Division of Science and Research

Research Project Summary

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Investigation of Levels of Perfluorinated Compounds in New Jersey Fish, Surface Water, and Sediment

Authors

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Abstract

The Division of Science, Research and Environmental Health (DSREH) performed an initial targeted assessment of 13 PFAS, all of which are perfluorinated compounds (PFCs), at 11 waterways across the state. Fourteen surface water and sediment samples and 94 fish tissue samples were collected at sites along these waterways. All surface water samples contained detectable levels of at least four PFAS. The lowest total PFAS in surface water was in the Cohansey River, with Horicon Lake and Echo Lake having the second and third lowest total PFAS, respectively. The highest total level of PFAS was found in Little Pine Lake, near the Joint Base McGuire-Dix-Lakehurst, with Mirror Lake and Pine Lake ranking the second and third highest, respectively. Consistent with the known characteristics of preferential partitioning of longer chain PFCs to sediment and shorter chain PFCs to the water column, the PFAS detected in surface water were those with a carbon chain length of nine carbons or less. Ten of the 14 sites where sediment samples were collected had detectable levels of at least one, and up to eight, PFAS. Pine Lake had the highest total PFAS concentration (30.93 ng/g) in the sediment, with the majority being perfluorooctane sulfonate (PFOS), the eight-carbon chain sulfonate. Echo Lake (West Milford in Passaic County), often used as a New Jersey "background" site, had no detectable levels of PFAS in the sediment, but had fish tissue concentrations that required a low-level consumption advisory. In all but one species at one site (channel catfish in the Cohansey River), the average levels of PFOS in fish tissue generated some level of fish consumption advisory, based on the draft preliminary fish consumption triggers included in this report. Additionally, PFUnA, which has a higher bioaccumulative potential than PFOS, was detected in all but one species at one site (common carp at Forge Pond), with a range of 0.75 ng/g in white catfish at the Raritan River to 27.20 ng/g in largemouth bass at Woodbury Creek).

Introduction

Per- and polyfluoroalkyl substances (PFAS) are a group of compounds that have been manufactured and used in multiple industrial processes since the 1950's (Prevedouros et al., 2006; Lindstrom et al., 2011). The structure of the compounds is based on a characteristic carbon chain that is surrounded by fluorine atoms. The *poly*-fluorinated compounds are not fully fluorinated and include another atom or atoms attached to at least one other carbon (e.g. hydrogen or oxygen atom(s)), whereas the *per*-fluorinated compounds have a carbon backbone that is fully fluorinated. The carbon-fluorine bond is extremely strong and is therefore highly resistant to degradation in the environment.

PFAS have surfactant properties and are widely used to coat solid materials such as paper, packaging (including food wrappers), textiles, and carpets (Renner et al., 2001). These coatings provide water-, grease-, and heat-proofing, and impart stain-resistance. PFAS compounds are also used to produce various materials, including fluoropolymers such as polytetrafluoroethylene used in non-stick cookware. In addition, PFAS are used in fire-fighting foams at military sites (as required by military specifications), firefighter training facilities, and in fighting petroleum fires (Moody and Field, 1999). Subsequently, these aqueous film-forming foams (AFFF) have led to groundwater contamination, particularly at multiple military installations (Backe et al., 2013 and Arias et al., 2015).

While the general population is exposed to low levels of PFAS from sources such as the food supply and consumer products, elevated exposures near contaminated sites may occur through ingestion of drinking water and consumption of fish from contaminated sites (Post et al., 2012; Fujii et al., 2015). Several studies by the Department have identified elevated levels of perfluorinated compounds in source water and finished drinking water throughout the state (Post et al., 2009; Post, et al., 2013).

In this study, three media - sediment, surface water, and fish tissue - were analyzed for a total of 13 perfluorinated compounds of various chain lengths.

Methods

Site Selection

Eleven waterbodies across the state were selected based on proximity to potential sources of PFAS in areas of likely recreational and/or sustenance fishing. The eleven sites, plus three additional locations along those waterbodies where a second water and sediment sample were collected, are shown in the table below.

