The occurrence and removal of the fluoro alkyl (PFAS) substances in (leachate) samples from a Norwegian waste handling facility and its surroundings

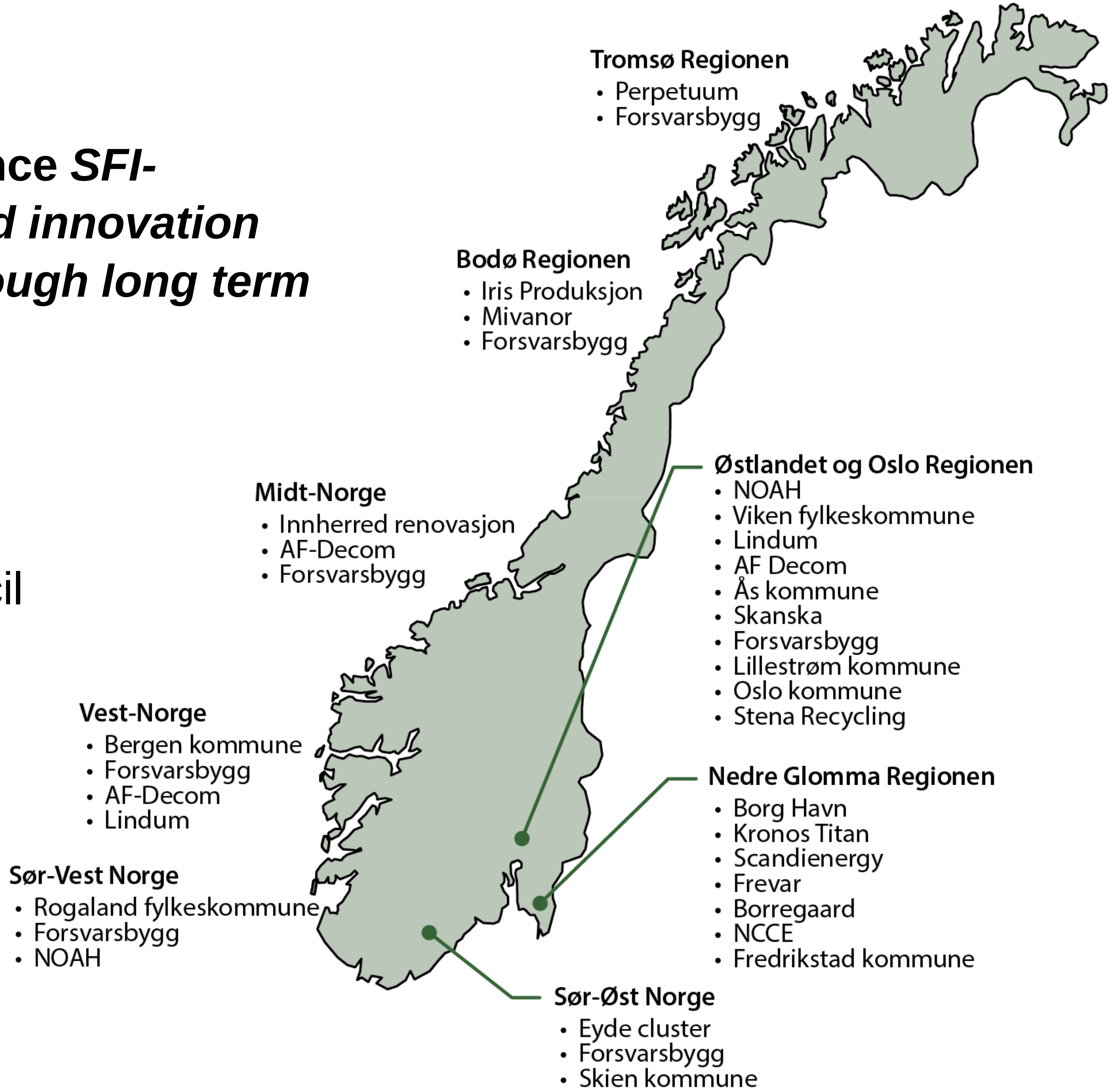
K. Haarstad*, J. Barlindhaug**
*Nibio, Ås. **Perpeetum, Balsfjord.

earthresQue

“The main goal for Senter for excellence SFI-financing is to contribute to improved innovation and value in Norwegian business through long term research”

- 24 partners, 8 in research
- Total budget: 220 mill. NOK
- 96 mill. NOK from the Research Council
- Duration: 8 years

NGI NIBIO NMBU IFE NORSUS NILU BI NIVA



Priority pollutants of concern:

Pesticides
Phenols (PCP)
PFAS

earthresQue

Senter for forskningsdrevet innovasjon

Table 4. Environmental quality standards (EQS) for PFOA and PFOS (Miljødirektoratet, 2016).

