Supporting Information

Occurrence of Per- and Polyfluoroalkyl Substances in Water: A Review

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Table S1. PFAS analytes included in the methods and the manual.

Analyte	Acronym	Chemical Abstract Services Registry Number (CASRN)	Method				Manual
			533 [a]	537.1 [b]	8327 [c]	1633 [d]	QSM [e]
Perfluorobutanoic acid	PFBA	375-22-4	✓		✓	✓	✓
Perfluoropentanoic acid	PFPeA	2706-90-3	✓		✓	✓	✓
Perfluorohexanoic acid	PFHxA	307-24-4	✓	✓	✓	✓	✓
Perfluoroheptanoic acid	PFHpA	375-85-9	✓	✓	✓	✓	✓
Perfluorooctanoic acid	PFOA	335-67-1	✓	✓	✓	✓	✓
Perfluorononanoic acid	PFNA	375-95-1		✓	✓	✓	✓
Perfluorodecanoic acid	PFDA	335-76-2	✓	✓	✓	✓	✓
Perfluoroundecanoic acid	PFUnA	2058-94-8	✓	✓	✓	✓	✓
Perfluorododecanoic acid	PFDoA	307-55-1	✓	✓	✓	✓	✓
Perfluorotridecanoic acid	PFTrDA	72629-94-8		✓	✓	✓	✓
Perfluorotetradecanoic acid	PFTeDA	376-06-7		✓	✓	✓	✓
Perfluorobutanesulfonic acid	PFBS	375-73-5	✓	✓	✓	✓	✓
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	✓		✓	✓	✓
Perfluorohexanesulfonic acid	PFHxS	355-46-4	✓	✓	✓	✓	✓
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	✓		✓	✓	✓
Perfluorooctanesulfonic acid	PFOS	1763-23-1	✓	✓	✓	✓	✓
Perfluorononanesulfonic acid	PFNS	68259-12-1			✓	✓	✓
Perfluorodecanesulfonic acid	PFDS	335-77-3			✓	✓	✓
Perfluorododecanesulfonic acid	PFDoS	79780-39-5				✓	
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid	4:2FTS	757124-72-4	✓		✓	✓	✓
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid	6:2FTS	27619-97-2	✓		✓	✓	✓
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid	8:2FTS	39108-34-4	✓		✓	✓	✓
Perfluorooctanesulfonamide	FOSA	754-91-6			✓	✓	✓
N-methylperfluorooctanesulfonamide	MeFOSA	31506-32-8				✓	✓
N-ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2				✓	
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6		✓	✓	✓	✓
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9		✓	✓	✓	✓
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7				✓	
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2				✓	

Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	✓	✓		✓	
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	✓			✓	
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	✓			✓	
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	✓			✓	
4,8-dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	✓	✓		✓	
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	✓	✓		✓	
9-chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	✓	✓		✓	
Perfluoro (2-ethoxyethane) sulfonic acid	PFEESA	113507-82-7	✓			✓	
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5				✓	
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3				✓	
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4				✓	

[a] USEPA [1]
[b] USEPA [2]
[c] USEPA [3]
[d] USEPA [4]
[e] USDoD [5]

Table S2. QA/QC procedures in Method 533, 537, 8327, and Manual QSM.

Requirement [a]	Specification	Objective	Acceptance Criteria	Method				Manual
				533 [b]	537.1 [c]	8327 [d]	1633 [e]	QSM [f]
	Initial Demonstration of Capability (IDC)							
Establish retention times for branched isomers (RTBI)	Each time chromatographic conditions change	To minimize the problem that all product ions in the linear PFOS are produced in all branched PFOS isomers.	All isomers of each analyte must elute within the same multiple reaction monitoring (MRM) window.	✓	✓	✓	✓	✓
Demonstration of low system background (LSB)	Analyze a Laboratory Reagent Blank (LRB) after the highest standard in the calibration range.	To determine if interferences are introduced from the laboratory environment, the reagents, glassware, or extraction apparatus.	Demonstrate that the method analytes are less than one-third of the minimum reporting level (MRL) or limit of quantification (LOQ).	✓	✓	✓	✓	✓
Precision (Pre.)	Extract and analyze 7 replicate Laboratory Fortified Blanks (LFBs) near the mid-range concentration.	To ensure high precision of measurements in the absence of sample matrix.	Percent relative standard deviation must be ≤20%.	✓	✓	✓	✓	✓
Accuracy (Acc.)	Calculate mean recovery for replicates used in the demonstration of precision.	To ensure high accuracy of measurements in the absence of sample matrix.	Mean recovery within 70–130% of the true value.	✓	✓	✓	✓	✓
Initial Demonstration of Peak Asymmetry Factor (PAF)	Calculate the peak asymmetry factor for the first two eluting chromatographic peaks in a mid-level calibration standard.	To avoid broad, split, or fronting peaks, and to ensure each method analyte is observed in its MS/MS window.	Peak asymmetry factor of 0.8 - 1.5.		✓			
Minimum Reporting Level/Limit of Quantification (MRL/LOQ)	Fortify and analyze 7 replicate LFBs at the proposed MRL/LOQ concentration. Confirm that the Upper Prediction Interval of Results (PIR) and Lower PIR meet the recovery criteria.	To confirm the minimum concentration that may be reported as a quantified value for a method analyte.	Prediction interval of results within 50-150%.	✓	✓	✓	✓	✓

