



Region
Syddanmark

TREE CORE SAMPLING AS A SCREENING METHOD FOR PFAS CONTAMINATION

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DEVELOPMENT FUND, REGION SYDDANMARK

Mette Algreen, Katrine Smith (WSP)
Anette Hansen, Anne Tipsmark Ottosen, Klaus Bundgaard
Mortensen, Steffen Gram Lauridsen (Region of Southern Denmark)
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Agenda

Background and purpose

Highlights of

- The method of tree coring
- PFAS and uptake in plants

Fieldwork

- Sites and sampling

Results

- Detection of PFAS in tree cores?
- Correlation between groundwater and tree core concentrations.

Summary

Perspectives

Background

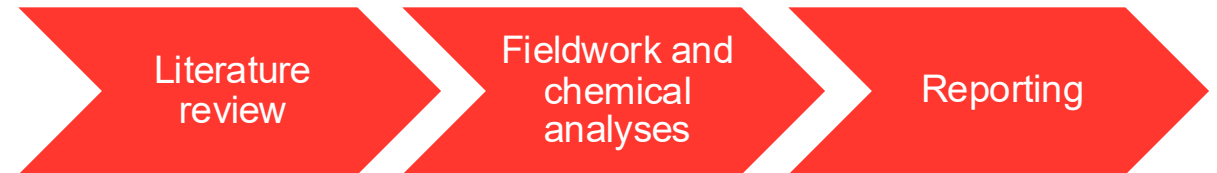
- The tree core method is a screening method.
 - Used (successfully) to detect sources of contamination with chlorinated solvents.
 - Tested for substance groups such as oil, heavy metals, PAHs and pesticides.
 - The applicability of the method is dependent on plant uptake and translocation in the tree, including the physicochemical properties of the substances.
-
- ***What about PFAS?***

Purpose

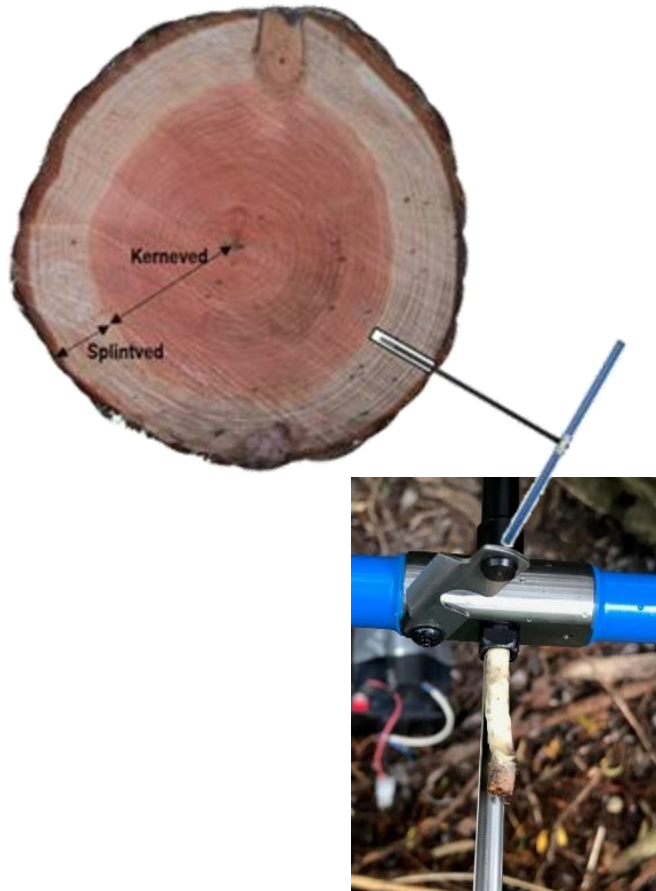
- To investigate whether the tree core method can be used for detection and localization of PFAS contaminants as a screening method.

The first sub-goal is to investigate whether PFAS can be detected in tree cores with the current detection limits.

Three project phases:



In brief...



