Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences
Department of Aquatic Sciences and Assessment

Analysis of per- and polyfluoroalkyl substances (PFASs) and phenolic compounds in Swedish rivers over four different seasons

Analys av PFAS och fenolära ämnen i flodmynningar

Lutz Ahrens, Lisa Vogel, Karin Wiberg

Rapport till Naturvårdsverket
Överenskommelse NV-2213-16-011

Uppsala, 2018-03-09

NATIONELL MILJÖÖVERVAKNING PÅ UPPDRAG AV NATURVÅRDSVERKET	ÄRENDENNUMMER	NV-04887-16
	AVTALSNUMMER	2213-16-011
	PROGRAMOMRÅDE	Miljögifter akvatiskt
	DELPROGRAM	Utveckling och analys

Analys av PFAS och fenolära ämnen i flodmynningar

Rapportförfattare Lutz Ahrens, SLU Lisa Vogel, SLU Karin Wiberg, SLU	**Utgivare** Institutionen för vatten och miljö (IVM) Sveriges lantbruksuniversitet (SLU) **Postadress** Box 7050, 750 07 Uppsala **Telefon** 018-671000
Rapporttitel och undertitel Analys av PFAS och fenolära ämnen i flodmynningar	**Beställare** Naturvårdsverket 106 48 Stockholm **Finansiering** Nationell MÖ
Nyckelord för plats screening, svenska vattendrag, flodmynningar	
Nyckelord för ämne PFAS och fenolära ämnen	
Tidpunkt för insamling av underlagsdata 2016-09-01 – 2018-02-28	

Sammanfattning

Syftet med denna studie var att undersöka miljökoncentrationer, sammansättning, säsongsvariation och flöden av 28 PFAS-substanser och 10 fenolära ämnen i 10 svenska vattendrag över fyra olika årstider (oktober 2016, januari 2017, april 2017 och juli 2017). Totalt detekterades 7 av 28 PFAS-ämnen i relativt låga nivåer (i genomsnitt 3,2 ng per liter för Σ_{28}PFAS) i flodvatten (n = 40). Koncentrationerna av de fenolära föreningarna var generellt högre (genomsnittshalt 230 ng per liter för summan av alla fenoler som mättes; n = 38). Detektionsfrekvensen var dock låg (i genomsnitt 50%), vilket resulterade i låga mediankoncentrationer för summahalten (0 ng per liter). De dominerande PFAS-substanserna var perfluorbutansulfonsyra (PFBS, 38% av Σ_{28}PFAS), perfluoroktansyra (PFOA, 21%) och perfluoroktansulfonsyra (PFOS (grenad), 8,9%) medan de dominerande fenolära föreningarna var 4-nonylfenol (4-NP, 67%), 4-tert-nonylfenol-dietoxilat (4-NP-EO2, 20%) och 2,4,6-tribromfenol (TBP, 10%). Koncentrationerna av PFAS och fenolföreningar uppvisade ingen säsongsvariation under de fyra undersökta årstiderna, vilket indikerar ett relativt stabilt flöde av dessa två ämnesklasser till vattendragen. De uppmätta PFAS-koncentrationerna var inte relaterade till koncentrationerna av fenolära föreningarna, vilket indikerar olika källor för de två ämnesklasserna. Flödena för totalhalterna uppskattades till 220 g per dag (81 kg per år) för Σ_{28}PFAS, och >70 gånger högre för de fenolära ämnena med totalflöden på 16000 g per dag (5700 kg per år). Miljökvalitetsstandarden för ett årligt genomsnitt (AA-EQS) som anges i EU: s ramdirektiv för vatten (WFD) överskreds för 33% (n = 13) av vattenproverna för summan av linjära och grenade PFOS och för 13% (n = 5) av för 4-NP. Detta indikerar att halterna av PFOS och 4-NP utgör en potentiell risk för vattenmiljön. AA-EQS för 4-oktylfenol (4-OP) och pentaklorfenol (PCP) överskreds inte i något fall.

Summary

Per- and polyfluoroalkyl substances (PFASs) and phenolic compounds are emerging organic pollutants characterized by their persistency, bioaccumulation and toxicity potential. In this study, 28 PFASs and 10 phenolic compounds were investigated in 10 Swedish rivers over four different seasons (October 2016, January 2017, April 2017 and July 2017). The objective was to investigate the levels, composition profiles, sesonal trends and fluxes for both compound classes. In total, 7 out of 28 PFASs and 9 out of 10 phenolic compounds were detected in surface water from the 10 rivers. The average concentration in all samples was 3.2 ng L^{-1} for $\sum_{28}$PFASs (median 2.4 ng L^{-1}, n = 40), while 230 ng L^{-1} for the sum of the phenolic compounds (median 0 ng L^{-1}, n = 38). Highest average $\sum_{28}$PFAS concentrations were found in Rönneån with 10 ng L^{-1} (median 11 ng L^{-1}), followed by Norrström with 9.0 ng L^{-1} (median 9.1 ng L^{-1}), whereas no PFASs were detected in Umeå älv and Ångermanälven. On the other hand, highest average of the sum of the phenolic compound concentrations were found in Nyköpingsån with 1500 ng L^{-1} (median 57 ng L^{-1}), while for the other rivers the average ranged between 50 ng L^{-1} and 140 ng L^{-1}, except for Emån where TBP was only detected in one sample with 0.33 ng L^{-1}. This indicates that PFASs and phenolic compounds origin from different sources. The dominant PFASs were perfluorobutane sulfonic acid (PFBS, 38 % of the $\sum_{28}$PFASs), perfluorooctanoic acid (PFOA, 21 %), and perfluorooctane sulfonic acid (PFOS (branched), 8.9 %), while the dominant phenolic compounds were 4-nonylphenol (4-NP, 67 %), 4-tert-nonylphenol-diethoxylate (4-NP-EO2, 20 %), and 2,4,6-tribromophenol (TBP, 10 %). The concentrations of PFASs and phenolic compounds were relatively constant during the four investigated seasons which indicates a relatively steady input of these two compound classes into the river systems. The daily fluxes of Σ_{28}PFAS was estimated to be in total 220 g d^{-1} (81 kg $year^{-1}$), whereas the daily fluxes of phenolic compounds was estimated to be 16000 g d^{-1} (5700 kg $year^{-1}$) for all 10 investigated rivers. The Annual Average Environmental Quality Standard (AA-EQS) of the EU Water Framework Directive (WFD) was exceeded in 33% (n = 13) of the surface water samples for the sum of linear and branched PFOS and in 13% (n = 5) of the surface water samples for 4-NP. This indicates that there is a potential risk for the aquatic environment. The AA-EQS of 4-octylphenol (4-OP) and pentachlorophenol (PCP) was not exceeded in any surface water sample.

1. Introduction

Per- and polyfluoroalkyl substances (PFASs) and phenolic compounds (e.g. alkylphenols, bisphenol A and triclosan) are emerging classes of compounds and have received increasing attention due to their persistency, bioaccumulation and toxicity potential (Giesy et al., 2010, Oehlmann et al., 2000). PFASs and phenolic compounds are used for a variety of industry and consumer products. PFASs, for example, have been used in dirt repellent for textiles or paper, and aqueous fire-fighting foams (AFFFs) (Buck et al., 2011), while phenolic compounds have been used in formulations such as detergents, emulsifiers, dispersants, antifoamers, and dyeing assists (Bennie, 1999). Due to their extensive usage, PFASs and phenolic compounds have been detected ubiquitously in the environment, humans and wildlife (Ahrens, 2011, Ahrens and Bundschuh, 2014, Bolz et al., 2001). Important point sources to the aquatic ecosystem are, for example, sewage treat-ment plants (STP) and landfills, while among diffuse sources, atmospheric deposition is considered to be important (Bennie, 1999, Ahrens and Bundschuh, 2014, Ahrens et al., 2015, Voutsa et al., 2006).

Among the PFASs, PFOS is included in the EU Water Framework Directive (WFD) with an Annual Average Environmental Quality Standard (AA-EQS) of 0.65 ng L^{-1} (The European Parliament and of the Council, 2013/39/EU). Among the phenolic compounds, nonylphenols, octylphenols, and pentachlorophenol are included in the EU WFD with AA-EQS of 300 ng L^{-1}, 100 ng L^{-1}, and 400 ng L^{-1} (The European Parliament and of the Council, 2013/39/EU). The Swedish National Food Agency has issued risk management recommendations for PFASs in drinking water, and these include 11 PFASs (i.e. PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFBS, PFHxS, PFOS, and 6:2 FTSA) with an action limit of 90 ng L^{-1} and a health-based guidance value of 900 ng $L^{-1}$for $\sum_7$PFASs (Swedish National Food Agency, 2018).

