APPENDIX B

SPME SPECIAL STUDY RESULTS

2020 PILOT STUDY: DMMP MONITORING OF THE PORT GARDNER NON-DISPERSIVE UNCONFINED OPEN-WATER DREDGED MATERIAL DISPOSAL SITE

July 12, 2021

Submitted to:

Washington State Department of Natural Resources
Aquatic Resources Division
Olympia, Washington 98504

Submitted by:

NewFields
115 2nd Avenue N, Suite 100
Edmonds, Washington 98020

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

BCOC	bioaccumulative chemical of concern
DMMP	Dredged Material Management Program
DU	decision unit
LOC	level of chlorination
LOD	level of detection
PCB	polychlorinated biphenyl
PDMS	polydimethylsiloxane
PRC	performance reference compounds
SPME	Solid-phase microextraction
TEF	toxicity equivalent factor
TEQ	toxic equivalency

1.0 INTRODUCTION

Solid-phase microextraction (SPME) passive sampling was added to the 2020 Port Gardner pilot study to explore the use of passive samplers as a substitute for measuring bioavailability at the disposal sites in the future. SPME data interpretation includes comparisons of concentrations and congener patterns of select bioaccumulative chemicals of concern (BCOCs) in sediment, tissue and SPME fibers , to determine if a relationship can be established. As a result, this appendix includes a more detailed analysis of polychlorinated biphenyl (PCB) congeners and dioxin/furans in sediments and tissues than was presented in Sections 5.2 and 5.3 of the pilot study monitoring report (NewFields 2021).

Bioaccumulation studies were conducted following Dredged Material Management Program (DMMP) guidance and are described in Section 4.3 of the monitoring report. Testing was conducted using the adult bivalve (*Macoma nasuta*) and adult polychaete (*Alitta virens*) using separate exposure tanks for a 45-day period. SPME fibers were included in three of the five *A. virens* test chambers for both the onsite Disposal Site (PGD-DU) and offsite Environs DU (PGE-DU) test sediments (total of 6 SPME passive samplers). The passive samplers consisted of 5-cm long fibers in stainless steel mesh holders placed at a depth of 2-3 cm below the sediment surface for the duration of the experiment, 45 days.

2.0 SPME DATA BACKGROUND AND DATA CALCULATIONS

Data for dioxins/furans and PCBs in SPME samples were reported by the laboratory in pg/mL (Table 1). These data were converted to ng/g of polydimethylsiloxane (ng/g_{PDMS}, the coating of the SPME fiber that serves as the passive sampler) by dividing the reported concentration by the density of PDMS (0.965 g/mL). For the purposes of showing contaminant patterns taken up by SPME and comparing SPME concentrations to tissue concentrations, SPME data are reported as ng/g_{PDMS}.

Concentrations of contaminants measured in SPME fibers were also used to calculate the dissolved porewater concentrations. At equilibrium, the concentration of contaminant in the SPME (C_{SPME}) and the dissolved concentration (C_D) are related as follows:

$$C_D = \frac{C_{SPME}}{K_{SPME}} \times 1000 \quad (1)$$

where K_{SPME} is the passive sampler-dissolved phase partition coefficient (in L/kg). K_{SPME} can be derived empirically or can be estimated from the more readily available octanol-water partition coefficient (K_{OW}) using the following equation:

$$\log K_{PDMS} = 0.017 + 0.947 \log K_{OW} \quad (2)$$

Equation 1, however, only applies when the passive sampler is at equilibrium with the surrounding environment. Performance reference compounds (PRCs) are used to correct for non-equilibrium conditions. The principle is that the passive sampler is deployed with one or more PRCs at a known concentration. The PRCs are compounds that are not found in the environment being sampled, and they desorb from the SPME at rate similar to how the contaminants absorb. Therefore, when the PRC cannot be detected in the SPME, absorbed contaminants are at equilibrium with concentrations in surrounding waters. Therefore, during non-equilibrium conditions, the dissolved concentration can be calculated from the passive sampler using the following equations (Adams et al. 2007):

$$C_d = \frac{C_{SPME}}{(1-e^{k_e t}) \times K_{SPME}} \quad (3)$$

and

$$k_e = \ln\left(\frac{C_{PRC-t}}{C_{PRC-0}}\right) \div t \quad (4)$$

where t is the deployment time (in days), $C_{PRC\text{-}0}$ is the concentration of PRC before deployment, and $C_{PRC\text{-}t}$ is the concentration of PRC after deployment. The amount of the correction decreases with increasing time, and as the SPME approaches equilibrium, the value calculated from Equation 3 approaches the value calculated from Equation 1. In other words, as the passive sampler approaches equilibrium, $e^{k_e t}$ approaches zero.

The following eight (8) PRCs were used in these experiments to correct for non-equilibrium concentrations and calculate dissolved porewater concentrations: $^{13}C_6$-1,2,3,4-TCDD, $^{13}C_{12}$-PCB-28, $^{13}C_{12}$-PCB-47, $^{13}C_{12}$-PCB-70, $^{13}C_{12}$-PCB-80, $^{13}C_{12}$-PCB-111, $^{13}C_{12}$-PCB-142, and $^{13}C_{12}$-PCB-182. $^{13}C_6$-1,2,3,4-TCDD was used to correct concentrations of all dioxin/furan concentrations. For individual PCB congeners, the PRC with the most similar logK_{PDMS} value was used to correct the concentration. Appendix A lists the PCB congeners, as well as the PRC used to correct for non-equilibrium conditions.

Data for dioxins/furans and PCB congeners in the *M. nasuta* and *A. virens* tissues were reported by the laboratory in pg/g (wet weight). These data were converted to lipid-normalized concentrations and are reported as ng/g_{lipid} in this report. Data for dioxins/furans and PCBs in sediment were reported by the laboratory as pg/g (dry weight). These data are reported in the equivalent ng/kg in this report.

2.1 Concentrations of Dioxins/Furans and PCBs in Porewater Calculated from SPME Data

Dissolved porewater concentrations were calculated from SPME data using the approach described in Section 2.0. Approximately 29-39% of the dioxin PRC ($^{13}C_6$-1,2,3,4-TCDD) was lost in the six SPME sediment exposures, indicating that the dioxins were not yet at equilibrium and necessitating the need to correct measured concentrations for non-equilibrium conditions. Average calculated dissolved porewater concentrations are shown in Figures 1 and 2.

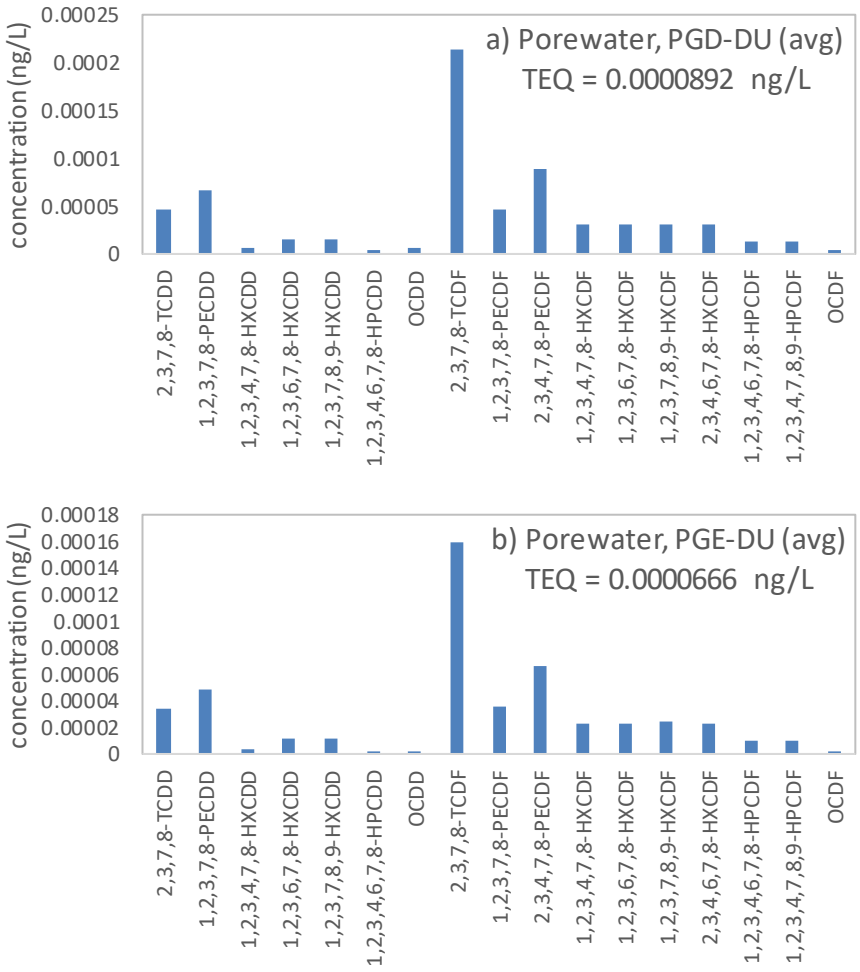


Figure 1. Dissolved Concentrations of Dioxins/Furans in Porewater Calculated from SPME Data