Matrix	Substance	AA-EQS (water) QS_{sed} $(E)QS_{biota}$	MAC-EQS (water) $QS_{sed, acute}$
Fresh water	PFOA	9100 ng/L	
	PFOS	0.65 ng/L	36000 ng/L
Sea water	PFOA	9100 ng/L	
	PFOS	0.13 ng/L	7200 ng/L
Sediment, fresh water	PFOA	713 µg/kg	
	PFOS	2.3 µg/kg	360 µg/kg
Sediment, sea water	PFOA	71 µg/kg	
	PFOS	0.23 µg/kg	72 µg/kg
Biota	PFOA	91.3 µg/kg ww	
	PFOS	9.1 µg/kg ww	

AA-EQS; chronic effects after long term exposure.
MAC-EQS, acute toxic effects from short exposure

A	B	C	D	E	F	G	H	I	J	K	L	M
Pesticid	**Kow**	**Koc**	**$T_{1/2}$**	**Vannløslighet**	**pKa**	**MAC-QS**	**Omsatt**	**MFI**	**EQS-Ger**	**AMF**	**ecreation wate**	**Eu ferskv.**
	Log	**Log**	**dissipation or**	**µg/L (pH 7 or**	**-**	**µg/l**	**Tonn/år (00-04**	**µg/l**	**µg/l**	**µg/l**	**µg/l**	**µg/l**
aclonifen	4,37	3,93	50	1400		0,12	2139	0,25		0,69		
alachlor	0,46	2,23		242000,00		0,70		20**	0,30		3	0,30
atrazine	2,50	1,98	45	33000	1,74	2,00		0,40	0,14	4,30		0,60
bifenox	4,48			350		0,04						
chlorfenvinphos	3,85	1,72	33	145000		0,30	1697	0,00025		0,00250	10	0,10
chlorpyriphos				2000		0,10						0,03
cybutryne						0,02						
cypermetrin		1,91	1103,00	4,00		6,00E-04						
DDT												
dichlorvos	1,40			low		7,00E-04						
dicofol	5,02	3,4		1200								
diuron	0,44			42000		1,80			0,20			0,20
endosulfan	3,13	4,09	150	330		0,01		0,050		0,260	40	0,005
endosulfan-alfa									0,0050			
endosulfan-beta									0,0050			
endosulfan-sulfat												
endosulfan-diol												
isoproturon	2,87	0,85	28	65000		1,00	4223	0,32 (9**)	0,58	2,10		0,30
quinoxyfen	4,66			100000	3,56	2,70						
simazin	2,10	2,10	89	6200	1,60	4,00		0,42 (2**)	0,18	4,20		1,00
terbutryn						0,34			0,0059			
triflualin								20**	0,12			0,03

earthresQ

CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives. Protecting People™

Search

EMERGING INFECTIOUS DISEASES®

EID Journal > Volume 15 > Number 9—September 2009 > Main Article

Volume 15, Number 9—September 2009

Historical Review

Program to Eradicate Malaria in Sardinia, 1946–1950

Eugenia Tognotti✉
Author affiliation: University of Sassari, Sardinia, Italy

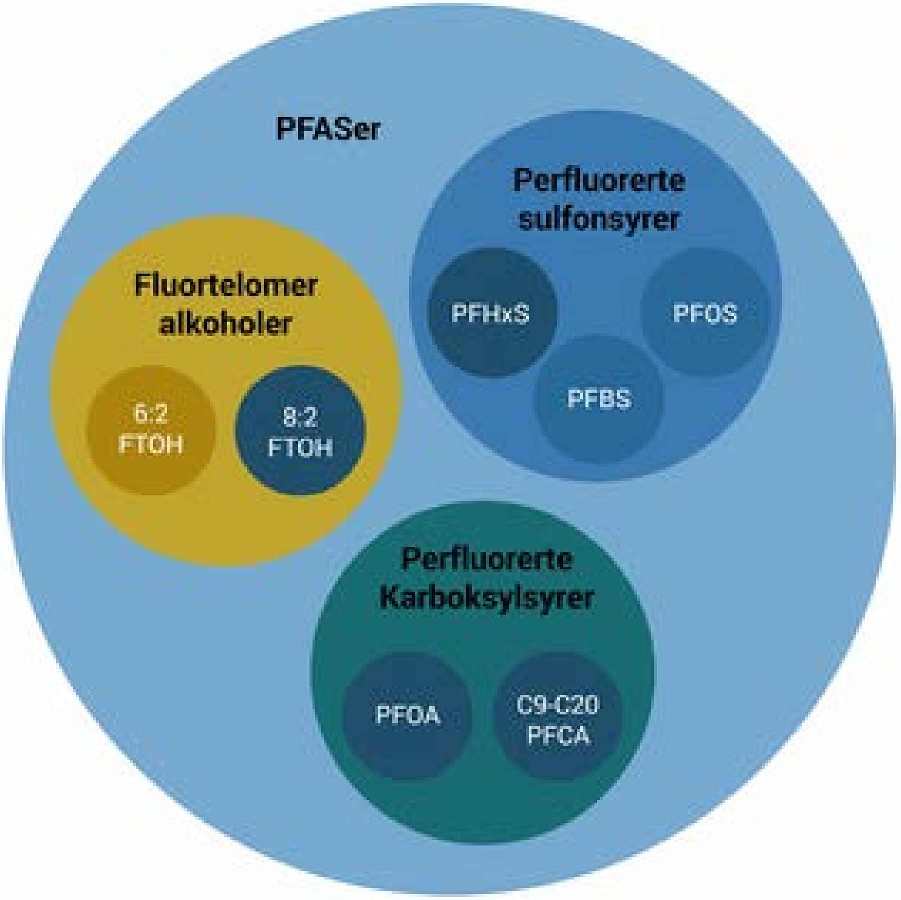
Cite This Article

Abstract

During 1946–1950, the Rockefeller Foundation conducted a large-scale experiment in Sardinia to test the feasibility of indigenous vector species eradication. The interruption of malaria transmission did not require vector eradication, but with a goal of developing a new strategy to fight malaria, the choice was made to wage a rapid attack with a powerful new chemical. Costing millions of dollars, 267 metric tons of DDT were spread over the island. Although malaria was eliminated, the main objective, complete eradication of the vector, was not achieved. Despite its being considered almost eradicated in the mid-1940s, malaria 60 years later is still a major public health problem throughout the world, and its eradication is back on the global health agenda.