Calibration Verification (CV)	Analyze a calibration standard prepared independently from the primary calibration solutions.	To verify the integrity of the primary calibration standards.	Results must be within 70–130% of the true value.	✓	✓	✓	✓	✓
Mass Calibration	Calibrate the mass scale of the MS with calibration compounds and procedures described by the manufacturer. Mass calibration range must bracket the ion masses of interest. The most recent mass calibration must be used for every acquisition in an analytical run.	To ensure the measurement system response provides valid data of known and documented quality.	Mass calibration must be verified to be ±0.5 amu of the true value, by acquiring a full scan continuum mass spectrum of a PFAS.					✓
Mass Spectral Acquisition Rate	Applied to each method analyte and IDA.	To identify each method analyte and IDA.	A minimum of 10 spectra scans are acquired across each chromatographic peak.					✓
Ongoing QC								
Initial calibration (IC)	Use the isotope dilution calibration technique to generate a linear or quadratic calibration curve. Use at least 5 standard concentrations.	To determine if reanalyzing the calibration standards, restricting the range of calibration, or performing instrument maintenance is needed.	When each calibration standard is calculated as an unknown using the calibration curve, analytes fortified at or below the MRL/LOQ should be within 50–150% of the true value. Analytes fortified at all other levels should be within 70–130% of the true value.	✓	✓	✓	✓	✓
LRB	Include one LRB with each extraction batch. Analyze one LRB with each analysis batch.	To determine if interferences are introduced from the laboratory environment, the reagents, glassware, or extraction apparatus.	Demonstrate that all method analytes are below one-third the Minimum Reporting Level (MRL), and that possible interference from reagents and glassware do not prevent identification and quantitation of method analytes.	✓	✓	✓	✓	✓
LFB	Include one LFB with each extraction batch.	To ensure high precision and accuracy of measurements.	For analytes fortified at concentrations ≤2 x the MRL/LOQ, the result must be within 50–150% of the true value; 70–130% of the true value if fortified at concentrations greater than 2 x the MRL/LOQ.	✓	✓	✓	✓	✓

Continuing Calibration Check (CCC)	Verify initial calibration by analyzing a low-level CCC (concentrations at or below the MRL/LOQ for each analyte) at the beginning of each analysis batch. Subsequent CCCs are required after every tenth field sample and to complete the batch.	To verify instrument sensitivity prior to the analysis of samples.	The lowest level CCC must be within 50–150% of the true value. All other levels must be within 70–130% of the true value.	✓	✓	✓	✓	✓
Isotope performance standards (IPS)	IPS are added to all standards and sample extracts.	To ensure instrument performance, and to calculate the recovery of the isotope dilution analogues through the extraction procedure.	Peak area counts for each isotope performance standard must be within 50–150% of the average peak area in the initial calibration.	✓	✓		✓	
Isotope dilution analogues (IDA)	IDA are added to all samples prior to extraction.	To measure analyte concentration using the ratio of the peak area of the native analyte to that of an isotopically labeled analogue.	50%–200% recovery for each analogue	✓	✓	✓	✓	✓
Laboratory Fortified Sample Matrix (LFSM)	Include one LFSM per extraction batch. Fortify the LFSM with method analytes at a concentration close to but greater than the native concentrations (if known).	To determine whether the sample matrix contributes bias to the analytical results.	For analytes fortified at concentrations ≤2 x the MRL, the result must be within 50–150% of the true value; 70–130% of the true value if fortified at concentrations greater than 2 x the MRL.	✓	✓	✓	✓	✓
Laboratory Fortified Sample Matrix Duplicate (LFSMD) or Field Duplicate (FD)	Include at least one LFSMD or FD with each extraction batch.	To assess method precision when the method analytes are rarely found at concentrations greater than the MRL/LOQ.	For LFSMDs or FDs, relative percent differences must be ≤30% (≤50% if analyte concentration ≤2 x the MRL).	✓	✓		✓	✓
Field Reagent Blank (FRB)	Analyze the FRB if any analyte is detected in the associated field samples.	To determine if method analytes or other interferences are introduced	If an analyte detected in the field sample is present in the associated FRB at greater	✓	✓	✓	✓	✓

		into the sample from shipping, storage, and the field environment.	than one-third the MRL, the results for that analyte are invalid.					
PAF	Calculate the peak asymmetry factor for the first two eluting chromatographic peaks in a mid-level calibration standard.	To avoid broad, split, or fronting peaks, and to ensure each method analyte is observed in its MS/MS window.	Peak asymmetry factor of 0.8 - 1.5.		✓			
CV	Perform a CV at least quarterly.	To verify the integrity of the primary calibration standards.	Results must be within 70–130% of the true value.	✓	✓	✓	✓	✓
Post Spike Sample	Only applied to aqueous samples not prepared by SPE that have reported value of < LOQ for analyte(s).	To ensure high precision and accuracy of measurements.	When analyte concentrations are calculated as < LOQ, the post spike for that analyte must recover within 70- 130% of its true value.					✓
Retention Time Window Width	Conducted for every field sample, standard, blank, and QC sample.	To ensure the total response is quantitated for each method analyte.	Analytes must elute within 0.1 minutes of the associated EIS. This criterion applies only to analyte and labeled analog pairs.			✓		✓

[a] RTBI = Establish Retention Times for Branched Isomers; LSB = Demonstration of Low System Background; Pre. = Precision; Acc. = Accuracy; PAF = Peak Asymmetry Factor; MRL/LOQ = Minimum Reporting Level/Limit of Quantification; CV = Calibration Verification; IC = Initial Calibration; LRB = Laboratory Reagent Blank; LFB = Laboratory Fortified Blank; CCC = Continuing Calibration Check; IPS = Isotope Performance Standards; IDA = Isotope Dilution Analogues; LFSM = Laboratory Fortified Sample Matrix.
[b] USEPA [1]
[c] USEPA [2]
[d] USEPA [3]
[e] USEPA [4]
[f] USDoD [5]

Table S3. PFASs in WWTPs, surface water, ground water, and DWTPs across the United States.