The aim of the current project was to investigate the occurrence of 28 PFASs and 10 phenolic compounds in 10 Swedish rivers. In addition, composition profiles, sesonal trends and fluxes were evaluated for both compound classes. The sampling was performed over four seasons including October 2016, January 2017, April 2017 and July 2017 and analysed by the POPs laboratory at the Department of Aquatic Sciences and Assessment (IVM) at the Swedish University of Agricultural Sciences (SLU), Uppsala.

2. Materials and methods

2.1 Chemicals

In total, 28 PFASs were included for analysis: four PFSAs (PFBS, PFHxS, PFOS, PFDS), 13 PFCAs (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTriDA, PFTeDA, PFHxDA, PFOcDA), three perfluorooctane sulfonamides (FOSAs) (FOSA, MeFOSA EtFOSA), two perfluorooctane sulfonamidoethanols (FOSEs) (MeFOSE, EtFOSE), three perfluorooctane sulfonamidoacetic acids (FOSAAs) (FOSAA, MeFOSAA, EtFOSAA) and three fluorotelomer carboxylate (6:2 FTSA, 8:2 FTSA, 10:2 FTSA) (Table 1).

In addition, 16 internal standards (IS) were used, which were spiked to the water sample before extraction (i.e. $^{13}C_8$-FOSA, d_3-MeFOSAA, d_5-EtFOSAA, d_3-MeFOSA, d_5-EtFOSA, d_7-MeFOSE, d_9-EtFOSE, $^{13}C_4$-PFBA, $^{13}C_2$-PFHxA, $^{13}C_4$-PFOA, $^{13}C_5$-PFNA, $^{13}C_2$-PFDA, $^{13}C_2$-PFUnDA, $^{13}C_2$-PFDoDA, $^{18}O_2$-PFHxS, $^{13}C_4$-PFOS).

Table 1. PFAS target compounds

Substance	Acronym	Molecular formula
PFCAs		
Perfluorobutanoic acid	PFBA	$C_3F_7CO_2H$
Perfluoropentanoic acid	PFPeA	$C_4F_9CO_2H$
Perfluorohexanoic acid	PFHxA	$C_5F_{11}CO_2H$
Perfluorohepanoic acid	PFHpA	$C_6F_{13}CO_2H$
Perfluorooctanoic acid	PFOA	$C_7F_{15}CO_2H$
Perfluorononanoic acid	PFNA	$C_8F_{17}CO_2H$
Perfluorodecanoic acid	PFDA	$C_9F_{19}CO_2H$
Perfluoroundecanoic acid	PFUnDA	$C_{10}F_{21}CO_2H$
Perfluorododecanoic acid	PFDoDA	$C_{11}F_{23}CO_2H$
Perfluorotridecanoic acid	PFTrDA	$C_{12}F_{25}CO_2H$
Perfluorotetradecanoic acid	PFTeDA	$C_{13}F_{27}CO_2H$
Perfluorohexadecanoic acid	PFHxDA	$C_{15}F_{31}CO_2H$
Perfluorooctadecanoic acid	PFOcDA	$C_{17}F_{35}CO_2H$
PFSAs		
Perfluorobutane sulfonic acid	PFBS	$C_4F_9SO_3H$
Perfluorohexane sulfonic acid	PFHxS	$C_6F_{13}SO_3H$
Perfluorooctane sulfonic acid	PFOS	$C_8F_{17}SO_3H$
Perfluorodecane sulfonic acid	PFDS	$C_{10}F_{21}SO_3H$
FASAAs		
Perfluorooctane sulfonamidoacetic acid	FOSAA	$C_8F_{17}SO_2N(CH_2CO_2H)H$
N-methylperfluoro-1-octanesulfonamidoacetic acid	MeFOSAA	$C_8F_{17}SO_2N(CH3)CH_2CO_2H$
N-ethylperfluoro-1-octanesulfonamidoacetic acid	EtFOSAA	$C_8F_{17}SO_2N(C_2H_5)CH_2CO_2H$
FOSAs		
Perfluorooctane sulfonamide	FOSA	$C_8F_{17}SO_2NH_2$
N-methylperfluoro-1-octansulfonamide	MeFOSA	$C_8F_{17}SO_2N(CH_3)H$
N-ethylperfluoro-1-octanesulfonamide	EtFOSA	$C_8F_{17}SO_2N(CH_2CH_3)H$
FOSEs		
2-(*N*-methylperfluoro-1-octanesulfonamido)-ethanol	MeFOSE	$C_8F_{17}SO_2N(CH_3)CH_2CH_2OH$
2-(*N*-ethylperfluoro-1-octanesulfonamido)-ethanol	EtFOSE	$C_8F_{17}SO_2N(C_2H_5)CH_2CH_2OH$
FTSAs		
6:2 fluorotelomer sulfonate	6:2 FTSA	$C_8H_4F_{13}SO_3H$

In addition, 10 phenolic substances were analysed including 4-octylphenol (4-OP), 4-tert-octylphenol-monoethoxylate (4-OP-EO1), 4-tert-octylphenol-diethoxylate (4-OP-EO2), 4-nonylphenol (4-NP), 4-tert-nonylphenol-monoethoxylate (4-NP-EO1), 4-tert-nonylphenol-diethoxylate (4-NP-EO2), 2,4,6-tribromophenol (TBP), pentachlorophenol (PCP), triclosan (TCS), and bishenol A (BPA) (Table 2).

Table 2. Phenolic target compounds

Substance	Acronym	Molecular formula
4- Octylphenol	4-OP	$C_{14}H_{22}O$
4-Tert-octylphenol-monoethoxylate	4-OP-EO1	$C_{16}H_{26}O_2$
4-Tert-octylphenol-diethoxylate	4-OP-EO2	$C_{18}H_{30}O_3$
4-Nonylphenol	4-NP	$C_{15}H_{24}O$
4-Tert-nonylphenol-monoethoxylate	4-NP-EO1	$C_{17}H_{28}O_2$
4-Tert-nonylphenol-diethoxylate	4-NP-EO2	$C_{19}H_{32}O_3$
2,4,6-Tribromophenol	TBP	$C_6H_3Br_3O$
Pentachlorophenol	PCP	C_6HCl_5O
Triclosan	TCS	$C_{12}H_7Cl_3O_2$
Bishenol A	BPA	$C_{15}H_{16}O_2$

2.2 Sampling sites and sampling

Surface water samples were collected at 10 sampling sites at the river mouth over four seasons including October 2016, January 2017, April 2017 and July 2017 (Table A1 in the Appendix). The 10 sampling sites included: Ume älv (Stornorrfors), Ångermanälven, Delångersån (Iggesund), Norrström, Nyköpingsån, Emån, Mörrumsån, Rönneån, Göta älv (Alelyckan), and Nordre älv. In total, 40 samples were analysed for PFASs, plus 4 triplicates, 5 field blanks, and 4 laboratory blanks. In addition, 38 samples (two brown glass bottles broke during shipment) + 4 triplicates + 7 field blanks were analysed for phenolic substances. The sampling sites were selected together by the Swedish EPA and IVM (SLU, Uppsala), based on the knowledge of elevated PFAS levels in these rivers. The water samples were collected at about 10 cm below the water surface using 1 L polypropylene (PP) bottles for PFASs and 1 L brown glass bottles for phenolic compounds. All PP and brown glass bottles were rinsed three times with the sample water before the bottles was completely filled. The water samples were stored a 4°C until analysis. Field blanks were collected by opening the PP or brown glass bottles shortly at the sampling site and then treating them like real samples.

2.3 PFAS analysis

All samples were analyzed by the POPs-lab at IVM (SLU, Uppsala). The samples were analysed according to methods described previously (Ahrens et al., 2009). Briefly, the water samples were filtered through glass fibre filters (Whatman™ Glass Microfiber Filters GF/C™, 47 mm diameter, 1.2 μm). The extraction was performed using solid phase extraction (SPE) with Oasis® WAX cartridges (6 cm^3, 150 mg, 30 μm, Waters, Massachusetts, USA). Before extraction, the cartridges were preconditioned with 4 mL 0.1% ammonium hydroxide, 4 mL methanol and 4 mL Millipore water. The samples were spiked with 100 μL IS mixture (c = 20 pg μL^{-1}), and each loaded onto the cartridge. The flow was regulated to a flow of one drop per second. After loading (~300 mL), the cartridges were washed with 4 mL of 25 mM ammonium acetate buffer (pH 4) and dried by centrifugation for 2 minutes at 3000 rpm. The cartridges were then eluted into 15 mL PP-tubes by adding 4 mL methanol, followed by 8 mL 0.1% ammonium hydroxide in methanol. The samples were placed under nitrogen evaporation (N-EVAP™ 112) to concentrate the sample to 0.5 mL using a gentle stream of nitrogen gas. Before analysis, 0.5 mL Millipore water was added and then subsequently analysed using high performance liquid chromatography-mass spectrophotometry (HPLC-MS/MS) according to the method described by Ahrens et al. (2009). For PFHxS, PFOS and FOSA, the linear and branched isomers were quantified separately. The concentrations of the branched isomers should be considered as semi-quantitative since they were quantified using the corresponding linear isomer due to lack of standards.