Study Sites

Id	Site Name	Waterway	Sample Site Description	County	X coord (State Feet)	Y coord (State Feet)
1	Echo Lake Reservoir	Echo Lake Channel	Pristine, wooded area	Passaic	516528.3	807686.8
2	Passaic River 1	Passaic River	Industrialized area, upstream, below Route 4	Bergen/Passaic	593434.5	757303.9
2a	Passaic Riv 2	Passaic River	Industrialized area, above Dundee Dam	Bergen/Passaic	595219.8	747080.7
3	Raritan River	Raritan River	Industrialized area, near Kin-Buclandfill	Middlesex	522954.0	602318.8
4	Metedeconk 2	Metedeconk River	Residential and light industry, by wastewater treatment plant discharge	Ocean	591702.4	452007.5
4a	Metedeconk 1	Forge Pond	Impoundment near residential, light industry, source identified. Drinking water intake located here.	Ocean	594375.9	449967.6
5	Pine Lake	Union Branch/Ridgeway Branch, northern portion	Impoundment east of Joint Base McGuire-Dix-Lakehurst; receiving drainage from norther portion of base	Ocean	561393.5	428026.8
6	Horicon Lake	Blacks Branch	Impoundment south of eastern edge of Joint Base McGuire-Dix-Lakehurst; recieves trib from Pine Lake and groundwater from base	Ocean	541862.2	428131.9
7	Little Pine Lake	Jacks Run	Impoundment receiving drainage from western edge of JB MDL	Burlington	472633.7	421150.1
8	Mirror Lake	North Branch Rancocas	Impoundment receiving drainage from central are of JB MDL	Burlington	472515.2	414430.7
9	Woodbury Creek	Delaware River	Tributary to Delaware River; near identified source	Gloucester	300571.7	373608.9
10	Fenwick Creek	Fenwick Creek Tributary	Downstream from rug manufacturer	Salem	221581.7	273032.6
11	Cohansey River	Cohansey River	Mouth of Rocaps Creek tributary to Cohansey; agriculture, residential, and light manufacturing	Cumberland	285609.4	208155.2
11a	Cohansey River 2	Cohansey	Upstream mainstem Cohansey; ag, residential, and light manufacturing	Cumberland	285001.3	213424.8

Sample Collection

One grab sample of surface water was collected from six (6) inches below the surface to eliminate surface debris at each of the 11 waterbodies. The surface water grab samples were collected directly into a PFAS-free plastic wide mouth lab-prepared sample bottles. One grab sample of sediment was collected by Ponar dredge from each of the 14 locations that were also sampled for water. The fish that were targeted in this study represented those freshwater species typically sought after for consumption by New Jersey anglers and likely inhabiting each of the waterbodies sampled. Fish were often collected by Direct Current (DC) boat electrofishing within a single day of sampling. The fish collected at each site were representative of the types of fish typically taken from the waterbody by anglers who fish for recreation and sustenance.

Analytical Methods

Analysis of water, sediment, and fish tissue samples was conducted according to the documented Standard Operating Procedures by the Axys Analytical Laboratories. Although not currently certified by the NJDEP for regulatory use, these analytical methods rely upon the use of Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS) and are based on the EPA 537 method. The analysis of the three media provided results that quantified 13 PFAS compounds. These 13 compounds, considered to be "traditional" PFAS, including perfluorinated carboxylates and sulfonates.

Results

Surface Water

All of the 14 surface water samples that were collected had detectable levels of at least four perfluorinated compounds, and three compounds, PFHpA, PFOA, and PFPeA, were detected in every sample. The concentration of PFOA ranged from 4.9 ng/L in the Echo Lake sample, to a high of 33.9 ng/L in the Forge Pond/Metedeconk sample that was taken just below the WWTP. It is noted that the Metedeconk River is known to be impacted by groundwater contaminated by an identified industrial source of PFOA (Procopio et al., 2017). Shorter chain compounds such as PFBA, PFBS, PFPeA, PFHxA, and PFHpA were found in the majority of the surface water samples.

