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PFAS in drinking water in Norway; generally, very low levels. Elevated concentrations were detected near known PFAS sources

Background

PFAS are contaminants that can be found in most ecosystems. Norway has had no production of PFAS, but PFOS have been used in fire-fighting foams and have been employed at a few industrial sites. In Norway, drinking water originate mostly from surface water. Norway has reported very few analytical measurements of PFAS in drinking water, and data was therefore warranted.

The aim of the study was to quantify PFAS in Norwegian drinking water, both source water and drinking water and relate findings to regulations.

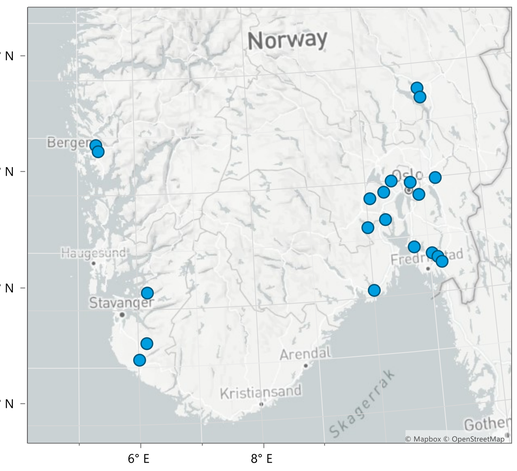


Figure 1 Map of drinking water sources

Approach

Drinking water from 20 drinking sources (**Figure 1**) and 11 waterworks were sampled and sent to NIVA for analyses of 31 PFAS, including the PFAS included in EU's drinking water directive (DWD) (European Parliament 2020) and a few other PFAS groups suspected to be present in water (**Figure 2**). Detection limits ranged from 0.04-0.1 ng/L (PFSAs, PFASA and FTS) to 0.1-0.2 ng/L (PFCAs). Both source water (n=93) and finished drinking water (n=71) were analysed. The surface waters had a wide geographical spread east-west-south but did not include northern Norway. Information about the technology used for treating the water was categorised into 3 categories (0, 1 and 2), where 0 represent treatment expected not to remove PFAS, 1 where some removal could be expected (coagulation, flotation, filtration) and 3 (category 2 and use of granulated activated carbon in addition). The removal efficiency was calculated based on PFAS ≥2×LOQ in source water).

Results

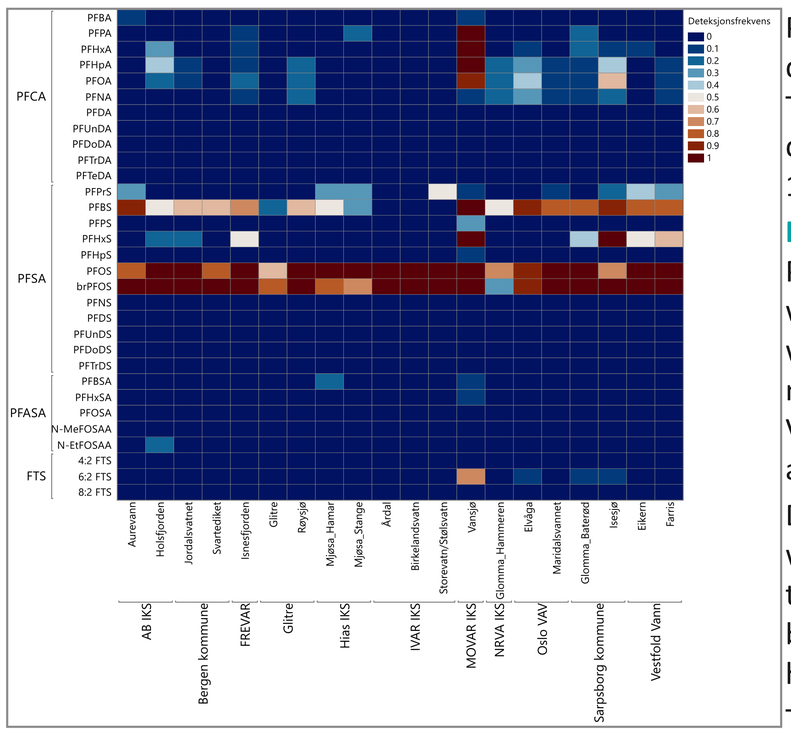


Figure 2 Detection frequencies (source water and drinking water)

PFOS and brPFOS had the highest detection frequencies (**Figure 2**). The median number of PFAS in drinking water was 3, but up to 14 PFAS were detected.

Figure 3 shows the sum of the 20 PFAS in EU's DWD . Both source water and drinking water was well below the limit. The maximum concentration was found in Vansjø (23 ng/L in source water and 12 ng/L in drinking water).

Denmark has regulated drinking water with a limit of 2 ng/L for the sum of 4 PFAS risk assessed by EFSA (**Figure 3**). Only Vansjø had concentrations above 2 ng/L.