11000 µg/m2
No changes in mortality
No changes in sex distribution in infants
No «changes» in prevalence of carinogenic diseases

sfi Senter for forskningsdrevet innovasjon



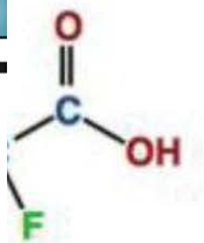
Long chain PFAS bio magnificate and can be toxic (PFOS, PFOA..). Now production focus on short chain, that however are persistent and mobile.
Animal studies: liver damage, fetus damage, cancerogenic. Can influence the immune defence and effect of vaccines.

PFAS[1]	Development Time Period							
	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s
PTFE	Invented	Non-Stick Coatings			Waterproof Fabrics			
PFOS		Initial Production	Stain & Water Resistant Products	Firefighting foam				U.S. Reduction of PFOS, PFOA, PFNA (and other select PFAS[2])
PFOA		Initial Production	Protective Coatings					
PFNA					Initial Production	Architectural Resins		
Fluoro-telomers					Initial Production	Firefighting Foams		Predominant form of firefighting foam
Dominant Process[3]		Electrochemical Fluorination (ECF)						Fluoro-telomerization (shorter chain ECF)

Senter for forskningsdrevet innovasjon

al Environment

vier.com/locate/scitotenv

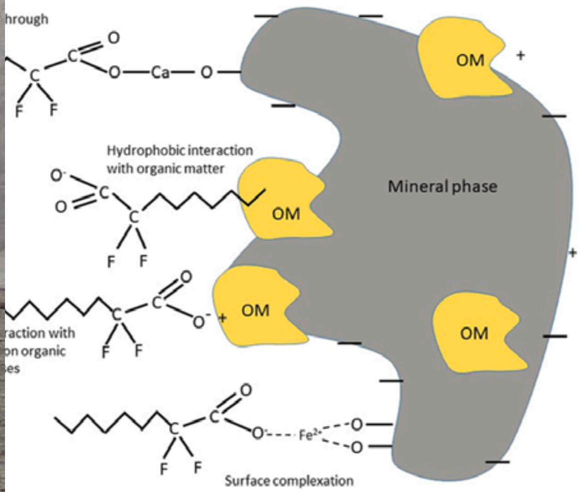


n the role of soil and
of per and polyfluoroalkyl

Check for updates

og

ACT



disse

og
020

earthresQue

Senter for forskningsdrevet innovasjon

Environmental Science Processes & Impacts

ROYAL SOCIETY OF CHEMISTRY

PAPER

View Article Online
View Journal

Check for updates

Cite this: DOI: 10.1039/c9em00170k

Leachate emissions of short- and long-chain per- and polyfluoralkyl substances (PFASs) from various Norwegian landfills†

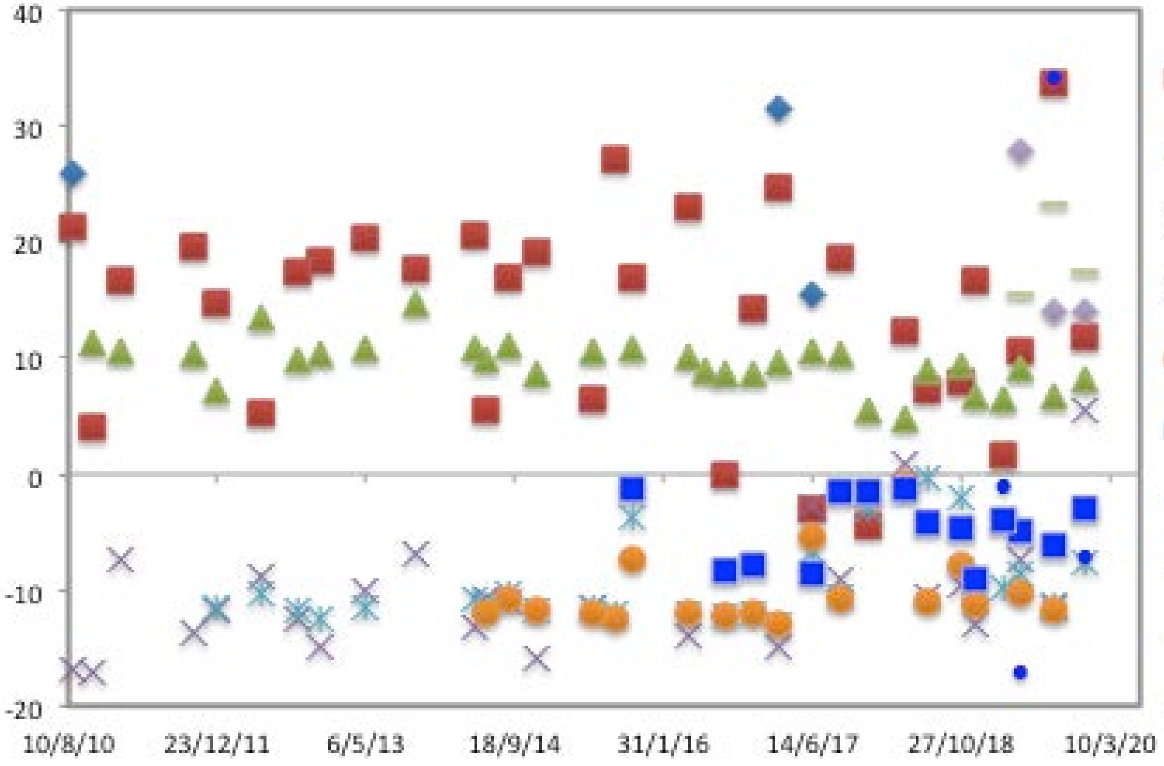
Table 2 Comparison of short- (PFBS, PFBA, PFPeA and PFHxA) and long-chain (PFHxS, PFHpS, PFOS, PFDS, PFHpA, HPFHpA, PFOA, PFNA, PFDA, PFUnDA, PF-3,7-DMOA, PFDoA, PFTrA, PFTA and PFHxDA) PFAS concentrations (ng L^{-1}) in landfill leachate from selected studies. Values < LOQ are excluded from the calculations

