PFASt and the Furious

Kemien der ikke slipper speederen, men hvor langt er vi?

Eirik Aas & Simone Skjødt Møller

Vingsted, 04-03-2026

eurofins

Hvad er PFAS?

- Er brandskum?
- Er det et pesticid?
- Er det en polymer?
- Er det en drivhusgass?

Per Fluorert

Pageant winner 2017
“Worst thing”
Miljødirektoratet

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Hvordan snakke om PFAS?

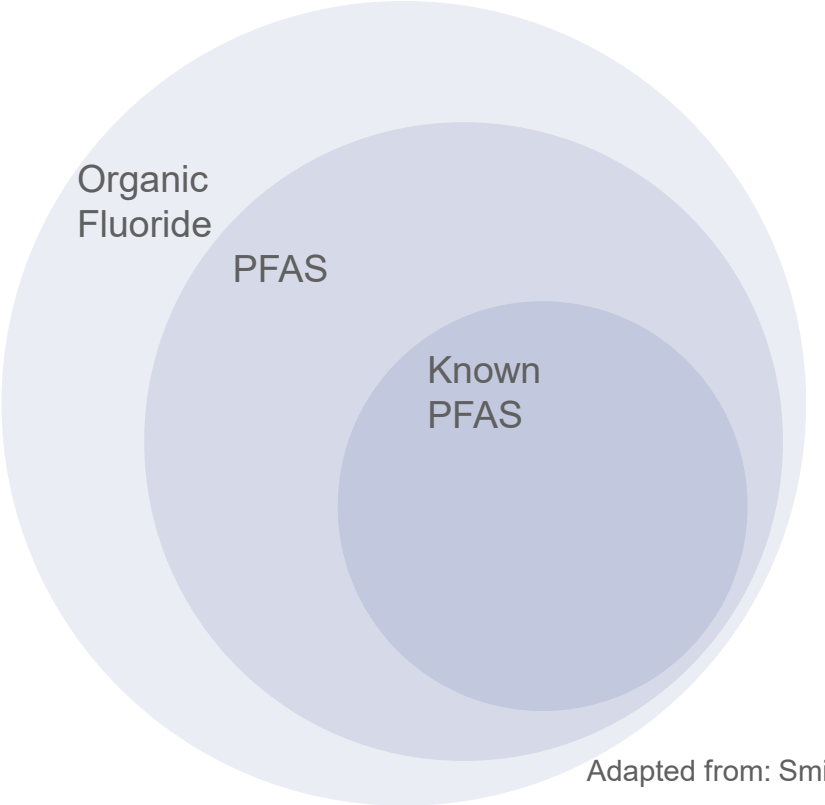
Kemi:

- Semi-volatile?
- Volatile?
- Very volatile?

- Anionic
- Cationic
- Zwitterionic

Brugsområde

Prøvetype



Adapted from: Smith et. al. 2024

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Hvor finder vi PFAS?

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Hvordan har udviklingen vært?

2020:
Drikkevand
Fødevare kontaktmaterialer

2021:
Drikkevand
Fødevare kontaktmaterialer Forbruger produkter
Slam
Overfladevand
Biota

2022:
Drikkevand
Fødevare kontaktmaterialer Forbruger produkter
Spildevand
Overfladevand
Jord
Biota
Slam
Sediment
Havvand
Byggematerialer
Kildesporing

2023:
Drikkevand
Fødevare kontaktmaterialer Forbruger produkter
Spildevand
Overfladevand
Jord
Biota
Slam
Sediment
Havvand
Byggematerialer
Kildesporing

2024
Drikkevand
Fødevare kontaktmaterialer Forbruger produkter
Spildevand
Overfladevand
Jord
Biota
Slam
Sediment
Havvand
Byggematerialer
Kildesporing

2025
Drikkevand
Fødevare kontaktmaterialer Forbruger produkter
Spildevand
Overfladevand
Jord
Biota
Slam
Sediment
Havvand
Byggematerialer
Kildesporing

2026
Drikkevand
Fødevare kontaktmaterialer Forbruger produkter
Spildevand
Overfladevand
Jord
Biota
Slam
Sediment
Havvand
Byggematerialer
Kildesporing

2020
12 PFAS

2021
12 PFAS

2021 Q4
22 PFAS

2021 Q4
22 PFAS
Low level 4 PFAS

2024
24 PFAS
30 PFAS
Non-Target PFAS

2025
AOF/EOF
TOF
PFAS 30
PFAS 24
Non-target
TOF

2026
AOF/EOF
TOF
PFAS 31
PFAS 25
PFAS 43
Non-target
TOF

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Case 1: Langt mere end PFAS 22

