

# Emerging per- and polyfluoroalkyl substances (PFASs) in sludge and effluent from Swedish wastewater treatment plants

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## Background



- PFAAs are globally distributed in the environment including humans and remote Arctic wildlife.<sup>1,2</sup>
- Extreme persistence and long blood elimination half lives (years).<sup>3</sup>
- Links to adverse health effects in humans and rodents.<sup>4</sup>

## Objective

- To assess the presence of per polyfluoroalkyl substances in the sludge and effluents from different WWTP in Sweden.
- To compare the differences in PFAS concentrations from the studied WWTP and to assess the differences in potential contamination sources of the studied PFASs.

## Experimental Method

37 PFAAs analyzed in sludge plus branched<sup>1</sup>

Effluent	Sludge
8 samples	8 samples

50 mL of effluent  
Spike with ISTD  
SPE Oasis HLB Plus  
Fortification with RSTD

1g of dried homogenized sludge  
Spike with ISTD  
Extract with MeOH  
Fortification with RSTD



Quantification of PFASs by (LC-MS/MS)

QC: Each batch contained a blank sample and 2 control samples. For quantification, two product ion transitions were monitored per analyte one for quantification and the other for confirmation.



## PFASs in Effluent

### Perfluoroalkyl carboxylic acid (PFCA)

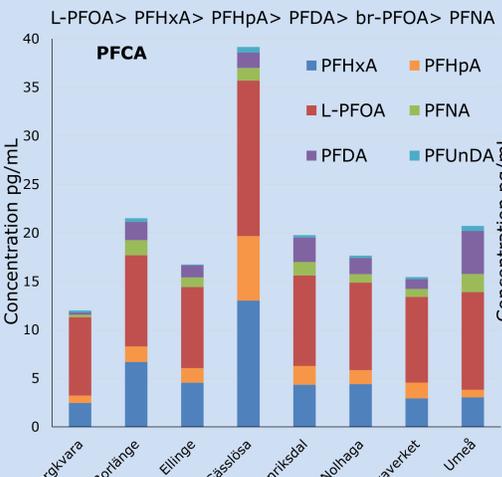


Figure 1. Concentration of PFCA in effluents.

### Perfluoroalkyl sulfonic acid (PFSA)

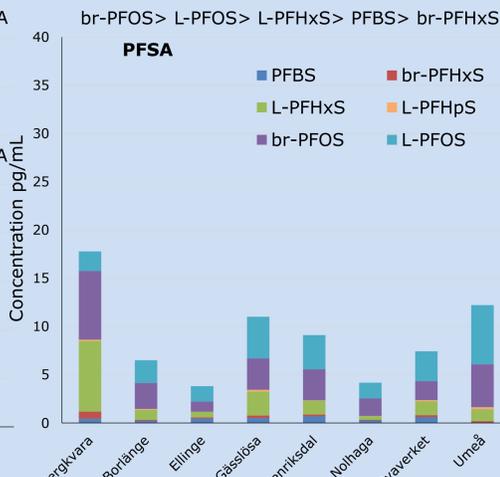


Figure 2. Concentration of PFSA in effluents.

### PFOS Precursors

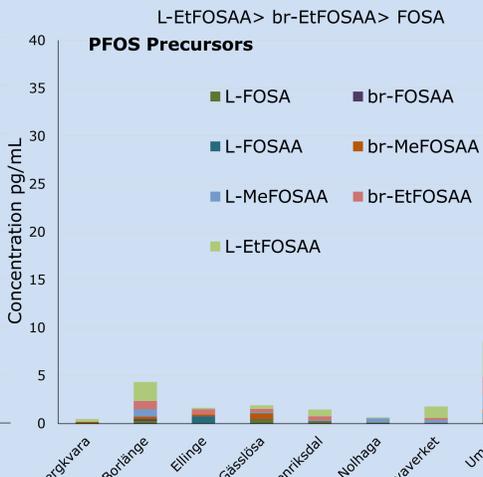


Figure 3. Concentration of PFOS Precursors in effluents.

