welcome to Telge Återvinning
And we do have VERY MUCH! algae and zooflagellates in our water
miniSAFF – Bench scale testing unit
IVL test for Avfall Sverige Rapport 2021:02
Foam Fractionation (leachate and municipal waste water)

Leachate from 5 landfills tested by IVL and Envytech

<table>
<thead>
<tr>
<th>Ämne</th>
<th>Antal kolatomer</th>
<th>OPEC Prediction model GW (full scale)</th>
<th>IVL/Envytech tests with leachate</th>
<th>Half life in Human body (years)</th>
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</thead>
<tbody>
<tr>
<td>PFDA (Perfluordekansyra)</td>
<td>C10</td>
<td>100%</td>
<td>100%</td>
<td>5,6</td>
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<td>PFNA (Perfluoronansyra)</td>
<td>C9</td>
<td>100%</td>
<td>100%</td>
<td>2,8</td>
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<td>6:2 FTS (Fluortelomer sulfonat)</td>
<td>C8</td>
<td>100%</td>
<td>100%</td>
<td>0,08</td>
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<tr>
<td>PFOA (Perfluoroktansyra)</td>
<td>C8</td>
<td>100%</td>
<td>100%</td>
<td>3,3</td>
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<tr>
<td>PFOS (Perfluoroktansulfonsyra)</td>
<td>C8</td>
<td>100%</td>
<td>100%</td>
<td>5,7</td>
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<td>PFHpA (Perfluorheptansyra)</td>
<td>C7</td>
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<td>80%</td>
<td>0,44</td>
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<td>PFHxS (Perfluorhexansulfonsyra)</td>
<td>C6</td>
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<td>99%</td>
<td>9,9</td>
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<td>PFHxA (Perfluorhexansyra)</td>
<td>C6</td>
<td>20-30%</td>
<td>30%</td>
<td>0,06</td>
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<td>25-35%</td>
<td>20%</td>
<td>0,1</td>
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<td>PFBA (Perfluorbutansyra)</td>
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<td>20-20%</td>
<td>10%</td>
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<td>PFBS (Perfluorbutansulfonsyra)</td>
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<td>30-40%</td>
<td>30%</td>
<td>0,107</td>
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<tr>
<td>Summa PFAS</td>
<td></td>
<td>30-70%</td>
<td></td>
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</table>
NSR Landfill – Results