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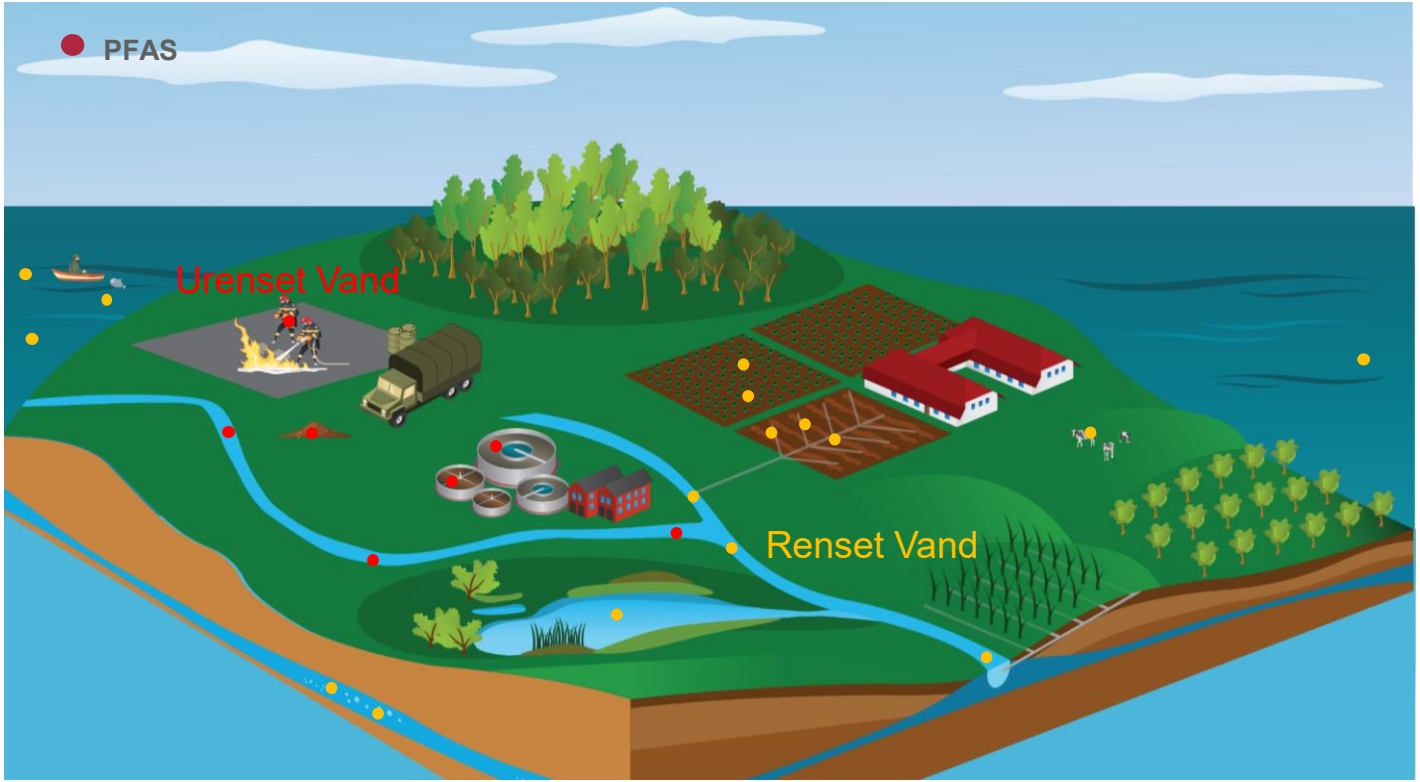
Case 1: Langt mere end PFAS 22



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Resultater efter rensning

Lav 22 PFAS

Rensningsmetode →

Høj 22 PFAS

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Case 1: Langt mere end PFAS 22

PFAS 22
PFBS
PFPeS
PFHxS
PFHpS
PFOS
PFNS
PFDS
PFUnDS
PFDoDS
PFTrDS
PFOSA
6:2 FTS
PFBeA
PFPA
PFHxA
PFHpA
PFOA
PFNA
PFDA
PFUnDA
PFDoDA
PFTrDA

Action: Test PFAS 22

- Hurtig
- Effektiv
- Lav detektionsgrænse
- Lav usikkerhed
- Vejledende grænseværdier
- sammenlighed

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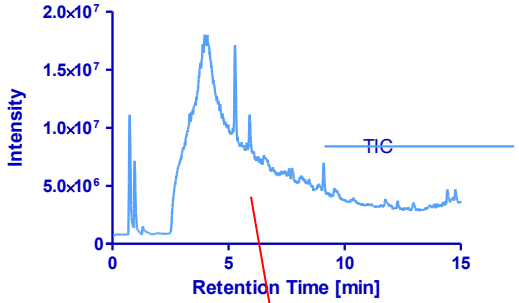
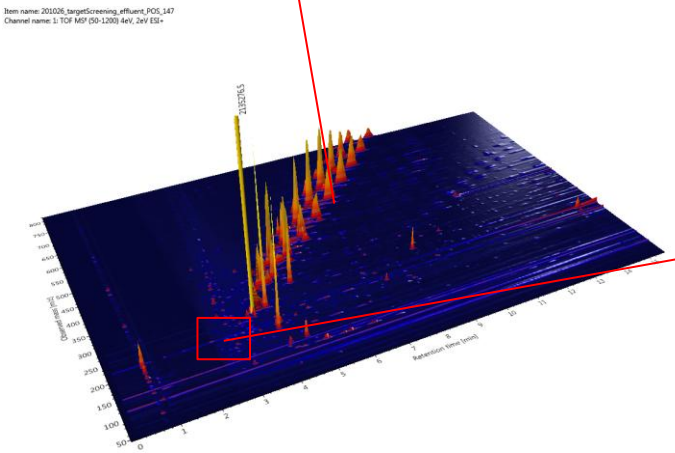
HRMS: Når vi vil have det hele med

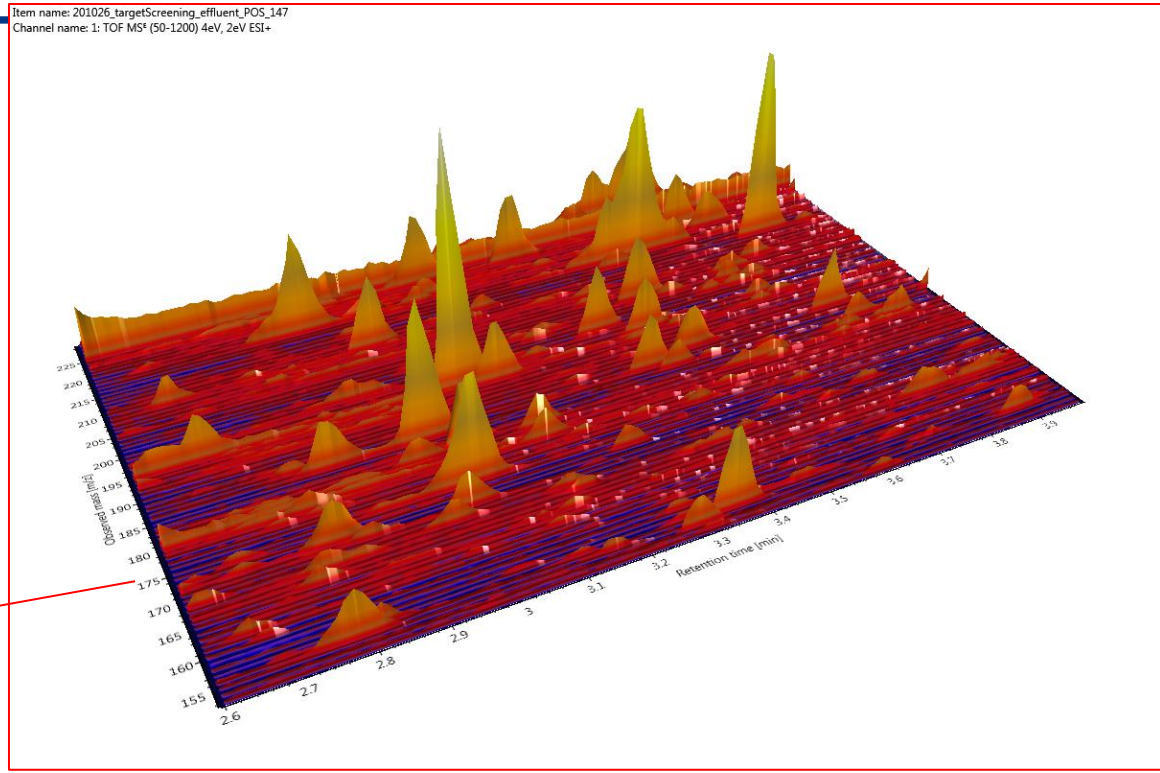
Mulighed for separering og identifikation af komplekse PFAS-blandinger.