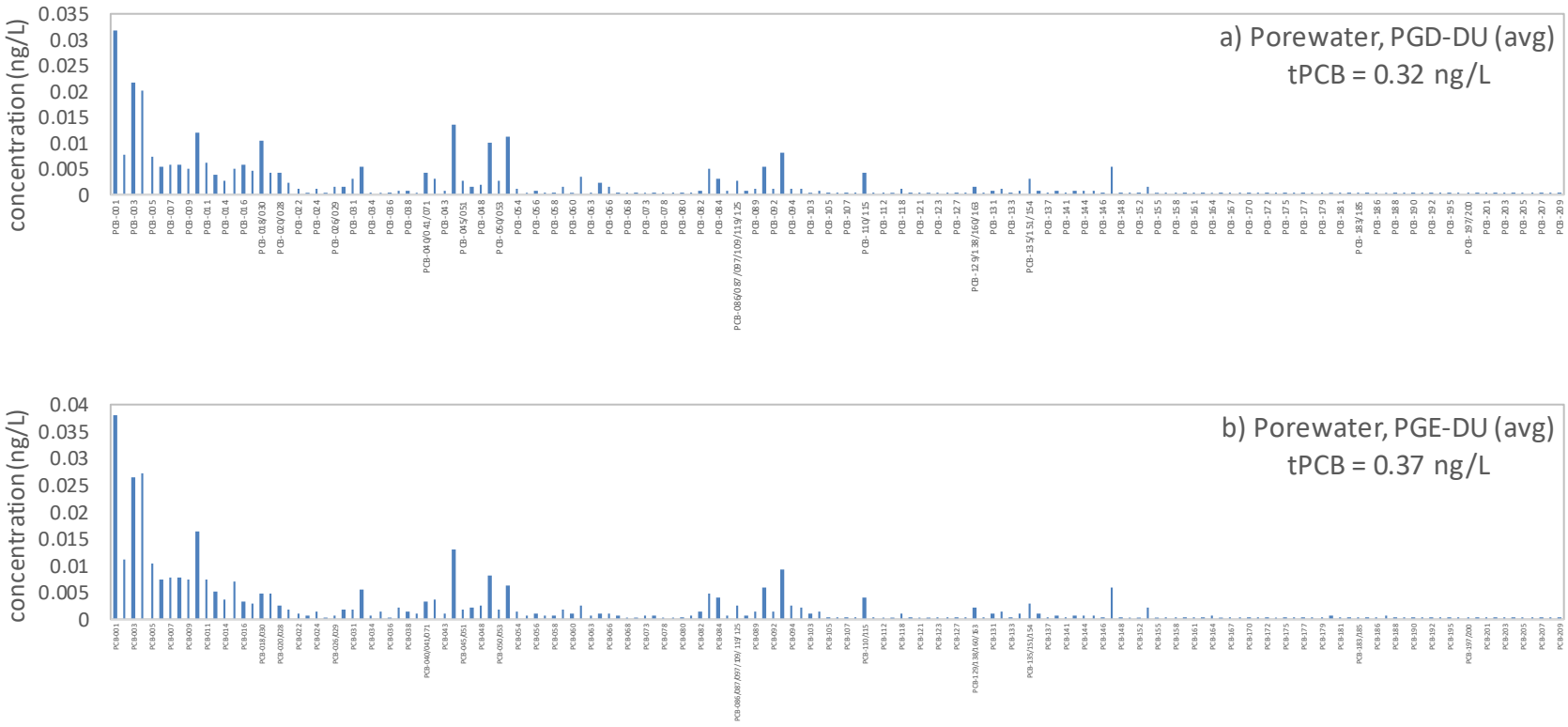


Figure 2. Dissolved Concentrations of PCBs in Porewater Calculated from SPME Data

Table 1. SPME Chemistry Results

SPMEs		Day Zero Sample		Trip Blank		PGD-DU Rep 1		PGD-DU Rep 2		PGD-DU Rep 3		PGE-DU Rep 1		PGE-DU Rep 2		PGE-DU Rep 5	
Compound	Units	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q
Dioxins/Furans																	
2,3,7,8-TCDD	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
1,2,3,7,8-PECDD	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
1,2,3,4,7,8-HXCDD	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
1,2,3,6,7,8-HXCDD	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
1,2,3,7,8,9-HXCDD	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
1,2,3,4,6,7,8-HPCDD	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
OCDD	pg/mL	34.9	U	34.9	U	79.7	J	71.6	J	174	J	57	J	44.3	J	41.3	U
2,3,7,8-TCDF	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
1,2,3,7,8-PECDF	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
2,3,4,7,8-PECDF	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
1,2,3,4,7,8-HXCDF	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
1,2,3,6,7,8-HXCDF	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
1,2,3,7,8,9-HXCDF	pg/mL	29.8	U	38.5	U	34.5	U	40.6	U	34.5	U	34.3	U	42	U	30	U
2,3,4,6,7,8-HXCDF	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
1,2,3,4,6,7,8-HPCDF	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
1,2,3,4,7,8,9-HPCDF	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
OCDF	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
Total TEQ (ND = 0)	pg/mL	0.0105		3.86		0.0239		0.0215		0.0522		0.0171		0.0133		0.0000	
Total TEQ (ND = 1/2 DL)	pg/mL	47.1		55.6		54.5		56.9		54.6		54.2		54.4		47.4	
TOTAL TETRA-DIOXINS	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
TOTAL PENTA-DIOXINS	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
TOTAL HEXA-DIOXINS	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
TOTAL HEPTA-DIOXINS	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
TOTAL TETRA-FURANS	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
TOTAL PENTA-FURANS	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
TOTAL HEXA-FURANS	pg/mL	29.8	U	38.5	U	34.5	U	42	U	34.5	U	34.3	U	32.8	U	30	U
TOTAL HEPTA-FURANS	pg/mL	29.8	U	33.8	U	34.5	U	34.5	U	34.5	U	34.3	U	32.8	U	30	U
PCB Congeners																	
PCB-001	pg/mL	201	U	174	U	201	U	190	U	180	U	200	U	196	U	197	U
PCB-002	pg/mL	112	U	112	U	90.5	U	87.9	U	97.8	U	115	U	119	U	114	U
PCB-003	pg/mL	291	U	221	U	197	U	209	U	241	U	217	U	219	U	272	U
PCB-004	pg/mL	287	U	239	U	259	U	193	U	253	U	286	U	293	U	251	U