Project period: September 2021 - February 2022

Total volume treated: 27,000 m³

Flow rate: 18 m³/h

Waste: 220 l / 27,000 m³ treated

<table>
<thead>
<tr>
<th>Åmne</th>
<th>Enhet</th>
<th>Inlet 2021-09-17</th>
<th>Outlet 2021-09-17</th>
<th>Removal rate</th>
<th>Inlet 2021-10-15</th>
<th>Outlet 2021-10-15</th>
<th>Removal rate</th>
<th>Inlet 2021-10-22</th>
<th>Outlet 2021-10-22</th>
<th>Removal rate</th>
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<tbody>
<tr>
<td>PFDA (Perfluordekansyra)</td>
<td>ng/l</td>
<td>11</td>
<td>&lt;1,0</td>
<td>100%</td>
<td>19</td>
<td>&lt;1,0</td>
<td>100%</td>
<td>8</td>
<td>&lt;1,0</td>
<td>100%</td>
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<tr>
<td>PFINA (Perfluormonansyra)</td>
<td>ng/l</td>
<td>31</td>
<td>&lt;1,0</td>
<td>100%</td>
<td>30</td>
<td>&lt;1,0</td>
<td>100%</td>
<td>21</td>
<td>&lt;1,0</td>
<td>100%</td>
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<tr>
<td>PFOS (Perfluoroktansulfonsyra)</td>
<td>ng/l</td>
<td>240</td>
<td>5,5</td>
<td>98%</td>
<td>230</td>
<td>3,4</td>
<td>99%</td>
<td>120</td>
<td>2,6</td>
<td>98%</td>
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<tr>
<td>PFOA (Perfluoroktansyra)</td>
<td>ng/l</td>
<td>330</td>
<td>4,3</td>
<td>99%</td>
<td>560</td>
<td>7,3</td>
<td>99%</td>
<td>490</td>
<td>3,8</td>
<td>99%</td>
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<tr>
<td>6:2 FTS (Fluortolomer sulfonat)</td>
<td>ng/l</td>
<td>870</td>
<td>32</td>
<td>96%</td>
<td>880</td>
<td>22</td>
<td>98%</td>
<td>830</td>
<td>10</td>
<td>99%</td>
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<tr>
<td>PFHpA (Perfluorheptansyra)</td>
<td>ng/l</td>
<td>280</td>
<td>110</td>
<td>61%</td>
<td>1000</td>
<td>79</td>
<td>92%</td>
<td>740</td>
<td>50</td>
<td>93%</td>
</tr>
<tr>
<td>PFHxS (Perfluorhexansulfonsyra)</td>
<td>ng/l</td>
<td>130</td>
<td>3,1</td>
<td>98%</td>
<td>200</td>
<td>3,3</td>
<td>98%</td>
<td>140</td>
<td>1,8</td>
<td>99%</td>
</tr>
<tr>
<td>PFHxA (Perfluorhexansyra)</td>
<td>ng/l</td>
<td>600</td>
<td>570</td>
<td>5%</td>
<td>640</td>
<td>620</td>
<td>3%</td>
<td>590</td>
<td>420</td>
<td>29%</td>
</tr>
<tr>
<td>PFPeA (Perfluorpentansyra)</td>
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<td>690</td>
<td>650</td>
<td>6%</td>
<td>660</td>
<td>740</td>
<td>0%</td>
<td>530</td>
<td>630</td>
<td>0%</td>
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<td>PFBS (Perfluorbutansulfonsyra)</td>
<td>ng/l</td>
<td>140</td>
<td>130</td>
<td>7%</td>
<td>140</td>
<td>140</td>
<td>0%</td>
<td>120</td>
<td>99</td>
<td>18%</td>
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<tr>
<td>PFBA (Perfluorbutsyra)</td>
<td>ng/l</td>
<td>470</td>
<td>440</td>
<td>6%</td>
<td>310</td>
<td>310</td>
<td>0%</td>
<td>340</td>
<td>400</td>
<td>0%</td>
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<tr>
<td>Summa PFAS SLV 11</td>
<td>ng/l</td>
<td>3800</td>
<td>1900</td>
<td>50%</td>
<td>4700</td>
<td>1900</td>
<td>60%</td>
<td>3900</td>
<td>1600</td>
<td>59%</td>
</tr>
</tbody>
</table>
SAFF – Surface Active Foam Fractionation

How it works and why
PFAS – Quick repeat of the nature of PFAS molecules

Perfluorinated substances has:
Hydrophilic head – Head loves water
Hydrophobic tail – Tail hates water

- The bubble becomes the perfect environment
  C6 PFAS and above – tail sticks in the bubble, easy to remove
  - More scientific wording: Langmuir constant > 1 x 10-6 can be caught

- Som C6 and shorter chains (< 1 x 10-6) do get caught but get released before getting collected – becomes top section swimmers
Mobile treatment, winter isolated
"Plug and play"

- Tuning after start up – needed because all waters are different, approx 2 days
- Remote surveillance, fine tuning, 24 h / 7 day controlled
- You can follow flow, status, electricity used, total volume and more via the app!

- Every pump, valve and sensor, reports data continuously. We can see exactly when, what and where a problem has occurred and can usually fix it remotely straight away
SAFF – Surface Active Foam Fractionation

SAFF uses the air bubbles physiochemistry as the perfect environment for PFAS to get them out of solution and into a removable foam.

By "final push", we get some shorter chain removal.

Primary step: 10 x conc
Secondary Step: 1500 x conc
Tertiary Step: 500-200 x conc
SAFF – Surface Active Foam Fractionation

How it works and why
Primary Fractionation: 10 x concentrationen (of volume)
SAFF – Surface Active Foam Fractionation

Secondary Fractionation: 1 500 x concentrationen

Tertiery Fractionation: 50 – 200 x Concentration

Total concentration increase: 500 - 200 000 x concentration
SAFF Economics

Wonderful results!
But how much does it cost?

Rental or Buy: Ask us for a quote

Capacity: > 40 m3/h or 20 m3/h

Installation: 40 h service technician. Included in rental at long time hire.

Electricity: 0,7 kwh / m3 treated – Sweden: < 0,1 euro/ m3 treated

Service: 16 h service technician per month – depending on water

Waste
From leachate: 0,2 - 3 m3 / 40 0000 m3 treated
From GW: < 0,1 (10 liters) per 50 000 m3 treated

Possibility! No waste – ”Closed loop” possibility within 6-12 months.
Envytech Solutions AB – Contact

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