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

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Perfluorinated Acids (PFAs)

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

Objective
- To assess the presence of perfluorooalky 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 PFASs analyzed in sludge plus branched1

10 mL of sludge
Spike with ISTD
SPE Oasis HLB Plus
Extract with MeOH

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.

Perfluoroalkyl carboxylic acid (PFCA) Precursors
L-PFDoDA > L-PFOSA > L-EtFOSAA > L-MeFOSAA > L-FOSA > PFHxA

Perfluoroalkyl sulfonic acid (PFSA) Precursors
L-PFOS > L-TPFOS > L-1PfPS > L-2PfPS > L-PFOSA > PFHxS

PFOS Precursors
L-EFOSAA > br-EFOSAA > L-FOSA

PFCA Precursors
6:2 dPAP > 4:2 dPAP

Long-chain PFCA were under LOQ in effluent and L-PFOA, PFHxA and PFHxS were the most dominant, the long-chain PFCA are concentrated in sludge. With the exception of PFHxA as it ranks second in the sequence of decreased concentration of PFCA in sludge. Long-chain PFCA 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 1.98) 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 8:2 dPAP and 10:2 dPAP. In sludge long-chain precursors were concentrated, L-EFOSAA were in the first order.

More investigation is needed on the presence of an extensive list of PFASs in effluents and sludge and on the time trend of those PFASs.

Although many long-chain PFAS 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 WWTP in Sweden shows the next order:
In the sludge: Beregvara > Gässlösa > Henriksdal > Umeå > Borlänge > Norhaga > Ellinge.
In the Effluent: Gässlösa > Umeå > Borlänge > Beregvara > Henriksdal > Ellinge > Ryavetket > Norhaga.

PFASs in Effluent

PFASs in Sludge

Concentration and Implications of this Work

References