SPMEs		Day Zero Sample		Trip Blank		PGD-DU Rep 1		PGD-DU Rep 2		PGD-DU Rep 3		PGE-DU Rep 1		PGE-DU Rep 2		PGE-DU Rep 5	
Compound	Units	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q
PCB-005	pg/mL	214	U	170	U	169	U	138	U	174	U	215	U	205	U	168	U
PCB-006	pg/mL	180	U	143	U	148	U	120	U	152	U	181	U	173	U	147	U
PCB-007	pg/mL	183	U	145	U	151	U	123	U	155	U	184	U	175	U	150	U
PCB-008	pg/mL	168	U	134	U	138	J	134	J	139	U	169	U	162	U	134	U
PCB-009	pg/mL	185	U	147	U	149	U	121	U	153	U	186	U	178	U	148	U
PCB-010	pg/mL	185	U	147	U	151	U	123	U	155	U	185	U	177	U	150	U
PCB-011	pg/mL	303	U	298	U	313	U	317	U	362	U	301	U	299	U	494	U
PCB-012/013	pg/mL	212	U	168	U	177	U	144	U	182	U	213	U	203	U	176	U
PCB-014	pg/mL	192	U	153	U	158	U	128	U	163	U	193	U	184	U	157	U
PCB-015	pg/mL	279	U	214	U	214	U	184	U	228	U	282	U	257	U	217	U
PCB-016	pg/mL	64	U	71.3	U	218	J	191	U	147	J	101	U	111	J	77.9	J
PCB-017	pg/mL	59.2	U	66	U	304	J	244	J	167	J	97.4	J	133	J	164	J
PCB-018/030	pg/mL	52.5	J	65.5	J	520	J	462	J	443	J	189	U	201	U	206	U
PCB-019	pg/mL	68.4	U	72.2	U	116	J	74.8	J	71.8	U	98.1	U	87.3	U	72.3	U
PCB-020/028	pg/mL	96.1	U	107	U	398	U	386	U	341	U	204	U	243	U	219	U
PCB-021/033	pg/mL	71	U	52.1	U	157	U	153	U	176	U	122	U	116	U	95.1	U
PCB-022	pg/mL	49.7	J	50.6	U	107	J	93.8	J	99.5	J	67.7	J	67.1	J	48.5	J
PCB-023	pg/mL	41.4	U	46.4	U	42	U	49.7	U	37.8	U	61.8	U	45.3	U	41.8	U
PCB-024	pg/mL	44.9	U	50.1	U	49.9	U	44.2	U	45.9	U	70.8	U	56.6	U	46.6	U
PCB-025	pg/mL	34.6	U	38.8	U	51.6	J	57.4	J	51.4	J	51.7	U	37.8	U	34.9	U
PCB-026/029	pg/mL	41.2	U	46.1	U	136	J	142	J	128	J	61.4	U	45	U	48.1	J
PCB-027	pg/mL	43	U	47.9	U	62.9	J	57.1	J	61.3	J	67.7	U	54.1	U	44.3	U
PCB-031	pg/mL	98.5	U	77.2	U	351	U	309	U	309	U	121	U	178	U	177	U
PCB-032	pg/mL	39.6	U	44.3	U	157	J	171	J	136	J	120	J	168	J	140	J
PCB-034	pg/mL	43.6	U	48.8	U	43.2	U	51.1	U	38.8	U	65	U	47.6	U	43	U
PCB-035	pg/mL	42.6	U	47.7	U	43.3	U	51.3	U	39	U	63.6	U	46.6	U	43.1	U
PCB-036	pg/mL	38.3	U	42.9	U	38.7	U	45.9	U	34.9	U	57.1	U	41.9	U	38.6	U
PCB-037	pg/mL	59.1	U	68.1	U	64.9	J	74.7	U	55.3	U	92.9	U	64.2	U	85.6	J
PCB-038	pg/mL	41	U	45.9	U	41.8	U	49.5	U	37.6	U	61.2	U	44.8	U	41.7	U
PCB-039	pg/mL	40.8	U	45.7	U	41.2	U	48.8	U	37	U	60.9	U	44.6	U	41	U
PCB-040/041/071	pg/mL	93.8	U	86.1	U	368	U	390	U	359	U	238	U	267	U	262	U
PCB-042	pg/mL	79.6	U	73.1	U	184	J	160	J	213	J	109	U	121	J	123	J
PCB-043	pg/mL	94.1	U	86.5	U	67	U	68	U	82.1	U	129	U	92.7	U	72.5	U
PCB-044/047/065	pg/mL	221	U	132	U	1020		826	U	832	U	382	U	544	U	572	U

SPMEs		Day Zero Sample		Trip Blank		PGD-DU Rep 1		PGD-DU Rep 2		PGD-DU Rep 3		PGE-DU Rep 1		PGE-DU Rep 2		PGE-DU Rep 5	
Compound	Units	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q
PCB-045/051	pg/mL	80	U	73.5	U	201	J	183	J	188	J	109	U	189	J	87.6	J
PCB-046	pg/mL	91.2	U	83.8	U	70.5	U	80.2	J	86.4	U	125	U	89.7	U	76.3	U
PCB-048	pg/mL	79.9	U	73.4	U	189	J	105	J	101	J	109	U	82.1	J	69.4	J
PCB-049/069	pg/mL	68	U	62.5	U	786	J	759	U	676	U	289	U	330	U	376	U
PCB-050/053	pg/mL	77.6	U	71.3	U	213	J	196	J	165	J	106	U	120	J	103	J
PCB-052	pg/mL	112	U	169	U	1440	U	1450	U	1120	U	646	U	656	U	669	U
PCB-054	pg/mL	61.3	U	53.8	U	50.3	U	48.7	U	58.2	U	69.8	U	60	U	51.9	U
PCB-055	pg/mL	69.7	U	60.8	U	75.9	U	62.4	U	71.2	U	111	U	78	U	66.8	U
PCB-056	pg/mL	73.6	U	64.2	U	155	J	127	J	128	J	118	U	82.3	U	69	U
PCB-057	pg/mL	65.2	U	56.9	U	71.5	U	58.8	U	67	U	104	U	72.9	U	62.9	U
PCB-058	pg/mL	70.2	U	61.3	U	75.3	U	62	U	70.6	U	112	U	78.5	U	66.3	U
PCB-059/062/075	pg/mL	60	U	55.1	U	100	J	82.2	J	110	J	82	U	59	U	54.6	J
PCB-060	pg/mL	70.9	U	61.9	U	76.3	U	62.7	U	71.5	U	113	U	79.3	U	67.1	U
PCB-061/070/074/076	pg/mL	98.4	U	118	U	701	U	603	U	612	U	280	U	338	U	396	U
PCB-063	pg/mL	65.7	U	57.4	U	70.1	U	57.7	U	65.7	U	105	U	73.5	U	61.7	U
PCB-064	pg/mL	60.5	J	52.6	U	281	U	302	U	239	U	99.2	U	151	U	130	U
PCB-066	pg/mL	69.8	U	60.9	U	313	J	309	J	302	J	112	U	126	J	176	J
PCB-067	pg/mL	57.6	U	50.3	U	60.3	U	49.6	U	56.6	U	92.1	U	64.4	U	53.1	U
PCB-068	pg/mL	62.3	U	54.4	U	67.9	U	55.9	U	63.7	U	99.7	U	69.8	U	59.7	U
PCB-072	pg/mL	62.5	U	54.6	U	68.9	U	56.6	U	64.6	U	99.9	U	69.9	U	60.6	U
PCB-073	pg/mL	59.2	U	54.4	U	47.5	U	48.2	U	58.2	U	81	U	58.3	U	51.4	U
PCB-077	pg/mL	90.4	U	80.5	U	92.3	U	78.2	U	88.6	U	158	U	101	U	84.1	U
PCB-078	pg/mL	71.1	U	62.1	U	75.6	U	62.2	U	70.9	U	114	U	79.6	U	66.5	U
PCB-079	pg/mL	57.9	U	50.6	U	61.5	U	50.5	U	57.6	U	92.6	U	64.8	U	54.1	U
PCB-080	pg/mL	62.6	U	54.6	U	69.6	U	57.2	U	65.2	U	100	U	70	U	61.2	U
PCB-081	pg/mL	84.4	U	75	U	90.2	U	74.7	U	86.3	U	146	U	94.7	U	79.5	U
PCB-082	pg/mL	102	U	82	U	111	U	97.6	U	94.8	U	145	U	124	U	89.1	U
PCB-083/099	pg/mL	101	U	184	U	849		704	U	978		575	U	477	U	581	U
PCB-084	pg/mL	104	U	83.8	U	414	J	247	J	263	J	173	J	253	J	298	J
PCB-085/116/117	pg/mL	78.9	U	63.7	U	177	U	108	U	151	U	113	U	96.5	U	178	U
PCB-086/087/097/109/119/125	pg/mL	130	U	102	U	541	U	627	U	582	U	340	U	374	U	502	U
PCB-088/091	pg/mL	92.3	U	74.5	U	247	U	263	U	166	U	132	U	162	U	186	U
PCB-089	pg/mL	99.4	U	80.3	U	107	U	94.4	U	91.7	U	142	U	122	U	86.2	U
PCB-090/101/113	pg/mL	209	U	178	U	1210	U	993	U	986	U	711	U	752	U	841	U

