Stabilization of PFAS contaminated soil
Two full scale projects in Sweden

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NOT Switzerland!!

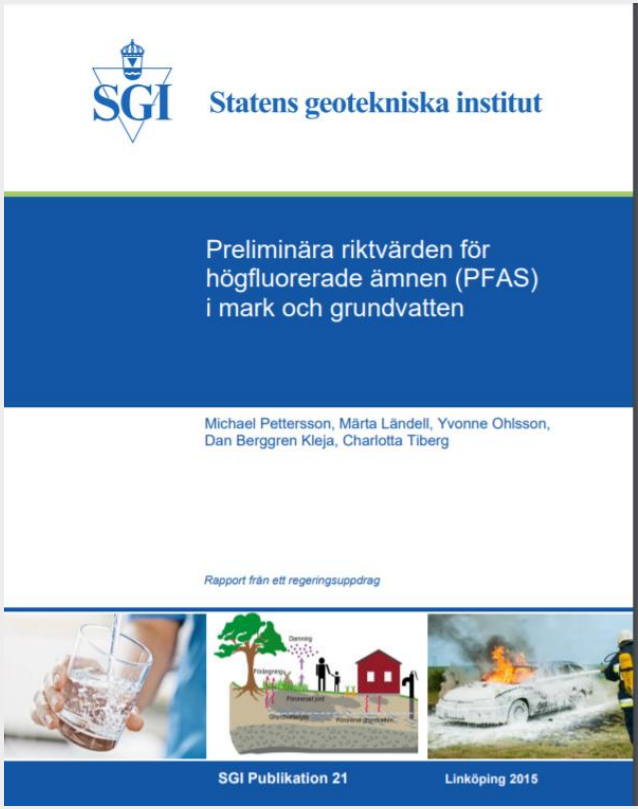
Guideline Values on PFAS in soil and groundwater
Sweden

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 1 90 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….

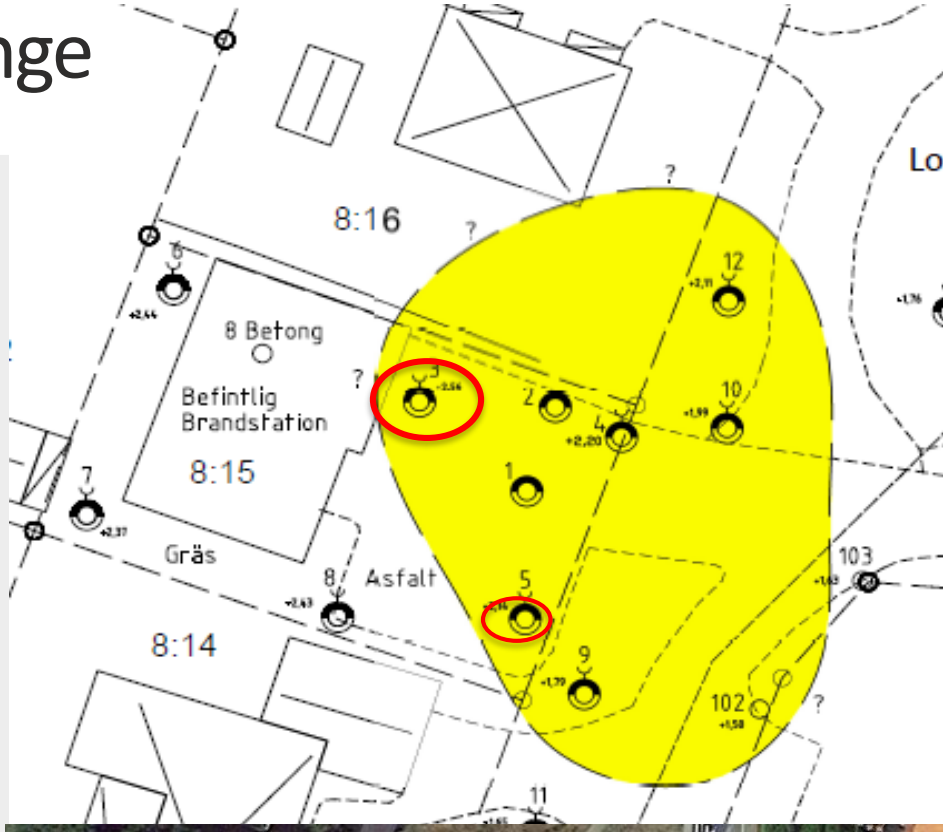
- **LOTS** of talking about the risks, fate and transport on consultant level
- **LOTS** of talking on EPA level both, national and council - *Kommun*
- **GREAT** awearness of the creation of source areas at landfills
- **GREAT** interest in new techniques on all levels
- **BUT**
- **NO** guidelines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