### PFCA Precursors

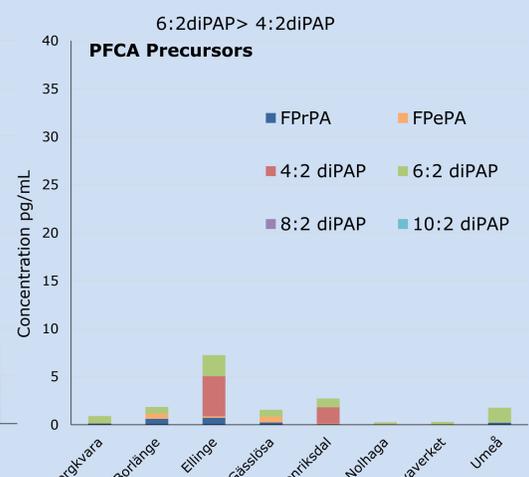


Figure 4. Concentration of PFCA Precursors in effluents.

## PFASs in Sludge

### Perfluoroalkyl carboxylic acid (PFCA)

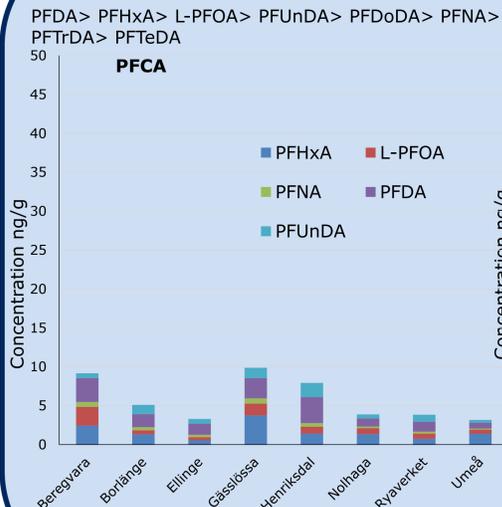


Figure 5. Concentration of PFCA in sludge.

### Perfluoroalkyl sulfonic acid (PFSA)

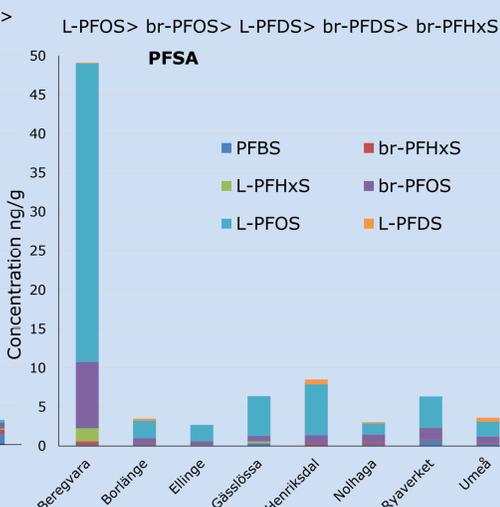


Figure 6. Concentration of PFSA in sludge.

### PFOS Precursors

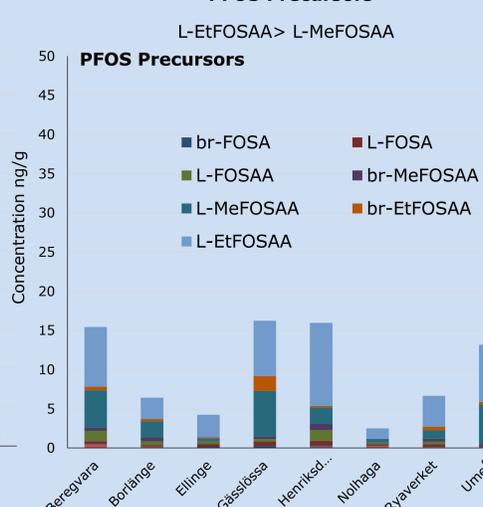


Figure 7. Concentration of PFOS Precursors in sludge.