Area, year (number of landfills/raw, diluted, mixed)	∑Short-chain PFASs mean ± SD (min–max)	∑Long-chain PFASs mean ± SD (min–max)	Short : long-chain ratio	*n* PFASs	$\sum_n$ PFASs	Reference
Norway, 2017–2018 (10, mixed)	980 ± 1800 (68–6800)	530 ± 730 (140–2900)	1.8 ± 0.94 (0.28–3.1)	28	1700 ± 2900 (320–11 000)	This study
Norway, 2006 (2, raw)	757	4784[a]	0.16	16	6123	Eggen *et al.*, 2010[19]
Canada, 2009 (1, raw)	2812 ± 1109 (1424–5150)	2719 ± 2160 (1021–7738)[b]	1.0	24	11 000 ± 10 000 (3800–3600)	Benskin *et al.*, 2012[13]
Sweden, 2015 (10, unknown)	171 ± 137 (<LOQ–508)	123 ± 78 (<LOQ–269)[c]	1.4	26	487 (0.30–1300)	Gobelius *et al.*, 2018[23]
Spain, 2015 (4, raw)	576 ± 317 (125–852)	506 ± 113 (413–663)[d]	1.1	16	1082 (639–1379)	Fuertes *et al.*, 2017[24]

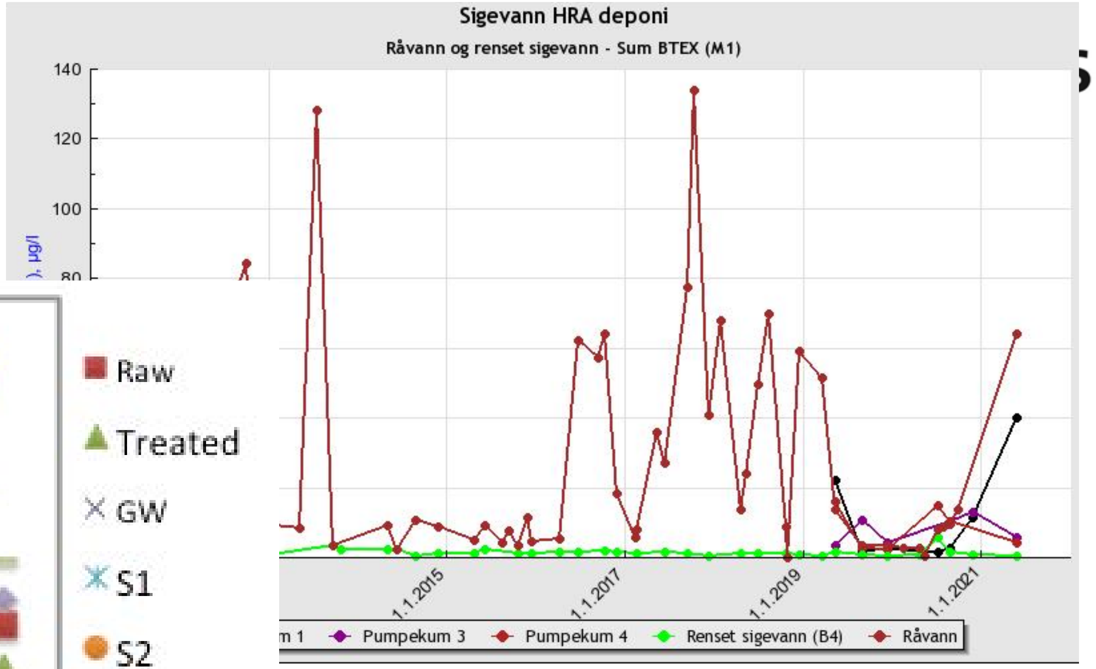
[a] With the exclusion of PFHpS, HPFHpA, PF-3,7-DMOA, PFTA and PFHxDA; note this was measured using non-target analysis. [b] With the exclusion of PFHpS, HPFHpA, PFDA, PF-3,7-DMOA, PFTrA and PFHxDA. [c] With the exclusion of PFHpS, HPFHpA, PFOA, PFDA and PF-3,7-DMOA. [d] With the exclusion of HPFHpA, PF-3,7-DMOA and PFHxDA.