Analysparameter	Id					Riktvärde
	3 GW	4 GW	5 GW	6 GW	7 GW	SGI
PFBA perfluorbutansyra	0,11	0,231	0,06	0,01	<0,010	
PFPeA perfluorpentansyra	0,881	2,12	0,503	0,062	0,017	
PFHxA perfluorhexansyra	0,582	2,51	0,355	0,048	0,014	
PFHpA perfluorheptansyra	0,332	1,12	0,163	0,019	<0,010	
PFOA perfluoroktansyra	0,057	0,114	0,0431	0,0113	<0,0100	
PFNA perfluornonansyra	<0,010	<0,010	<0,010	<0,010	<0,010	
PFDA perfluordekansyra	<0,010	<0,010	<0,010	<0,010	<0,010	
PFUnDA perfluorundekansyra	<0,010	<0,010	<0,010	<0,010	<0,010	
PFDoDA perfluordodekansyra	<0,010	<0,010	<0,010	<0,010	<0,010	
PFBS perfluorbutansulfonat	0,022	0,025	<0,010	<0,010	<0,010	
PFHxS perfluorhexansulfonat	0,411	0,26	0,041	0,069	<0,010	
PFOS perfluoroktansulfonat	**0,219**	0,0136	**0,0555**	0,0364	<0,0100	0,045
PFDS perfluordekansulfonat	<0,010	<0,010	<0,010	<0,010	<0,010	
PFOSA perfluoroktan-sulfonamid	<0,010	<0,010	<0,010	<0,010	<0,010	
6:2 FTS Fluortelomersulfonat	0,015	<0,010	<0,010	<0,010	<0,010	
Summa PFAS-ämnen	*2,629*	*6,3936*	*1,2206*	*0,2557*	*0,031*	
Analysrapport	T1605984	T1612648	T1612648	T1612648	T1612648	



- One very limited ”hot spot” in soil located

Analysparameter	Id och djup (m)				Riktvärde	
	3 (0,05-0,2)	4 (1,5-2,2)	5 (1,5-2,2)	6 (1,5-2,2)	KM	MKM
PFBA perfluorbutan-syra	<0,0030	<0,0030	<0,0030	<0,0030		
PFPeA perfluorpentan-syra	<0,0030	<0,0030	<0,0030	<0,0030		
PFHxA perfluorhexan-syra	<0,0030	<0,0030	<0,0030	<0,0030		
PFHpA perfluorheptan-syra	<0,0030	<0,0030	<0,0030	<0,0030		
PFOA perfluoroktan-syra	<0,0030	<0,0030	<0,0030	<0,0030		
PFNA perfluornonan-syra	<0,0030	<0,0030	<0,0030	<0,0030		
PFDA perfluordekan-syra	<0,0030	<0,0030	<0,0030	<0,0030		
PFUnDA perfluorunde-kansyra	<0,0030	<0,0030	<0,0030	<0,0030		
PFDoDA perfluordode-kansyra	<0,0030	<0,0030	<0,0030	<0,0030		
PFBS perfluorbutan-sulfonat	<0,0030	<0,0030	<0,0030	<0,0030		
PFHxS perfluorhexan-sulfonat	<0,0030	<0,0030	<0,0030	<0,0030		
PFOS perfluoroktan-sulfonat	**0,0088**	<0,0030	<0,0030	<0,0030	0,003	0,02
PFDS perfluordekansulfonat	<0,0030	<0,0030	<0,0030	<0,0030		
PFOSA perfluoroktan-sulfonamid	<0,0030	<0,0030	<0,0030	<0,0030		
6:2 FTS Fluortelomer-sulfonat	<0,0030	<0,0030	<0,0030	<0,0030		
Summa PFAS-ämnen	*0,0088*	*<0,045*	*<0,045*	*<0,045*		
Analysrapport	T1612642	T1612642	T1612642	T1612642		