2.4 Analysis of phenolic compounds

The analysis was performed by validated methods from the Swedish Environmental Institute (IVL) (www.ivl.se).

2.5 Blanks and method detection limits (MDLs)

For PFASs, no differences were observed between field and laboratory blanks and therefore both blanks were evaluated together (n = 9). The average blank levels ranged between not detected to 0.41 ng absolute. The method detection limits (MDLs) ranged between 0.16 to 2.5 ng L^{-1} (for details see Table 3)

Table 3 Blank concentrations and method detection limits (MDLs) for PFASs[a]

Compound	**Average blank (ng absolute, *n* = 9)**	**MDL (ng L^{-1})**
PFBA	0.36	2.5
PFPeA	0.41	1.4
PFHxA	0.22	0.77
PFHpA	0.014	0.18
PFOA	0.020	0.21
PFNA	0.0019	0.16
PFDA	0.0039	0.16
PFUnDA	0.0080	0.16
PFDoDA	0.0012	0.16

PFTriDA	0.0032	0.16
PFTeDA	0.028	0.91
PFHxDA	0.067	0.60
PFOcDA	0.048	0.87
PFBS	0.00056	0.16
PFHxS (linear)	0.015	0.16
PFHxS (branched)	0.0068	0.16
PFOS (linear)	0.038	0.49
PFOS (branched)	0.022	0.25
PFDS	0.0034	0.16
FOSA (linear)	0.027	0.16
FOSA (branched)	0.015	0.16
Me-FOSA	0.0078	0.19
Et-FOSA	0.0088	0.22
Me-FOSE	0.0089	0.16
Et-FOSE	0.0088	0.16
FOSAA	0.019	0.24
Me-FOSAA	0.010	0.16
Et-FOSAA	0.013	0.16
6:2 FTSA	0.025	0.23
8:2 FTSA	ND	0.16
10:2 FTSA	0.0068	0.16

[a] ND = not detected

For phenolic compounds, the average blank levels ranged between not detected to 70 ng absolute. The method detection limits (MDLs) ranged between 0.013 to 407 ng L^{-1} (for details see Table 4).

Table 4 Blank concentrations and method detection limits (MDLs) for phenolic compounds[a]

Compound	**Average blank (ng absolute, *n* = 7)**	**MDL (ng L^{-1})**
4-OP	ND	0.47
4-OP-EO1	ND	0.93
4-OP-EO2	0.15	0.92
4-NP	ND	5.5
4-NP-EO1	ND	7.5
4-NP-EO2	70	407
TBP	0.033	0.29
PECP	ND	0.013
TCS	ND	6.2
BPA	ND	21

[a] ND = not detected

2.6 Calculation of river fluxes

Fluxes were calculated based on the measured concentration of individual target compound multiplied with the average river flow for Ume älv (367 m^3 s^{-1}), Ångermanälven (399 m^3 s^{-1}), Delångersån (12 m^3 s^{-1}), Norrström (118 m^3 s^{-1}), Nyköpingsån (13 m^3 s^{-1}), Emån (15 m^3 s^{-1}), Mörrumsån (18 m^3 s^{-1}), Rönneån (9.0 m^3 s^{-1}), Göta älv (Alelyckan) (173 m^3 s^{-1}), and Nordre älv (403 m^3 s^{-1}). It is important to note that the flux calculation is subject to uncertainties such as varying compound concentration and water flow over time.

3. Results and discussion

3.1 PFAS concentrations, composition profile, sesonal variations and fluxes

In total, 7 out of 28 PFASs were detected in surface water from the 10 rivers (Table A2 in the Appendix). The average concentration of $\sum_{28}$PFASs in all samples was 3.2 ng L^{-1} and the median 2.4 ng L^{-1} (n = 40). The PFASs with the highest detection frequency in all samples were PFBS (70%), PFOA (65%), PFOS (branched) (33%), PFHpA (28%), and PFHxS (linear) (20%). Highest average $\sum_{28}$PFAS concentrations were found in Rönneån with 10 ng L^{-1} (median 11 ng L^{-1}), followed by Norrström with 9.0 ng L^{-1} (median 9.1 ng L^{-1}) (Figure 1). No PFASs were detected in Umeå älv and Ångermanälven.

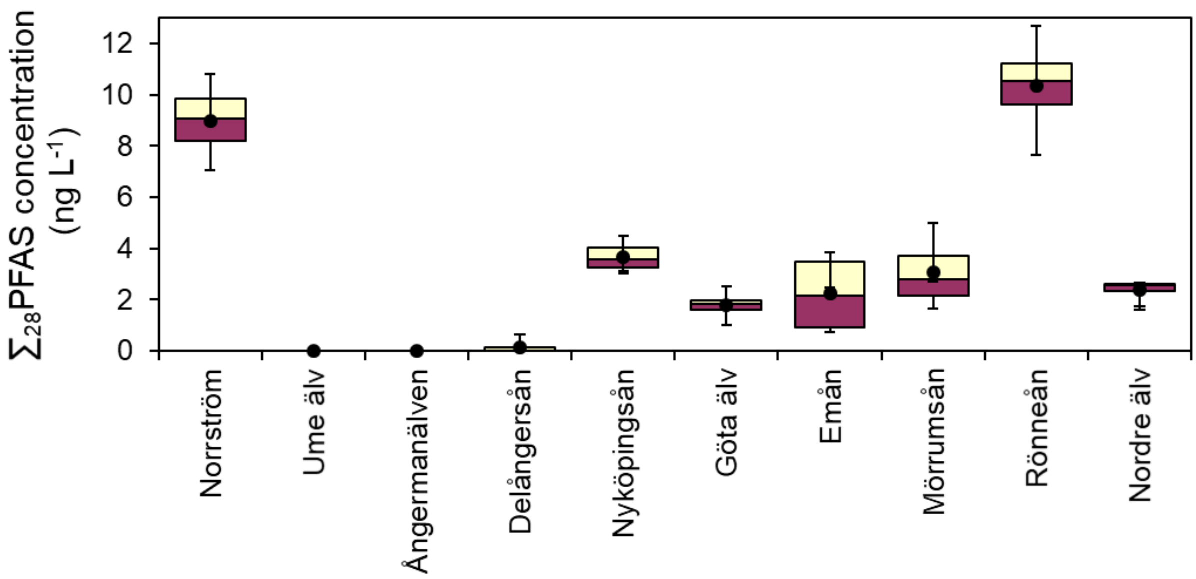

Figure 1. Box-and-whisker plots for $\sum_{28}$PFAS concentrations in surface water of 10 Swedish rivers.

The composition profile of the PFASs differed between the rivers (Figure 2). The highest composition of the $\sum_{28}$PFASs had PFBS (38 %), PFOA (21%), PFOS (branched) (8.9 %), PFHpA (4.3 %), PFOS (linear) (4.0 %), and PFHxS (linear) (3.3 %). The composition of the other PFASs was generally <1 %.

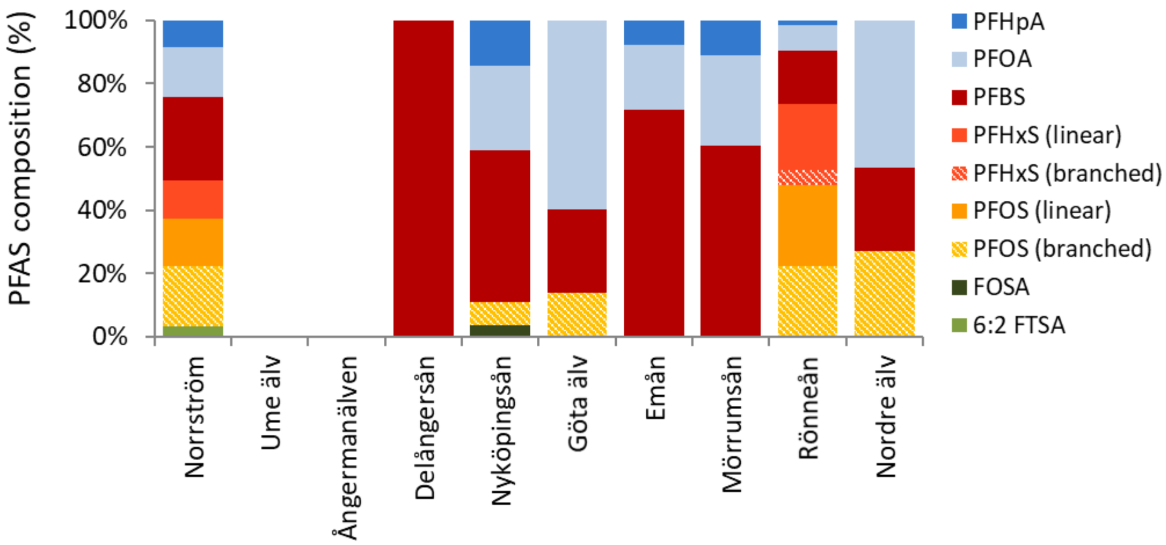

Figure 2. Composition profiles (%) for individual PFASs in surface water of 10 Swedish rivers.