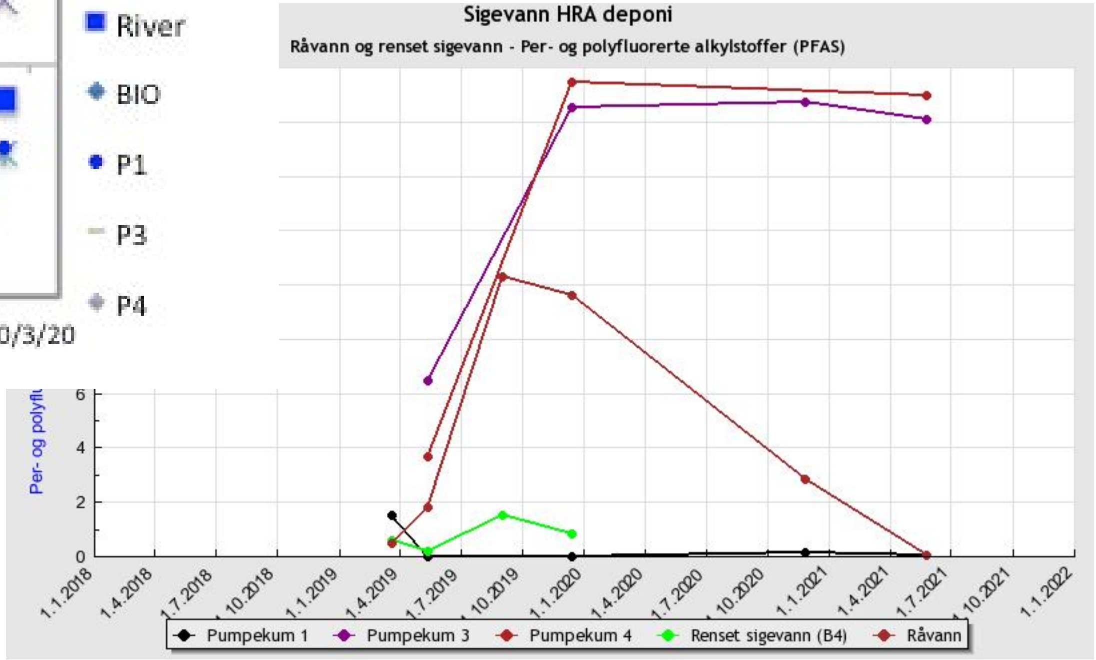
earthresQue

Senter for forskningsdrevet innovasjon



Arrows indicate flow directions.





	Raw	Bio	L1	L2	Treated	GW	Source1	Source2	River
Ca	239	253	175	172	67	22	56	65	7,5
Fe	25	47	13	13	32	5,95	0,11	0,03	0,05
Tot-N	1236	947	757	911	69	0,66	0,2	1,8	0,62
Oil	7311	10713	2161	3767	17	89	21	54	-
SO_4	52	20	121	116	2,5	6,8	19	18	0,3
Na	512	369	694	716	62	3,1	3	3,6	1,4
HCO_3	4340	2296	4723	5135	632	78	176	200	18
El.cond	1142	594	902	952	124	14	33	37	5,6
pH	7,6	6	7,8	7,9	7,2	7,3	8	8,2	7,4

Raw =untreated mix of all leachates, Bio = from biogas and composting and some surface runoff, L1 and L2 = leachate from landfill, Treated = collected in downstream well, GW =upstream well, Sources = gw to river. All in mg/l except Oil = C10-40 in µg/l, and EC in mS/m.

Table 4. Physiochemical water types*.

	Raw	P1	P3	P4	Treated	GW	S1	S2
Type	Na-HCO_3	Na-HCO_3	Na-HCO_3	Na-HCO_3	Ca-HCO_3	Ca-HCO_3	Ca-HCO_3	Ca-HCO_3
Saturation	Super	Super	Super	Super	Super	Under	Super	Super
CO_2 ppm	734	7256	586	573	384	3	18	0.1

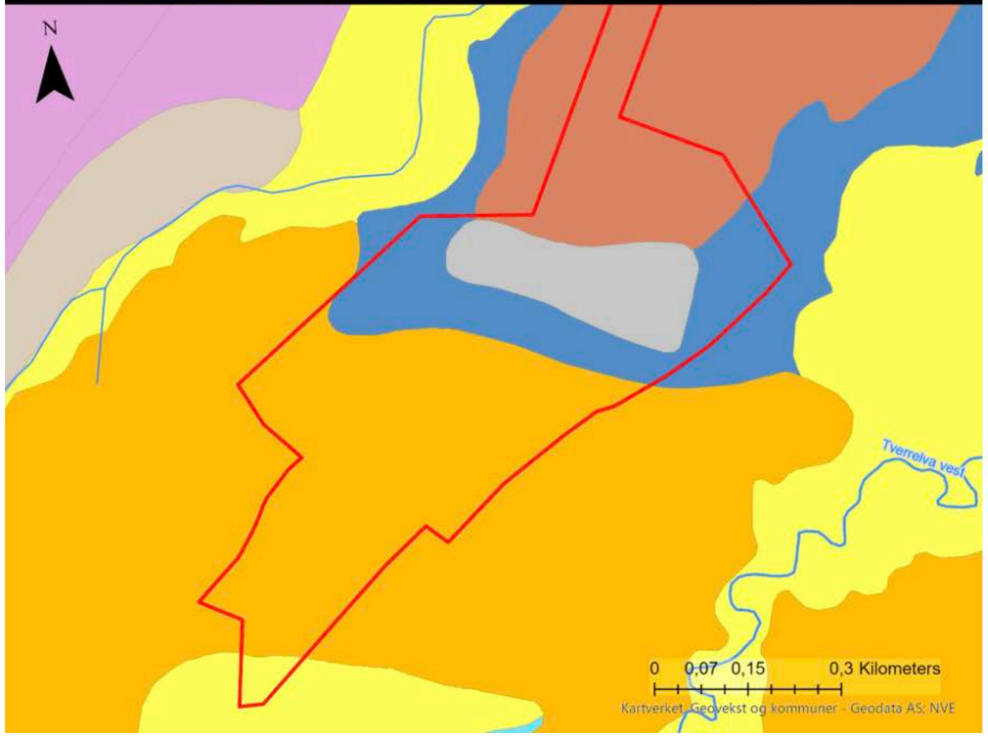
*Type = dominating ions. Saturation relative to Ca. Equilibrium CO_2 partial pressure.