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Lotsplatsen 1, Fire station Vellinge

Remediation proposal plan submittd 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!"*

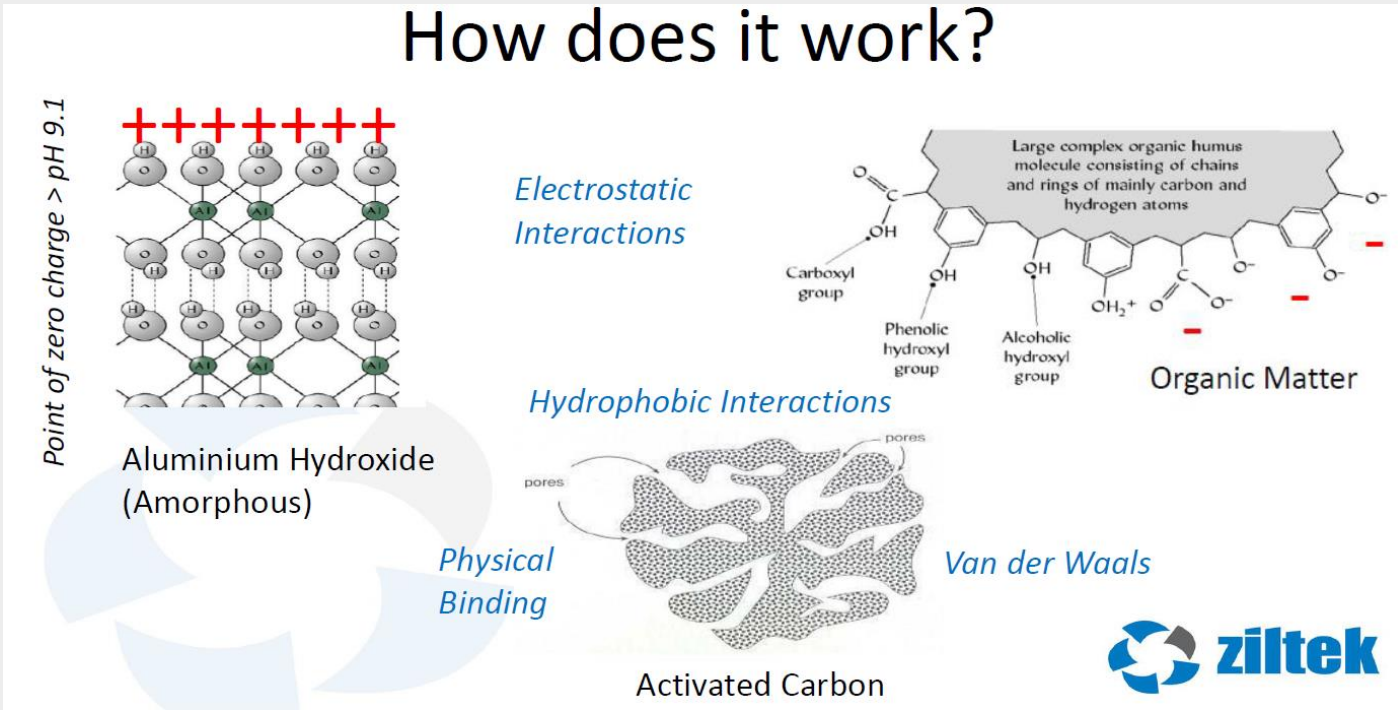
Soil – *"**Only aloud to move and deposit the soil if we could show that the ladfill have a clear concept and plan for handling PFAS contaminated soil and leachate water. We are not to spread this contaminant elsewhere**"*

Lotsplatsen 1, Fire station Vellinge

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



Lotsplatsen 1, Fire station Vellinge

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
  - Recomeded 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, didnt really know what this ment, but,
  low enough numbers
  +
  good %
  = Yes!