A comparison of the PFAS concentrations during the four seasons October 2016, January 2017, April 2017 and July 2017 is shown in Figure 3. The PFAS concentrations were generally stable over one year. This can be explained by the fact that main PFASs sources such as STP effluents are relatively stable over time (Gago-Ferrero et al., 2017).

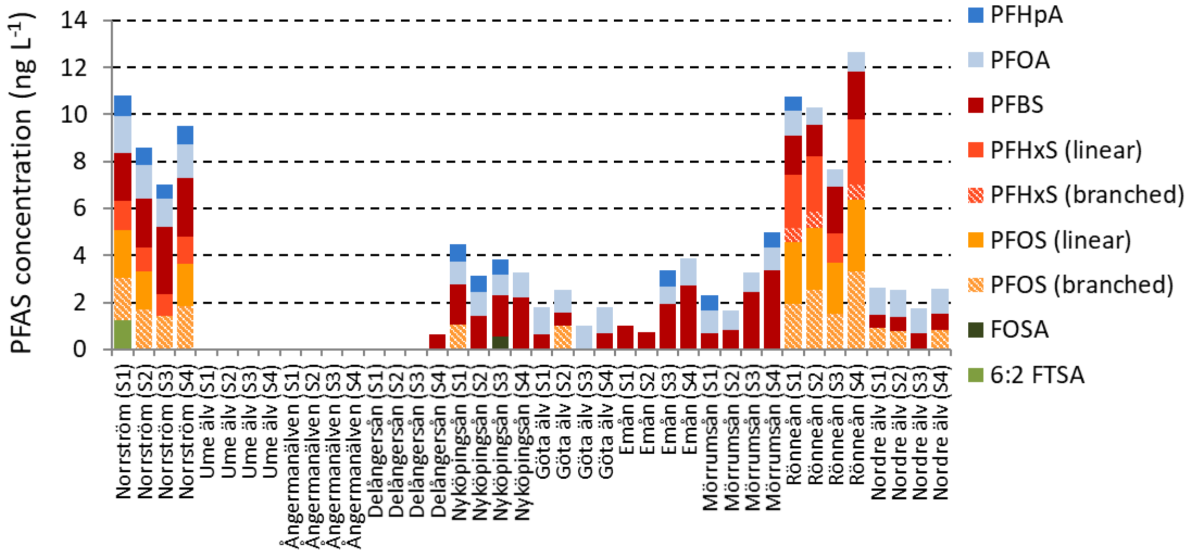

Figure 3. Individual PFAS concentrations in surface water of 10 Swedish rivers for the seasons October 2016 (S1), January 2017 (S2), April 2017 (S3) and July 2017 (S4).

PFOS has an AA-EQS value of 0.65 ng L^{-1} for fresh water systems (The European Parliament and of the Council, 2013/39/EU) . The AA-EQS was exceeded in 33% (*n* = 13) of the surface water samples considering the sum of linear and branched PFOS (Figure 4).

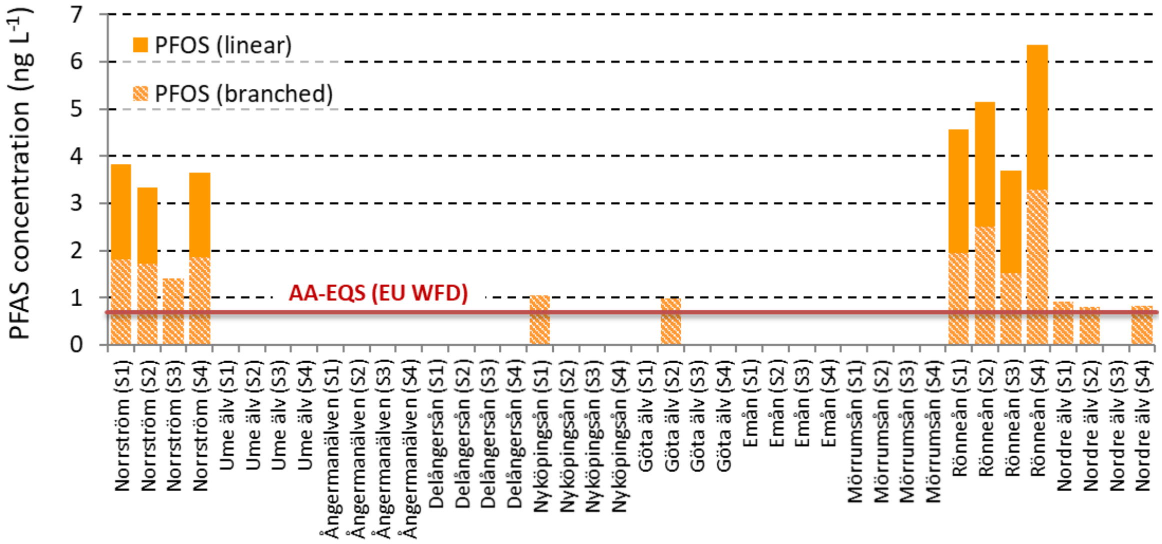

Figure 4. Linear and branched PFOS concentrations in surface water of 10 Swedish rivers for the seasons October 2016 (S1), January 2017 (S2), April 2017 (S3) and July 2017 (S4) and Annual Average Environmental Quality Standard (AA-EQS) of PFOS (0.65 ng L^{-1}) based on the EU Water Framework Directive (WFD).

The daily fluxes of Σ_{28}PFAS was estimated to range between 0 and 92 g d^{-1} with in total 220 g d^{-1} for all 10 investigated rivers (Figure 5, Table A3 in the Appendix). The yearly flux was estimated to range between 0 and 33 kg $year^{-1}$ with in total 81 kg $year^{-1}$ for all 10 investigated rivers.

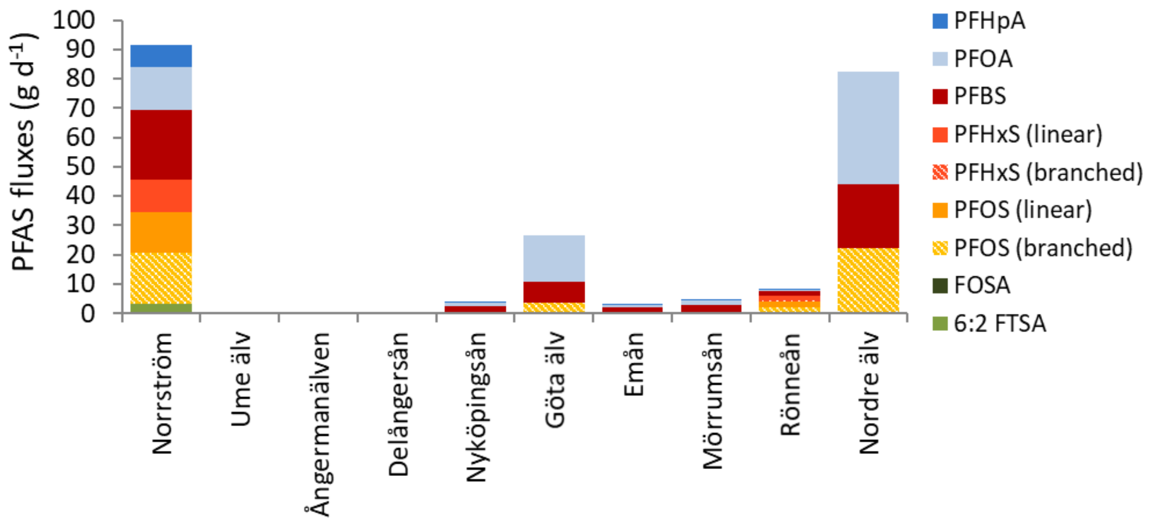

Figure 5. PFAS fluxes in g d^{-1} for individual compound in surface water of 10 Swedish rivers.

3.2 Phenolic compound concentrations, composition profile, sesonal variations and fluxes

In total, 9 out of 10 phenolic compounds were detected in surface water from the 10 rivers (Table A4 in the Appendix). The average concentration of the sum of the phenolic compounds in all samples was 230 ng L^{-1}, whereas the median was 0 ng L^{-1} (n = 38). The low median can be explained by the low detection frequency of 50% for the sum of the phenolic compounds. The phenolic compounds with the highest detection frequency in all samples were 4-NP (32 %), TBP (24 %), 4-OP-EO2 (7.9 %), BPA (5.3 %), and PCP (5.3 %). Highest average of the sum of the phenolic compound concentrations were found in Nyköpingsån with 1500 ng L^{-1} (median 57 ng L^{-1}), while the for the other rivers the average ranged between 50 ng L^{-1} and 140 ng L^{-1}, except for Emån where TBP was only detected in one sample with 0.30 ng L^{-1} (Figure 6).

