Diffuse Deposition: The Spread of PFAS from Sky to Supply

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Introduction & Motivation



Figure 1. Potential sources and transport of PFAS between environmental matrices.

- PFAS are ubiquitous in the environment and pose a threat to both human health and ecosystems.
- Atmospheric PFAS can contaminate soils, surface waters, and eventually groundwater through wet and dry deposition.^{1,2}
- Atmospheric PFAS contamination is a potential threat to drinking water production sites.

Research Aim: Quantify the contribution of atmospheric deposition at two drinking water production sites.

Methodology





Figure 2. Sampling locations and weather stations within the Netherlands. Sites A-C are surface waters.

- Two locations compared for urban and rural inputs (135 km apart)
- Sea spray aerosol (SSA) tracer ions (Na⁺) measured in aerosols
- Impact of PFAS deposition in hydrologically isolated heathland pools
- PFAS analysis included (ultra)short-chain PFAS
- Sampling: April to September 2023



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Results



Figure 3. PFAS aerosol concentrations measured in Huijbergen and Ellecom (n = 6). Dashed horizontal lines indicate the median detection limit (DL), adjusted for the volume of air.



Figure 4. PFAS deposition concentrations measured in Huijbergen (n = 12) and Ellecom (n = 15). Dashed horizontal lines indicate the median DL, adjusted for sample volume and exposure time.



Figure 5. PFAS concentrations measured in surface waters of heathland pools from sites A, B and C in Huijbergen (n=3). Detection frequency 100% unless indicated, horizontal dashed lines indicate the DL.





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<u>References</u>

1. Schroeder, T., et al. (2021). https://doi.org/10.1039/d0em00427h 2. Shimizu, M. S., et al. (2021). https://doi.org/10.1021/acs.estlett.1c00251 3. RIVM PEQ Tool. https://www.rivm.nl/documenten/rivm-peq-tool

[‡]TFMS was only measured in aerosols ⁺PFHxS was found once in Ellecom deposition, but never in Huijbergen

Discussion



- Nine PFAS common between all matrices, including legacy PFAS
- 6:2 FTS specific to aerosols
- Short-chains abundant (e.g. TFA, PFBA)

Table 1. Top 5 components, PFOA-equivalent (PEQ) concentrations (median ± std). PFOA and PFOS are given as the sum of the branched and linear isomers.³

Aerosols (PEQ - pg/m ³)		Deposition - Annual Flux (PEQ - ng/m ²)		Surface Water (PEQ -ng/l)	
PFNA	0.68 ± 0.4	PFNA	1423 ± 1592	PFOS	10.2 ± 4.6
PFDA	0.41 ± 0.5	PFDA	969 ± 1160	PFOA	8.9 ± 4.5
PFOS	0.33 ± 0.7	TFA	451 ± 416	PFNA	5.1 ± 3.3
6:2 FTS	0.23 ± 0.2	PFHpA	311 ± 307	PFHpA	4.4 ± 0.4
PFOA	0.18 ± 0.1	PFOS	235 ± 475	TFA	2.2 ± 0.5

Conclusions

- Atmospheric deposition is a diffuse source of PFAS contamination in soils, ground- and surface waters.
- Legacy PFAS still present decades after bans.
- Understanding the fate and transport of short-chain PFAS is key to predicting and mitigating future risks for drinking water supplies.

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TFA

PFHxA PFOA

PFHpA PFBS

PFNA HFPO-DA

br-PFOA

PFBA PFOS