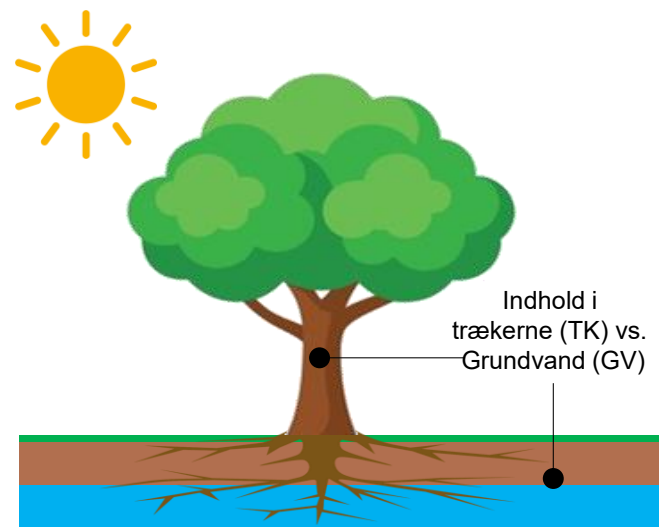
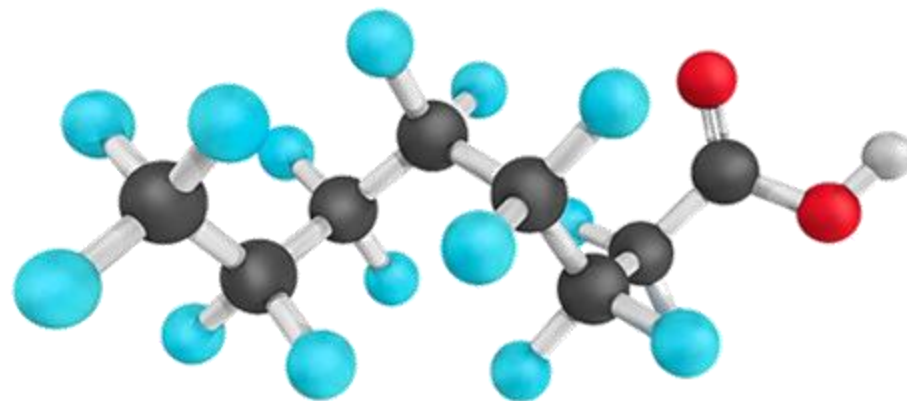
The tree core method

- Method that uses the trees' natural mechanisms for root uptake.
- The trees absorb substances from the soil, soil gas and the shallow groundwater.
- A "biopsy" from the trunk of the tree is taken with an increment borer and sent for chemical analysis.
- Detection of environmental contaminants in the wood is an indication of an underlying contamination.
- The screening can be used to find the optimal placement more costly and invasive methods, such as groundwater boreholes, in order to optimize the investigation of the contaminated sites.
- Can be used to find overlooked source areas.
- The applicability of the method depends on the bioavailability of the contaminants (water-soluble, stability, etc.), but also on surrounding conditions such as weather, geology, tree species, etc.
- A screening method

In brief...

PFAS and uptake in plants

- Many different substances with different properties.
- Surfactant properties. Accumulates in the water-air surface.
- Sorption to the soil is important. Short-chain PFAS bind less to the soil than long-chain PFAS.
- Studies show that PFAS are taken up via the roots and translocated.
- The relationship between the properties of the substances, tree species and the properties of the soil is complex.
- There may be contributions from atmospheric deposition in the bark.



Fieldwork

9 possible sites selected by the region

									
Primære forureningskomponenter	PFOS	PFOS, PFPA, PFNA	Sum 4 PFAS	PFAS og Oksidstoffer	6,2,7,5, PFPA, PFNA	PFOS, PFPA, PFNA	PFPA, PFNA, 6,2,7,5	PFOS, PFOS	PFPA, PFNA
Planlagt indhold (µg/l) i færdigkommande GV	20	2000 ng/l	0,31 (B11)	2,7	36 (Sum 22 PFAS), (dybde 14,5-16,5 m)	19 (Sum 12 PFAS)	17 (Sum 22 PFAS) 4-8 m	5,6 (Sum 4 PFAS)	45 (Sum 22 PFAS ved ny BOP)
dybde til færdigkommande grundvand (m v.v.)	20	4,5	3,7	1,28	1,5	1,5	1,5	1,5	5
Spærreindsigter af GV	ukendt	Ukendt, varierer afhængig af hvor man er på grunden	Ukendt, varierer afhængig af hvor man er på grunden. På den nordlige	Nordvest	sydvendt til sydlig	vestlig	nord til nordvestlig	sydvendt	Vest til nordvestlig
indhold jern (mg/kg) i jorden	ikke undersøgt	ikke undersøgt	ikke undersøgt	0,04	30	Sum 4 pfas	Sum 4 og 22 PFAS	ikke undersøgt	ja - se rap. fra 2023
Geologi til færdigkommande GV	SAND	SAND	moræner	Fuld	SAND	SAND	SAND (er. 4, sandet (dybde 14,5-16,5 m))	SAND	lert sand
Udvalgte træslag	Nåletræer og løvtræer	Blåbærtræer	Løvtræer	Løvtræer	Blåbærtræer, løvtræer	Løvtræer	Løvtræer	Nåletræer, løvtræer	Blåbærtræer
Udvalgte afstand til kilden (træer til kilden)	100 m	4	Placeret overalt	0	På kanten	10 m	20 til 25 m	10 m	100 m ved gammel BOP
Proport fremstillet (m³)	30	30	30	30	30	30	30	30	30
Bemærkning		"Der er ikke taget prøver i hotspot da det ikke var undersøgelsesformål. Det var en overfladeundersøgelse med boringer i kant af operation med overfladevand. Der er således taget prøver af PFAS i grundvand i områder med træer i nærheden (B10).		Påbudssag, der afventer kommune	Forventet	Forventet	Forventet	Forventet	Forventet