SPMEs		Day Zero Sample		Trip Blank		PGD-DU Rep 1		PGD-DU Rep 2		PGD-DU Rep 3		PGE-DU Rep 1		PGE-DU Rep 2		PGE-DU Rep 5	
Compound	Units	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q
PCB-092	pg/mL	96.1	U	77.6	U	233	U	260	U	196	U	197	U	147	U	162	U
PCB-093/095/098/100/102	pg/mL	285	U	171	U	1170	U	1300		1180	U	854	U	971	U	1110	U
PCB-094	pg/mL	99.5	U	80.3	U	107	U	94.5	U	91.8	U	142	U	122	U	86.2	U
PCB-096	pg/mL	54.3	U	54.6	U	64.5	U	64	U	76.6	U	79.8	U	65.4	U	65.9	U
PCB-103	pg/mL	81.6	U	65.9	U	88.1	U	77.6	U	75.4	U	116	U	99.8	U	70.8	U
PCB-104	pg/mL	68.2	U	53.1	U	68	U	62.4	U	74.6	U	92.1	U	78.7	U	61.6	U
PCB-105	pg/mL	116	J	88.4	J	154	U	160	U	150	U	147	U	170	U	198	U
PCB-106	pg/mL	56.8	U	61.1	U	71.3	U	49.9	U	67.7	U	93.8	U	66.1	U	65.5	U
PCB-107	pg/mL	60.9	U	65.4	U	83.9	U	58.7	U	79.6	U	101	U	70.8	U	77	U
PCB-108/124	pg/mL	64.4	U	69.2	U	83	U	58	U	78.7	U	106	U	74.9	U	76.1	U
PCB-110/115	pg/mL	178	U	119	U	1040	U	896	U	937	U	555	U	623	U	789	U
PCB-111	pg/mL	70.6	U	57	U	75.9	U	66.8	U	64.9	U	101	U	86.3	U	61	U
PCB-112	pg/mL	62.7	U	50.6	U	65.5	U	57.7	U	56	U	89.4	U	76.6	U	52.7	U
PCB-114	pg/mL	69.5	U	78.5	U	93.2	U	66.1	U	90.3	U	119	U	82.8	U	87.5	U
PCB-118	pg/mL	182	U	134	U	610	U	515	U	628	U	408	U	430	U	477	U
PCB-120	pg/mL	66.3	U	53.5	U	73	U	64.3	U	62.5	U	94.5	U	81	U	58.7	U
PCB-121	pg/mL	72.2	U	58.2	U	77.8	U	68.5	U	66.6	U	103	U	88.2	U	62.6	U
PCB-122	pg/mL	71.5	U	76.9	U	92.3	U	64.6	U	87.6	U	118	U	83.2	U	84.7	U
PCB-123	pg/mL	71.9	U	81.1	U	98.1	U	68.3	U	93.4	U	122	U	85.2	U	90.4	U
PCB-126	pg/mL	89.8	U	103	U	115	U	83.3	U	112	U	187	U	103	U	113	U
PCB-127	pg/mL	66.5	U	71.5	U	88.4	U	61.8	U	83.8	U	110	U	77.4	U	81.1	U
PCB-128/166	pg/mL	115	U	120	U	115	U	114	U	111	J	169	U	155	U	120	J
PCB-129/138/160/163	pg/mL	265	U	291	U	842	U	713	U	1100	U	993	U	892	U	1080	U
PCB-130	pg/mL	143	U	149	U	144	U	144	U	106	U	210	U	193	U	137	U
PCB-131	pg/mL	129	U	135	U	132	U	132	U	97	U	190	U	174	U	125	U
PCB-132	pg/mL	136	U	142	U	365	U	259	U	297	U	276	U	388	U	306	U
PCB-133	pg/mL	130	U	136	U	129	U	129	U	95	U	192	U	176	U	122	U
PCB-134/143	pg/mL	132	U	138	U	132	U	132	U	97.3	U	194	U	178	U	125	U
PCB-135/151/154	pg/mL	141	U	88.1	U	483	U	435	U	479	U	376	U	479	U	530	U
PCB-136	pg/mL	67.6	U	68.1	U	153	U	175	U	173	U	146	U	158	U	179	U
PCB-137	pg/mL	139	U	145	U	140	U	140	U	103	U	205	U	188	U	133	U
PCB-139/140	pg/mL	119	U	125	U	119	U	119	U	87.4	U	176	U	161	U	113	U
PCB-141	pg/mL	121	U	127	U	119	U	119	U	146	U	179	U	164	U	112	U
PCB-142	pg/mL	131	U	137	U	132	U	131	U	96.7	U	193	U	177	U	125	U

SPMEs		Day Zero Sample		Trip Blank		PGD-DU Rep 1		PGD-DU Rep 2		PGD-DU Rep 3		PGE-DU Rep 1		PGE-DU Rep 2		PGE-DU Rep 5	
Compound	Units	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q	Results	Q
PCB-144	pg/mL	89.6	U	90.4	U	110	U	112	U	119	U	134	U	100	U	104	U
PCB-145	pg/mL	71.2	U	71.8	U	86	U	87.9	U	93.2	U	107	U	79.5	U	81.4	U
PCB-146	pg/mL	119	U	125	U	180	U	161	U	230	U	175	U	161	U	112	U
PCB-147/149	pg/mL	242	U	217	U	838	U	829	U	900	U	876	U	985	U	1000	U
PCB-148	pg/mL	89.7	U	90.5	U	111	U	113	U	120	U	135	U	100	U	105	U
PCB-150	pg/mL	67.8	U	68.4	U	83.7	U	85.5	U	90.6	U	102	U	75.8	U	79.2	U
PCB-152	pg/mL	65.4	U	66	U	79.3	U	81.1	U	85.9	U	98.1	U	73.1	U	75.1	U
PCB-153/168	pg/mL	284	U	297	U	907	U	827	U	1080	U	1130	U	983	U	1040	U
PCB-155	pg/mL	72.2	U	60.1	U	82.5	U	76.9	U	83.2	U	98.7	U	80.8	U	64.5	U
PCB-156/157	pg/mL	124	U	137	U	134	U	138	U	102	U	180	U	170	U	135	U
PCB-158	pg/mL	86.2	U	90.2	U	88.1	U	87.9	U	64.8	U	127	U	117	U	83.4	U
PCB-159	pg/mL	99.1	U	104	U	99.5	U	99.4	U	73.2	U	146	U	134	U	94.2	U
PCB-161	pg/mL	86.4	U	90.5	U	91.3	U	91.1	U	67.1	U	127	U	117	U	86.5	U
PCB-162	pg/mL	100	U	105	U	102	U	102	U	75	U	147	U	135	U	96.6	U
PCB-164	pg/mL	89.7	U	93.9	U	89.3	U	89.1	U	65.6	U	132	U	121	U	84.5	U
PCB-165	pg/mL	105	U	110	U	106	U	105	U	77.7	U	155	U	143	U	100	U
PCB-167	pg/mL	98.1	U	109	U	108	U	108	U	79.9	U	140	U	133	U	109	U
PCB-169	pg/mL	130	U	141	U	137	U	140	U	101	U	233	U	169	U	133	U
PCB-170	pg/mL	123	U	98.2	U	126	U	129	U	142	U	205	U	158	U	117	U
PCB-171/173	pg/mL	106	U	92.9	U	113	U	89.1	U	129	U	162	U	120	U	98.9	U
PCB-172	pg/mL	109	U	96.1	U	118	U	92.5	U	134	U	168	U	124	U	103	U
PCB-174	pg/mL	92.6	U	81.4	U	134	U	121	U	160	U	142	U	198	U	159	U
PCB-175	pg/mL	93.3	U	82	U	101	U	79.1	U	115	U	143	U	106	U	87.9	U
PCB-176	pg/mL	70	U	61.6	U	76.1	U	59.7	U	86.5	U	107	U	79.4	U	66.3	U
PCB-177	pg/mL	100	U	88.1	U	111	U	118	U	126	U	154	U	129	U	202	U
PCB-178	pg/mL	97	U	85.3	U	105	U	82.4	U	119	U	149	U	110	U	91.6	U
PCB-179	pg/mL	69	U	60.7	U	85.6	U	75.7	U	119	U	109	U	81	U	93.7	U
PCB-180/193	pg/mL	175	U	150	U	304	U	317	U	446	U	410	U	451	U	228	U
PCB-181	pg/mL	102	U	89.4	U	110	U	86.4	U	125	U	156	U	115	U	96	U
PCB-182	pg/mL	89.6	U	78.8	U	97	U	76.2	U	110	U	137	U	102	U	84.6	U
PCB-183/185	pg/mL	97.4	U	85.6	U	104	U	93	U	120	U	149	U	226	U	168	U
PCB-184	pg/mL	68.4	U	60.1	U	73.7	U	57.8	U	83.7	U	105	U	77.5	U	64.2	U
PCB-186	pg/mL	74	U	65.1	U	79	U	62	U	89.8	U	114	U	83.9	U	68.9	U
PCB-187	pg/mL	119	U	99.6	U	275	U	252	U	293	U	402	U	312	U	310	U

