

Section 17-1 Occurrences in soil, sediment, and biosolids tables

These tables belong with the ITRC PFAS Tech Reg Document. They provide information about the studies used in developing the figures included in Section 6. The observed concentrations of PFAS that have been reported in the recent literature are included for soil, sediment, and biosolids. These tables are intended to provide context to the reader and a starting point for further study. Media-specific occurrences of PFAS are constantly being added in the literature and on state, federal, and other countries' PFAS websites.

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Table 17-2A. Observed PFAS concentrations in soil

Reference/Location	Summary	Reported Soil Concentrations
Memo from Maine DEP on July 19, 2022 Maine, USA	Background study- Statewide survey of shallow soil concentrations of per- and polyfluoroalkyl substances (PFAS) and related chemical and physical data across Maine, 2021 63 Samples- from 0 to 6 inches in depth Only those with >10% detections	Reported concentrations of PFAS ranged from (ng/g) PFBA 0.03- 0.72 PFPeA 0.05- 1.58 PFHxA 0.06- 13.7 PFHpA 0.05 - 1.62 PFOA 0.05 - 5.29 PFNA 0.09 - 2.02 PFDA 0.08 - 3.24 PFUnA 0.06 - 1.93 PFOS 0.15- 5.32
Söregård et al. 2022 Nationwide- Sweden	Spatial distribution and load of per- and polyfluoroalkyl substances (PFAS) in background soils in Sweden, 2017 27 Samples from 0-10cm in the O soil horizon.	Reported concentrations of PFAS ranged from (ng/g) PFBS 0.08- 0.96 PFHxS 0.03 - 0.4 PFOS 0.09 - 1.7 FOSAA 0.33 - 0.88 PFHpA 0.23 - 1.9 PFOA 0.11 - 0.57 PFNA 0.06 - 0.7 PFDA 0.04 - 0.68 PFUnA 0.03 - 0.76
Santangelo et al. 2022 New Hampshire, USA	Background study- Statewide survey of shallow soil concentrations of per- and polyfluoroalkyl substances (PFAS) and related chemical and physical data across New Hampshire, 2021	Reported concentrations of PFAS ranged from (ng/g) PFBA 0.28- 1.8 PFPeA 0.05- 0.84 PFHxA 0.13 - 1.1 PFHpA 0.05- 1.3 PFOA 0.08- 4.1 PFNA 0.08- 7.2 PFDA 0.07- 3.2

	<p>100 locations- from 0 to 6 inches in depth</p> <p>50 locations- from 6 to 12 inches</p> <p>6 locations- soil profiles were collected in 6-inch increments to a maximum of 36 inches</p>	<p>PFUnA 0.08- 2.4</p> <p>PFBS 0.03- 0.82</p> <p>PFHxS 0.07- 0.46</p> <p>PFOS 0.14- 5.4</p>
Wang et al. 2018 Nationwide- China	<p>Occurrence and distribution of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) in natural forest soils: A nationwide study in China, 2012-2013</p> <p>28 Samples with depths of 0-10 cm</p> <p>detects only listed- PFOA min = lowest detect reported in text</p>	<p>Reported concentrations of PFAS ranged from (ng/g)</p> <p>PFOA 0.00- 0.009</p> <p>PFOS 0.00- 0.0027</p>
Brusseau et al. 2020 Worldwide	<p>PFAS concentrations in soils: Background levels versus contaminated sites</p> <p>Data compiled for three types of sites:</p> <ol style="list-style-type: none"> 1. Background sites 2. Primary-source sites (fire-training areas, manufacturing plants) 3. Secondary-source sites (biosolids application, irrigation water use) <p>Data set: >30,000 soil samples collected from >2500 sites worldwide</p>	<p>Reported concentrations of PFAS ranged from (ug/kg)</p> <p>PFOA 0.07 - 50000</p> <p>PFOS 0.09 - 373000</p> <p>PFBA 0.10 - 820</p> <p>PFHxA 0.07 - 15300</p> <p>PFDA 0.03 - 430</p> <p>PFBS 0.05 - 5550</p> <p>PFHxS 0.07 - 21000</p> <p>PFOSA 0.09 - 20000</p> <p>6:2 FTS 0.20 - 68000</p>
Groffen et al. 2019 Antwerp, Belgium	<p>Data from point source- air deposition from a fluorochemical plant</p> <p>PFAA concentrations in soil decreased with distance from a fluorochemical plant</p>	<p>Reported average concentrations of PFAS (ng/g)</p> <p>PFOS 1700</p> <p>PFOA 24</p>