The treatment efficiency at the waterworks were calculated based on PFAS concentrations in source water and drinking water taken the same day. The removal rate for treatments with a combination of coagulation, flocculation, filtration and activated carbon performed best (up to median 60%)(**Figure 4**). The removal rate was lower for shorter chain PFSAs, and <20% for PFBS. The removal of PFOA and PFHpA was as expected lower than PFOS. Removal rates of lower chain PFCAs was low, and 0 for PFPA.

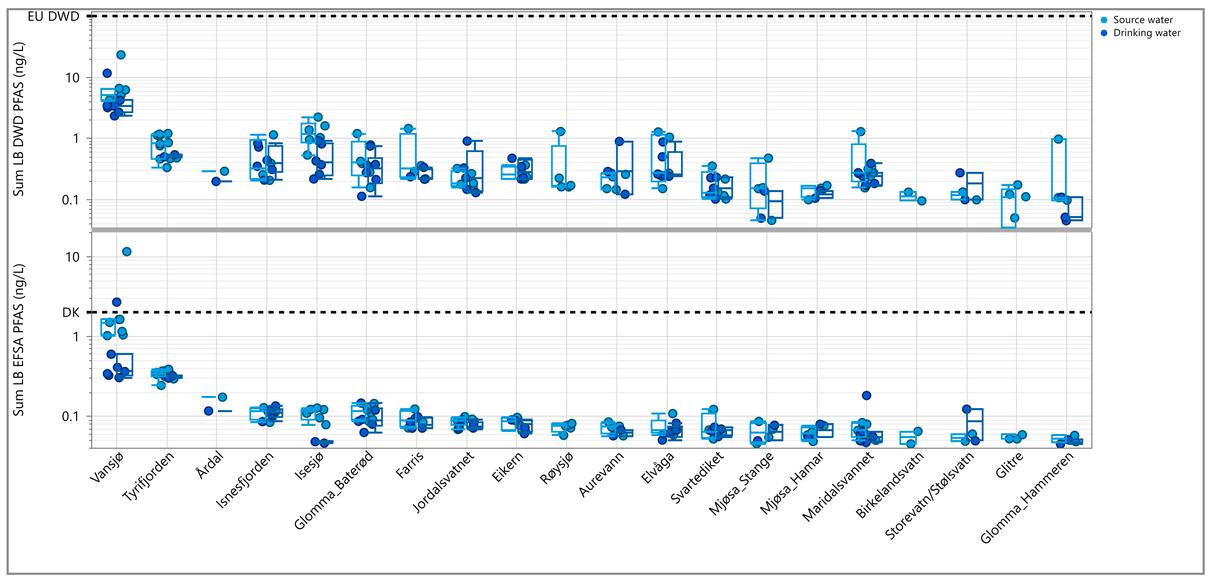


Figure 3 Sum of 20 PFAS in DWD (upper) and sum of 4 PFAS in EFSA RA (lower). Partial sums below LOQ set to 0.