Table 4. PFAS in leachate ($\mu g/l$)

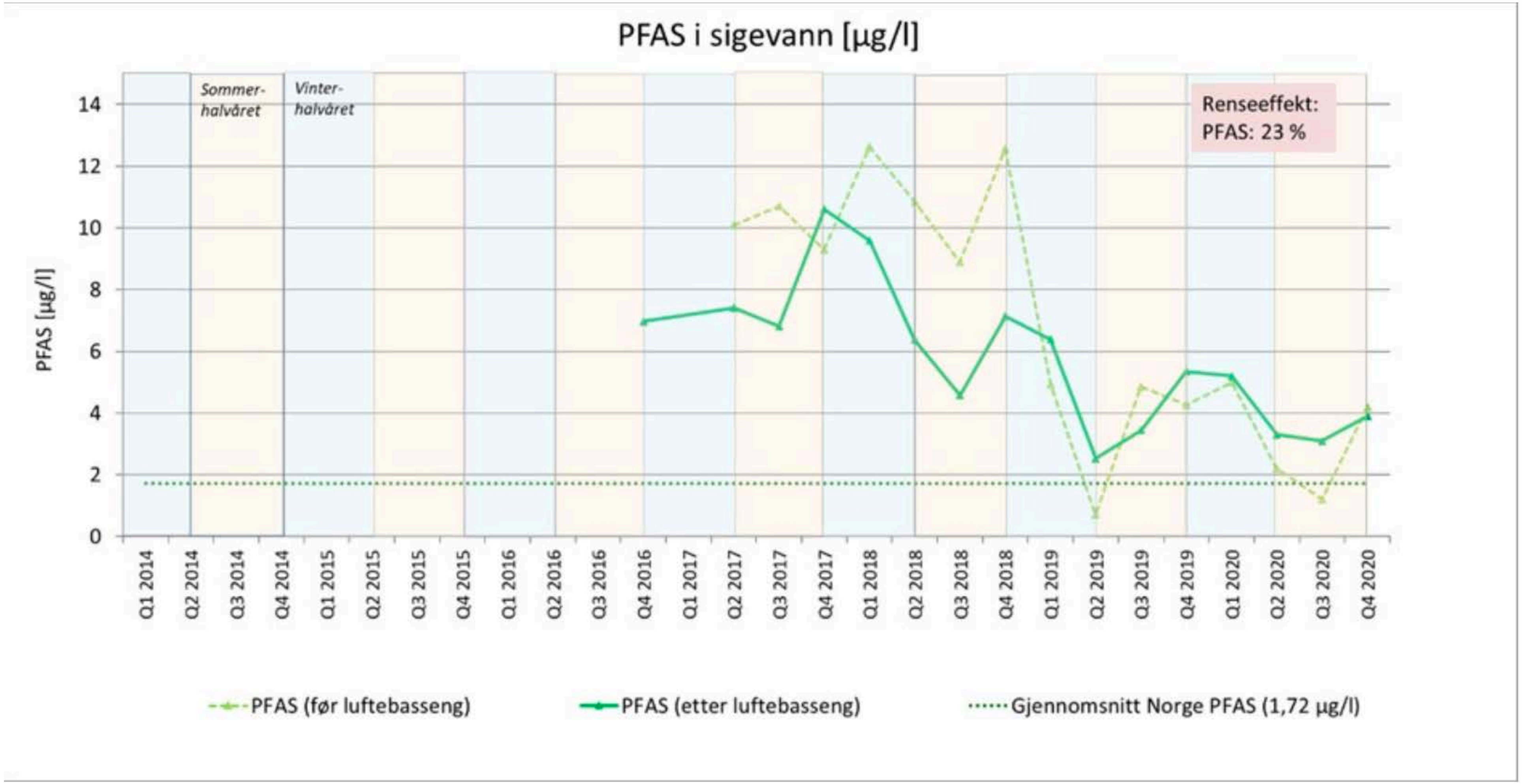
Date	BIO	L1	L2	Treated	Raw
21.03.2019	1,54			0,58	0,49
13.05.2019		6,48	3,7	0,21	1,81
02.09.2019		0		1,51	10,3
13.12.2019	0,013	16,5	17,5	0,846	9,6
26.11.2020	0,124	16,7			2,84
26.05.2021	0,0473	16,1	17		0,0319
26.08.2021	0,012	13	11,3		4,186
Average	0,049	11,5	14,2	0,7865	4,1797

*Bio = leachate from composting and digestion, Leachate 1 & 2 = landfill leachate, possible from different parts of the landfill. Treated=pumped from downstream groundwater, Raw = mix from first 3.