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Table 17-2B. Observed PFAS concentrations in sediment

Reference/Location	Summary	Reported Sediment Concentrations
Bežkoski et al. 2013 Pančevo, Serbia	<p>Perfluorinated compounds in sediment samples from the wastewater canal of Pančevo (Serbia) industrial area</p> <p>Samples were from an artificial canal with no natural inlets, and carries wastewater from several effluents and stormwater runoff from the complex directly into the Danube River The canal is about 2 km long, around 70 m wide</p> <p>Surface sediments were sampled in 15cm layers</p>	<p>Reported concentrations of PFAS ranged from (ug/kg)</p> <p>PFOS 0-5.7 PFHxS 0-0.23 PFOA 0-0.13 PFHxA 0-0.17</p>

	Utilized a Van Veen grab sampler (0.5 L capacity) Samples collected in 2011	
Balگوoyen and Remucal, 2022 Great Lakes/Green Bay, WI, USA	Tributary Loading and Sediment Desorption as Sources of PFAS to Receiving Waters Polypropylene dipper was used to retrieve riverbed sediment Then transferred to 50 mL polypropylene Falcon tubes Attempted 41 locations, were successful in collecting 34 samples	Reported concentrations of PFAS ranged from (ug/kg) PFBS 6 44 PFPeA 15 403 PFHxA 22 268 PFHpA 15 147 PFHxS 7 135 PFOA 21 678 PFNA 9 375 PFDA 9 132 PFOS 19 2898
Ahmadireskety et al. 2021 Pensacola Bay, FL, USA	Per- and polyfluoroalkyl substances (PFAS) in sediments collected from the Pensacola Bay System watershed 34 Samples over 3 time periods and 25 sites 8 Samples used Ponar dredge 17 Samples collected using stainless steel scoop Resampled 9 locations	Reported concentrations of PFAS ranged from (ng/g) PFOS 0-0.46 PFOA 0-0.07 PFBA 0-0.48
Mussabek et al. 2019 Sweden	Temporal trends and sediment water partitioning of per- and polyfluoroalkyl substances (PFAS) in lake sediment 17 Samples from AFFF impacted lake/ponds 500m from a firefighting training facility inner diameter) and piston based mechanism. Sediment cores were sectioned by 1 or 2 cm intervals Cores collected with manual sampler and transparent acrylic tube (50 cm long and 7 cm Found highest concentrations of PFAS in top 1-2 cm	Reported concentrations of PFAS ranged from (ng/g) PFOS 1-64 PFHxS 1-13

<p>Bai and Son 2021 Nevada, USA</p>	<p>Perfluoroalkyl substances (PFAS) in surface water and sediments from two urban watersheds in Nevada, USA</p> <p>21 Sediment Samples and 18 Surface water samples from two urban watersheds.</p> <p>Short-chain PFAS (≤ 8 carbons) were predominant in water. Long-chain PFAS (> 8 carbons) were predominant in sediments.</p>	<p>Reported concentrations of PFAS ranged from (ug/kg)</p> <p>PFHxA 2.8-18.7 PFOA 0.9-6.3 PFUnA 2.1-9.8 PFBS 2.6-10 PFHxS 1.8-12.1 PFHpS 1-6.9 PFDS 12.2-88.2 PFNS 1.7-8.9 PFHxA 4.9-20.3 PFHpA 2.7-21.8 PFOA 1.3-10 PFUnA 4.6-22.9 PFBS 5.2-29.1 PFHxS 3.3-21.3 PFHpS 3.3-15.5 PFDS 3-12.5</p>
<p>Goodrow et al. 2020 New Jersey</p>	<p>13 PFAS tested in surface water, sediment and fish from 11 waterbodies in New Jersey. Lakes, rivers and creeks waterbody types were selected, one identified as a reference site. PFAS were detected at every location in sediment except at the reference location.</p> <p>A single surface sediment sample was collected at each location using a Ponar dredge.</p>	<p>Reported range of PFAS (ug/kg)</p> <p><u>Carboxylates</u> PFBA ND (0.1-0.25) PFPeA ND (0.1-0.25) PFHxA ND (0.1-0.25) PFHpA ND (0.1-0.25) PFOA 0.11-0.4 PFNA 0.13-1.0 PFDA 0.14-0.19 PFUnA 0.14-2.14 PFDoA 0.11-0.65</p> <p><u>Sulfonates</u> PFBS ND (0.18-0.49) PFHxS 0.23-0.99 PFOS 0.51-27.1</p> <p><u>Sulfonamide</u> PFOSA 0.24-6.53</p>
<p>Sharp et al. 2020 Victoria, Australia</p>	<p>Study of PFAS in 19 wetlands in Victoria Australia, data from ducks, sediment, surface water, and soils.</p> <p>Sediment samples were 3-part composites, aliquots were collected within 10 cm of each other from the top 5 cm of sediment with a stainless steel trowel, at the same location as the surface water samples.</p>	<p>PFPeA max value - 12 PFHxA max value - 1.4 PFHpA max value - 1.4 PFOS max value - 16 8:2 FTS max value - 2.9</p>