SPMEs		Day Zero Sample		Trip Blank		PGD-DU Rep 1		PGD-DU Rep 2		PGD-DU Rep 3		PGE-DU Rep 1		PGE-DU Rep 2		PGE-DU Rep 5	
Compound	**Units**	**Results**	**Q**	**Results**	**Q**	**Results**	**Q**	**Results**	**Q**	**Results**	**Q**	**Results**	**Q**	**Results**	**Q**	**Results**	**Q**
PCB-188	pg/mL	74.8	U	61.4	U	80.6	U	62.5	U	88.2	U	110	U	82.4	U	65.5	U
PCB-189	pg/mL	82.9	U	93.6	U	87.2	U	64.5	U	94.1	U	122	U	100	U	79.8	U
PCB-190	pg/mL	83.3	U	73.2	U	96.6	U	75.8	U	110	U	128	U	94.4	U	84.2	U
PCB-191	pg/mL	80.8	U	71.1	U	87.3	U	68.5	U	99.2	U	124	U	91.6	U	76.1	U
PCB-192	pg/mL	88.6	U	77.9	U	95.4	U	74.9	U	108	U	136	U	100	U	83.2	U
PCB-194	pg/mL	84.8	U	84.4	U	76.9	U	67.4	U	95.3	U	145	U	117	U	86.1	U
PCB-195	pg/mL	95.9	U	95.4	U	87.3	U	76.5	U	106	U	164	U	132	U	97.7	U
PCB-196	pg/mL	118	U	114	U	120	U	107	U	137	U	156	U	148	U	118	U
PCB-197/200	pg/mL	83.7	U	81.3	U	83.1	U	73.7	U	94.7	U	111	U	105	U	81.5	U
PCB-198/199	pg/mL	121	U	118	U	122	U	108	U	139	U	160	U	152	U	165	J
PCB-201	pg/mL	82.7	U	80.4	U	81.8	U	72.7	U	93.3	U	109	U	104	U	80.3	U
PCB-202	pg/mL	92	U	77.7	U	86.1	U	75.6	U	95.5	U	124	U	116	U	79.1	U
PCB-203	pg/mL	112	U	109	U	114	U	101	U	129	U	149	U	141	U	111	U
PCB-204	pg/mL	83.7	U	81.4	U	83.5	U	74.2	U	95.3	U	111	U	105	U	82	U
PCB-205	pg/mL	75.3	U	85.5	U	75.8	U	66.8	U	93.8	U	127	U	103	U	89.4	U
PCB-206	pg/mL	183	U	206	U	199	U	149	U	253	U	292	U	207	U	221	U
PCB-207	pg/mL	126	U	137	U	134	U	99.9	U	170	U	203	U	146	U	149	U
PCB-208	pg/mL	127	U	135	U	144	U	108	U	184	U	206	U	151	U	160	U
PCB-209	pg/mL	137	U	141	U	109	U	142	U	141	U	179	U	144	U	129	U
Total PCBs (ND=0)	pg/mL	278.7		153.9		6299.4		4225.5		3792.2		458.1		1370.2		1760.7	
Total PCBs (ND=1/2)	pg/mL	8458.45		7794.3		18760.9		16292.9		16999.85		14713.55		14310.45		13993.5	

Q: final validation qualifer

Qualifiers

J: concentration less than limit of quantification

U: this analyte is not detected above the reporting limit (RL) or if noted, not detected above the limit of detection (LOD).

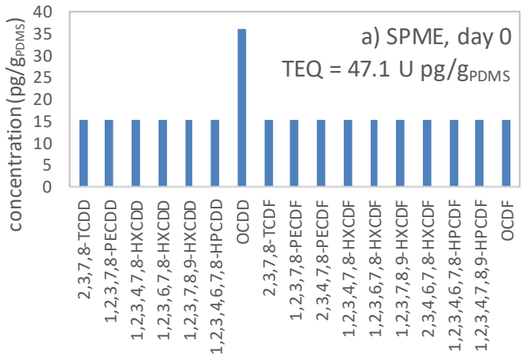
3.0 RESULTS

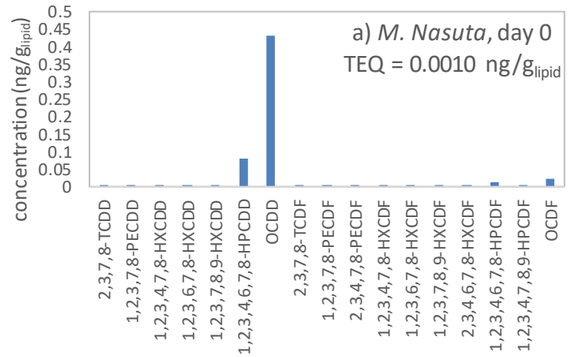
3.1 Concentrations of Dioxins/Furans and PCBs in SPME Fibers

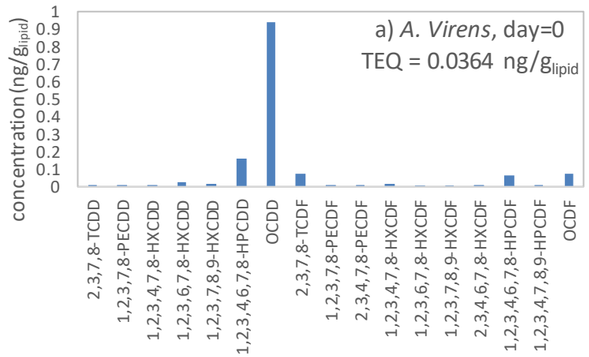
Dioxins/furans and PCB congeners were measured in SPME fibers before deployment and after exposure to Disposal Site DU and Environs DU sediments (Figures 3 through 6). For the purposes of plotting the data and interpreting results in this section, 1) dioxins/furans and PCB concentrations are reported as pg/g_{PDMS}; 2) non-detects have been replaced with a value of one-half the DL (ND=½DL); and 3) the values shown on the figures represent the average concentration calculated from three replicate exposures to PGD-DU or PGE-DU sediments.

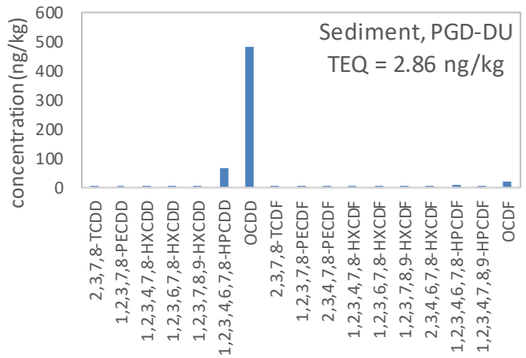
A relationship between SPME dioxins/furans concentrations and tissue concentrations could not be established for this experiment. Dioxins/furans were not detected in the day zero SPME sample, and concentrations of only a few individual congeners were measured in SPME fibers after exposure to either sediment (Figure 3). Only OCDD was measured in most of the SPME fibers after exposure to either sediment. Other dioxins/furans measured in the sediment samples (e.g., 1,2,3,4,6,7,8-HPCDD, OCDF, etc., Figure 3) were not detected in the SPME fibers. The toxic equivalency (TEQ) (ND=½DL) was similar in the pre-deployment SPME fiber (48.8 pg/mL) to that in SPME fibers after exposure to each sediment (55.3 and 52.0 pg/mL for PGD-DU and PGE-DU, respectively). The marginal increase in TEQ is attributable to the increase in OCDD concentrations following exposure to sediment, coupled with OCDD having the lowest toxicity equivalent factor (TEF) of 0.0003 amongst all dioxins/furans. There were only marginal increases in dioxins/furans concentrations and TEQ before and after exposure to the sediment.