Omfattende dataindsamling: Giver mulighed for at opdage nye PFAS både med og uden forudgående viden.

HRMS







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PFAS er langt mere end PFAS 22

Mere end 10.000 PFAS forbindelser, der er defineret med kemisk formular

Kilde: https://comptox.epa.gov/dashboard/chemical-lists/pfasmaster

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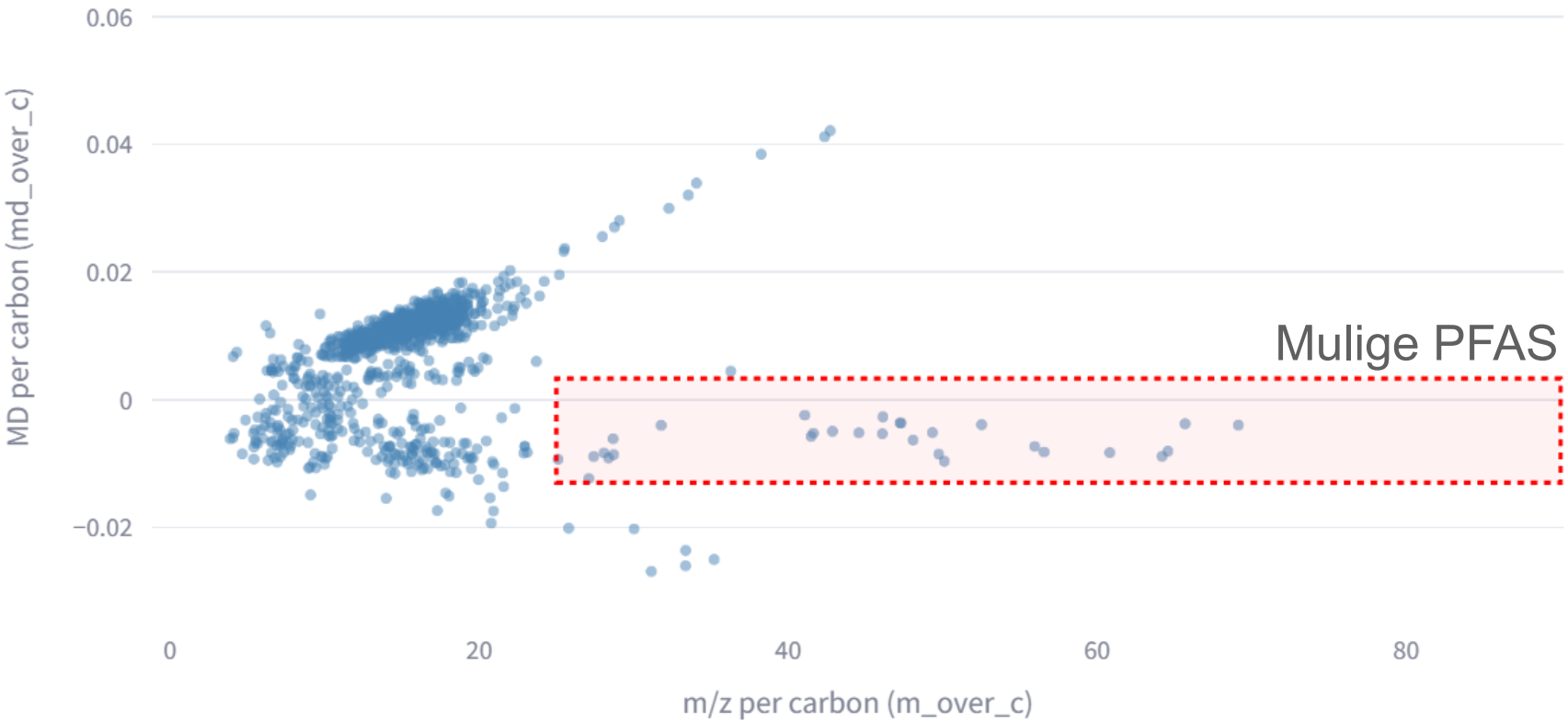
HRMS