4 selected (1 as a back-up)
former fire fighting training sites

Selection of test sites based on:

- Trees present
- Maximum possible concentration of PFAS (preferably above 1-2 µg/l).
- The source area must be known and investigated.
- The groundwater as close to the ground as possible.
- The trees are placed as close as possible to established boreholes (For comparison of measurement data).

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Site H

-
- Map of the study area showing sampling locations and results. The map includes a red line representing a boundary, a yellow area representing a specific region, and various sampling points labeled B1 through B13. Each point has associated data values for different parameters. A scale bar indicates distances from 0 to 1000 meters.
- | Sampling Point | Parameter 1 | Parameter 2 | Parameter 3 | Parameter 4 | Parameter 5 | Parameter 6 | Parameter 7 | Parameter 8 | Parameter 9 |
|------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| B301 (2-4) | 6: 0,11 | 5: 0,13 | 4: 0,0083 | | | | | | |
| B307 (16,5-19,5) | 7: 1.p. | 6: 1.p. | 5: 1.p. | 4: 0,0025 | | | | | |
| B102 (1-3) | 5: 0,042 | 2: 0,016 | | | | | | | |
| B201 (2,5-4,5) | 6: 0,73 | 5: 0,82 | 4: 0,55 | 3: 1,1 | | | | | |
| B101 (1-3) | 3: 4,8 | 2: 5,6 | | | | | | | |
| B102 (1-3) | 6: 12 | 5: 16 | 4: 11 | 2: 19 | | | | | |
| B103 (1-3) | 3: 6,40 | 2: 16 | 1: 5,77 | | | | | | |
| B104 (1-3) | 5: 0,042 | 2: 0,016 | | | | | | | |
| B105 (1-3) | 5: 0,042 | 2: 0,016 | | | | | | | |
| B106 (1-3) | 5: 0,042 | 2: 0,016 | | | | | | | |
| B107 (1-3) | 5: 0,042 | 2: 0,016 | | | | | | | |
| B108 (1-3) | 5: 0,042 | 2: 0,016 | | | | | | | |
| B109 (1-3) | 5: 0,042 | 2: 0,016 | | | | | | | |
| B110 (1-3) | 5: 0,042 | 2: 0,016 | | | | | | | |
| B111 (0,8-2,8) | 2: 1,1 | | | | | | | | |
| B112 (1-3) | 6: 12 | 5: 16 | 4: 11 | 2: 19 | | | | | |
| B113 (1-3) | 3: 6,40 | 2: 16 | 1: 5,77 | | | | | | |
| B202 (1,5-3,5) | 6: 0,82 | 5: 1,70 | 4: 1,4 | | | | | | |



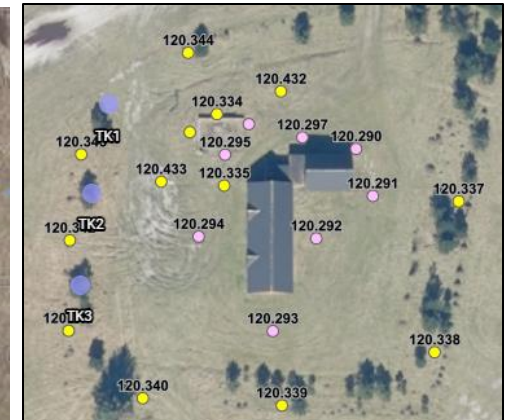
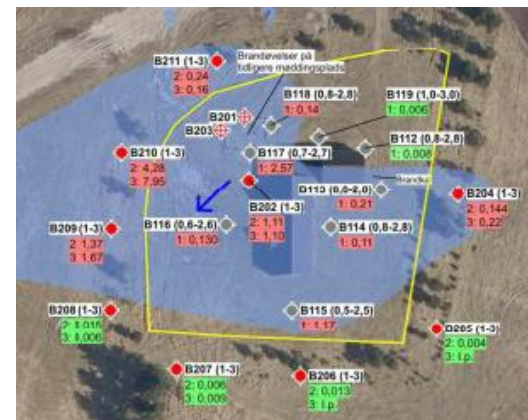
Site S