			IDC [b]						Ongoing QC [b]							
Study	Water Body [a]	PFAS Analyte Count	RTBI	LSB	Pre.	Acc.	MRL/LOQ	CV	IC	LRB	LFB	CCC	IDA	LFSM/FD	FRB	CV
Hansen, et al. [6]	S	2						✓	✓			✓				✓
Boulanger, et al. [7]	S	8						✓	✓					✓	✓	✓
Kannan, et al. [8]	S	4							✓							
Simcik and Dorweiler [9]	S	7							✓					✓	✓	
Boulanger, et al. [10]	W	8							✓	✓						
Sinclair, et al. [11]	S	4				✓			✓				✓			
Sinclair and Kannan [12]	W	8				✓			✓				✓			
Schultz, et al. [13]	W	12	✓		✓	✓			✓	✓	✓		✓	✓	✓	
Nakayama, et al. [14]	S	10			✓	✓		✓	✓				✓		✓	✓
Loganathan, et al. [15]	W	10							✓				✓			
Plumlee, et al. [16]	S, G, W	8			✓	✓			✓	✓			✓	✓		
Post, et al. [17]	S, G	1								✓			✓		✓	
Quiñones and Snyder [18]	S, G, D	8		✓			✓		✓	✓			✓	✓	✓	
Lindstrom, et al. [19]	S	10		✓	✓	✓			✓	✓	✓		✓	✓	✓	
Furl, et al. [20]	S, W	13		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	
Appleman, et al. [21]	W, D	16		✓		✓	✓		✓	✓	✓		✓	✓	✓	
Sun, et al. [22]	S, D	16	✓						✓				✓			
Glassmeyer, et al. [23]	W	15		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Elmoznino, et al. [24]	W	16		✓			✓		✓	✓	✓		✓			
Boone, et al. [25]	D	17		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Goodrow, et al. [26]	S	13		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Schwichtenberg, et al. [27]	S	50	✓		✓	✓		✓	✓				✓			✓
Bai and Son [28]	S	17							✓				✓			

[a] S = Surface water; W = WWTP; G = Ground water; D = DWTP.
[b] RTBI = Establish Retention Times for Branched Isomers; LSB = Demonstration of Low System Background; Pre. = Precision; Acc. = Accuracy; MRL/LOQ = Minimum Reporting Level/Limit of Quantification; CV = Calibration Verification; IC = Initial Calibration; LRB = Laboratory Reagent Blank; LFB = Laboratory Fortified Blank; CCC = Continuing Calibration Check; IDA = Isotope Dilution Analogues; LFSM = Laboratory Fortified Sample Matrix.

Table S4. Source water and PFAS influent concentrations in WWTPs in the United States.

Study	Site and Location	Detected PFASs	Influent Concentration Range (ng/L)	Source of Wastewater
Boulanger, et al. [10]	WWTP (Iowa)	PFOA, PFOS, N-EtFOSAA	$10^{0} – 10^{2}$	Domestic, commercial
Sinclair and Kannan [12]	6 WWTPs (New York)	PFOA, PFOS, PFHxS, PFNA, PFDA, PFUnA, 8:2 FTCA, 8:2 FTUCA	$10^{0} – 10^{1}$	Domestic, industrial, commercial
Schultz, et al. [13]	10 WWTPs	PFOA, PFOS, PFBS, PFHxS, 6:2 FtS, PFHxA, PFNA, PFDA, FOSA	$10^{-1} – 10^{1}$	Domestic, industrial, commercial
Plumlee, et al. [16]	4 WWTPs (California)	PFOA, PFOS, PFHxS, PFDS, PFHxA, PFHpA, PFNA, PFDA, 6:2 FtS, FOSA, N-EtFOSAA	NA	Domestic, industrial, commercial
Loganathan, et al. [15]	2 WWTPs (Georgia, Kentucky)	PFOA, PFOS, PFHxS, PFNA, PFOSA, PFDA, PFUnA, PFDoDA	$10^{-1} – 10^{2}$	Domestic, commercial
Xiao, et al. [29]	37 WWTPs (Minnesota)	PFOA, PFOS, PFHxA, PFHpA, PFNA	$10^{0} – 10^{2}$	Domestic, industrial, commercial
Moody and Field [30]	2 Air Force bases (Nevada, Florida)	PFHxA, PFHpA, PFOA, PFDoA	$10^{1} – 10^{3}$	Industrial
Nickerson, et al. [31]	Military installation	PFCAs, PFSAs, Fluorotelomer, Fluorotelomer-derived sulfonamide	$10^{1} – 10^{5}$	Industrial

Table S5. Source water and PFAS influent concentrations in WWTPs in other countries.