Stormoen, next to Tromsø 70 north



XXXX


PFAS i sigevann [µg/l]
PFAS [µg/l]
14
12
10
8
6
4
2
0
Sommer-
halvåret
Vinter-
halvåret
Renseeffekt:
PFAS: 23 %
Q1 2014
Q2 2014
Q3 2014
Q4 2014
Q1 2015
Q2 2015
Q3 2015
Q4 2015
Q1 2016
Q2 2016
Q3 2016
Q4 2016
Q1 2017
Q2 2017
Q3 2017
Q4 2017
Q1 2018
Q2 2018
Q3 2018
Q4 2018
Q1 2019
Q2 2019
Q3 2019
Q4 2019
Q1 2020
Q2 2020
Q3 2020
Q4 2020
PFAS (før luftebasseng)
PFAS (etter luftebasseng)
Gjennomsnitt Norge PFAS (1,72 µg/l)

SUMMARY:
PFAS ON OF THE LOWEST EQS
WHAT DOES THAT MEAN FOR HUMAN AND ENVIRONMENT?
SHOULD WE SPEND LOTS OF MONEY ON MONITORING?

PHD ON PFAS REMOVAL FROM LEACHATE

earthresQue

Table 4. PFAS in leachate (∝g/l)

Date	BIO	L1	L2	Treated	Raw
21.03.2019	1,54			0,58	0,49
13.05.2019		6,48	3,7	0,21	1,81
02.09.2019		0		1,51	10,3
13.12.2019	0,013	16,5	17,5	0,846	9,6
26.11.2020	0,124	16,7			2,84
26.05.2021	0,0473	16,1	17		0,0319
26.08.2021	0,012	13	11,3		4,186
Average	0,049	11,5	14,2	0,7865	4,1797

*Bio = leachate from composting and digestion, Leachate 1 & 2 = landfill leachate, possible from different parts of the landfill. Treated=pumped from downstream groundwater, Raw = mix from first 3.

sfi Senter for forskningsdrevet innovasjon

Table 5. PFOS in leachate (∝g/l)

Date	BIO	L1	L2	Treated	Raw
21.03.2019	0,112			0,0362	0,086
13.05.2019	0,005	0,23	0,128	0,005	0,0589
02.09.2019	0	0		0,0389	0,129
13.12.2019	0,005	0,15	0,19	0,0127	0,104
09.07.2020	0,005	0	0,157		
25.08.2020	0,005	0,174	0,124	0,0225	
26.11.2020	0,05	0,157			0,05
26.05.2021	0,0212	0,18	0,176		0,0187
26.08.2021	<0,01	0,189	0,211		<,1
Average	0,013	0,135	0,211	0,023	0,072

*Bio = leachate from composting and digestion, Leachate 1 & 2 = landfill leachate, possible from different parts of the landfill. Treated=pumped from downstream groundwater, Raw = mix from first 3.

Limit = 0,00065 μg/l

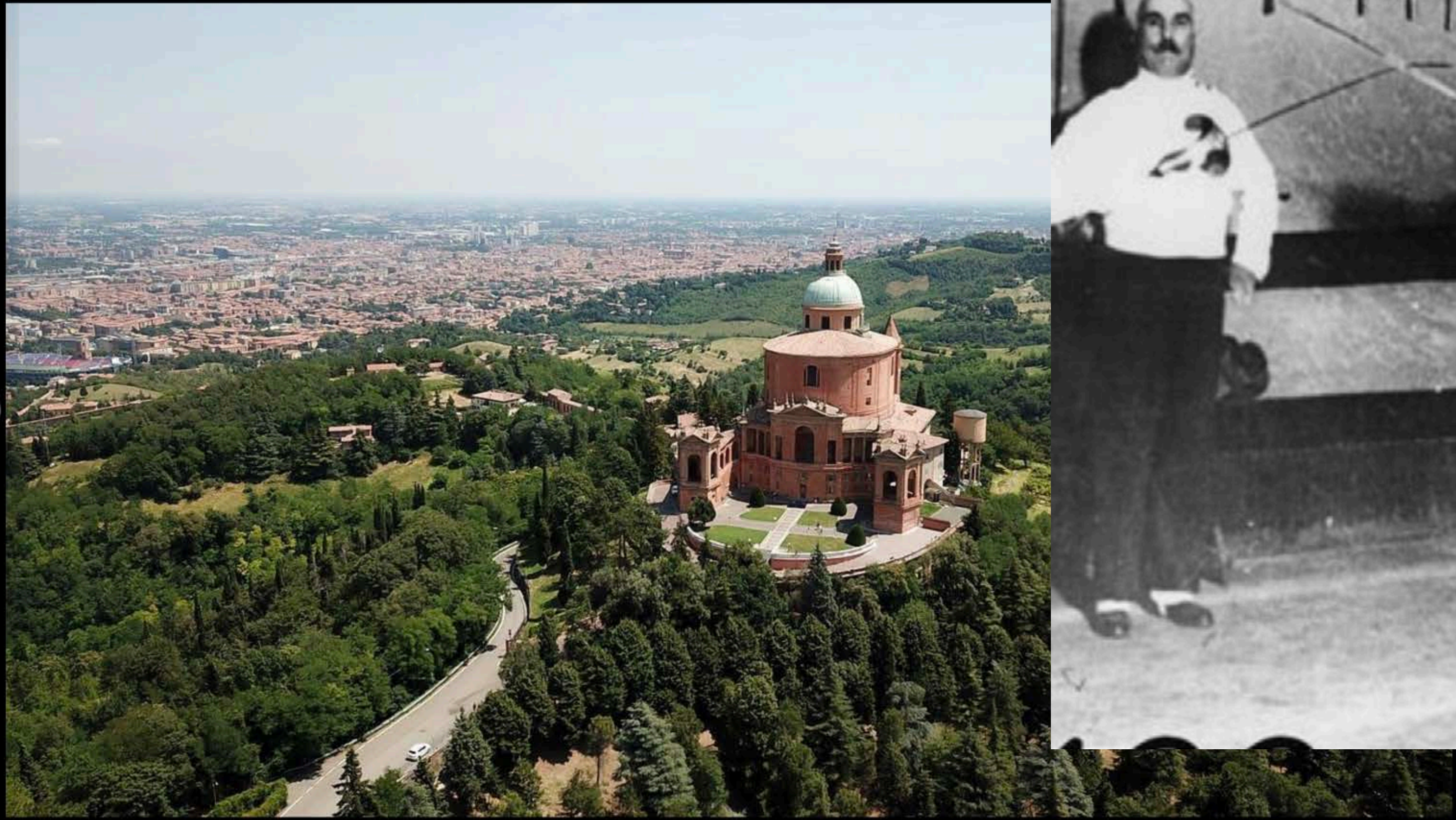
PFOA (caroboxylic) in leachate (µg/l)