- Concentration: 12/22 PFAS, e.g. 63 µg/l (4-7 m.u.t). Heavy contamination detected over a number of years.
- PFAS: Many PFAS, predominant are 6:2 FTS and PFPeA.
- Geology: Sand
- Shallow groundwater. Flow direction NW
- Tree species: Birch, hazel, willow etc.
- Sampled: 9 tree core samples (5 close to the fire-fighting training area and 4 NW of the fire-fighting training area)



Site 0

- Concentration: 12 PFAS up to 7.95 µg/l (1-3 m.u.t)
- PFAS: PFOS and PFOA are dominant
- Geology: Sand to min. 4 m u.t.
- Shallow groundwater. Flow direction SW
- Tree species: Spruce trees
- Sampled: 3 tree core samples



Results

Samples are analyzed for 22 PFAS

Biota analysis

PFAS detected in tree cores!

The following has been detected:

- 6:2 FTS (9 samples)
- PFOS (7 samples)
- PFOA (2 samples)
- PFHpA (2 samples)
- PFHxS (1 sample)

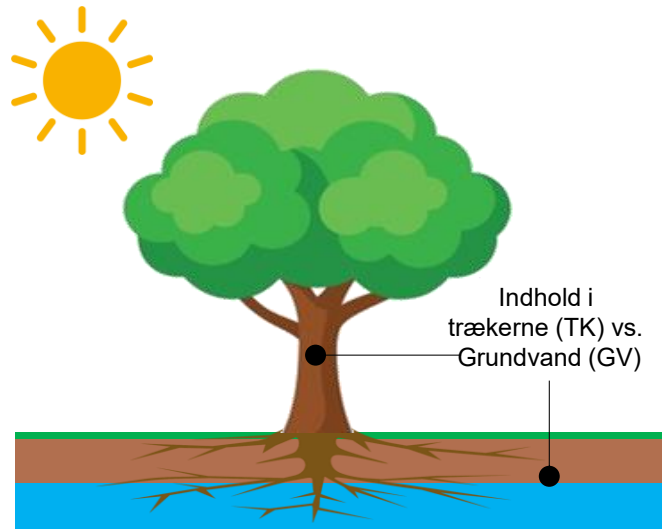
Prøve ID:	TK1	TK2	TK3	TK4	TK5	TK6	TK7	TK8	TK9	TK10	TK11	TK12	TK13	TK14	TK15	TK16	TK17	TK18	TK19	TK20	TK21	TK22	TK23	TK24	TK25
Lokalitet:	Lokalitet O			Lokalitet S									Lokalitet K						Lokalitet H					Ref.	
PFTrDS	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0
PFUnDS	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0
PFDoDS	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0
PFNS	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60
PFPeS	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20
PFDS	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0
PFHxS	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	0,32	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20
PFTTrDA	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20
PFOS	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	0,28	<0,20	0,80	2,8	0,60	<0,20	<0,20	0,28	<0,20	6,4	0,31	<0,20
PFHpS	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60	<0,60
PFPeA	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	3,10	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0
PFBA	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0
6:2 FTS	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	14	3,2	9,6	1,5	0,88	<0,20	<0,20	0,34	1,8	11	<0,20	<0,20	<0,20	<0,20	<0,20	2,3	<0,20	<0,20
PFDoDA	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20
PFUnDA	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20
PFOSA	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20
PFDA	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20
PFNA	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20
PFOA	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	0,46	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	0,30	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20
PFHpA	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	0,29	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	0,32	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20
PFHxA	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0	<2,0
PFBS	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20	<0,20