### PFCA Precursors

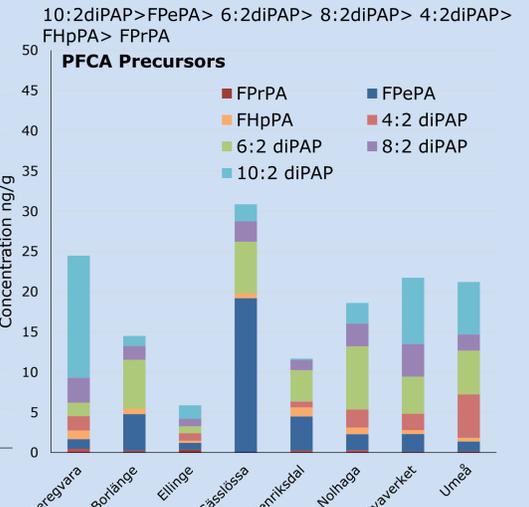


Figure 8. Concentration of PFCA Precursors in sludge.

## Conclusion and Implications of this Work

- Long-chain PFCAs were under LOQ in effluent and L-PFOA, PFHxA and PFHpA were the most dominants, the long-chain PFCAs are concentrated in sludge. With the exception of PFHxA as it ranks second in the sequence of decreased concentration of PFCAs in sludge.
- Long-chain PFASs were concentrated in sludge. In both effluent and sludge, PFOS linear and branched isomers were in the first and second ranks, but the br-PFOS was the dominant one in effluent, while the linear was the dominant in sludge. The ratio of linear to branched in effluent ranged between (0.3 to 1.58) while in sludge (1.37 to 5.64), this indicates that the branched isomer has less inclined to coagulate to the sludge.
- Precursors concentrations in effluents were very low and close to LOQ, with no detectable amount of the long-chain like 8:2diPAP and 10:2diPAP. In sludge long-chain precursors were concentrated, L-EtFOSAA were in the first order.
- More investigation is needed on the presence of an extent list of PFASs in effluents and

sludge and on the time trend of those PFASs.

- Although many long-chain PFASs find their way to the sludge but the remaining concentrations of precursors in effluents, in spite they are low but with the large amount of effluents more studies are needed to assess the risk and the fate of those precursors in the environment.
- A comparison of total PFAS concentrations in Effluent and sludge from different stations in Sweden shows the next order:

In the sludge: Bergkvara > Gässlösa > Henriksdal > Umeå > Ryaverket > Borlänge > Nohaga > Ellinge.

In the Effluent: Gässlösa > Umeå > Borlänge > Bergkvara > Henriksdal > Ellinge > Ryaverket > Nohaga.

## References

- <sup>1</sup>Giesy, J.P., Kannan, K., 2001. Global distribution of perfluorooctane sulfonate in wildlife. Environ. Sci. Technol. 35, 1339–1342. <sup>2</sup>Houde M, Martin JW, Letcher RJ, Solomon KR, Muir DCG. Biological monitoring of polyfluoroalkyl substances: A review, Environ. Sci. Technol. , 2006a, vol. 40 (pg. 3463-3473). <sup>3</sup>Olsen GW, Mair D, Reagen W, Ellefson ME, Ehresman DJ, Butenhoff JL, Zobel L. Pilot study to assess serum fluorochemical concentrations in American Red Cross blood donors, 2005, 2006 Final Report, 3M Medical Department, January 9, 2006. US EPA Administrative Record, AR-226-3666. <sup>4</sup>DeWitt, J.C. (Ed.), Toxicological Effects of Perfluoroalkyl and Polyfluoroalkyl Substances, Humana Press Heidelberg, New York, Dordrecht, London (2015).