Sample markning	Sample treated L/S=2	Sample not treated L/S=2	Sample treated L/S=8	Sample not treated L/S=8
Units ng/l				
6:2 FTS	<10	12	<0,30	<10
PFBA	<20	24	<0,60	<20
PFBS	<10	<0,30	<10	<10
PFDA	<10	220	<0,30	57
PFHpA	<10	21	<0,30	<10
PFHxA	<10	58	<0,30	<10
PFHxS	<10	10	<0,20	<10
PFNA	<10	42	<0,30	<10
PFOA	<10	20	<0,30	<10
PFOS	<10	830	0,77	220
PFPeA	<10	150	<0,30	12
Sum PFAS SLV 11 (ng/l)	<50	**1400**	**0,77**	**290**

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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

Conclusion - or confusion !!??		
Contamination level in sample	22	µg/kg
L/S 2	2200	ng/l
L/S 8	48	ng/l
Suggested target value for protection of surfacewater	230	ng/l

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Results PFAS in leachate from HMAB Landfill, Hässleholm

Delström	Februari	April	Juni*	Augusti	Oktober
FA	2 800	2 000	1 820	2 000	3 500
IFA	9 800	11 000	10 300	11 000	13 000
Gamla IFA	10 000	9 700	9 380	8 600	8 400
TBA	300	310	138	390	1 000
SBR UTG	5 600	5 900	4 600	6 800	4 900

HÄSSLEHOLM MILJÖ AB
VI BRINNER FÖR EN HÅLLBAR FRAMTID

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Full scale project - 60 tonnes of PFAS contaminated soil stabilized with Rembind

Surface treatment plant Markaryd

Partnering project with a consultant, Sweco, Envytech and the client.
Started august 2018, finished in may 2019.
Ca 4000 tonnes contaminated soil, 3000 PFAS contaminated
Groundwater **HEAVILY** contaminated with cyanid, zink, chromium, chromium6+, cupper and lead

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.

} 2 step leachability test EN 12457-3

Ämne	Halt Summa PFAS SLV 11	Lakning	PFHxS	PFOS	Rembind	pH	Summa PFAS SLV 11	Reduktion lakning
Enhet	ng/kg		ng/l	ng/l	%	ng/kg	ng/l	%
Samlingsprov 1	1100 + 710	L/S 2	2 800	230 000	0	7,5	230000	0,0
Samlingsprov 1	1100 + 710	L/S 8	150	27 000	0	7,6	27000	0,0
Samlingsprov 1	1100 + 710	L/S 2	77	8400	3	7,8	8500	96,3
Samlingsprov 1	1100 + 710	L/S 8	11	1500	3	7,7	1500	94,4
Samlingsprov 1	1100 + 710	L/S 2	45	4600	5	7,5	4600	98,0
Samlingsprov 1	1100 + 710	L/S 8	10	1100	5	7,7	1100	99,5
Samlingsprov 2	22+31+23+13+21+59	L/S 2	270	3800	0	7,6	4300	0
Samlingsprov 2	22+31+23+13+21+59	L/S 8	12	960	0	7,7	970	0
Samlingsprov 2	22+31+23+13+21+59	L/S 2	17	570	3	7,6	590	86,3
Samlingsprov 2	22+31+23+13+21+59	L/S 8	<10	77	3	7,7	77	92

Full scale project - 3000 tonnes of PFAS contaminated soil stabilized with Rembind

Remediation

- Tearing down 2500 m2of building
- ”Digg and dump” app 3000 m3

- Pre classification of soils in 20 x 20 m, 0,5 m depth intervalls

- Soil noted to contain lots of gravel and rocks

- Concrete with PFAS levels abouve target levels

- Foundations found under groundwater level ➔ water treatment

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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

Soil to landfill	PFAS < KM	948,1	tonnes
	FA metals	20,56	tonnes
	PFAS 3%	2 585,90	tonnes
	PFAS 5%	432,64	tonnes
	concrete	964	tonnes
Sum to landfill		**4951,2**	**tonnes**
Reused gravel		584,76	**tonnes**

The End

…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 ☺☺

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