Results

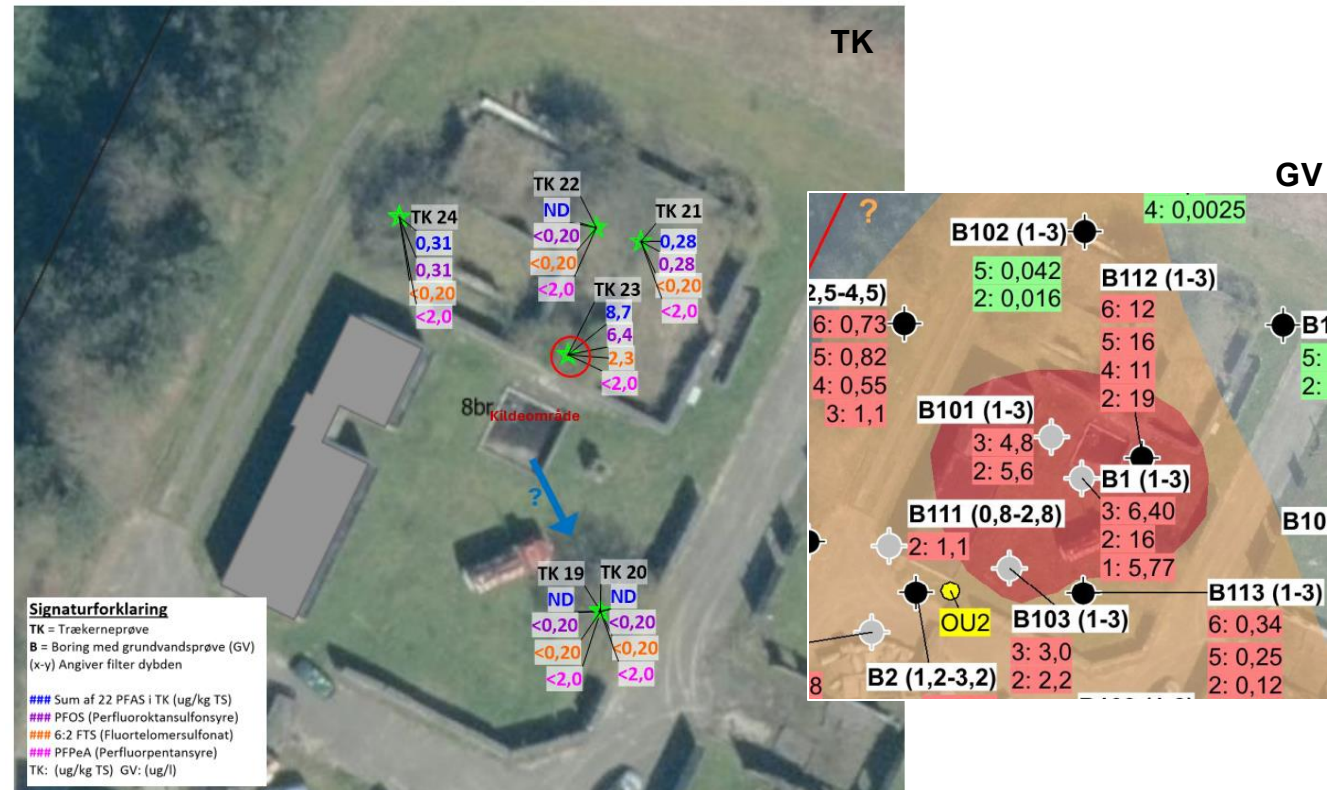
Correlation of data

Site H (6x TK, moraine clays, deciduous trees):

- PFAS detected in 3 tree core samples
- PFOS in 3 TK + single content of 6:2 FTS
- Good correlation between TK and GV