Relatively elevated levels of PFOS, a typical component of AFFF, were found in Pine Lake, Mirror Lake, and Little Pine Lake, with levels up to 102.0 ng/L. These waterbodies may be impacted by the hydrologic connection with the Department of Defense site, Joint Base Maguire Dix Lakehurst (JB MDL), which has been identified as a source of PFOS due to use of AFFF in training and/or fire-fighting. PFHxS is also known to be a component of AFFF and was also found at elevated levels in these samples.

Sediment

Thirteen (13) of the 14 sediment samples collected contained detectable levels of at least one perfluorinated compound, while there were no detections in the sediment samples from the Echo Lake Reservoir site (intended background site). PFOS was the only compound detected in the sediment samples from both Passaic River sites (0.29 ng/g near Route 4 location; higher levels of 0.51 ng/g closer to Dundee Dam). Nine of the 14 samples did contain detectable levels PFUnA (C11), and seven of the 14 samples contained detectable levels of PFDoA (C12). PFOS was detected in all but three samples - Echo Lake Reservoir, Forge Pond (Metedeconk), and one of the Cohansey River sites; PFOSA, a precursor of PFOS, was also not detected in these three samples. The highest concentrations of PFOS were found in Little Pine Lake (27.1 ng/g) and Pine Lake (19.3 ng/g), likely due to their proximity to the DOD site, JB MDL, a known source. At the remaining sites with detectable PFOS in the sediments, levels ranged from 0.29 ng/g at the Passaic River by Route 4 to 3.07 ng/g in Mirror Lake.

Fish Tissue

The maximum concentration of PFOS in fish tissue was much higher than for the other PFAS, consistent with studies from other locations. PFOS and the longest chain carboxylates (PFDA, PFUnA, and PFDoA) were found at all or almost all sites. Other PFAS that are less bioaccumulative (e.g. PFOA, PFNA, PFHxS) were found much less frequently, at one to three sites that are, in several cases, impacted by known sources of these compounds. Additionally, maximum fish tissue concentrations of PFOA, PFNA, and PFHxS were lower than for the longer chain compounds.

Summary of detections of PFAS in fish tissue

Compound	Number of Sites Detected (n=11)	Number of Species-Sites Detected (n=32)	Maximum concentration (ppb; ng/g)
PFOS	11	30	162.5
PFUnA	11	31	27.2
PFDoA	10	28	5.42
PFDA	10	24	3.57
PFOSA	3	5	2.83
PFHxS	3	4	1.66
PFNA	2	4	1.39
PFOA	1	2	0.72

For additional statistical descriptors, see Table 22 in full report[2]

Fish Consumption Advisory Triggers

For the purposes of this report, draft *preliminary* fish consumption advisory triggers for PFOS, PFOA, and PFNA in fish tissue have been calculated. These preliminary fish consumption triggers are based on currently available New Jersey Reference Doses (the daily dose not expected to pose a risk with lifetime exposure). The PFNA Reference Dose, 0.74 ng/kg/day, was used as the basis for the recently finalized NJDEP Ground Water Quality Standard and drinking water Maximum Contaminant Level (MCL) for PFNA. The PFOA Reference Dose, 2.0 ng/kg/day, is used as the basis for the New Jersey Drinking Water Quality Institute MCL recommendation and NJDEP drinking water guidance for PFOA. The PFOS Reference Dose, 1.8 ng/kg/day, was developed by the New Jersey Drinking Water Quality Institute as the basis for its PFOS MCL recommendation.

The fish consumption advisory triggers are based on the same exposure assumptions (227 gram [8 ounce] meal size and 70 kg body weight) and recommended consumption frequency categories: no limit applied for consumption (**unlimited)**, no more than one meal per week (**weekly**), no more than one meal per month (**monthly**), no more than once meal every 3 months (**once/ 3 months**), no more than one meal per year (**yearly**), and consumption not recommended (**do not eat**) used in existing New Jersey fish consumption advisories.