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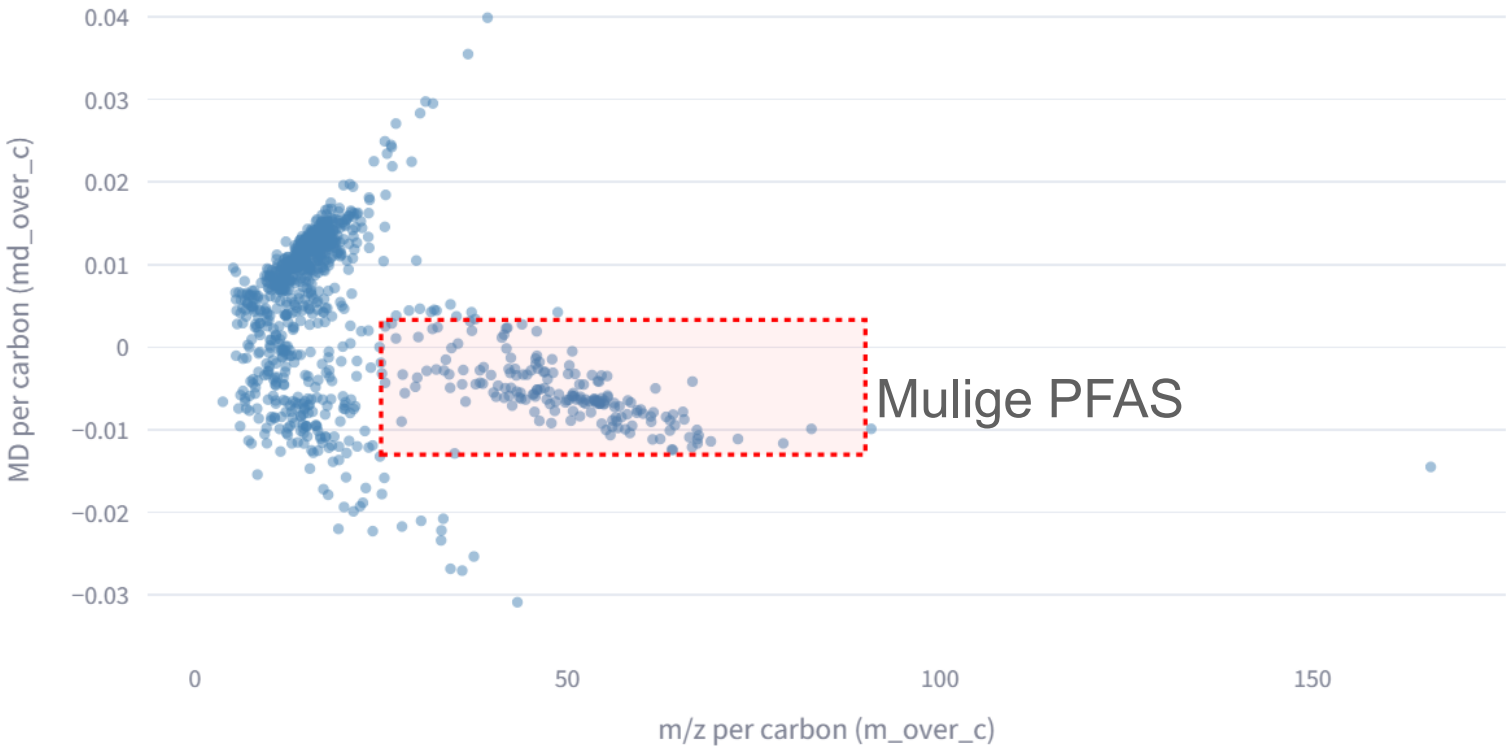
HRMS



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Case 2: Ny måde at viser PFAS

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Hvornår kommer der PFAS total analyse (TOF)?

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Analyse af fire jordprøver

- Her er vist en case med fire jordprøver.
- Jordprøverne er blevet ekstraheret med methanol.
- Prøverne er målt ved LC-HRMS.

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Features fordeling

Prøve med flest features, har ikke nødvendigvis flest PFAS forbindelser.
Prøve 3 og Prøve 4, stammer fra samme lokalitet.

	Features i alt	Mulige PFAS Features
Prøve 1	382	84
Prøve 2	1031	30
Prøve 3	969	186
Prøve 4	895	182

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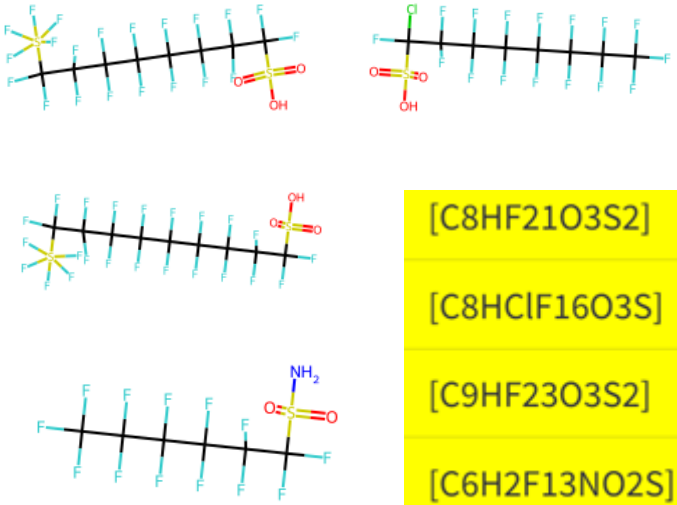
Screening

- Disse ukendte features, kan screenes i henhold til EPA Comptox (>10.000 mulige PFAS forbindelser).

- Vi screener efter forventet precursor ioner, og bakker fund op med predikterede retentionstider og fragmentationsmønstre.

- For prøve 3 finder vi at **fire ud af de seks PFAS forbindelser med højst intensitet ikke er velkendte PFAS forbindelser**. Kun PFOS og PFHxS gav højere signaler.