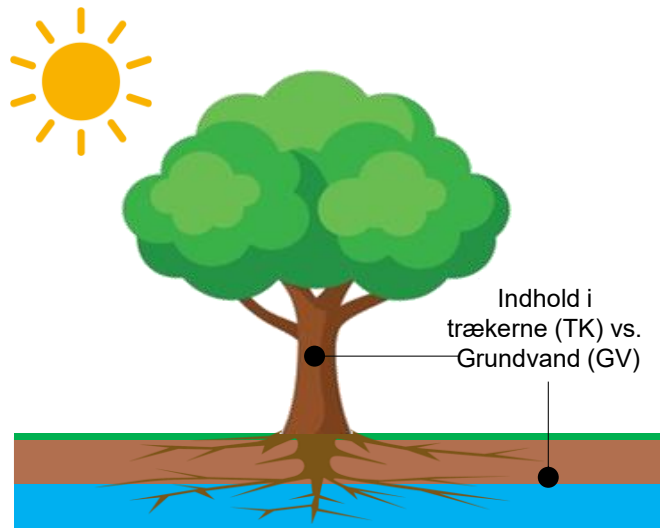


TK – tree core
 GV - groundwater



Results

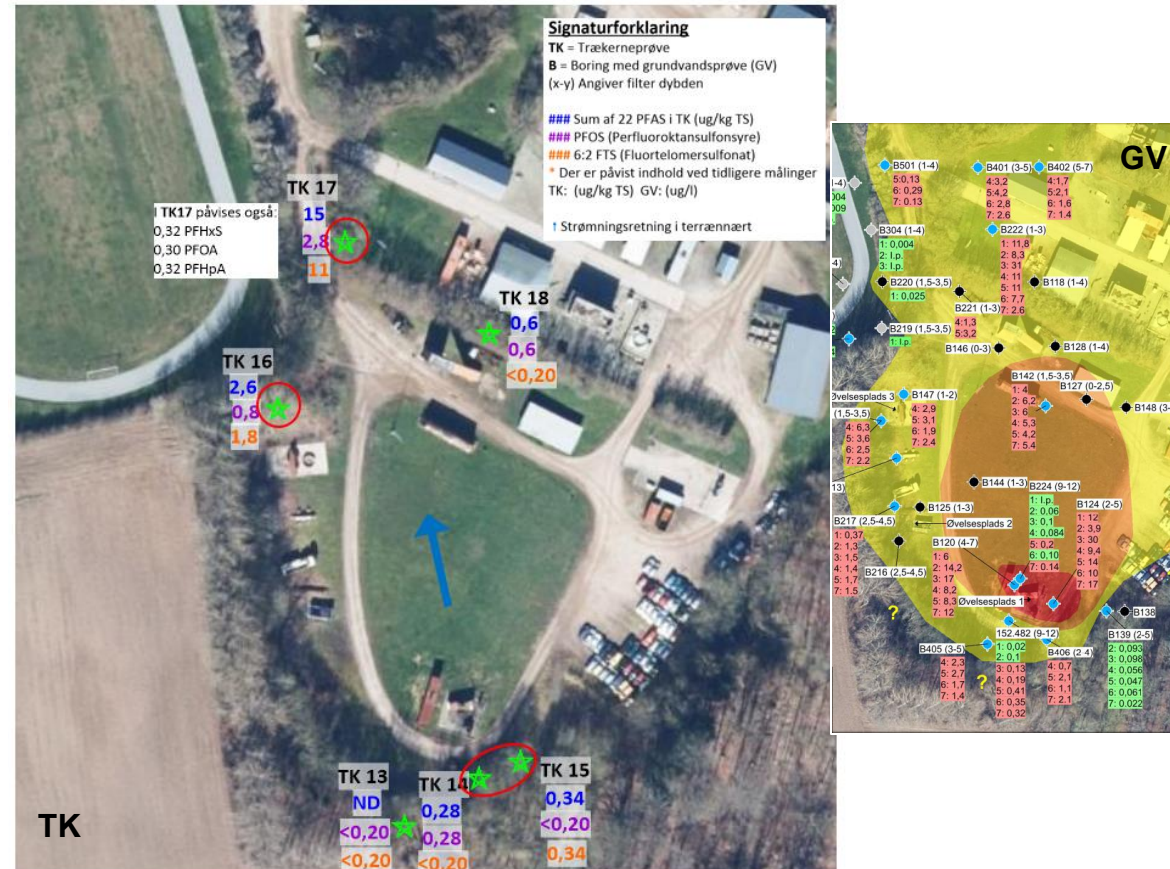
Correlation of data



TK – tree core
GV - groundwater

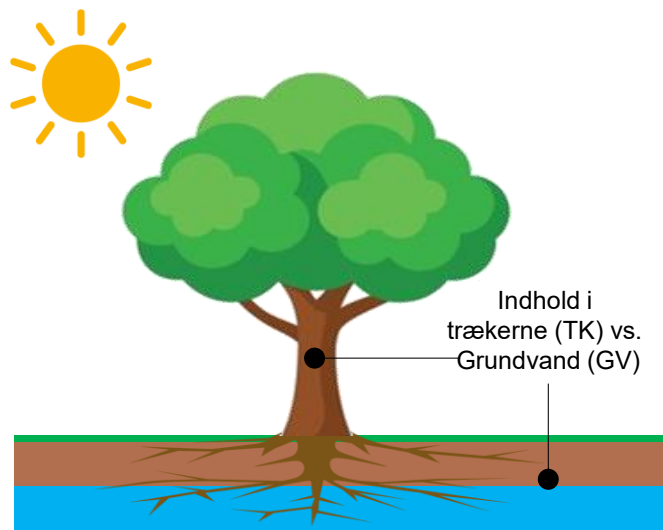
Site K (6x TK, moraine clays, deciduous trees,):

- PFAS detected in 5 tree core samples
- PFOS in 4 TK + 6:2 FTS in 3 TK + single content of PFHxS, PFOA and PFHxA
- Reasonable correlation between findings in TK and GV (historical use)