Study	Country	Source: Type	Source: Specification	PFAS Concentration Range (ng/L)
Chen, et al. [32] Lin, et al. [33] Guo, et al. [34] Yu, et al. [35]	China Taiwan South Korea Singapore	Domestic	Food packaging products, indoor air and dust, and home and workplace products	$10^1 – 10^2$
Wang, et al. [36] Chirikona, et al. [37] Eriksson, et al. [38]	China Kenya Sweden	Commercial	Chrome plating, hospital	$10^2 – 10^3$
Bräunig, et al. [39] Høisæter, et al. [40]	Australia Norway	Industrial	Aqueous film forming foam	$>10^3$

Table S6. PFAS concentration changes after treatment in WWTPs in the United States.

Study	WWTP No.	Treatment Type [a]	PFOA	PFNA	PFHxA	PFHpA	PFDA	FOSA	N-EtFOSAA	PFUnA	PFDoDA	8:2 FTUCA	PFOS	PFBS	PFHxS	PFDS	6:2 FtS	Effluent ∑ PFOA + PFOS (ng/L)
Boulanger, et al. [10]	1	PS + AS + Cl	400%	NA	NA	NA	NA	NA	-30%	NA	NA	NA	-90%	NA	NA	NA	NA	48
Sinclair and Kannan [12]	2	PS + AS + Cl	100%	200%	NA	NA	100%	NA	NA	~0	NA	100%	100%	NA	~0	NA	NA	270
	3	PS + AS + Cl	100%	~0	NA	NA	NA	NA	NA	NA	NA	NA	~ 0	NA	~0	NA	NA	141
Schultz, et al. [13]	4	PS + AS	~0	~0	-100%	-100%	NA	100%	NA	NA	NA	NA	-50%	-100%	-50%	NA	-50%	14
	5	PS + AS	50%	-50%	+1000%[b]	~0	200%	NA	NA	NA	NA	NA	-50%	~0	-50%	-100%	+1000% [b]	158
	6	PS + AS	~0	~0	~0	200%	~0	+1000% [b]	NA	NA	NA	NA	-50%	~0	~0	-100%	100%	113
	7	PS + AS	~0	~0	100%	~0	300%	200%	NA	NA	NA	NA	~0	~0	~0	~0	-75%	121
	8	PS + AS	200%	~0	~0	400%	~0	100%	NA	NA	NA	NA	-50%	~0	-50%	~0	-50%	20
	9	PS + AS	100%	~0	~0	~0	+1500% [b]	+1000% [b]	NA	NA	NA	NA	~0	400%	~0	~0	+3000% [b]	71
	10	PS + AS + MF	300%	~0	-67%	200%	~0	~0	NA	NA	NA	NA	~0	~0	-100%	-100%	~0	19
	11	PS + AS + MF	50%	~0	~0	100%	~0	~0	NA	NA	NA	NA	-50%	~0	~0	-100%	~0	19
	12	PS + AS	~0	~0	~0	-100%	~0	400%	NA	NA	NA	NA	~0	300%	~0	~0	50%	36
	13	PS + AS	33%	-90%	~0	~0	~0	~0	NA	NA	NA	NA	~0	-100%	-50%	~0	-100%	66
Loganathan, et al. [15]	14	PS + AS + Cl	~0	~0	NA	NA	100%	100%	NA	~0	~0	NA	~0	NA	50%	NA	NA	328
	15	PS + AS + Cl	150%	100%	NA	NA	500%	50%	NA	~0	~0	NA	~0	NA	50%	NA	NA	62
Xiao, et al. [29]	16 (37 WWTPs Included)	PS + AS + UV/Cl	300%	50%	300%	200%	NA	NA	NA	NA	NA	NA	200%	NA	NA	NA	NA	NA
Elmoznino, et al. [24]	17	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	65
	18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	68

19	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	57
20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	45
21	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	30
22	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	30
23	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	43
24	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	73
25	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	47
26	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	38
27	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	76
28	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	57

a PS = primary sedimentation; AS = activated sludge; Cl = chlorination; MF = membrane filtration; UV = ultraviolet radiation.
b Data were deemed statistically outliers.

Table S7. Concentrations of PFASs (ng/L) in surface water and ground water in the United States.

Surface Water																	
Study	State	Upstream[a]	Sample Site	PFBA	PFBS	PFPeA	PFHxA	PFHxS	GenX	PFHpA	PFOS	PFOA	FOSA	PFNA	PFDA	PFUdA	PFDoA
Goodrow, et al. [26]	New Jersey	IP	1	10	3	18	25	2	NA	11	3	11	1	7	1	NA	1
		WWTP	2	3	3	6	6	2	NA	5	2	19	1	2	1	NA	1
		FTS	4	3	4	6	13	46	NA	5	71	14	1	1	1	NA	1
		Others	4	7	3	11	11	3	NA	8	6	9	1	4	1	NA	1
Schwichtenberg, et al. [27]	Michigan	Others	8	NA	NA	NA	6	25	NA	NA	21	9	NA	0	0	0	NA
Bai and Son [28]	Nevada	FTS	10	3	18	52	81	11	NA	12	13	27	NA	0	0	1	0
		Others	8	0	5	6	18	6	NA	2	2	7	NA	0	0	0	0
Boulanger, et al. [10]	-[b]	Others	2	NA	NA	NA	NA	NA	NA	NA	43	40	1	NA	NA	NA	NA
Hansen, et al. [6]	Tennessee	IP	1	NA	NA	NA	NA	NA	NA	NA	69	189	NA	NA	NA	NA	NA
Kannan, et al. [8]	Michigan	Others	2	NA	NA	NA	NA	NA	NA	NA	3	9	10			NA	NA
Lindstrom, et al. [19]	Alabama [c]	IP	51	230	48	530	799	79	NA	1328	39	1049	NA	54	196	NA	NA
Nakayama, et al. [14]	North Carolina	IP	7	NA	3	NA	13	7	NA	59	54	168	NA	115	70	21	2
		FTS	4	NA	1	NA	9	10	NA	92	65	48	NA	36	15	7	1
Post, et al. [17]	New Jersey	Others	12	NA	NA	NA	NA	NA	NA	NA	NA	18	NA	NA	NA	NA	NA
Simcik and Dorweiler [9]	Minnesota	WWTP	4	NA	NA	NA	NA	NA	NA	3	20	6	NA	1	0	NA	NA
		Others	6	NA	NA	NA	NA	NA	NA	3	2	1	NA	0	0	NA	NA
Sun, et al. [22]	North Carolina	IP	1	22	10	36	10	10	631	10	25	10	NA	10	25	NA	NA
		Others	2	23	10	41	45	12	10	39	35	28	NA	10	25	NA	NA