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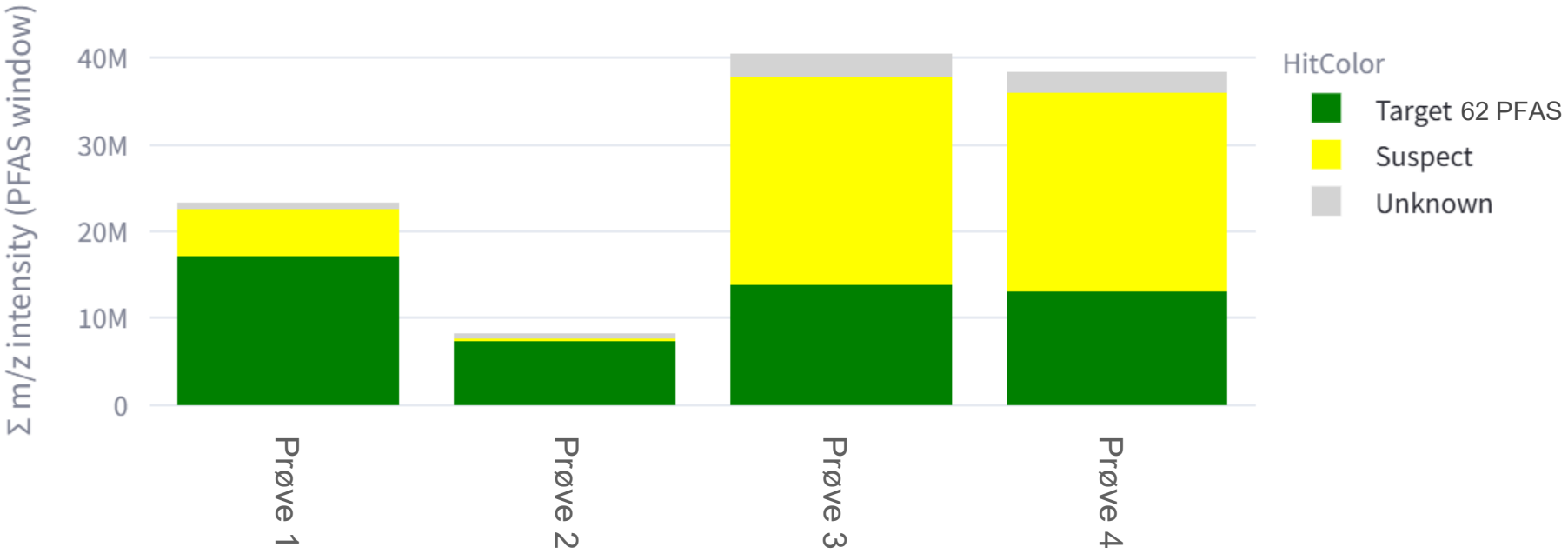
Mulige PFAS i jordprøverne – summen af intensiteter



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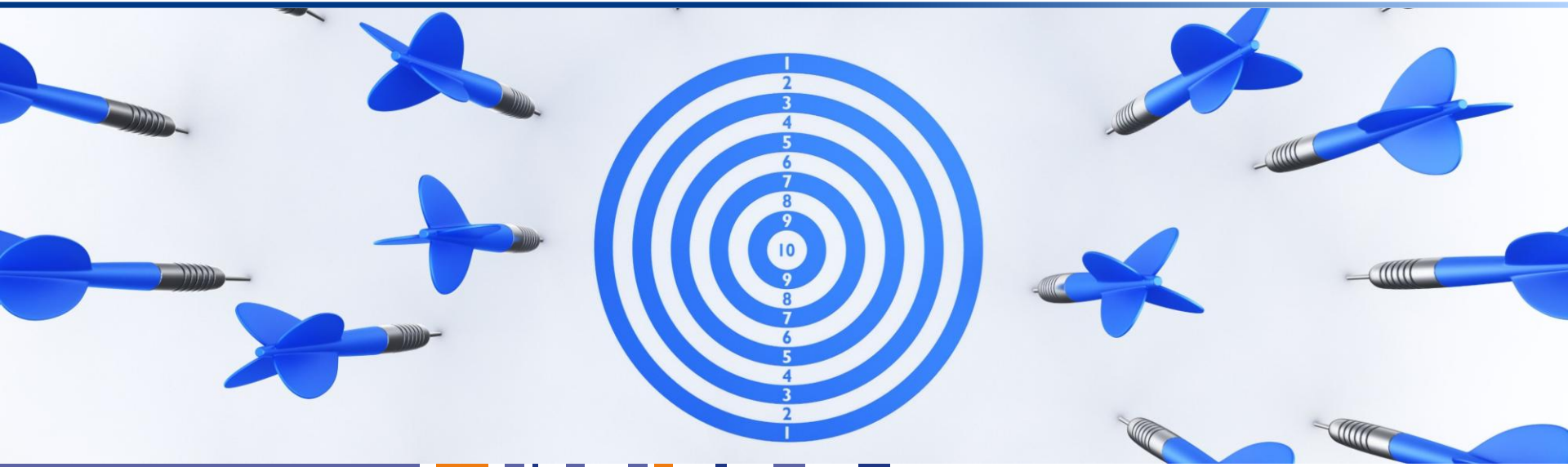