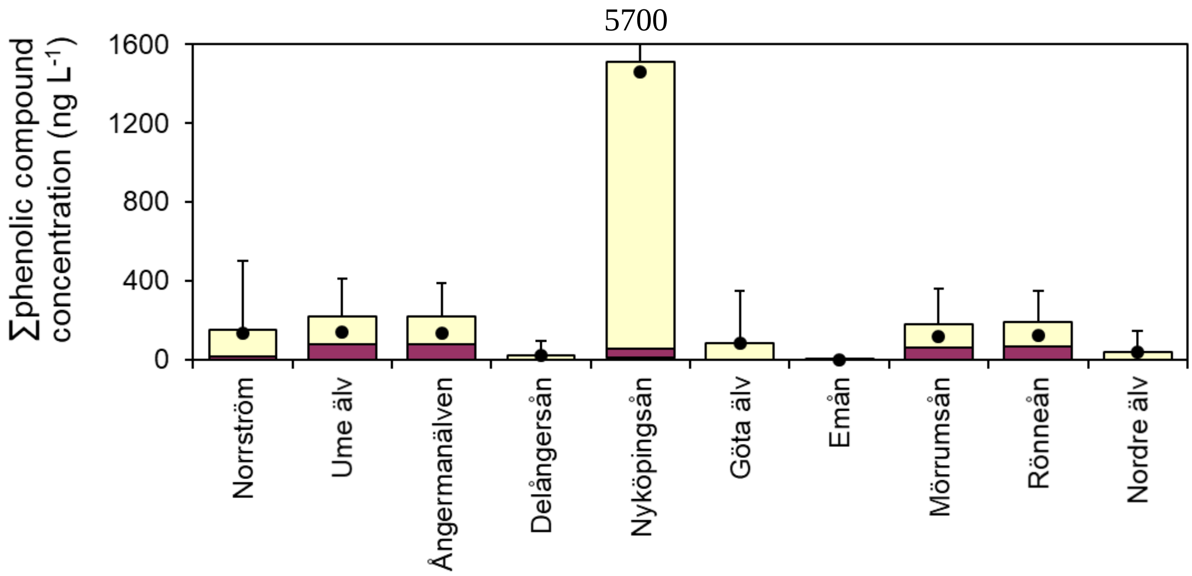

Figure 6. Box-and-whisker plots for phenolic compound concentrations in surface water of 10 Swedish rivers.

The composition profile of the phenolic compounds differed between the rivers (Figure 7). The highest composition of the sum of the phenolic compounds had 4-NP (67 %), 4-NP-EO2 (20 %), TBP (10 %), and BPA (2.6 %). The composition of the other phenolic compounds was generally <1 %.

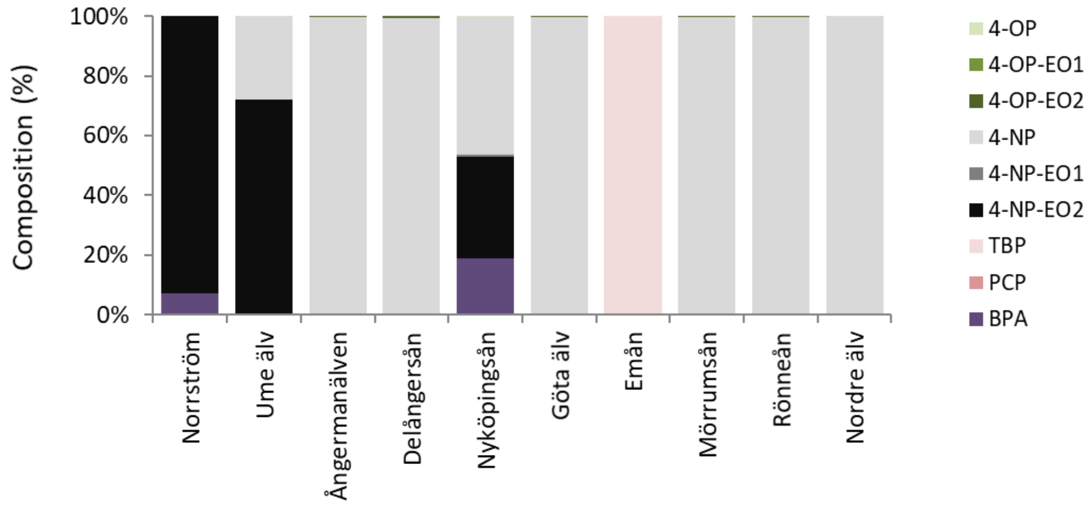

Figure 7. Composition profiles (%) for individual phenolic compounds in surface water of 10 Swedish rivers.

A comparison of the phenolic compound concentrations during the four seasons October 2016, January 2017, April 2017 and July 2017 is shown in Figure 8. In general, no seasonal trend could be observed. However, one sample at Nyköpingsån showed very high concentrations of the sum of the phenolic compounds (5700 ng L^{-1}) in April 2017, but not during the other seasons.

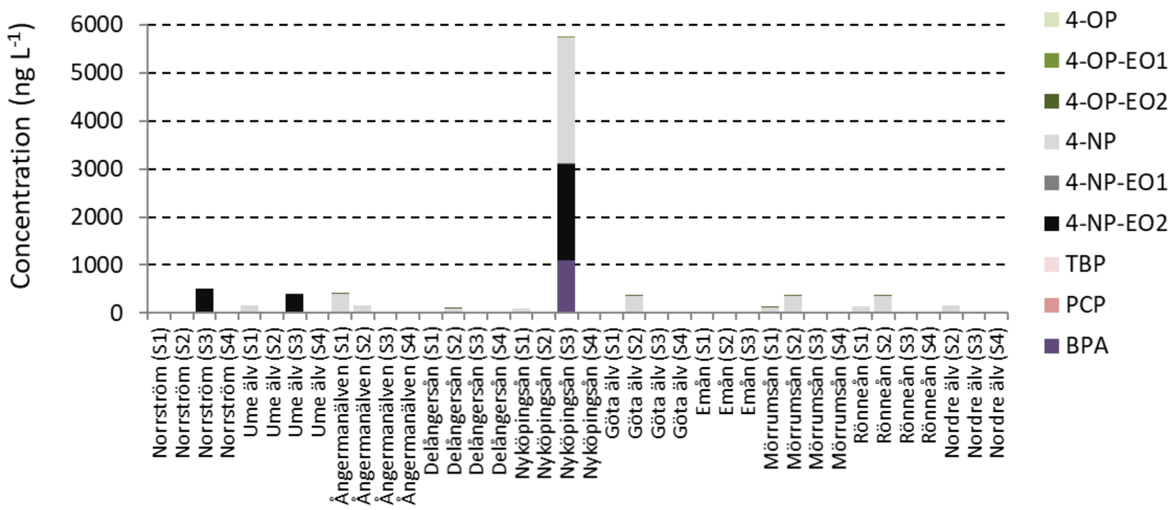

Figure 8. Individual phenolic compound concentrations in surface water of 10 Swedish rivers for the seasons October 2016 (S1), January 2017 (S2), April 2017 (S3) and July 2017 (S4).

Among the phenolic compounds, 4-NP, 4-OP, and PCP are included in the WFD with an AA-EQS of 300 ng L^{-1}, 100 ng L^{-1}, and 400 ng L^{-1} (The European Parliament and of the Council, 2013/39/EU). The AA-EQS of 4-NP was exceeded in 13% (n = 5) of the surface water samples (Figure 9). The AA-EQS of 4-OP and PCP ws not exceeded in any surface water sample (Figures 10 and 11).

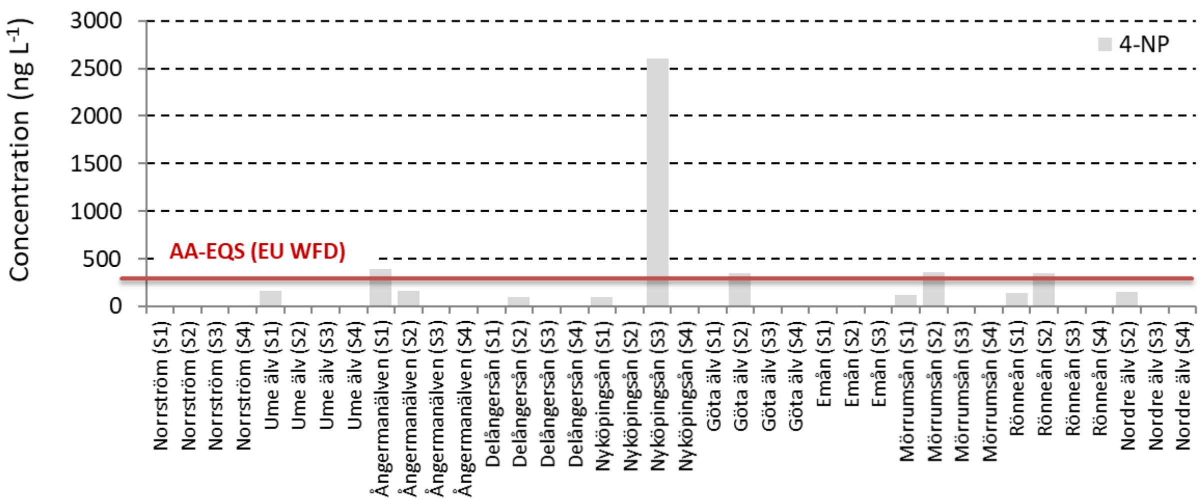

Figure 9. 4-nonylphenol (4-NP) in surface water of 10 Swedish rivers for the seasons October 2016 (S1), January 2017 (S2), April 2017 (S3) and July 2017 (S4) and Annual Average Environmental Quality Standard (AA-EQS) of 4-NP (300 ng L^{-1}) based on the EU Water Framework Directive (WFD).