Results

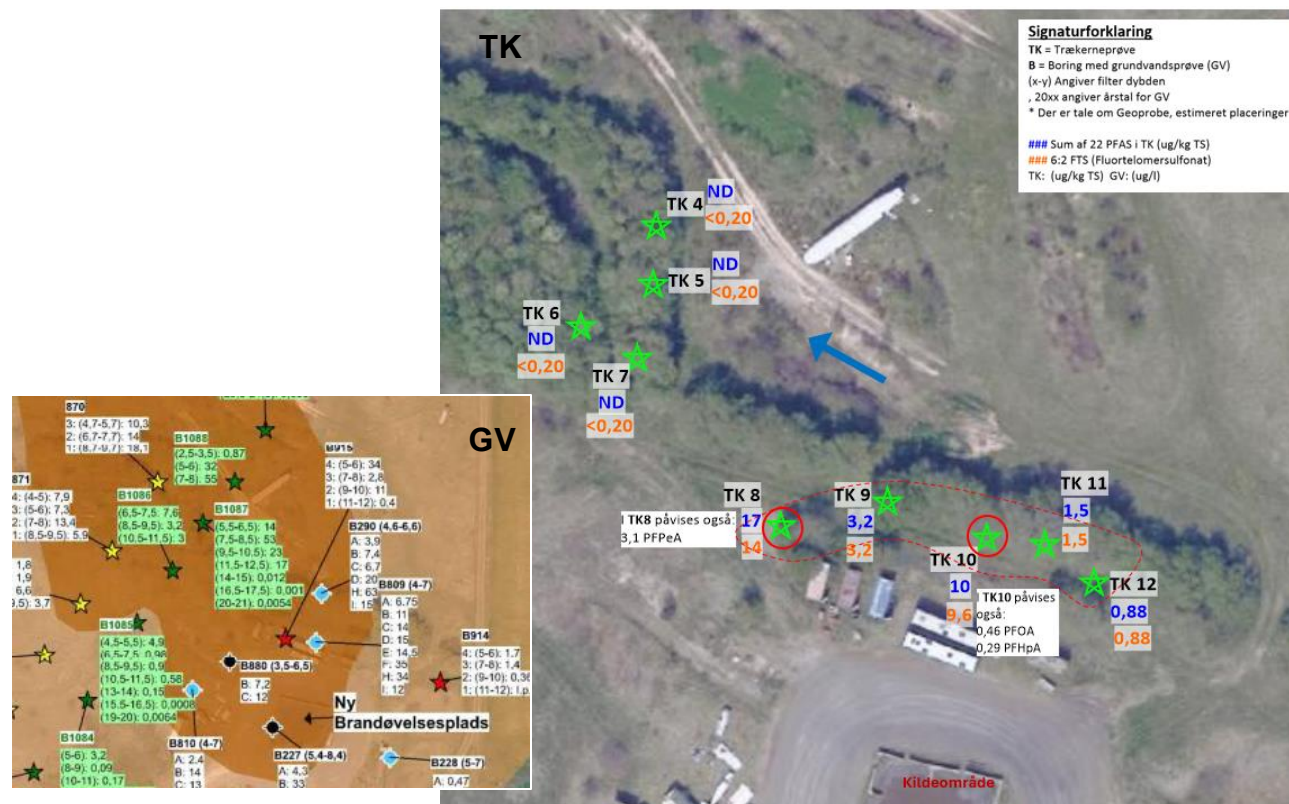
Correlation of data



TK – tree core
GV - groundwater

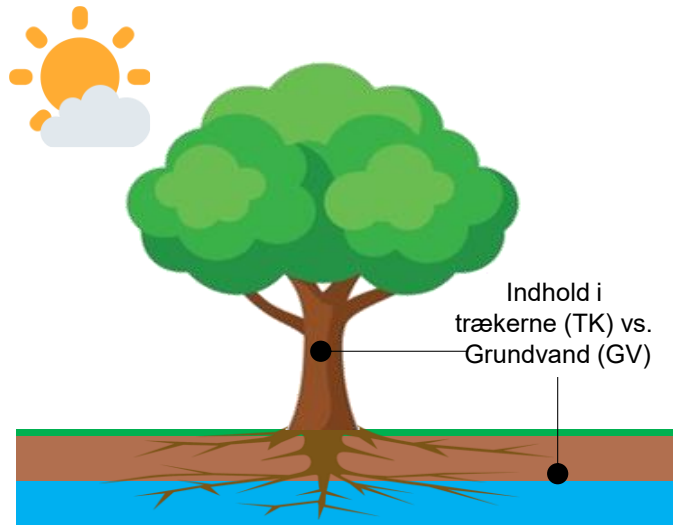
Site S (9x TK, senglacial freshwater sand, deciduous trees):

- PFAS detected in 5 tree core samples
- 6:2 FTS in 5 TK + single content of PFPeA, PFOA and PFHpA
- Good correlation between TK and GV
- No detected content in trees anymore from the hot spot. Possibly because the substance sinks too deep and is not bioavailable.