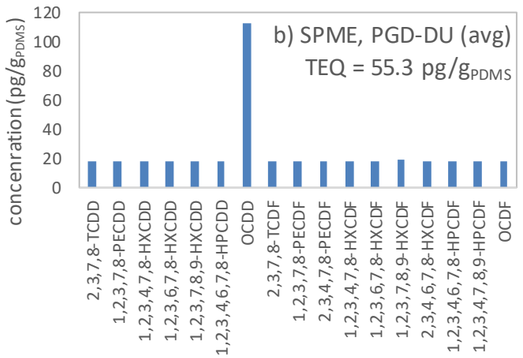
PCBs were measured in the day zero SPME sample and increased significantly after exposure to either sediment (Figures 4 through 6). The patterns of PCBs in SPME fibers exposed to the disposal site (PGD-DU) sediment also exhibited a greater relative abundance of lower molecular weight PCBs compared to those exposed to the environs (PGE-DU) sediment. The total PCB concentration increased from 8,795 pg/g_{PDMS} in the day zero SPME sample to an average concentration of 17,981 pg/g_{PDMS} in the fibers exposed to the PGD-DU sediment and 14,859 pg/g_{PDMS} in the fibers exposed to the PGE-DU sediment. The pattern of PCB congeners measured in the SPME fibers reflected the sediment to which they were exposed (Figures 5 and 6).

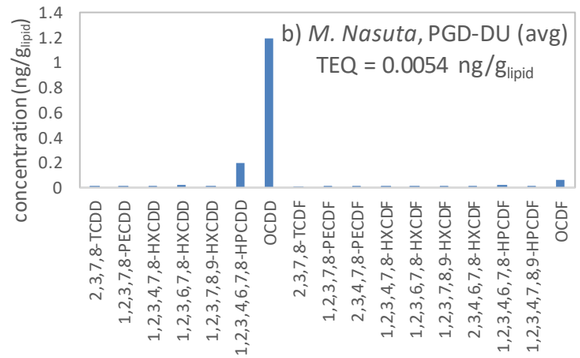


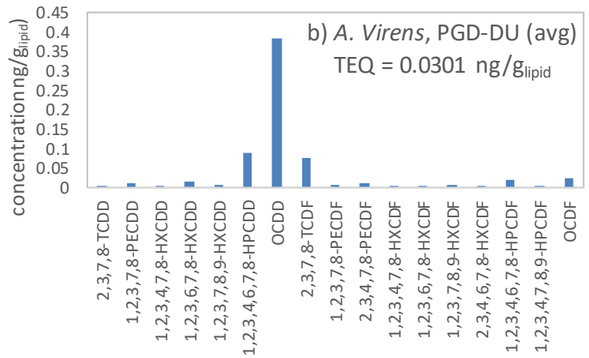


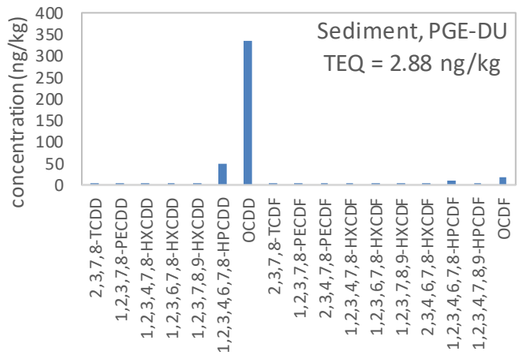


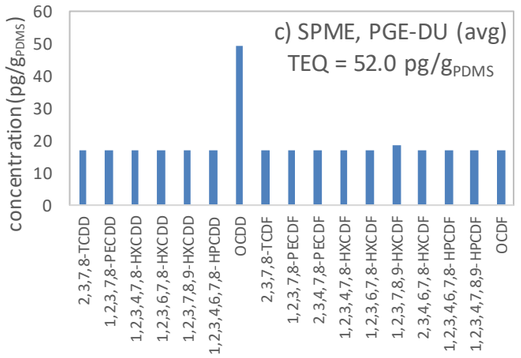


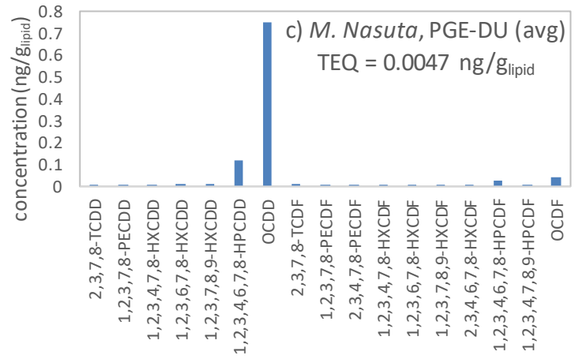












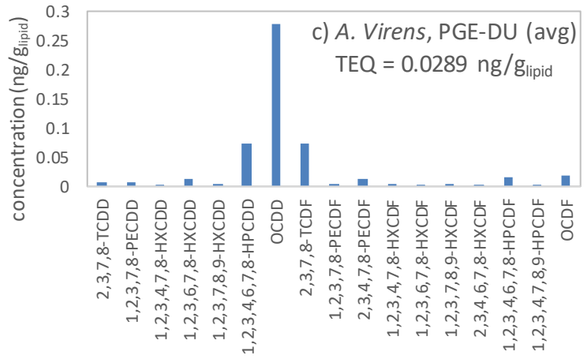


Figure 3. Concentrations of Dioxins/Furans in Sediments, SPME, *M. Nasuta*, and *A. Virens* for a) Day 0, b) PBD-DU, and c) PGE-DU