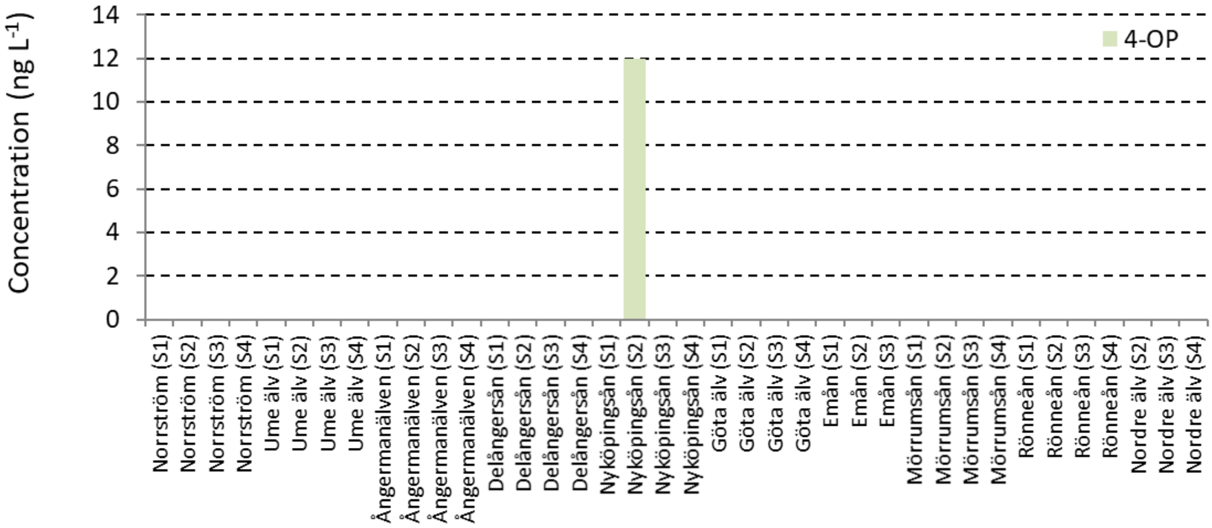

Figure 10. 4-octylphenol (4-OP) in surface water of 10 Swedish rivers for the seasons October 2016 (S1), January 2017 (S2), April 2017 (S3) and July 2017 (S4). The Annual Average Environmental Quality Standard (AA-EQS) of the EU Water Framework Directive (WFD) is 100 ng L^{-1} for 4-OP.

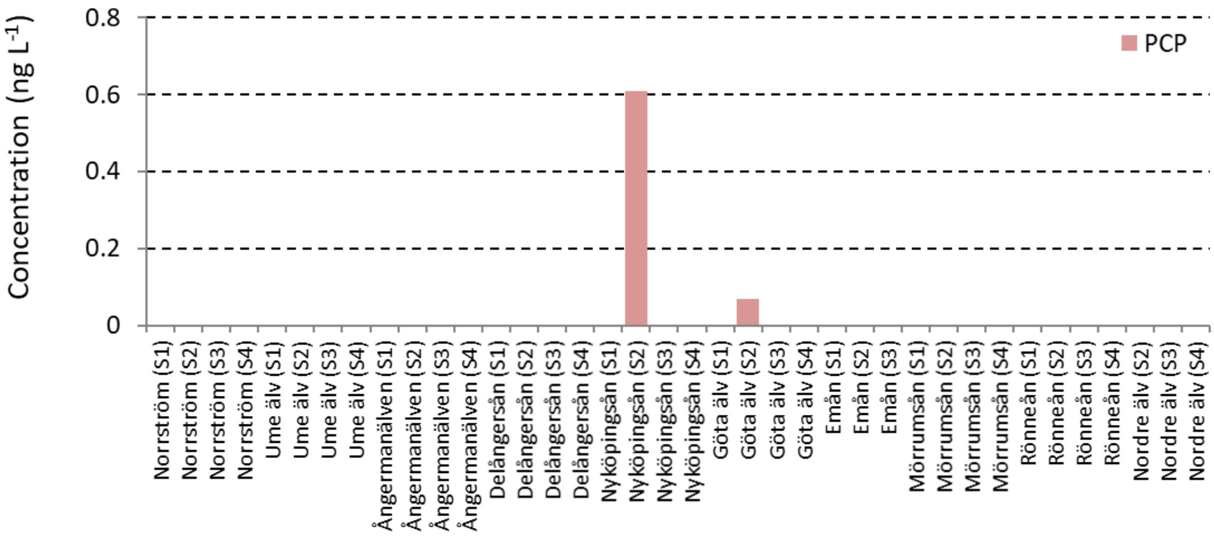

Figure 11. Pentachlorophenol (PCP) in surface water of 10 Swedish rivers for the seasons October 2016 (S1), January 2017 (S2), April 2017 (S3) and July 2017 (S4). The Annual Average Environmental Quality Standard (AA-EQS) of the EU Water Framework Directive (WFD) is 400 ng L^{-1} for PCP.

The daily fluxes of the sum of phenolic compounds was estimated to range between 0.13

and 4800 g d^{-1} with in total 16000 g d^{-1} for all 10 investigated rivers (Figure 12, Table A5 in the Appendix). The yearly flux was estimated to range between 0.049 and 1700 kg $year^{-1}$ with in total 5700 kg $year^{-1}$ for all 10 investigated rivers.

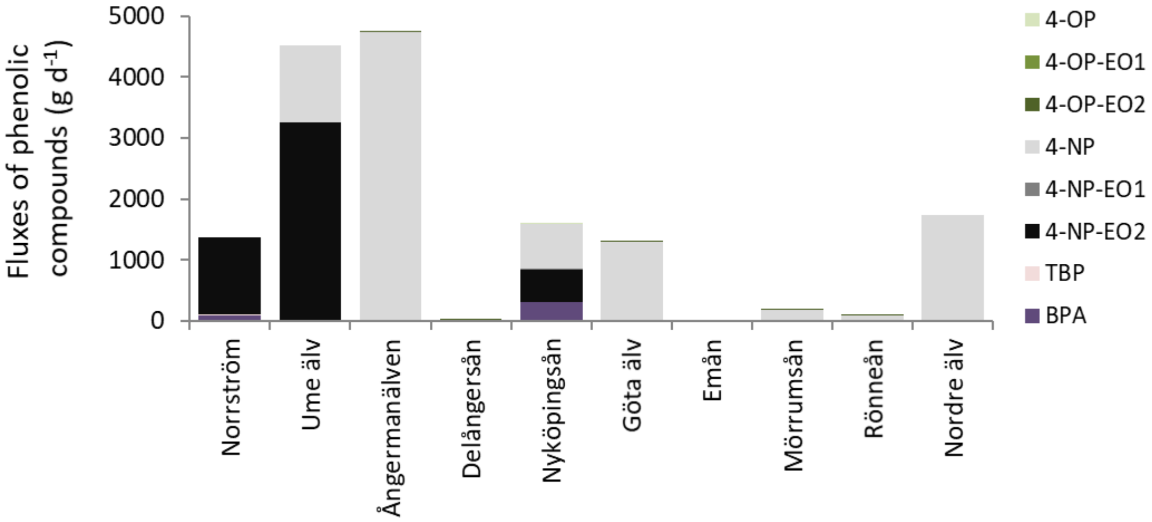

Figure 12. Fluxes of individual phenolic compound in g d^{-1} in surface water of 10 Swedish rivers.