Sinclair, et al. [11]	New York	IP	1	NA	NA	NA	NA	7	NA	NA	756	49	NA	NA	NA	NA	NA
		Others	9	NA	NA	NA	NA	1	NA	NA	3	20	NA	NA	NA	NA	NA
Plumlee, et al. [16]	California	Others	6	NA	NA	NA	NA	7	NA	8	29	17	3	NA	13	NA	NA
Quiñones and Snyder [18]	Georgia	WWTP	1	NA	NA	NA	54	10	NA	NA	18	70	NA	13	8	1	1
	Arizona and Nevada	Others	6	NA	NA	NA	1	0	NA	NA	1	3	NA	1	0	0	0
Ground Water																	
Plumlee, et al. [16]	California	Others	3	NA	NA	NA	NA	7	NA	1	70	11	1	NA	3	NA	NA
Post, et al. [17]	New Jersey	Others	12	NA	NA	NA	NA	NA	NA	NA	NA	12	NA	NA	NA	NA	NA
Quiñones and Snyder [18]	Arizona and Nevada	WWTP	5	NA	NA	NA	35	6	NA	NA	11	74	NA	11	7	1	1

[a] IP = Industrial Plant; FTS = Firefighting Training Site.
[b] Samples were taken in Lake Erie and Lake Ontario.
[c] Data were deemed statistically outliers.

Table S8. Solid-water distribution coefficient K_d (L/kg) of PFAS in WWTPs.

			K_d								
Study	Country	WWTP No.	PFHxA	PFNA	PFDA	PFUnA	PFDoDA	PFOA	FOSA	PFOS	PFHxS
Loganathan, et al. [15]	USA	1	NA	0.4	10.3	11.8	14.4	1.4	6.8	6.8	0.4
			NA	1.3	22	15.4	20	0.1	13.8	13.8	0.3
			NA	1.3	10.9	5	5	0.2	3.9	3.9	0.5
		2	NA	0.1	0	1	0.1	0	0	0	1
			NA	0.2	0.6	5	5	0.3	3.8	3.8	0.3
			NA	1	0.3	1	0.1	0.4	0.6	0.6	1
			NA	0.2	0	1	0.1	0.1	0	0	1
Sinclair and Kannan [12]	USA	3	NA	NA	3.4	15.9	NA	1.3	NA	4.9	2.6
		4	NA	NA	NA	NA	NA	0.9	NA	4.7	3.2
Yu, et al. [35]	USA	5	NA	NA	NA	NA	NA	1.5	NA	3.1	NA
			NA	NA	NA	NA	NA	1.1	NA	4.2	NA
			NA	NA	NA	NA	NA	1.3	NA	3.2	NA
		6	NA	NA	NA	NA	NA	0.9	NA	1.6	NA
			NA	NA	NA	NA	NA	0.6	NA	4.7	NA
			NA	NA	NA	NA	NA	0.2	NA	4.5	NA
Coggan, et al. [41]	Australia	7	NA	0	14.5	NA	0.1	0.3	NA	3.5	0
		8	NA	0	5.9	NA	0.9	0.6	NA	2.8	0.3
		9	NA	0	0.9	NA	0	0	NA	2.2	0
		10	NA	0.7	4.7	NA	0.1	0.2	NA	2.9	0.2
		11	NA	0	0.2	NA	0	0	NA	0.1	0.1
		12	NA	0	0	NA	0.1	0.1	NA	0.3	0.2
		13	NA	0	1.4	NA	0.1	0.1	NA	0.6	0
		14	NA	0	0.9	NA	0.1	0.2	NA	0.7	0.1

Pan, et al. [42]	China	15	0	1.2	3.8	NA	NA	0.1	NA	1.7	NA
		16	0.2	2.4	16.9	NA	NA	0.4	NA	5.3	NA
		17	0.1	1.4	8.6	NA	NA	0.2	NA	5.6	NA
Bossi, et al. [43]	Denmark	18	NA	0.8	5	NA	NA	0.4	2.9	3.1	7.1
		19	NA	1.8	5	NA	NA	0.3	2.2	1.5	5
		20	NA	1	4.7	NA	NA	0.7	10	3	6.3
		21	NA	0.8	3.6	NA	NA	0.3	10	2.4	8.3
		22	NA	1.4	5	NA	NA	0.3	1.8	2.8	3.6
		23	NA	2.5	5	NA	NA	0	10	0	0
Arvaniti, et al. [44]	Greece	24	3.3	0.7	0.4	0.3	0.2	0.2	0.8	0.5	0.8
		25	4.2	0	0	0.7	0	0.3	1.2	23.8	0.6
Campo, et al. [45]	Spain	26	2.3	0.3	0.5	0.1	1.4	0.1	0	3	0
		27	0.1	0.8	7.4	1.5	0	1.5	3.4	0.5	0

Table S9. PFAS concentration changes in DWTPs in both the United States and other countries.