Case 3: Total indholdet af PFAS

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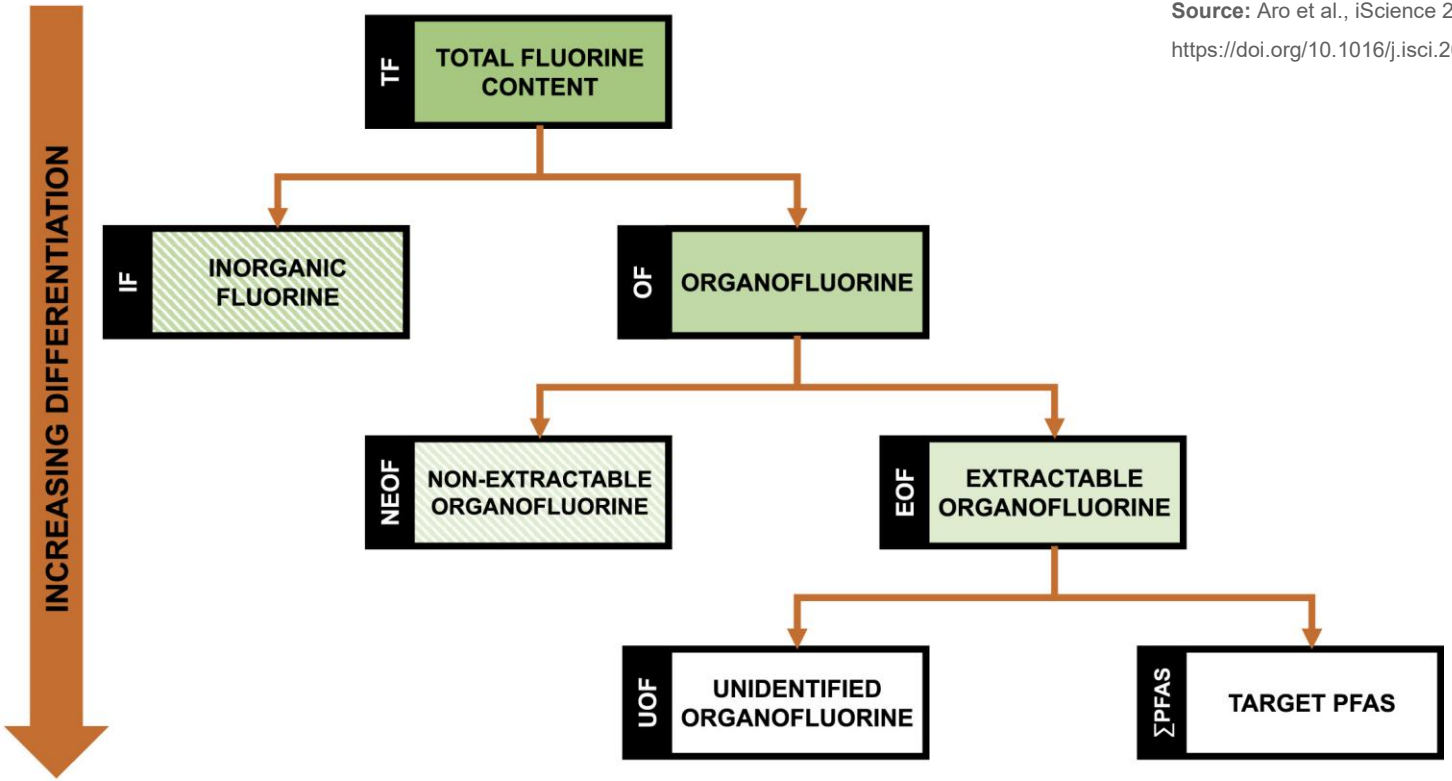
Case 3: Total indholdet af PFAS

Source: Aro et al., iScience 24, 102968 September 24, 2021
https://doi.org/10.1016/j.isci.2021.102968



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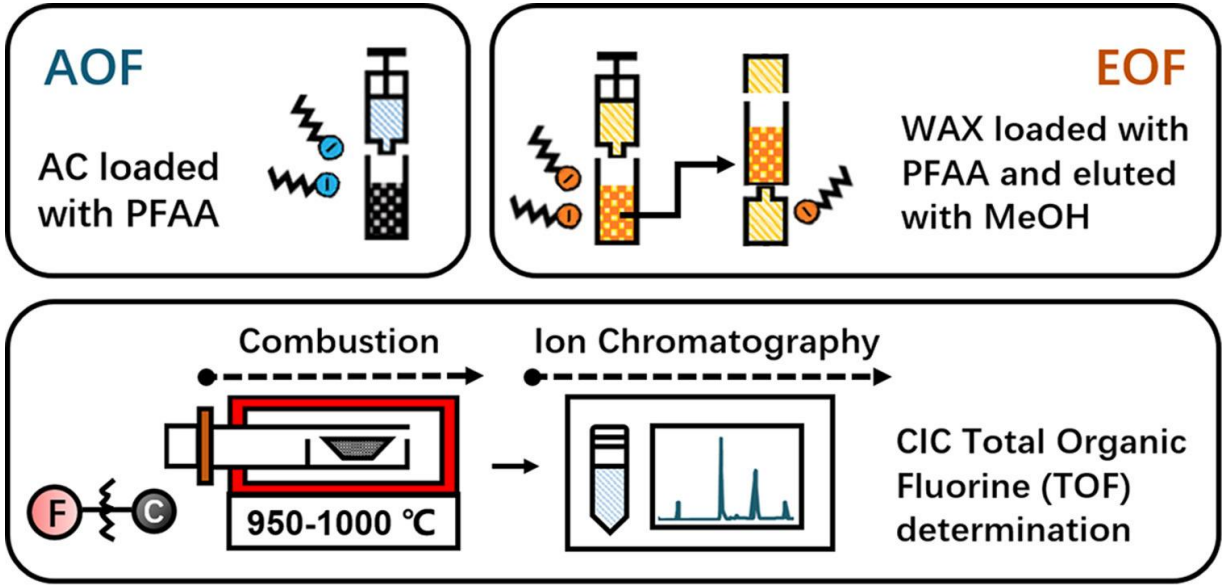
Case 3: Total indholdet af PFAS



Ny standard under udvikling (Aragorn)

TF

Directly in the combustion, Sample prep critical! (especially for "non-combustible materials)

Source: Volume 244, 1 October 2023, 120497

https://www.sciencedirect.com/science/article/abs/pii/S0043135423009375

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Case 3: Total indholdet af PFAS

Eksempel resultater: Lossepladser

Tabel 1: Sammenligning av PFAS(22), EOF og NTS for 4 prøver og forklaringsprocent (Fluor fra PFAS(22) som andel af EOF, beregnet som andel fluor = 0,69 × PFAS(22))

Prøvenummer	**1**	**2**	**3**	**4**
PFAS22 (µg/kg TS)	850	1800	4700	3600
Ekstraherbar Organisk Fluor (µg/kg TS)	1380	2900	9850	12200
Forklaringsgrad PFAS(22) av EOF (%)	43	43	33	20

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Case 3: Total indholdet af PFAS

Hvad fortæller så AOF/EOF (TF)

Hvor?

Worst case
(max koncentration)

Kildeområdet
(er du sikker på at du forstår kilden)

Forklaringsprocent
(andel ukendte)
Har du ”kontrol”?

Lovgivning: Er der ikke en værdi i at sørge for, at vi ikke overser "de værste" kilder?