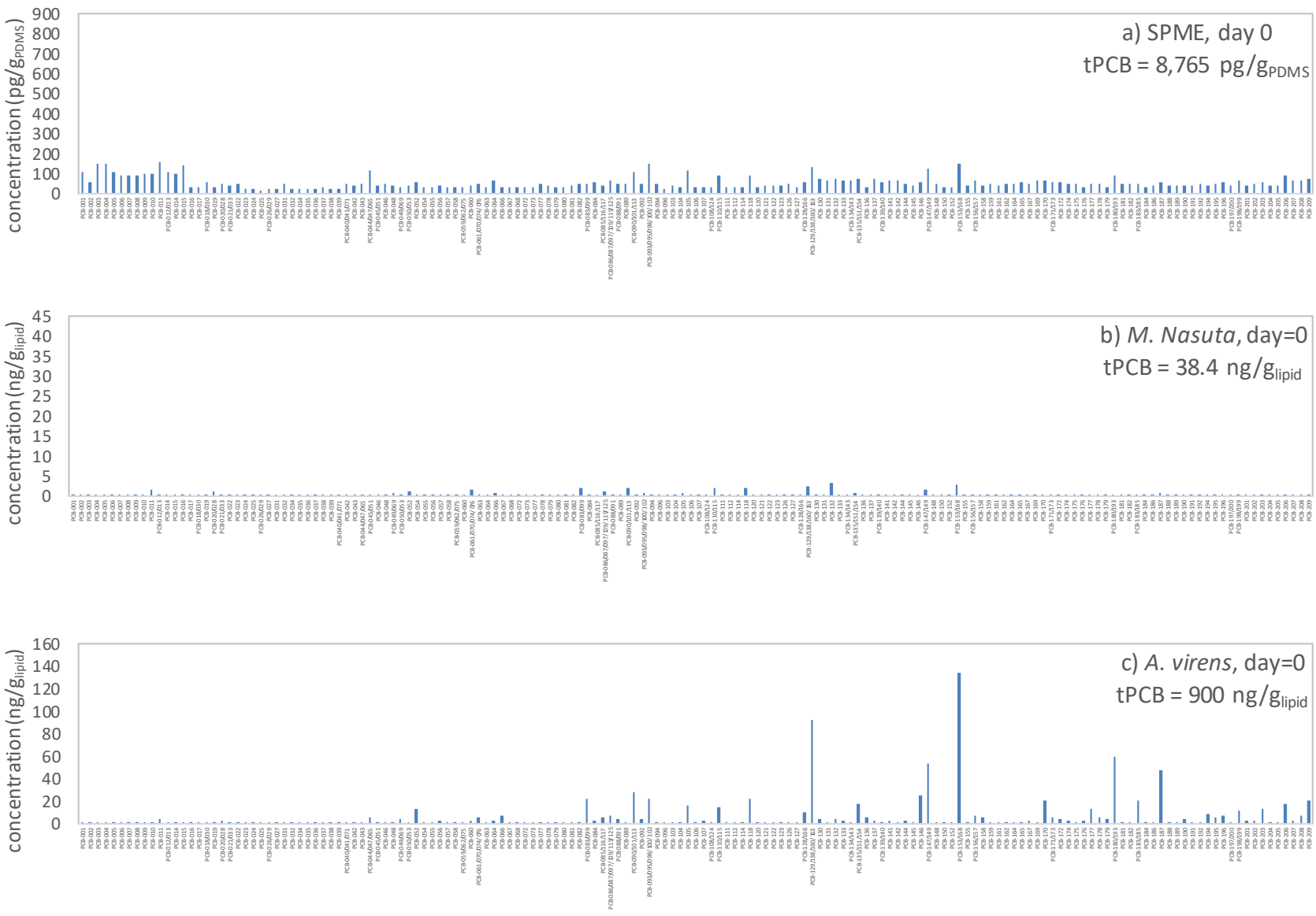


Figure 4. Concentrations of PCBs Before Exposure (Day 0) in a) SPME, b) *M. Nasuta*, and c) *A. virens* Tissues

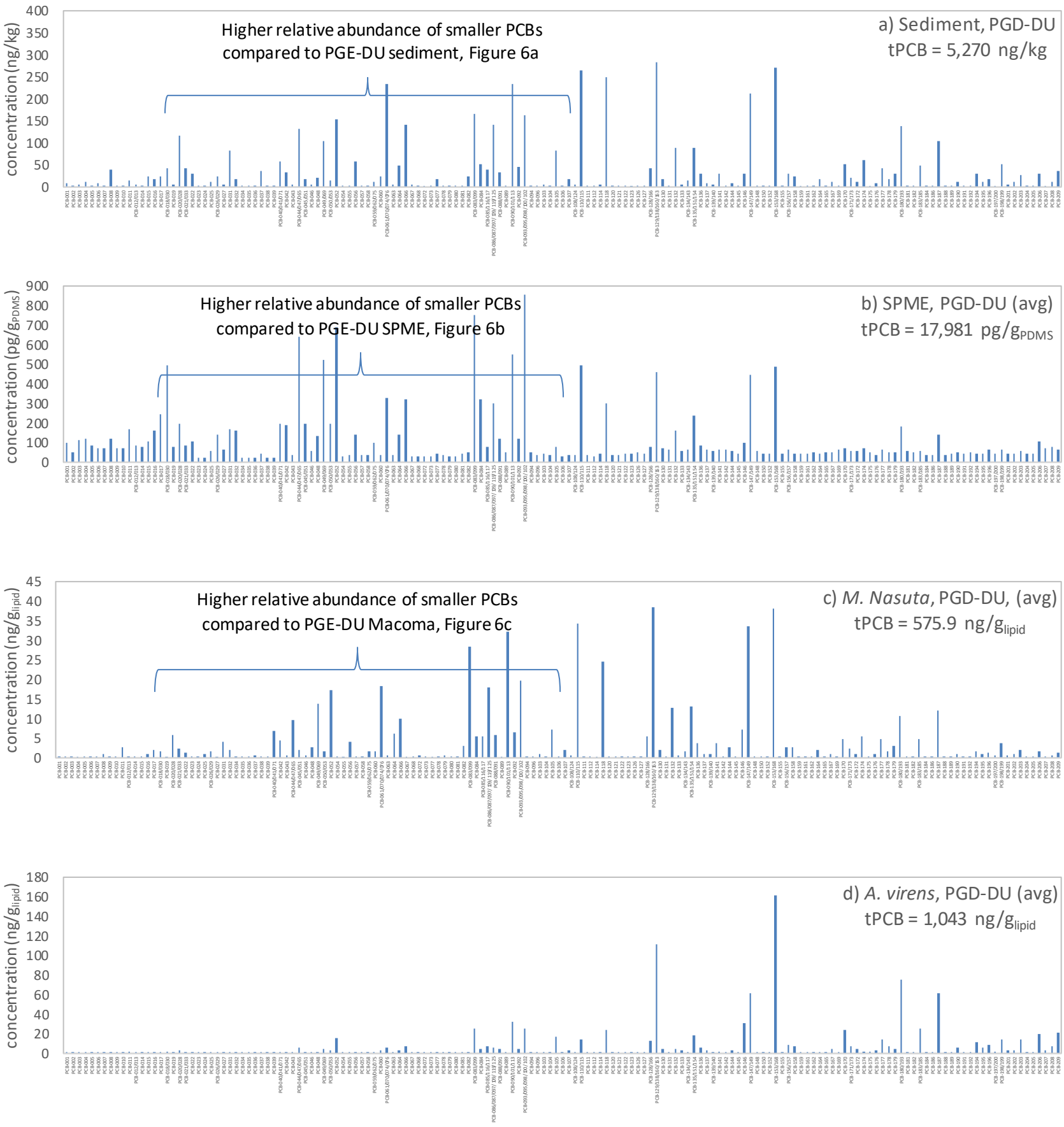


Figure 5. Concentrations of PCBs in a) PGD-DU Sediment and after 45-day Exposure in b) SPME, c) *M. Nasuta*, and d) *A. virens* Tissues

