Ecological Risk Assessment of PFAS

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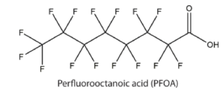
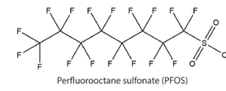
Although regulations for per– and polyfluoroalkyl substances (PFAS) are at present focused on human health, ecological risks will also need to be addressed within baseline risk assessments. Ecological risk assessment guidance for PFAS is not well developed, but is starting to emerge from the Department of Defense, the Environmental Protection Agency, and other organizations.

This poster presents and discusses some considerations and observations regarding early indications for PFAS ecological risk assessment.



Perfluorooctanoic acid (PFOA)



Perfluorooctane sulfonate (PFOS)

Direct Aquatic Toxicity

- The table below compares aquatic screening levels and the results of statewide surface water surveys
- Data show a wide range and variation for aquatic toxicity data and screening levels, plus limited studies
- HC5 values for PFOA and PFOS, the most studied PFAS, suggest screening levels will decrease for other PFAS
- *Generally, observed surface water concentrations are well below screening values; hence PFAS are unlikely to be directly toxic to aquatic organisms in most surface waters*

Summary of Toxicity Screening Levels

	Screening Levels (µg/L)						Sample Results (µg/L)		
	Freshwater		Saltwater (applies to Estuarine Water)		Surface Water RWQ RBSL Aquatic Life (aquatic plants, aquatic invertebrates, fish, and amphibians)		Surface Water Sampling Maximum Reported Concentrations		
PFAS	Plants	Animals	Plants	Animals	Acute	Chronic	Michigan	Wisconsin	Pennsylvania
PFBA	<214,000	137,000	-	-	4,200	470	0.13	-	0.009
PFBS	-	7.7	-	2.9	17,000	3,400	0.08	0.02	0.023
PFPeA	81,700	1,000	-	13,200	1,200	140	1	0.02	0.020
PFHxA	628,000	6,280	999,000	15,700	8,800	2,300	0.69	0.04	0.012
PFHxS	-	80		-	-	-	0.55	0.21	0..009
PFHpA	>1,019,000	>1,019,000	517,000	517,000	7,800	870	1.5	0.01	0.006
PFHpS	-	-	-	-	-	-	0.18	0.01	-
PFOA	1,112		25,000	11.4	53,000	3,900	7.70	0.04	0.016
PFOS	5.85		7.70		570	51	11	0.36	0.023
PFNA	<464,000	8	130,000	9.3	1,100	120	0.1	0.00	0.016
PFOSA	-	15.5	-	-	-	-	-	-	-
6:2 FTS	> 125,000	108,000	-	-	-	-	-	-	-
8:2 FTS	-	-	-	-	-	-	-	-	-

HC5 from SERDP Guidance (Condor)
NOEC from EcoTox
LOEC from EcoTox
NR-ZERO from EcoTox
EC50 from EcoTox
NR from EcoTox
IC50 from EcoTox
Recommended Water Quality Risk-based Screening Levels for Aquatic Life (aquatic plants, aquatic invertebrates, fish, and amphibians), SERDP[2]

Acronyms applied in EcoTox Database
HC5 *= concentration of a substance at which 5% of a species exhibits the specified effect*
NOEC *= no observed effects concentration*
LOEC *= lowest observed effects concentration*

EC50 *= median effective concentration or concentration that causes 50% of maximal response*
IC50 *= median inhibition concentration or concentration expected to cause a 50% inhibition of a biological process*
NR-ZERO *= zero percent mortality or 100% survival of organisms*
NR *= Endpoint Not Reported from EcoTox*

PFAS Bioconcentration

- As with screening levels, a wide range of bioconcentration factors has been reported for PFAS (see table below)
- Although data are "spotty," indications are that bioconcentration factors are highest for long-chain sulfonic acids, particularly for PFOS, which is one of the most frequently detected PFAS in surface water
- Surface water observations (table at left) are generally lower than foodweb screening levels (table at right) except for PFOS, for which levels near release sites may exceed NOAEL-based modeled values for aquatic receptors

NOAEL-Based Aquatic Screening Levels for Wildlife (µg/L) (Divine[2])

PFAS	Aquatic Receptors	Terrestrial Receptors
PFBA	660	460,000
PFBS	640	320,000
PFHxA	210	530,000
PFOA	4.4	1,900
PFOS	0.075	300
PFNA	2.2	5,200

Mink | Tree Swallow | Little Brown Bat
Brown Pelican | Muskrat | House Wren

Bioconcentration Factors to Predict Uptake of PFAS by Aquatic Biota

PFAS	SERDP (Conder)[1]			SERDP (Divine)[2]				ITRC[3]	Florida[4]	Minnesota[5]	New Jersey[6]
	Aquatic Plant Bioconcentration Factor (L/kg, ww)	Fish Bioconcentration Factor (L/kg, ww)	Pelagic Invertebrate Bioconcentration Factor (L/kg, ww)	Aquatic Plant Bioconcentration Factor (L/kg, ww)	Fish Bioconcentration Factor (L/kg, ww)	Aquatic Benthic Invertebraes Bioconcentration Factor (L/kg, ww)	Aquatic Crustaceans Bioconcentration Factor (L/kg, ww)	Fish Bioconcentration Factor (L/kg, ww)	Fish Bioconcentration Factor (L/kg)	Fish Bioconcentration Factor (L/kg, ww)	Emperical Fish Bioconcentration Factor (L/kg)
PFBA	-	0.60	-	1.2	640	-	-	-	-	-	-
PFBS	19	1.0	0.0065	0.5	183	33	97	-	-	-	-
PFPeA	26	0.23	-	-	4,855	-	-	-	-	-	-
PFHxA	25	0.69	-	11.9	63	249	194	-	-	-	-
PFHxS	28	9.6	-	0.8	251	147	369	10	-	-	11
PFHpA	25	3.2	-	-	50	39	38	-	-	-	-
PFHpS	-	-	-	-	-	-	-	-	-	-	-
PFOA	28	4.0	91	14.3	179	42	176	4	68	40 (lakes) 24 (rivers)	-
PFOS	90	1,100	179	81.6	2,646	172	1,402	1,100	2,358	6,087 (lakes) 3,877 (rivers)	1,593
PFNA	58	39	152	324.3	669	109	878	-	-	-	181
PFOSA	-	39	-	-	-	-	-	-	-	-	-