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Case 4: PFAS i poreluft

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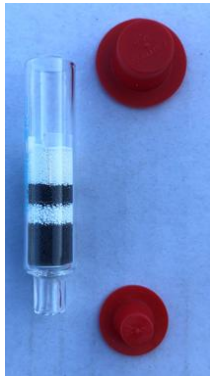
Prøvetagning

- Aktiv prøvetagning (XAD2/PUF)

- Innendørs:
  - 0.1 L/min (high levels)
  - 1 L/min (low level)
  - 24 timer
- Poreluft:
  - 0.25 L/min
  - 5-6 timer



OVS- XAD-2/ PUF + glass fibre filter

XAD-2

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Eurofins measurements:

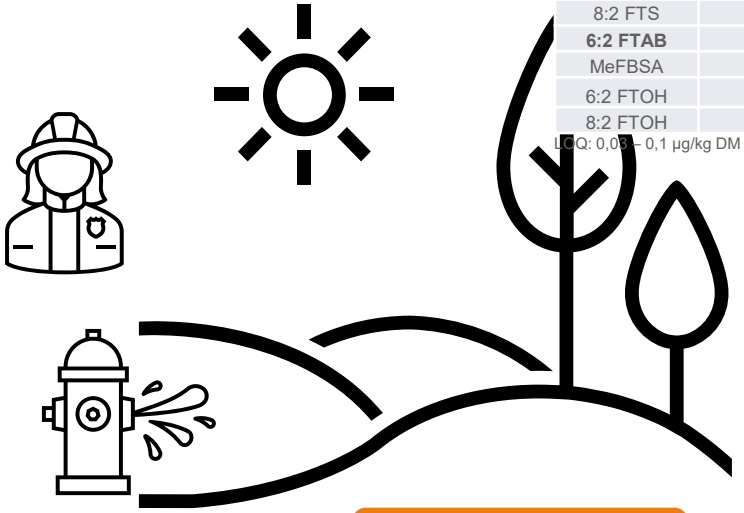
Air

ng /m ³	East	West
6:2FTOH	**5,6**	**58**
8:2FTOH		
10:2 FTOH		
12:2FTOH		
PFHxA		0,36
PFBSA		
MeFBSA		0,89
PFHxSA		
PFOSA		
MeFOSA		
MeFOSE		
EtFOSA		
EtFOSE		

Soil

µg/kg DM	Hotspot
PFPeA	0,09
PFHxA	0,21
PFHpA	0,06
PFOA	0,28
PFNA	0,56
PFDA	0,16
PFHxS	1,8
PFHpS	1,6
PFOS	**640**
PFDS	0,19
6:2 FTS	1,0
8:2 FTS	0,15
6:2 FTAB	**2000**
MeFBSA	
6:2 FTOH	
8:2 FTOH	

LOQ: 0,03 – 0,1 µg/kg DM



6:2 FTAB

Soil

µg/kg DM	North
PFPeA	0,78
PFHxA	0,33
PFHpA	0,13
PFOA	0,11
PFNA	0,09
PFDA	0,32
PFHxS	0,31
PFHpS	
PFOS	**31**
PFDS	0,24
6:2 FTS	0,55
8:2 FTS	
6:2 FTAB	**300**
MeFBSA	
6:2 FTOH	
8:2 FTOH	

LOQ: 0,03 – 0,1 µg/kg DM

Air

ng/m ³	North
6:2FTOH	2,4
8:2FTOH	
10:2 FTOH	
12:2FTOH	
PFHxA	
PFBSA	
MeFBSA	
PFHxSA	
PFOSA	
MeFOSA	
MeFOSE	
EtFOSA	
EtFOSE	

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Indeluft og støv – Brandstation og øvelsesbane

Office

Air	
ng/m³	Office
6:2FTOH	3,4
8:2FTOH	5,8
10:2 FTOH	1,6
12:2FTOH	0,3
PFHxA	tr
PFBSA	tr
MeFBSA	
PFHxSA	
PFOSA	tr
MeFOSA	0,19
MeFOSE	tr
EtFOSA	0,11
EtFOSE	

Dust	
µg/kg	
PFBA	11
PFPeA	<1
PFHxPA	<1
PFBS	2,5
HPFHpA	<1
PFHxA	<1
PFHpA	1,6
6:2 FTS	2,8
PFOA	2,6
PFOS	1,8
6:2FTAB	<10
DPOSA	6,3
PFNA	<1
8:2 FTS	2,1
PFDA	1,5
PFOSA	<1
EtFOSAA	1,3
EtFOSE	<10
MeFOSE	<10
MeFOSAA	<1
PFUdA	<1
PFDoA	2,3
PFTrDA	<1
PFTeDA	2,4
PFHxDA	1,2
10:2FTS	1,1
6:2diPAP	4,7
6:2/8:2diPAP	4,7
8:2diPAP	3,4
10:2 diPAP	<1
6:2 FTOH	<20
8:2 FTOH	30
10:2 FTOH	35
12:2 FTOH	31

Basement Storage Room

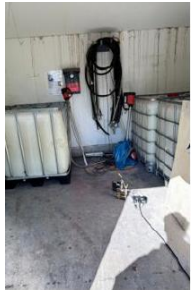
Air	
ng/m³	Storage room
6:2FTOH	16
8:2FTOH	245
10:2 FTOH	53
12:2FTOH	2,3
PFHxA	
PFBSA	
MeFBSA	0,48
PFHxSA	
PFOSA	
MeFOSA	
MeFOSE	
EtFOSA	
EtFOSE	

Dust	
µg/kg	
PFBA	15
PFPeA	7,0
PFHxPA	<1
PFBS	43
HPFHpA	<1
PFHxA	51
PFHpA	23
6:2 FTS	56
PFOA	220
PFOS	510
6:2FTAB	18
DPOSA	<10
PFNA	47
8:2 FTS	27
PFDA	160
PFOSA	18
EtFOSAA	12
EtFOSE	150
MeFOSE	63
MeFOSAA	20
PFUdA	15
PFDoA	63
PFTrDA	2,8
PFTeDA	18
PFHxDA	20
10:2FTS	26
6:2diPAP	6,4
6:2/8:2diPAP	3,4
8:2diPAP	2,5
10:2 diPAP	<1
6:2 FTOH	<20
8:2 FTOH	<100
10:2 FTOH	48
12:2 FTOH	<10