[2] The full report can be found at https://www.nj.gov/dep/dsr/publications/Investigation%20of%20Levels%20of%20Perfluorinated%20Compounds%20in%20New%20Jersey%20Fish,%20Surface%20Water,%20and%20Sediment.pdf

Table 8: DRAFT Preliminary Fish Consumption Advisory Triggers

	General Population			High Risk Population*		
	PFOA (ng/g; ppb)	PFNA (ng/g; ppb)	PFOS (ng/g; ppb)	PFOA (ng/g; ppb)	PFNA (ng/g; ppb)	PFOS (ng/g; ppb)
Unlimited	0.62	0.23	0.56	0.62	0.23	0.56
Weekly	4.3	1.6	3.9	4.3	1.6	3.9
Monthly	18.6	6.9	17	18.6	6.9	17
Once/3 months	57	21	51	N/A	N/A	N/A
Yearly	226	84	204	N/A	N/A	N/A
Do Not Eat	**>226**	**>84**	**>204**	**>18.6**	**>6.9**	**>17**

**High risk individuals are considered to be at higher risk from contaminants in fish than members of the general public. This group includes infants, children, pregnant women, nursing mothers and women of childbearing age.*

Fish Tissue Consumption Advisories based on PFAS concentrations

Consumption advisories in New Jersey are based on multiple bioaccumulative compounds including mercury and PCBs. Final fish tissue consumption advisories can be found on the NJDEP's FishSmartEatSmartNJ.org website (or https://www.nj.gov/dep/dsr/njmainfish.htm) and are based on the most protective level after reviewing all contaminant concentrations in the fish tissue. The following advisories are based only on the PFAS concentration and may not represent the final consumption advisory.

The table below provides the calculated fish tissue consumption advisory based on the concentration of PFAS in the fish tissue collected at the select sites around New Jersey.

Waterbody	Species	Avg. PFOS (ng/g)	Advisory
Echo Lake	Bluegill	2.33	Weekly
	Brown Bullhead	2.43	Weekly
	Largemouth Bass	4.63	Monthly
Passaic River	Bluegill	47.43	Once/3 months
	Common Carp	9.10	Monthly
	Largemouth Bass	39.30	Once/3 months
Raritan	Channel Catfish	3.10	Weekly
	Common Carp	11.54	Monthly
	White Catfish	2.27	Weekly
	White Perch	13.11	Monthly
Forge Pond	Common Carp	6.36	Monthly
	Largemouth Bass	21.20	Once/3 months
	White Perch	7.51	Monthly
Pine Lake	American Eel	162.50	Yearly
	Largemouth Bass	114.00	Yearly
	Pumpkinseed	119.20	Yearly

Waterbody	Species	Avg. PFOS (ng/g)	Advisory
Horicon	Chain pickerel	15.21	Monthly
	Yellow bullhead	1.43	Weekly
Little Pine	Largemouth Bass	73.67	Yearly
	Pumpkinseed	31.80	Once/3 months
	Yellow perch	118.60	Yearly
Mirror Lake	American Eel	33.73	Once/3 months
	Bluegill	22.20	Once/3 months
	Largemouth Bass	39.63	Once/3 months
Woodbury	Channel Catfish	0.44	Unlimited
	Largemouth Bass	21.30	Once/3 months
	Pumpkinseed	21.91	Once/3 months
Fenwick	Channel Catfish	0.57	Weekly
	Common Carp	12.39	Monthly
	White Catfish	2.53	Weekly

**However, the Woodbury Channel catfish contained concentrations of PFNA that required an advisory of "no more than weekly" consumption.

Conclusions

In summary, perfluorinated compounds are widely distributed in the State of New Jersey due to historic and current industrial activities, as well as the presence of military facilities. These compounds are of concern because they do not break down in the environment, bioaccumulate in humans and biota, and may pose risks to human receptors. This initial study indicates the presence of some of these compounds in fish tissue at levels that might impact human health. Given the distribution of potential sources of these compounds throughout the state, additional studies are recommended to more fully understand sources at each site included in this study and occurrence of PFAS at additional sites statewide. The results of this study also suggest that it would be beneficial to the State to develop health-based triggers for additional PFAS, such as PFUnA, that have been detected in fish, when the necessary health effects data are available. Such additional information is essential to better understand the occurrence and potential risks of these compounds in the fish tissue that is consumed by the public.

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[1] New Jersey Department of Environmental Protection, Division of Science and Research

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