Study	Country	DWTP No.	Primary Treatment[a]	PFBS	PFPeA	PFHxS	PFHxA	PFBA	PFHpA	PFOS	PFOA	PFNA	PFDA	Effluent ∑ PFOA + PFOS (ng/L)
Appleman, et al. [21]	USA	1	MF+RO+UV-AOP+Cl_2	-97%	-82%	-95%	-97%	-83%	-85%	-98%	-50%	-87%	-67%	<5.25
		2	AEX+MF+ Cl_2	-21%	11%	14%	24%	12%	17%	30%	NA	4%	NA	111
		3	UV-AOP+GAC	-98%	-77%	-99%	-95%	-38%	-94%	-97%	-79%	-77%	NA	<5.25
		4	GAC+ Cl_2	-56%	NA	-17%	-25%	NA	NA	-42%	-11%	NA	NA	<5.25
		5	MF+UF+RO+UV-AOP	-94%	-98%	-91%	-99%	-95%	-95%	-96%	-98%	-95%	-99%	<5.25
		6	ClO_2	25%	15%	NA	19%	NA	16%	53%	14%	23%	NA	35.6
		7	O_3 + Cl_2+NH2Cl	14%	3%	-4%	7%	NA	3%	-24%	9%	-10%	NA	15.2
		8	UV+ Cl_2	-11%	-8%	-33%	5%	8%	-4%	-44%	-7%	-17%	NA	29
		9	AEX + Cl_2	-86%	7%	-98%	14%	NA	-19%	-94%	-83%	-67%	NA	21.25
		10	Cl_2+MnO4	-4%	NA	-6%	5%	NA	-7%	3%	NA	17%	9%	41.4
		11	ClO_2 + Cl_2	NA	8%	-8%	NA	-17%	-8%	6%	-6%	8%	NA	17.51
		12	MnO4+ O_3 + Cl_2	20%	6%	3%	5%	NA	-7%	2%	8%	24%	17%	19.6
		13	GAC+ Cl_2	-6%	26%	8%	25%	12%	-5%	104%	29%	29%	78%	36.4
		14	Cl_2	7%	-2%	-5%	-7%	4%	3%	5%	16%	4%	7%	59.2
Boone, et al. [25]	USA	15	O_3 +NH2Cl	7%	4%	-4%	8%	3%	-7%	-13%	-8%	-9%	-12%	14.2
		16	GAC + Cl_2	-90%	-54%	NA	-76%	-19%	-93%	NA	-96%	NA	NA	1.1
		17	GAC + Cl_2+UV	-4%	-2%	-30%	4%	4%	-19%	-55%	-20%	-33%	-33%	4
		18	Cl_2+NH2Cl	-5%	-6%	-3%	NA	1%	-4%	9%	NA	1%	3%	11.6
		19	Cl_2	NA	NA	NA	25%	NA	NA	NA	NA	NA	NA	0
		20	NH2Cl	7%	10%	-14%	-2%	-1%	-2%	-11%	-10%	-7%	-26%	10.3

		21	O_3 + GAC + Cl_2	581%[b]	NA	-57%	12%	NA	-8%	-65%	NA	NA	NA	0.2
		22	Cl2 +GAC + Cl_2	-2%	-8%	10%	NA	3%	-3%	13%	10%	7%	6%	32.2
		23	Cl_2	-3%	1%	13%	9%	NA	10%	9%	9%	15%	NA	1.4
		24	ClO_2 + GAC + Cl_2	-1%	58%	-13%	3%	1%	-9%	3%	NA	2%	NA	0.4
		25	Cl_2	-5%	17%	-12%	NA	-2%	3%	NA	NA	-14%	NA	0
		26	GAC+NH2Cl	55%	23%	16%	12%	9%	-4%	4%	2%	-1%	NA	2.7
		27	Cl_2	-3%	-3%	5%	5%	4%	-8%	2%	-4%	7%	5%	8
		28	O_3 + GAC + NH2Cl	-35%	-32%	-56%	-31%	-18%	-49%	-67%	-48%	-59%	-70%	6.4
		29	PAC + NH2Cl	4%	-5%	-4%	-1%	5%	-12%	-7%	8%	NA	NA	2
		30	O_3 + GAC+ Cl_2	25%	46%	NA	88%	4%	15%	NA	NA	-20%	NA	0
		31	Cl_2	1%	NA	6%	9%	1%	NA	-1%	-6%	6%	2%	21.7
		32	O_3 + Cl_2+GAC+UV	30%	3%	7%	10%	7%	-4%	-24%	-7%	-7%	-21%	140.9
		33	ClO_2 + UV+ Cl_2	16%	-9%	-12%	18%	-3%	-3%	-3%	76%	34%	75%	36.3
		34	PAC + GAC + NH2Cl	-8%	NA	NA	-4%	4%	-10%	37%	-11%	1%	NA	7.6
		35	O_3 +GAC+NH2Cl	11%	-3%	-6%	-2%	1%	-1%	-46%	-7%	-27%	-74%	3.9
		36	PAC+ Cl_2	5%	2%	5%	6%	8%	2%	22%	14%	15%	40%	6.6
		37	PAC+NH2Cl+UV	-35%	-17%	-44%	-20%	57%	-34%	-47%	-42%	-46%	NA	1.1
		38	PAC+O3+NH2Cl	8%	-3%	1%	3%	13%	-2%	3%	7%	-2%	-5%	2.6
		39	PAC+ Cl_2	1%	-25%	NA	6%	12%	-16%	NA	NA	-1%	NA	0
		40	Clm	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0
		41	UV+ Cl_2	NA	NA	5%	-7%	NA	NA	-6%	0%	0%	NA	20.4
		42	O_3 + Cl_2	NA	NA	NA	0%	NA	NA	0%	-100%	NA	NA	1.4
Quiñones and Snyder [18]	USA	43	PAC+Clm	NA	NA	-44%	0%	NA	NA	12%	-100%	NA	NA	1.9
		44	Cl_2+UV	NA	NA	0%	-21%	NA	NA	0%	-3%	-3%	0%	52
		45	MF/RO+UV/H2O2	NA	NA	-100%	-100%	NA	NA	-100%	-100%	-100%	-100%	0
		46	Cl_2	NA	NA	20%	-86%	NA	NA	97%	-28%	-36%	-29%	75