Results

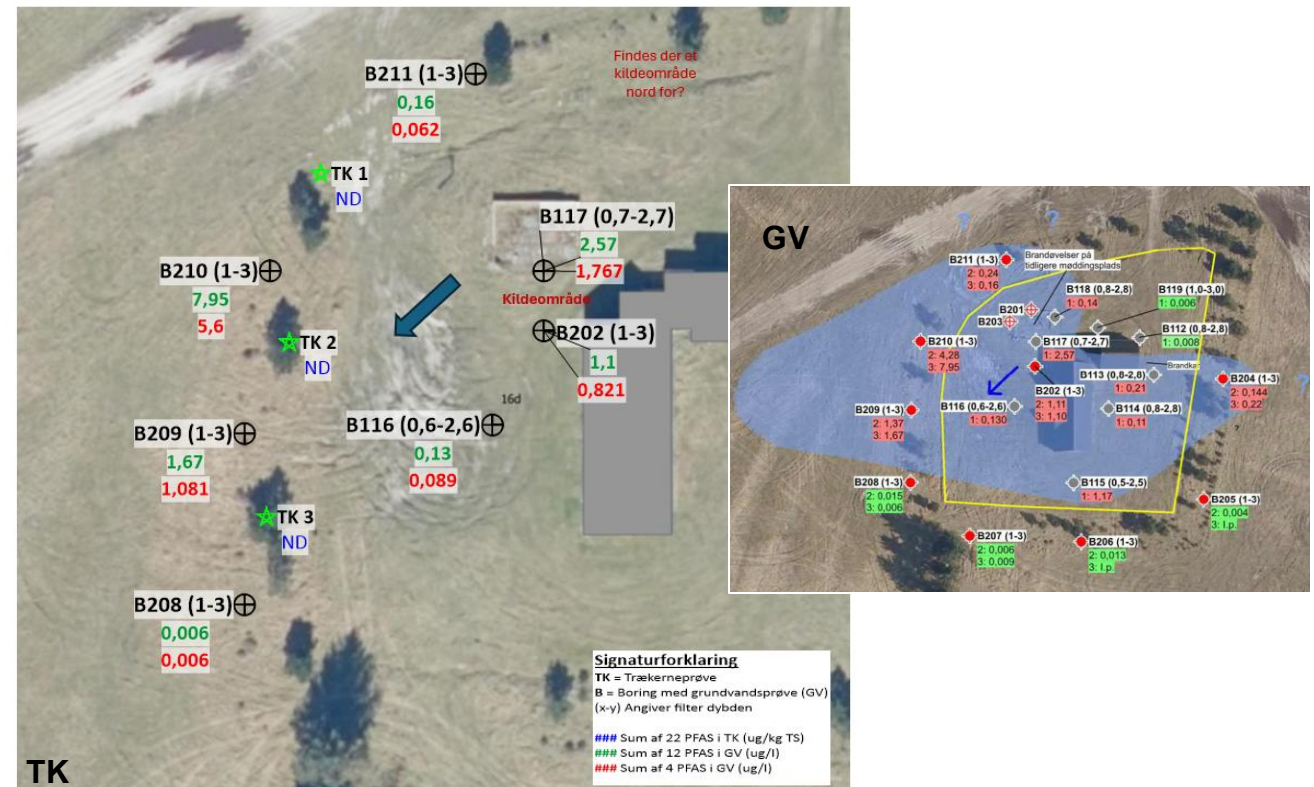
Correlation of data



TK – tree core
GV - groundwater

Site O (3x TK, sand, spruce trees,):

- PFAS not detected in tree cores
 - Substances not bioavailable (geology, tree species)
 - Lower concentrations for the individual substances



Summary

- Small dataset
- **PFAS substances can be detected in tree core samples**
- **6:2 FTS, PFOS, PFOA, PFHpA and PFHxS** has been found
- Detected at 3 out of 4 sites.
- Good correlation between content in tree cores and groundwater
- **Known (and "unknown") hot spots were detected with the method.**
- **Screening method: qualitative and not quantitative,**
- **Minimizing the risk of overlooking source areas – but cannot be used to demonstrate that an area is uncontaminated.**



Perspective:

A quick, easy and inexpensive screening method.

Another project is started – supported by the Southern Denmark development fund.

Obtain a larger data basis for assessing the use of the method

- Tree species deciduous trees versus spruce trees
- Sites with lower concentrations, varying depth to groundwater
- Old landfills

Expanding the use of the method

- Sampling branches (unbarked)
- Distinguish between current and past load (treecores are split in two).





THANK YOU FOR LISTENING

THANKS TO THE REGION OF SOUTHERN DENMARK

Feel free to contact us to hear more:

Mette Heyn Algreen: mette.algreen@wsp.com

Katrine Hauge Smith: katrine.smith@wsp.com

wsp.com