References

1. Giesy, J.P., Naile, J.E., Khim, J.S., Jones, K.C., Newsted, J.L. 2010. Aquatic toxicology of perfluorinated chemicals. Rev Environ Contam T. 202, 1–52.
2. Oehlmann, J., Schulte-Oehlmann, U., Tillmann, M., Markert, B. 2000. Effects of endocrine disruptors on prosobranch snails (mollusca: Gastropoda) in the laboratory. Part I: Bisphenol A and octylphenol as xeno-estrogens. Ecotoxicology. 9, 383–97.
3. Buck, R.C., Franklin, J., Berger, U., Conder, J.M., Cousins, I.T., De Voogt, P., Jensen, A.A., Kannan, K., Mabury, S.A., Van Leeuwen, S.P.J. 2011. Perfluoroalkyl and polyfluoroalkyl substances in the environment: Terminology, classification, and origins. Integr Environ Assess Manag. 7, 513–41.
4. Bennie, D.T. 1999. Review of the environmental occurrence of alkylphenols and alkylphenol ethoxylates. Water Qual Res J Can. 34, 79–122.
5. Ahrens, L. 2011. Polyfluoroalkyl compounds in the aquatic environment: A review of their occurrence and fate. J Environ Monitor. 13, 20–31.
6. Ahrens, L., Bundschuh, M. 2014. Fate and effects of poly- and perfluoroalkyl substances in the aquatic environment: A review. Environ Toxicol Chem. 33, 1921–9.
7. Bolz, U., Hagenmaier, H., Körner, W. 2001. Phenolic xenoestrogens in surface water, sediments, and sewage sludge from Baden-Württemberg, south-west Germany. Environ Pollut. 115, 291–301.
8. Ahrens, L., Norström, K., Viktor, T., Palm Cousins, A., Josefsson, S. 2015. Stockholm Arlanda Airport as a source of per- and polyfluoroalkyl substances to water, sediment and fish. Chemosphere. 129, 33–8.
9. Voutsa, D., Hartmann, P., Schaffner, C., Giger, W. 2006. Benzotriazoles, alkylphenols and bisphenol A in municipal wastewaters and in the Glatt River, Switzerland. Environ Sci Pollut R. 13, 333–41.
10. EU. European Parliament and Council, European Community Directive 2006/122/ECOF, Off. J. Eur. Union, 2006, L 372, 32-34 [
11. The European Parliament and of the Council. *Off J Eur Commun* EC Directive 2013/39/EU, in Amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy.
12. Swedish National Food Agency (Livsmedelsverket) 2018. Riskhantering - PFAA I dricksvatten. http://www.livsmedelsverket.se/livsmedel-och-innehall/oonskade-amnen/miljogifter/pfas-poly-och-perfluorerade-alkylsubstanser/riskhantering-pfaa-i-dricksvatten/ (28/02/2018).
13. Ahrens, L., Barber, J.L., Xie, Z., Ebinghaus, R. 2009. Longitudinal and latitudinal distribution of perfluoroalkyl compounds in the surface water of the Atlantic Ocean. Environ Sci Technol. 43, 3122–7.
14. Gago-Ferrero, P., Gros, M., Ahrens, L., Wiberg, K. 2017. Impact of on-site, small and large scale wastewater treatment facilities on levels and fate of pharmaceuticals, personal care products, artificial sweeteners, pesticides, and perfluoroalkyl substances in recipient waters. Sci Total Environ. 601-602, 1289–97.

Appendix

Table A1 Sampling details for the sampling sites

ID	Station name	SLU-site code	Latitude[a]	Longitude[a]	Sampling date	Sampling time
October 2016						
PFAS - AC1017-1	Ume älv (Stornorrfors)	AC1017	7090408	748141	2016-10-17	08:15
PFAS - Y0022-1	Ångermanälven	Y0022	7006749	614061	2016-10-18	12:40
PFAS - X0027-1[b]	Delångersån (Iggesund)	X0027	6835609	610559	2016-10-12	11:30
PFAS - AB0037-1	Norrström	AB0037	6580488	674315	2016-10-14	08:00
PFAS - D0040-1	Nyköpingsån	D0040	6520892	611899	2016-10-12	10:00
PFAS - H0044-1	Emån	H0044	6334282	587847	2016-10-11	13:00
PFAS - K0047-1	Mörrumsån	K0047	6227369	484539	2016-10-25	NA
PFAS - M0053-1	Rönneån	M0053	6221174	384636	2016-10-20	09:25
PFAS - O0069-1	Göta älv (Alelyckan)	O0069	6406625	321848	2016-10-18	09:40
PFAS - O0075-1[c]	Nordre älv	O0075	6415821	316588	2016-10-18	10:40
January 2017						
PFAS - AC1017-2	Ume älv (Stornorrfors)	AC1017	7090408	748141	2017-02-06	NA
PFAS - Y0022-2	Ångermanälven	Y0022	7006749	614061	2017-01-13	13:13
PFAS - X0027-2[b]	Delångersån (Iggesund)	X0027	6835609	610559	2017-01-17	11:20

PFAS - AB0037-2	Norrström	AB0037	6580488	674315	2017-01-17	08:20
PFAS - D0040-2	Nyköpingsån	D0040	6520892	611899	2017-01-19	11:05
PFAS - H0044-2	Emån	H0044	6334282	587847	2017-01-17	13:20
PFAS - K0047-2	Mörrumsån	K0047	6227369	484539	2017-01-16	13:00
PFAS - M0053-2	Rönneån	M0053	6221174	384636	2017-01-18	12:45
PFAS - O0069-2	Göta älv (Alelyckan)	O0069	6406625	321848	2017-01-17	09:50
PFAS - O0075-2	Nordre älv	O0075	6415821	316588	2017-01-17	11:10
April 2017						
PFAS - AC1017-3	Ume älv (Stornorrfors)	AC1017	7090408	748141	2017-04-11	08:00
PFAS - Y0022-3	Ångermanälven	Y0022	7006749	614061	2017-04-10	14:00
PFAS - X0027-3[b]	Delångersån (Iggesund)	X0027	6835609	610559	2017-04-10	08:45
PFAS - AB0037-3	Norrström	AB0037	6580488	674315	2017-04-18	17:00
PFAS - D0040-3	Nyköpingsån	D0040	6520892	611899	2017-04-12	10:35
PFAS - H0044-3	Emån	H0044	6334282	587847	2017-05-08	14:00
PFAS - K0047-3	Mörrumsån	K0047	6227369	484539	2017-04-19	07:30
PFAS - M0053-3	Rönneån	M0053	6221174	384636	2017-04-20	08:05
PFAS - O0069-3	Göta älv (Alelyckan)	O0069	6406625	321848	2017-04-11	09:40
PFAS - O0075-3	Nordre älv	O0075	6415821	316588	2017-04-12	NA
July 2017						
PFAS - AC1017-4	Ume älv (Stornorrfors)	AC1017	7090408	748141	2017-07-12	16:00
PFAS - Y0022-4	Ångermanälven	Y0022	7006749	614061	2017-07-24	13:28

PFAS - X0027-4[b]	Delångersån (Iggesund)	X0027	6835609	610559	2017-07-03	09:40
PFAS - AB0037-4	Norrström	AB0037	6580488	674315	2017-07-12	09:45
PFAS - D0040-4	Nyköpingsån	D0040	6520892	611899	2017-07-12	09:20
PFAS - H0044-4[c]	Emån	H0044	6334282	587847	2017-07-11	11:10
PFAS - K0047-4	Mörrumsån	K0047	6227369	484539	2017-07-13	13:30
PFAS - M0053-4	Rönneån	M0053	6221174	384636	2017-07-19	13:30
PFAS - O0069-4	Göta älv (Alelyckan)	O0069	6406625	321848	2017-07-20	09:18
PFAS - O0075-4	Nordre älv	O0075	6415821	316588	2017-07-20	11:00

[a] SWEREF99. [b] Triplicates. [c] Brown glass bottle broke, so no data available for phenolic compounds.