Boiteux, et al. [46]	France	47	Cl_2	NA	-15%	NA	-16%	0%	-24%	0%	0%	NA	NA	8
		48	GAC+ Cl_2	NA	-2%	NA	23%	-11%	6%	0%	8%	NA	NA	8.3
		49	O_3 + GAC	NA	358%	NA	356%	67%	208%	0%	-11%	NA	NA	9
			O_3 + MF+NF	0%	25%	0%	15%	0%	-5%	0%	-19%	0%	NA	8
Pan, et al. [42]	China	50	O_3 + GAC	123%	6%	NA	-4%	0%	-5%	NA	8%	-17%	NA	2.5
		51	GAC+PAC	-82%	-16%	NA	-63%	272%[b]	-88%	NA	-94%	-100%	NA	0.7
Tröger, et al. [47]	Sweden	52	UV + Cl_2	0%	0%	0%	0%	0%	0%	0%	24%	3%	14%	NA
		53	UV + Cl_2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	NA
		54	GAC+ UV + Cl_2	0%	0%	15%	0%	0%	0%	51%	0%	32%	31%	NA
		55	UV	0%	0%	0%	0%	0%	0%	0%	2%	56%	78%	NA
		56	UV + ClO_2	0%	0%	27%	0%	0%	0%	52%	22%	17%	0%	NA
		57	GAC+ UV + Cl_2	0%	0%	2%	0%	0%	0%	16%	0%	8%	0%	NA
		58	GAC + UF + ClO_2	0%	0%	26%	0%	0%	0%	59%	56%	42%	30%	NA
Kim, et al. [48]	South Korea	59	Cl_2+ PAC + O_3 + Cl_2	-32%	-38%	2%	3%	NA	-7%	-67%	-22%	-41%	-91%	12.8
		60	Cl_2+ O_3 + GAC + O_3 + Cl_2	-2%	-26%	-17%	9%	NA	10%	-12%	6%	-1%	-3%	
		61	Cl_2+ O_3 + GAC + O_3 + Cl_2	-25%	-16%	-34%	-4%	NA	-13%	-40%	-21%	-25%	-22%	
		62	Cl_2+ O_3 + GAC + Cl_2	7%	-8%	-39%	-1%	NA	-1%	-84%	-23%	-49%	-64%	
		63	Cl_2+ O_3 + GAC + Cl_2	-19%	-22%	-76%	-10%	NA	-29%	-87%	-59%	-68%	-86%	
Qu, et al. [49]	China	64	Cl_2+ Cl_2	5%	3%	-2%	36%	4%	16%	3%	6%	-4%	NA	10.4
			GAC	-81%	-100%	-100%	-100%	-100%	-100%	-73%	-100%	-100%	NA	
Takagi, et al. [50]	Japan	65	O_3 + GAC + Cl_2	NA	NA	NA	NA	NA	NA	62%	110%	NA	NA	38.5
		66	O_3 + GAC + Cl_2	NA	NA	NA	NA	NA	NA	-2%	12%	NA	NA	35.5

		67	O_3 + GAC + Cl_2	NA	NA	NA	NA	NA	NA	1%	63%	NA	NA	22.8
		68	O_3 + GAC + Cl_2	NA	NA	NA	NA	NA	NA	9%	29%	NA	NA	35.6
		69	GAC + Cl_2	NA	NA	NA	NA	NA	NA	-88%	-81%	NA	NA	8.4
Flores, et al. [51]	Spain	70	O_3 + GAC	NA	NA	NA	NA	NA	NA	-72%	-38%	NA	NA	46
			UF + RO	NA	NA	NA	NA	NA	NA	-85%	-57%	NA	NA	16
Belkouteb, et al. [52]	Sweden	71	GAC + Cl_2	NA	NA	-83%	-65%	NA	NA	-100%	-85%	NA	NA	0.4

[a] MF = Microfiltration; RO = Reverse Osmosis; UV-AOP = UV Photolysis with Advanced Oxidation (Hydrogen Peroxide); AEX = Anion Exchange Resins; Cl_2= Hypocholorous/Hypocholorite; GAC = Granular Activated Carbon; UF = Ultrafiltration; ClO_2 = Chlorine Dioxide; O_3 = Ozone; PAC = Powdered Activated Carbons; Clm = Chloramination; NF = Nanofiltration.
[b] Data were deemed statistically outliers.