<p>Campo et al. 2016 Jucar River, Spain</p>	<p>Sediment surface water and biota sampled for PFAS across the Jucar River basin.</p>	<p>PFBA 10.7 - 2.7 PFPeA 6.18 - 0.4 PFHxA 0.04 - 0.04 PFHpA 1.06 - 0.39 PFOA 6.69 - 0.15 i,p-PFNA 1.97 - 1.97 PFNA 3.63 - 3.63 PFDA 1.65 - 0.37 PFUdA 0.04 - 0.04 PFDoA 0.04 - 0.04 PFTrDA 0.04 - 0.04 PFTeDA 4.44 - 2.4 PFHxDA 0.04 - 0.04 PFODA 0.04 - 0.04 PFBS 29.2 - 2.17 PFHxS 0.04 - 0.04 PFHpS 0.58 - 0.05 PFOS 9.83 - 0.06 i,p-PFNS 0.04 - 0.04 PFDS 0.04 - 0.04 PFSAsa 0.04 - 0.04 PFOSA 0.04 - 0.04</p>
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Table 17-2C. Observed PFAS concentrations in biosolids

Reference/Location	Summary	PFAS	Reported biosolids concentrations. All Data ug/kg	
			MIN	MAX
Venkatesan and Halden 2013 Nationwide United States	23 archived biosolids samples from 2001 were tested for 13 PFAAs. PFOS was the most abundant and detected at the highest concentrations, followed by PFOA. Estimated loading of PFAS to agricultural land nationwide is estimated to have been 1375-2070 Kg annually for that time period.	PFBA	1.2	3.2
		PFPeA	1.8	6.7
		PFHxA	2.5	11.7
		PFHpA	1.2	5.4
		PFOA	11.8	70.3
		PFNA	3.2	21.1
		PFDA	6.9	59.1
		PFUnDA	2.8	38.7
		PFDoDA	4.5	26
		PFBS	2.5	4.8
		PFHxS	5.3	6.6
		PFOS	308	618
		PFOSA	2.2	68.1
Venkatesan and Halden 2014 Nationwide United States	Analysis of 13 PFAAs in 3-year mesocosm study of soil/biosolids mixture exposed to outdoor conditions, data for short-chain PFCAs indicated half-lives in soil of 385-866	PFOA		MAX 24.1
		PFUnDA		18.4
		PFDA		17.4

Reference/Location	Summary	PFAS	Reported biosolids concentrations. All Data ug/kg	
	days, compared to more stable concentrations of PFASs.	PFOS		13.2
Schaefer et al. (2022) Biosolids samples from seven facilities nationwide United States	<p>Biosolids were collected at seven facilities as a time-weighted composite grab over a 6-hour period. The facilities utilize a variety of treatment trains and Class A, B and Unclassified finished biosolids were tested. Analysis for an extended list of 54 target PFAS and TOP Assay were performed. Data indicate that precursors such as DiPAPs represented the majority of the total fluorine present in the samples.</p> <p>TOP Assay was not effective at oxidizing some precursors, and typical PFAA reporting lists likely underestimate the PFAS present in biosolids.</p>	<p>Class A</p> <p>10:2 / 8:2 diPAPs</p> <p>10:2 diPAPs</p> <p>5:3 FTA</p> <p>6:2 diPAP</p> <p>6:2 FTS</p> <p>6:6 PFPI</p> <p>6:8 PFPI</p> <p>7:3 FTA</p> <p>8:2 / 6:2 diPAPs</p> <p>8:2 diPAP</p> <p>8:2 FTS</p> <p>HFPO-DA</p> <p>N-EtFOSAA</p> <p>N-MeFOSAA</p> <p>PFBA</p> <p>PFBS</p> <p>PFDA</p> <p>PFDoA</p> <p>PFDS</p> <p>PFHpA</p> <p>PFHxA</p> <p>PFNA</p> <p>PFOA</p> <p>PFOS</p>	<p>MIN</p> <p>17.6</p> <p>9.86</p> <p>17.5</p> <p>102</p> <p>1.11</p> <p>0.63</p> <p>0.669</p> <p>3.24</p> <p>34</p> <p>25.5</p> <p>0.504</p> <p>0.111</p> <p>0.297</p> <p>9.81</p> <p>1.51</p> <p>1.94</p> <p>1.57</p> <p>1.69</p> <p>0.471</p> <p>2.08</p> <p>5.14</p> <p>0.15</p> <p>1.73</p> <p>14.6</p>	<p>Max</p> <p>115</p> <p>22.1</p> <p>21.4</p> <p>175</p> <p>2.62</p> <p>1.19</p> <p>1.18</p> <p>4.03</p> <p>142</p> <p>178</p> <p>1.22</p> <p>0.686</p> <p>7.03</p> <p>22.4</p> <p>2.94</p> <p>8.73</p> <p>3.38</p> <p>2.2</p> <p>5.32</p> <p>2.51</p> <p>9.75</p> <p>3.71</p> <p>2.77</p> <p>21.2</p>