Table A2 Levels of detected PFASs in Swedish rivers (ng L^{-1})[a]

Station name	ID	PFHpA	PFOA	PFBS	PFHxS (linear)	PFHxS (branched)	PFOS (linear)	PFOS (branched)	FOSA	6:2 FTSA	ΣPFASs
October 2016											
Ume älv (Stornorrfors)	AC1017-1	<0.18	<0.21	<0.16	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	ND
Ångermanälven	Y0022-1	<0.18	<0.21	<0.16	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	ND
Delångersån (Iggesund)	X0027-1-AVG	<0.18	<0.21	<0.16	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	ND
Norrström	AB0037-1	0.89	1.6	2.0	1.2	<0.16	2.0	1.8	<0.16	1.2	11
Nyköpingsån	D0040-1	0.74	1.0	1.7	<0.16	<0.16	<0.49	1.1	<0.16	<0.23	4.5
Emån	H0044-1	<0.18	<0.21	0.98	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	0.98
Mörrumsån	K0047-1	0.67	0.94	0.71	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	2.3
Rönneån	M0053-1	0.62	1.0	1.6	2.3	0.62	2.6	2.0	<0.16	<0.23	11
Göta älv (Alelyckan)	O0069-1	<0.18	1.2	0.65	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	1.8
Nordra älv	O0075-1	<0.18	1.2	0.54	<0.16	<0.16	<0.49	0.93	<0.16	<0.23	2.6
January 2017											
Ume älv (Stornorrfors)	AC1017-2	<0.18	<0.21	<0.16	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	ND
Ångermanälven	Y0022-2	<0.18	<0.21	<0.16	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	ND
Delångersån (Iggesund)	X0027-2-AVG	<0.18	<0.21	<0.16	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	ND
Norrström	AB0037-2	0.74	1.4	2.11	0.98	<0.16	1.6	1.7	<0.16	<0.23	8.6
Nyköpingsån	D0040-2	0.69	0.99	1.4	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	3.1
Emån	H0044-2	<0.18	<0.21	0.73	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	0.73
Mörrumsån	K0047-2	<0.18	0.81	0.82	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	1.6
Rönneån	M0053-2	<0.18	0.75	1.3	2.3	0.72	2.6	2.5	<0.16	<0.23	10
Göta älv (Alelyckan)	O0069-2	<0.18	0.97	0.55	<0.16	<0.16	<0.49	0.99	<0.16	<0.23	2.5
Nordra älv	O0075-2	<0.18	1.1	0.60	<0.16	<0.16	<0.49	0.80	<0.16	<0.23	2.5
April 2017											
Ume älv (Stornorrfors)	AC1017-3	<0.18	<0.21	<0.16	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	ND
Ångermanälven	Y0022-3	<0.18	<0.21	<0.16	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	ND

Delångersån (Iggesund)	X0027-3-AVG	<0.18	<0.21	<0.16	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	ND
Norrström	AB0037-3	0.62	1.2	2.8	0.94	<0.16	<0.49	1.4	<0.16	<0.23	7.0
Nyköpingsån	D0040-3	0.68	0.87	1.7	<0.16	<0.16	<0.49	<0.25	0.563	<0.23	3.8
Emån	H0044-3	0.68	0.73	1.9	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	3.3
Mörrumsån	K0047-3	<0.18	0.81	2.5	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	3.3
Rönneån	M0053-3	<0.18	0.71	2.0	1.2	<0.16	2.2	1.5	<0.16	<0.23	7.6
Göta älv (Alelyckan)	O0069-3	<0.18	1.0	<0.16	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	1.0
Nordra älv	O0075-3	<0.18	1.1	0.66	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	1.7
July 2017											
Ume älv (Stornorrfors)	AC1017-4	<0.18	<0.21	<0.16	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	ND
Ångermanälven	Y0022-4	<0.18	<0.21	<0.16	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	ND
Delångersån (Iggesund)	X0027-4-AVG	<0.18	<0.21	0.63	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	0.63
Norrström	AB0037-4	0.77	1.4	2.5	1.2	<0.16	1.8	1.9	<0.16	<0.23	9.5
Nyköpingsån	D0040-4	<0.18	1.1	2.2	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	3.3
Emån	H0044-4	<0.18	1.1	2.7	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	3.9
Mörrumsån	K0047-4	0.67	0.95	3.4	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	5.0
Rönneån	M0053-4	<0.18	0.87	2.0	2.75	0.66	3.1	3.3	<0.16	<0.23	13
Göta älv (Alelyckan)	O0069-4	<0.18	1.1	0.70	<0.16	<0.16	<0.49	<0.25	<0.16	<0.23	1.8
Nordra älv	O0075-4	<0.18	1.0	0.69	<0.16	<0.16	<0.49	0.83	<0.16	<0.23	2.6

[a] <x than the respective method detection limit (MDL). ND = not detected.

Table A3 Fluxes for individual PFASs in g d^{-1}

	PFHpA	PFOA	PFBS	PFHxS (linear)	PFHxS (branched)	PFOS (linear)	PFOS (branched)	FOSA (linear)	6:2 FTSA	ΣPFASs
Ume älv (Stornorrfors)	0	0	0	0	0	0	0	0	0	0
Ångermanälven	0	0	0	0	0	0	0	0	0	0
Delångersån (Iggesund)	0	0	0.17	0	0	0	0	0	0	0.17
Norrström	7.7	14	24	11	0	14	17	0	3.2	92
Nyköpingsån	0.58	1.1	1.9	0	0	0	0.29	0.15	0	4.0
Emån	0.23	0.62	2.1	0	0	0	0	0	0	3.0
Mörrumsån	0.52	1.4	2.9	0	0	0	0	0	0	4.8
Rönneån	0.12	0.67	1.4	1.7	0.40	2.1	1.8	0	0	8.2
Göta älv (Alelyckan)	0	16	7.1	0	0	0	3.7	0	0	27
Nordre älv	0	38	22	0	0	0	22	0	0	82

Table A4 Levels of detected phenolic compounds in Swedish rivers (ng L^{-1})[a]

Station name	ID	4-OP	4-NP	TBP	PCP	4-NP-EO1	4-OP-EO1	BPA	4-OP-EO2	4-NP-EO2
October 2016										
Ume älv (Stornorrfors)	AC1017-1	<0.47	160	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Ångermanälven	Y0022-1	<0.47	390	0.56	<0.013	<7.5	<0.93	<21	1.1	<407
Delångersån (Iggesund)	X0027-1-AVG	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Norrström	AB0037-1	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	38	<0.92	<407
Nyköpingsån	D0040-1	<0.47	100	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Emån	H0044-1	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Mörrumsån	K0047-1	<0.47	120	<0.29	<0.013	<7.5	<0.93	<21	1.0	<407
Rönneån	M0053-1	<0.47	140	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Göta älv (Alelyckan)	O0069-1	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Nordra älv	O0075-1	NA	NA	NA	NA	NA	NA	NA	NA	NA
January 2017										
Ume älv (Stornorrfors)	AC1017-2	<0.47	<5.5	0.35	<0.013	<7.5	<0.93	<21	<0.92	<407
Ångermanälven	Y0022-2	<0.47	160	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Delångersån (Iggesund)	X0027-2-AVG	<0.47	93	<0.29	<0.013	<7.5	<0.93	<21	0.43	<407
Norrström	AB0037-2	<0.47	<5.5	0.72	<0.013	<7.5	<0.93	<21	<0.92	<407
Nyköpingsån	D0040-2	12	<5.5	1.1	0.61	<7.5	<0.93	<21	<0.92	<407
Emån	H0044-2	<0.47	<5.5	0.30	<0.013	<7.5	<0.93	<21	<0.92	<407
Mörrumsån	K0047-2	<0.47	360	0.65	<0.013	<7.5	<0.93	<21	1.0	<407
Rönneån	M0053-2	<0.47	350	0.77	<0.013	<7.5	<0.93	<21	0.94	<407
Göta älv (Alelyckan)	O0069-2	<0.47	350	0.42	0.07	<7.5	<0.93	<21	1.1	<407
Nordra älv	O0075-2	<0.47	150	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
April 2017										
Ume älv (Stornorrfors)	AC1017-3	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	410
Ångermanälven	Y0022-3	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Delångersån (Iggesund)	X0027-3-AVG	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Norrström	AB0037-3	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	500
Nyköpingsån	D0040-3	<0.47	2600	<0.29	<0.013	34	1.5	1100	<0.92	2000

Emån	H0044-3	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Mörrumsån	K0047-3	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Rönneån	M0053-3	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Göta älv (Alelyckan)	O0069-3	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Nordra älv	O0075-3	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
July 2017										
Ume älv (Stornorrfors)	AC1017-4	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Ångermanälven	Y0022-4	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Delångersån (Iggesund)	X0027-4B-AVG	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Norrström	AB0037-4	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Nyköpingsån	D0040-4	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Emån	H0044-4	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mörrumsån	K0047-4	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Rönneån	M0053-4	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Göta älv (Alelyckan)	O0069-4	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407
Nordra älv	O0075-4	<0.47	<5.5	<0.29	<0.013	<7.5	<0.93	<21	<0.92	<407

[a] <x than the respective method detection limit (MDL). NA = not available.

Table A5 Fluxes for individual phenolic compound in g d^{-1}

	4-OP	4-OP-EO1	4-OP-EO2	4-NP	4-NP-EO1	4-NP-EO2	TBP	PCP	BPA
Ume älv (Stornorrfors)	0	0	0	462	0	1185	1.0	0	0
Ångermanälven	0	0	3.5	1732	0	0	1.8	0	0
Delångersån (Iggesund)	0	0	0.041	8.9	0	0	0.032	0	0
Norrström	0	0	0	0	0	465	0.67	0	35
Nyköpingsån	1.2	0.15	0	269	3.4	199	0.11	0.061	110
Emån	0	0	0	0	0	0	0.049	0	0
Mörrumsån	0	0	0.28	68	0	0	0.093	0	0
Rönneån	0	0	0.068	35	0	0	0.056	0	0
Göta älv (Alelyckan)	0	0	1.5	476	0	0	0.57	0.10	0
Nordre älv	0	0	0	635	0	0	0	0	0