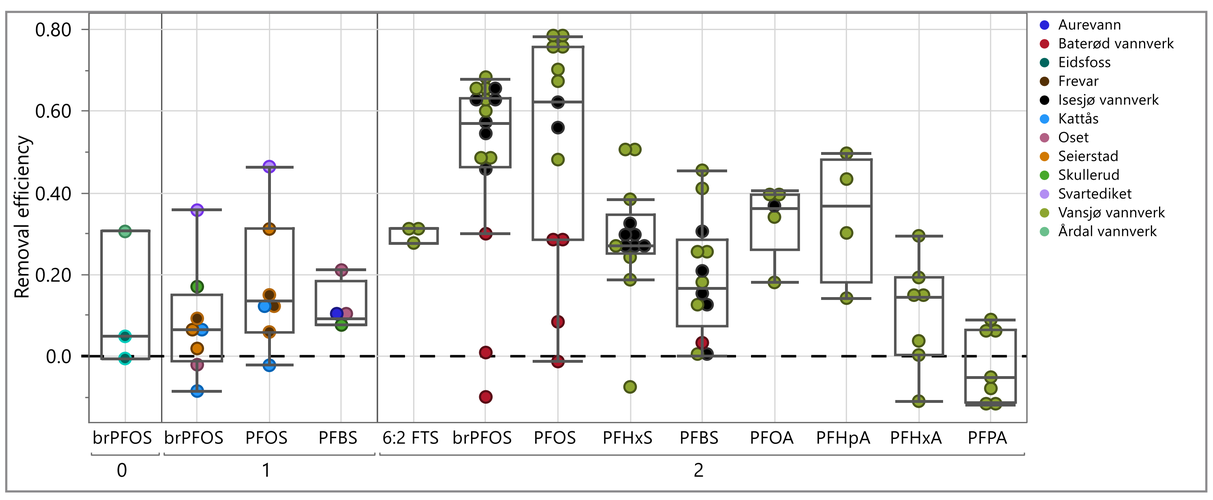
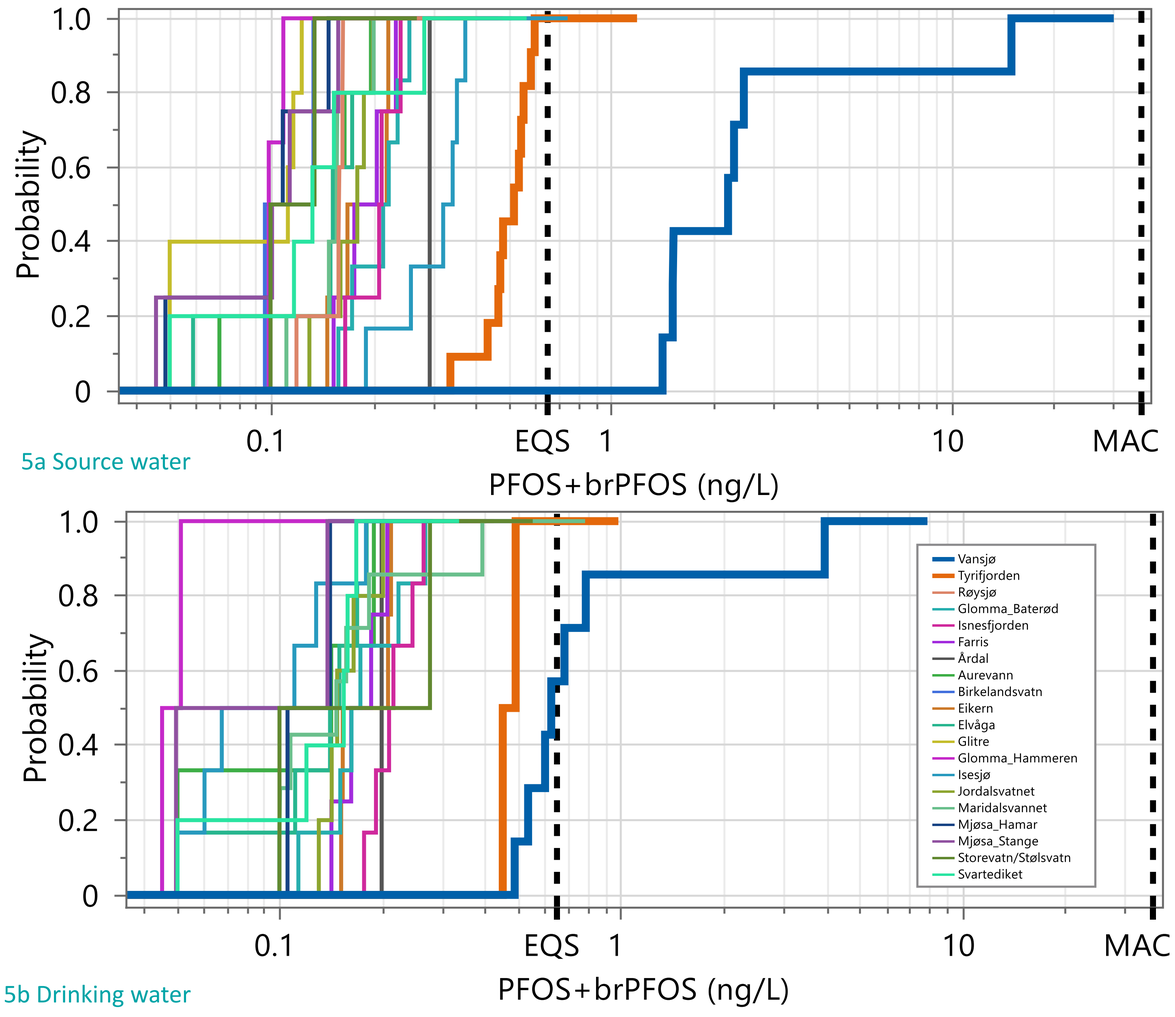


Figure 4 Removal rates of PFAS by water treatment facilities employing various treatment categories

A Kaplan Meyer plot (Shoari and Dubé 2018, **Figure 5**) of brPFOS+PFOS concentrations in source water and drinking water vs. the probability shows that two water sources (in bold) in Norway nearby known PFAS contaminations had higher levels of PFOS than other water sources. PFOS is a priority substance in the Water framework directive, and regulatory limits are shown with dotted lines. Lake Vansjø (blue) is located near an airport where PFAS was used at training sites for fire-fighing, and Lake Tyrifjorden is located downstream a factory that produced paper plates coated with PFAS (Langberg et al, 2019 and 2020). Both the factory and the airport are shut down today.



5a Source water

5b Drinking water

Figure 5 Kaplan Meyer plot of PFOS concentrations (brPFOS + PFOS) in (a) source water and (b) drinking water

Conclusions

- PFAS in Norwegian surface waters used as drinking water has been investigated. In general, **very low levels** were found, but more **elevated concentrations** were detected **near known PFAS sources**.
- Water sources investigated **cover >40%** (ca. 2.3 millions) of Norwegian population.
- **Detection frequencies of PFOS and brPFOS was high** in both surface water and drinking water.
- **Removal rates** of PFAS was investigated and found to be **close to 60% for PFOS and brPFOS** at waterworks with **advanced treatment**. The removal rates were lower for other PFAS and for waterworks employing less advanced treatment.

References

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