Reference/Location	Summary		PFAS	Reported biosolids concentrations. All Data ug/kg	
		Class B	PFPeA	2.61	26.3
			PFTrDA	0.911	0.945
			PFUdA	0.705	2.32
			10:2 / 8:2 diPAPs	41.8	164
			10:2 diPAPs	25.7	65.6
			5:3 FTA	14.4	70.7
			6:2 diPAP	64.5	340
			6:2 FTS	1.05	1.84
			6:6 PFPI	1.23	1.29
			6:8 PFPI	0.316	2.23
			7:3 FTA	2.34	4.56
			8:2 / 6:2 diPAPs	53.3	268
			8:2 diPAP	82.3	396
			8:2 FTS	0.54	1.59
			HFPO-DA	0.274	0.668
			N-EtFOSAA	4.12	18
			N-MeFOSAA	3.06	17.3
			PFBA	1.05	1.8
			PFBS	1.08	9.31
			PFDA	1.21	3.32
			PFDoA	2.37	4.25
			PFDS	0.933	2.23
			PFHpA	0.294	0.63
			PFHxA	2.06	5.29
			PFNA	0.636	0.899

Reference/Location	Summary		PFAS	Reported biosolids concentrations. All Data ug/kg	
		Unclassified	PFOA	1.02	3.21
			PFOS	0.386	11.3
			PFPeA	10.9	52.8
			PFUdA	1.46	2.29
			10:2 / 8:2 diPAPs	32.1	111
			10:2 diPAPs	11.4	51.4
			10:2 FTA	12.5	14.3
			5:3 FTA	22.3	47.6
			6:2 diPAP	23.3	120
			6:2 FTS	0.294	5.15
			6:6 PFPI	0.44	1.91
			6:8 PFPI	0.418	2.71
			7:3 FTA	4.63	12.9
			8:2 / 6:2 diPAPs	22.3	172
			8:2 diPAP	13.5	179
			8:2 FTS	0.547	11
			HFPO-DA	0.146	0.607
			N-EtFOSAA	0.42	17.2
			N-MeFOSAA	17	34.9
			PFBA	1.66	3.1
			PFBS	1.93	4.32
			PFDA	2.28	11.1
			PFDoA	1.77	3.28
			PFDS	1.34	7.12
			PFHpA	0.475	4.28

Reference/Location	Summary		PFAS	Reported biosolids concentrations. All Data ug/kg	
			PFHpS	0.505	0.894
			PFHxA	1.72	6.68
			PFHxS	0.867	3.32
			PFNA	1.29	3.91
			PFOA	0.8	8.12
			PFOS	0.986	150
			PFPeA	11.4	18.1
			PFTTrDA	0.602	0.757
			PFUdA	0.717	1.75
Pepper et al. 2021 One facility in Arizona, U.S.	Sampled current biosolids from a municipal facility. Studied soil at 5 field sites in AZ with a history of biosolids application from 1984-2019. Sites ranged from desert to irrigated fields with no biosolids to fields with varying application rates historically.	Data from current biosolids at the source facility (4 sample events in July 2020		<u>MIN</u>	<u>Max</u>
			PFBS	ND	6.5
			PFHxS	ND	15
			PFHxA	2	4.2
			NEtFOSAA	ND	11
			NMeFOSAA	18	23
			PFOS	14	36
			PFOA	ND	1.2
			PFNA	ND	2
			PFDA	12	13
			PFUnA	1.8	2.4
			PFDoA	6.5	8
			PFTeA	ND	3.3

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