Date	BIO	L1	L2	Treated	Raw
21.03.2019	0,452			0,211	0,121
13.05.2019	0,005	1,79	1,19	0,079	0,482
02.09.2019	0	0		0,196	0,155
13.12.2019	0,005	2,04	2,23	0,0992	1,16
09.07.2020	0,005	0	1,92		
26.05.2021	0,026	2,3	2,45		0,013
26.08.2021	0,012	1,87	1,56		0,66
Average	0,009	1,33	2,01	0,146	0,3365

..and sediments (µg/kg DM)

Date	PFAS	PFOA	PFOS
21.03.2019	44100	16000	7100
13.05.2019	131	21	24
02.09.2019	30	6	12
Average	14754	5343	2379
Limit		713	2,3

Bologna first in the EU to introduce Social credits for «moral behavior" meaning uphold rules and acceptance of the public narrative, clearly limiting freedom of speech and personal liberties.



overholder klimanarrativets agenda ved å vise «god oppførsel», for eksempel korrekt resirkulering eller bruk av offentlig transport, vil bli belønnet med kryptovaluta og rabatter i ulike butikker, ifølge lokalavisen Bologna Today.

Deltakerne i prosjektet vil bli gitt en "smart digital lommebok" der belønningen overføres. Jo høyere poengsum som samsvarer med forventende atferdsendringer, jo flere fordeler. Deltakelse i prosjektet er frivillig, men mange

Mussolini from Bologna?

No, from Predappion in Romagna

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

NORSUS

sfi Senter for forskningsdrevet innovasjon

A critical analysis of published data to discern the role of soil and sediment properties in determining sorption of per and polyfluoroalkyl substances (PFASs)

Check for updates

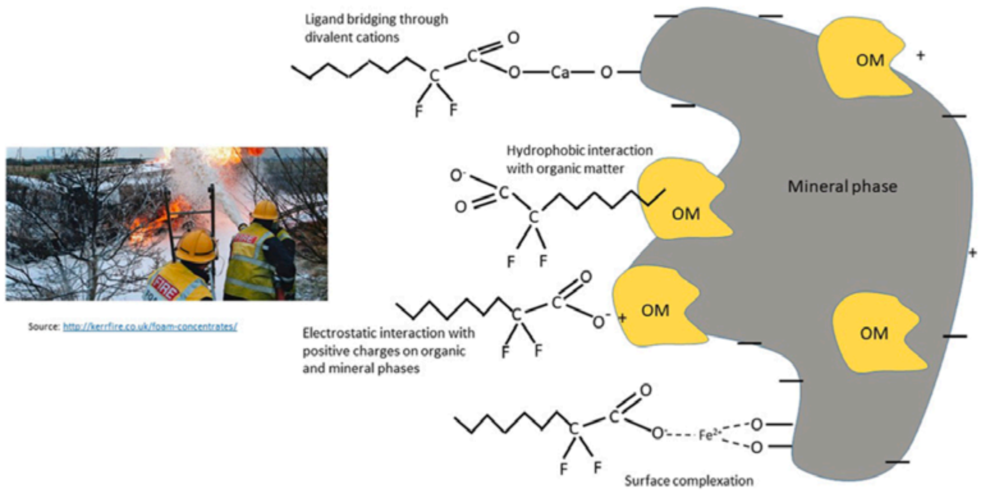
Yasong Li [a,1], Danielle P. Oliver [a,*], Rai S. Kookana [a,b]

[a] *CSIRO Land and Water, Locked Bag 2, Glen Osmond, 5064, South Australia, Australia*
[b] *University of Adelaide, Glen Osmond, 5064, South Australia, Australia*

HIGHLIGHTS

- Significant relationships between K_d values and OC for some PFASs, but generally $R^2 < 0.40$.
- Strong relationships between K_d values and OC and pH for 9 PFASs with $R^2 > 0.60$.
- Field based K_d values were always larger than those measured in laboratory by batch method.
- Lack of full characterisation of sorbent properties is limiting the utility of literature data.

GRAPHICAL ABSTRACT



XXXX

XXXX

XXXX

XXXX