PFAS Bioaccumulation from Sediment

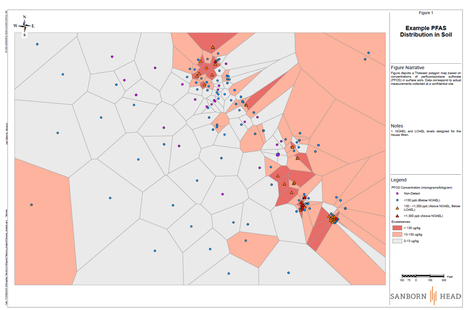
- Biota-sediment accumulation factors (BSAF) have been developed for PFAS (see table at right)
- A limited attempt to apply BSAF to reported Chesapeake Bay data suggests overprediction in oyster tissue, supporting literature that indicates biota levels are tied to water levels
- Suggests a need for accounting for PFAS bioavailability from sediments

Concentrations of Sediment and Oysters with Comparison of Accumulation Factors

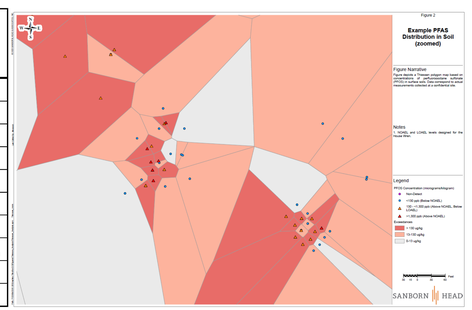
PFAS Compound	Chesapeake Bay Mussel Watch Sediment					Chesapeake Bay Mussel Watch Oyster Tissue					SERDP (Conder)[1]		SERDP (Divine)[2]	
	CBBO	CBMP	CBBH	CBCP	CBSB	CBBO	CBMP	CBBH	CBCP	CBSB	Invertebrate Biota-Sediment Accumulation Factor (g sediment/g tissue, ww)	Predicted Concentration in Oyster Tissue (ng/g, ww)	Invertebrate Biota-Sediment Accumulation Factor (g sediment/g tissue, ww)	Predicted Concentration in Oyster Tissue (ng/g, ww)
PFBA											-		-	
PFBS											34		-	
PFPeA											-		-	
PFHxA											4		-	
PFHxS											86		29	
PFHpA											18		13	
PFHpS											-		-	
PFOA	ND	ND	ND	0.41	0.27	ND	ND	ND	ND	ND	95		31	
PFOS	0.319	0.729	0.372	0.92	1.08	ND	ND	ND	ND	1.05	120	130	12	13
PFNA											160		51	
PFOSA	ND	ND	ND	ND	0.24	3.36	1.9	1.4	0.84	ND	10		-	

Soil Screening

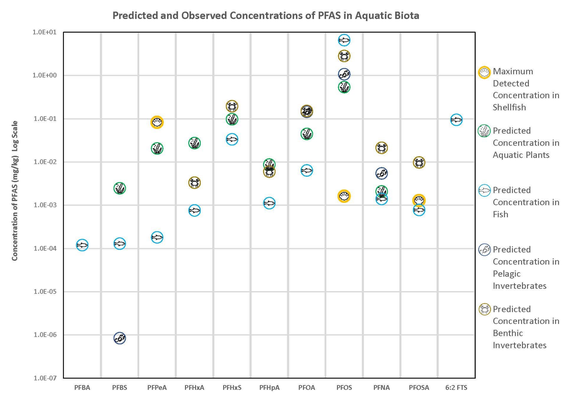
- Foodweb-based screening levels for PFAS in soil are generally above background levels, but will likely be exceeded in areas of PFAS releases
- Example to the right compares UCL95s for an example data set to area-weighted averages derived from Thiessen polygon maps — area averages are considerably lower than UCL95s, as high values dominate the UCL95s
- Polygons in light and dark pink exceed the NOAEL- and LOAEL-based screening levels, respectively
- Maps emphasize the potential importance of considering species habitat ranges



Metric	Figure 1	Figure 2 Blowup Region
Number of Samples	166	51
Number of Detects	141	43
Median Detect (ppb)	30.95	42.1
Maximum (ppb)	98000	2280
Mean Detect (ppb)	1046	202.5
DL/2 Mean (ppb)	895.5	171.3
UCL95 (ppb)	1172	982.8
UCL95 Type	KM H-UCL	KM H-UCL
Projection Area (acres)	245	12
Area Average (ppb)	41.1	370



PFAS Concentrations - Predicted and Observed



Conclusions

- Data for many PFAS remain scarce
- Direct aquatic toxicity may be rare and limited to areas of concentrated releases
- Bioconcentration of long-chain sulfonic acids may affect wildlife in areas of elevated PFAS in surface water
- Fauna with limited ranges might be affected by high PFAS concentrations in soil near source areas
- Bioconcentration models based on sediments may not be reliable

References (Scan or See Handout)

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