Foam Storage Shed

Air	
ng/m³	Foam storage
6:2FTOH	30
8:2FTOH	20
10:2 FTOH	6,8
12:2FTOH	2,7
PFHxA	5,0
PFBSA	
MeFBSA	
PFHxSA	
PFOSA	
MeFOSA	
MeFOSE	
EtFOSA	
EtFOSE	
DPOSA	3,2
6:2 FTS	3,3
8:2 FTS	0,51

Dust	
µg/kg	
PFBA	97
PFPeA	48
PFHxPA	<1
PFBS	260
HPFHpA	<1
PFHxA	590
PFHpA	66
6:2 FTS	950
PFOA	2,6
PFOS	1,8
6:2FTAB	110
DPOSA	2500000
PFNA	17
8:2 FTS	430
PFDA	74
PFOSA	<1
EtFOSAA	<1
EtFOSE	<10
MeFOSE	<10
MeFOSAA	<1
PFUdA	<1
PFDoA	120
PFTrDA	140
PFTeDA	120
PFHxDA	46
10:2FTS	34
6:2diPAP	<1
6:2/8:2diPAP	<1
8:2diPAP	<1
10:2 diPAP	<1
6:2 FTOH	NA
8:2 FTOH	250
10:2 FTOH	200
12:2 FTOH	360



Ulige forbindelser i luft og i støv

Hvad er mest relevant i dit projekt?

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Eurofins measurements:

Dust

µg/kg	Living room
PFBA	
PFPeA	0,8
PFHxPA	25
PFBS	
HPFHpA	
PFHxA	5,4
PFHpA	1,1
6:2 FTS	
PFOA	7,5
PFOS	1,5
6:2FTAB	1,5
DPOSA	
PFNA	0,85
8:2 FTS	
PFDA	
PFOSA	
EtFOSAA	1,7
EtFOSE	
MeFOSE	
MeFOSAA	
PFUdA	
PFDoA	2,3
PFTrDA	
PFTeDA	0,87
PFHxDA	2,2
10:2FTS	0,88
6:2diPAP	8,7
6:2/8:2diPAP	10
8:2diPAP	18
10:2 diPAP	37
6:2 FTOH	
8:2 FTOH	
10:2 FTOH	

LOQ: 1 – 10 µg/kg

Air

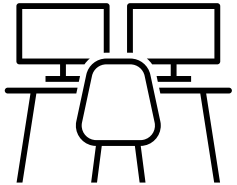
ng/m³	Living room
6:2FTOH	11
8:2FTOH	20
10:2 FTOH	5,6
12:2FTOH	1,3
PFHxA	
PFBSA	
MeFBSA	
PFHxSA	
PFOSA	
MeFOSA	
MeFOSE	0,30
EtFOSA	
EtFOSE	trace

Living room

Air

ng/m³	Home office
6:2FTOH	10
8:2FTOH	13
10:2 FTOH	4,0
12:2FTOH	1,4
PFHxA	
PFBSA	
MeFBSA	
PFHxSA	
PFOSA	
MeFOSA	0,35
MeFOSE	2,0
EtFOSA	0,13
EtFOSE	0,96

Home office



Dust

µg/kg	Home office
PFBA	4,9
PFPeA	
PFHxPA	trace
PFBS	
HPFHpA	
PFHxA	4
PFHpA	3
6:2 FTS	
PFOA	17
PFOS	12
6:2FTAB	
DPOSA	
PFNA	
8:2 FTS	
PFDA	2,0
PFOSA	
EtFOSAA	2,3
EtFOSE	3,6
MeFOSE	5,5
MeFOSAA	1,3
PFUdA	
PFDoA	
PFTrDA	
PFTeDA	
10:2FTS	1,7
6:2diPAP	11
6:2/8:2diPAP	1,7
8:2diPAP	1,1
6:2 FTOH	
8:2 FTOH	
10:2 FTOH	

LOQ: 1 – 10 µg/kg

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Eksponering tilsvarer*:

Example concentrations, Indoor air	
Compounds	**ng/m ³**
6:2 FTOH	10
8:2 FTOH	15
10:2 FTOH	5
12:2 FTOH	1
Me-FOSE/A	1
Et-FOSE/A	0,5

EFSA TWI: 0,44 ng/kg body weight per week

Voksen: 1–170 %

Børn: 16 – 310%

Hvor vigtig er eksponering for PFAS i luft?

Hvor stort er bidraget fra luft til jord/vand?

*Beregninger på neste slide

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I. Introduction – Exposure (two models)

Example concentrations, Indoor air	
Compounds	**ng/m ^{3}**
6:2 FTOH	10
8:2 FTOH	15
10:2 FTOH	5
12:2 FTOH	1
Me-FOSE/A	1
Et-FOSE/A	0,5

Uptake (F) and biotransformation (Fb)*

Model	Body weight	Breathing	F_{uptake}	$F_{biotransformation}$			Exposure	
	kg	m^3/dag		8:2 FTOH-PFOA	8:2 FTOH-PFNA	Me/Et-FOSE/A-PFOS	ng/kg body weight/week	**%EFSA**
EFSA PFAS4	15	7,6	1	0,003	0,0003	0,1	0,71	16
	70	20					0,40	0,91

*selected compounds (not including FTCA/FTUCA intermediates)

Uptake (F) and RPF (PFOA eqv)**

Model	Body weight	Breathing	F_{uptake}	RPF			Exponering	
	kg	m^3/dag		6:2 FTOH	8:2 FTOH	Me/Et-FOSE/A	ng/kg body weight / week	**%EFSA**
RPF-PFOA ekv	15	7,6	1	0,02	0,04	2***	13,5	**310**
	70	20					7,6	**170**

***Estimate based on PFOS **(driving risk)**

**selected compounds

EFSA TWI: 0,44 ng/kg body weight per week

Very typical values used!

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Sources methodology/factors: NV 5976; Padilla-Sanchez et al, 2017; EFSA, 2020; RIVM, 2023

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