Table S10. PFAS-treatment technologies.

	Technology	*Application Scale*	*Advantages*	*Disadvantage*
Separation	Activated carbon [53-55]	Laboratory Pilot Full	Efficient removal of long-chain PFASs High capacity Low cost Easy O&M	Low selectivity Competition of co-contaminants Disposal issue
	Anion exchange resin [56-58]	Laboratory Pilot	High capacity High selectivity Easy O&M	Competition of co-contaminants Harsh conditions for regeneration High cost Only effective for anionic PFASs
	Foam fractionation [59, 60]	Laboratory	High efficiency Low cost Easy O&M	Post treatment needed More research needed
Destruction	Advanced oxidation process [61, 62]	Laboratory	High efficiency	Fluoride byproducts Not effective for some PFASs High cost
	Thermal destruction [63-66]	Laboratory Pilot	Effective degradation	Toxic gas High cost
	Plasma [67, 68]	Laboratory Pilot	Effective degradation	Special equipment Demanding conditions High cost
	Electrochemical oxidation [69, 70]	Laboratory Pilot	High efficiency Low cost	Generation of toxic byproducts Addition of electrolyte
	Advanced reduction [71-73]	Laboratory	High efficiency	High Cost Partial degradation products Addition of reductants

Table S11. PFAS concentration changes after wastewater treatment in other countries.

Study	Country	WWTP No.	Treatment Type [a]	PFBA	PFPeA	PFBS	PFHxA	PFHpA	PFHxS	PFOA	PFNA	PFOS	PFDA	PFOSA	6:2 FTS	PFDS
Pan, et al. [42]	China	1	PS+ANA+AS	15%	32%	-5%	-13%	23%	-20%	2%	-34%	99%	88%	NA	NA	NA
		2	PS+ANA+MF	-13%	-23%	9%	-33%	-4%	NA	8%	-78%	-25%	-58%	NA	NA	NA
		3	PS+Unitank	-27%	-7%	1%	14%	12%	NA	29%	-71%	-50%	-20%	NA	NA	NA
Campo, et al. [45]	Spain	4[c]	PS+AS+DIS	-13%	30%	87%	718%	-38%	-10%	-24%	11%	-9%	1800%[b]	0%	NA	NA
Coggan, et al. [41]	Australia	5[d]	PS+AS+DIS	171%	83%	-20%	149%	101%	58%	214%	66%	-6%	105%	NA	-16%	NA
Dalahmeh, et al. [74]	Uganda	6	PS+AS	NA	NA	NA	NA	NA	72%	30%	67%	156%	NA	NA	NA	NA
Huset, et al. [75]	Switzerland	7	PS+AS+DN	NA	NA	3%	0%	-96%	500%	471%	0%	45%	0%	0%	100%	-64%
		8	PS+AS+DN	NA	NA	-31%	93%	-6%	-77%	233%	0%	-11%	47%	0%	-71%	0%
		9	PS+AS+DN	NA	NA	24%	686%[b]	273%	18%	0%	-92%	-33%	0%	-50%	-86%	0%
		10	PS+AS+DN	NA	NA	7%	0%	117%	63%	8%	0%	-11%	0%	65%	-50%	-88%
		11	PS+AS+DN	NA	NA	-15%	0%	-18%	13%	35%	0%	21%	0%	0%	-32%	-48%
		12	PS+AS+DN	NA	NA	267%	0%	-92%	80%	200%	0%	-30%	0%	0%	-88%	-93%
		13	PS+AS+N	NA	NA	-100%	1038%[b]	-75%	19%	44%	0%	23%	0%	0%	-58%	-99%
Bossi, et al. [43]	Denmark	14	NA	NA	NA	NA	NA	NA	-96%	-34%	-52%	-10%	0%	250%	NA	NA
		15		NA	NA	NA	NA	NA	-93%	660%[b]	-52%	433%	0%	350%	NA	NA
		16		NA	NA	NA	NA	NA	-68%	-50%	62%	23%	6%	0%	NA	NA
		17		NA	NA	NA	NA	NA	-84%	39%	-13%	11%	38%	0%	NA	NA
		18		NA	NA	NA	NA	NA	-82%	171%	-46%	191%	0%	450%	NA	NA
		19		NA	NA	NA	NA	NA	-100%	-100%	0%	-100%	0%	-80%	NA	NA
Arvaniti, et al. [44]	Greece	20	PS+AS+ANA	NA	185%	0%	-29%	141%	-52%	28%	92%	-7%	210%	-29%	NA	228%
		21	PS+AS+Cl	NA	125%	0%	14%	17%	-94%	71%	0%	-98%	-100%	-82%	NA	-85%

[a] ANA = anaerobic treatment; DIS = disinfection process; DN = denitrifying process; N = nitrifying process.
[b] Data were deemed statistically outliers.
[c] 16 WWTPs included.
[d] 19 WWTPs included.

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