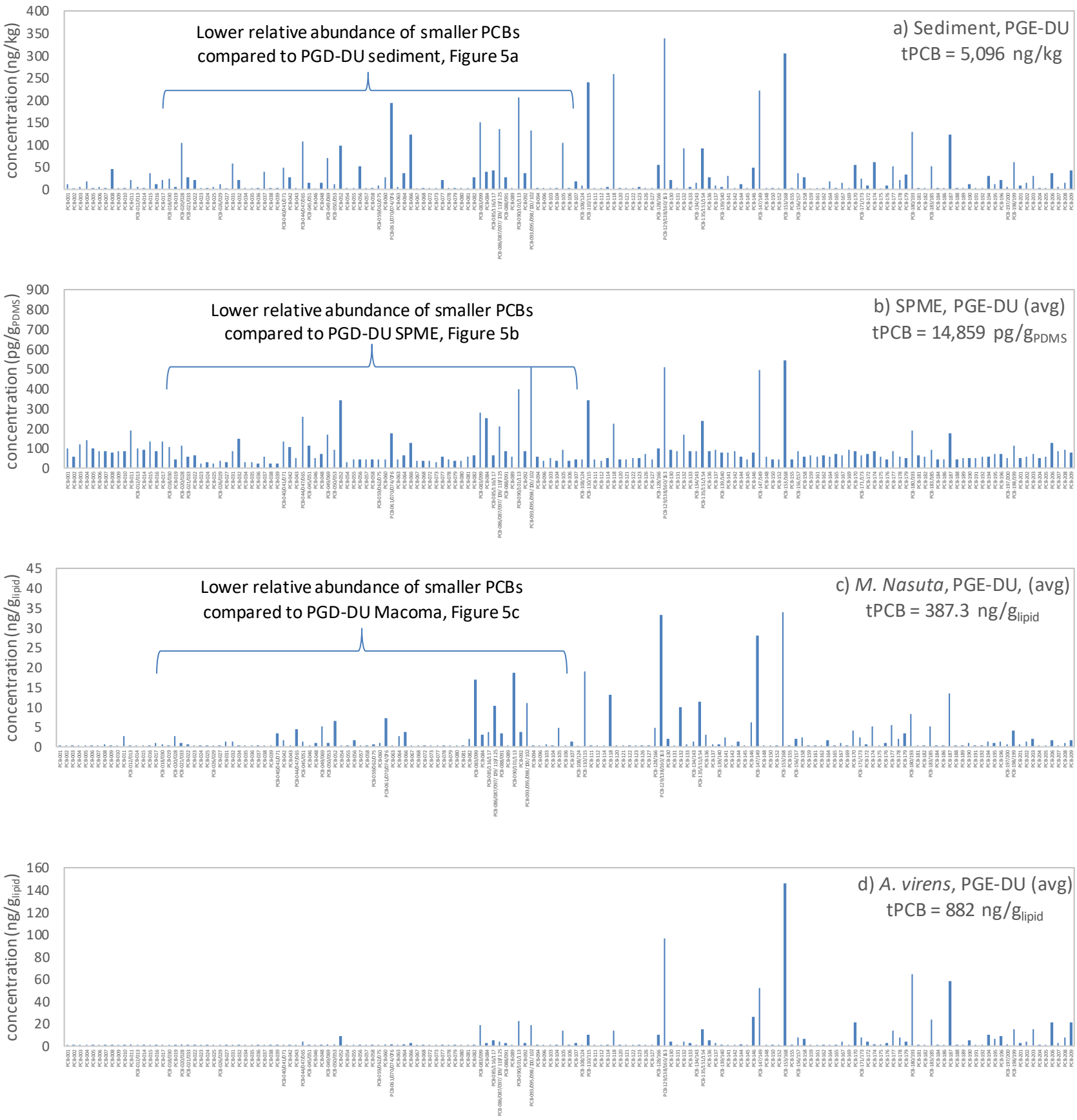


Figure 6. Concentrations of PCBs in a) PGE-DU Sediment and after 45-day Exposure in b) SPME, c) *M. Nasuta*, and d) *A. virens* Tissues

3.2 Sediment Evaluation

Dioxin/furan and PCB congeners were measured in both Disposal Site DU and Environs DU sediment samples (Figures 3, 5, and 6). For the purposes of plotting the dioxins/furans and PCB congener data and interpreting results in this section, non-detects have been replaced with a value of one-half the detection limit (ND=½DL). The patterns of measured dioxins/furans concentrations were similar in the sediment samples (Figure 3). The concentration of total PCBs was similar: 5,270 ng/kg for PGD-DU versus 5,097 ng/kg for PGE-DU (Figures 5 and 6). However, different patterns of measured PCB congeners were observed for the two samples. PCB congeners in the disposal site DU had a greater relative abundance of lower molecular weight congeners compared to those of the environs DU.

3.3 *Macoma nasuta* Tissue Evaluation

Dioxins/furans and PCBs were measured in *M. nasuta* clam tissue before deployment, and after exposure to both sediments (Figures 3 through 6). For the purposes of plotting the data and interpreting results, non-detects have been replaced with a value of one-half the DL (ND=½DL), and the values shown on the figures represent the average concentration calculated from five replicate exposures to PGD-DU or PGE-DU sediments.

A relationship between SPME dioxin/furan concentrations and *M. nasuta* tissue concentrations could not be established for this experiment. Dioxins/furans were low in the day zero *M. nasuta* tissue sample and increased marginally after exposure to either sediment (Figure 3). The most commonly measured dioxins/furans in *M. nasuta* before or after exposure to sediment were the more highly substituted congeners (1,2,3,6,7,8-HXCDD, 1,2,3,7,8,9-HXCDD, 1,2,3,4,6,7,8-HPCDD, OCDD, and OCDF) as well as 2,3,7,8-TCDF. The TEQ was similar in the day zero *M. nasuta* tissues (0.0010 ng TEQ/g_{lipid}) to that in *M. nasuta* tissues after exposure to each sediment (0.0054 ng TEQ/g_{lipid} and 0.0047 ng TEQ/g_{lipid} for PGD-DU and PGE-DU, respectively). Like the SPME data, there were only marginal increases in dioxin/furan concentrations and TEQ in *M. nasuta* tissues before and after exposure to the sediment.

PCBs were measured in the day zero *M. nasuta* tissue sample and increased significantly after exposure to either sediment (Figure 4 through 6). The total PCB concentration increased from 38.4 ng/g_{lipid} in the day zero *M. nasuta* tissue sample to an average concentration of 575.9 ng/g_{lipid} in tissues exposed to the PGD-DU sediment and 387.3 ng/g_{lipid} in the tissues exposed to the PGE-DU sediment. Additionally, the pattern of PCB congeners measured in the *M. nasuta* tissue samples was reflective of the sediment to which they were exposed. Patterns of PCBs in *M. nasuta* tissues exposed to the PGD-DU sediment exhibited a greater relative abundance of lower molecular weight congeners compared to those exposed to the PGE-DU sediment. The increase in total PCB concentrations in tissue, coupled with the fact that post-exposure PCB congener distributions in tissue reflected distributions in sediment , suggested that a relationship between SPME concentrations and *M. nasuta* could be established for PCBs in this experiment.

3.4 *Alitta virens* Tissue Evaluation

Dioxins/furans and PCBs were measured in *A. virens* worm tissue before and after exposure to Disposal Site DU and Environs DU sediments (Figures 3 through 6). For the purposes of plotting the data and interpreting results, non-detects were replaced with a value of one-half the DL (ND=½DL), and the values shown on the figures represent the average concentration calculated from five replicate exposures to PGD-DU or PGE-DU sediments.

A relationship between SPME concentrations and *A. virens* tissue concentrations could not be established for dioxins/furans in this experiment. Dioxin/furan concentrations were relatively high in the day zero *A.*

virens tissue sample and did not increase after exposure to either sediment (Figure 3). In fact, the TEQ decreased from 0.0364 ng TEQ/g_{lipid} in the day zero *A. virens* tissue sample to 0.0301 ng TEQ/g_{lipid} and 0.0289 ng TEQ/g_{lipid} after exposure to the PGD-DU and PGE-DU sediments, respectively. The elevated pre-exposure dioxin/furan tissue concentrations was likely because *A. virens* were collected from sediments more contaminated with dioxins/furans than either PGD-DU or PGE-DU. Thus, their body burdens of dioxins/furans were already higher than what could be attributed to PGD-DU or PGE-DU. The decrease in TEQ suggested that dioxins/furans were depurated from *A. virens* tissue during their exposure to PGD-DU and PGE-DU sediments.

Similarly, a relationship between SPME concentrations and *A. virens* tissue concentrations could not be established for PCBs in this experiment. PCBs were measured in the day zero *A. virens* tissue sample and increased only marginally after exposure to the PGD-DU sediment. PCBs did not increase after exposure to the PGE-DU sediment (Figures 4 through 6). The total PCB concentration increased from 900 ng/g_{lipid} in the day zero *A. virens* tissue sample to an average concentration of 1,043 ng/g_{lipid} in tissues exposed to the PGD-DU sediment. The total PCB concentration in the tissues exposed to the PGE-DU sediment (882 ng/g_{lipid}) was similar to the day zero concentration. Additionally, the pattern of PCB congeners measured in the *A. virens* tissue samples was not reflective of the sediment to which they were exposed. The pattern of relative enrichment of low molecular weight congeners that was observed for *M. nasuta* exposed to disposal site sediments was not observed in *A. virens* tissues exposed to the PGD-DU sediments (Figure 5).

3.5 Comparison of SPME and *M. nasuta* Data

The relationship between contaminant concentrations in SPME and *M. nasuta* tissues could not be calculated for dioxins/furans. Because most of the dioxins/furans were not detected in the SPME sample exposed to both PGD-DU and PGE-DU sediments, the plot of individual dioxin/furan congener concentrations in the SPME versus in *M. nasuta* tissue (Figure 7) yielded a relationship that was not linear and was heavily biased by values that were ½ the DL of the SPME measurements. In other words, all but one y-value were nearly identical whereas there was some spread in the x-values. A linear regression calculated from these data describing the relationship between SPME concentrations and *M. nasuta* tissue concentrations would be defined by ½ the DL of SPME concentrations as well as one data point (for OCDD). It is important to evaluate these relationships using detected concentrations for a majority of, if not all, of the data. Therefore, regressions were not calculated for the dioxin/furan data.

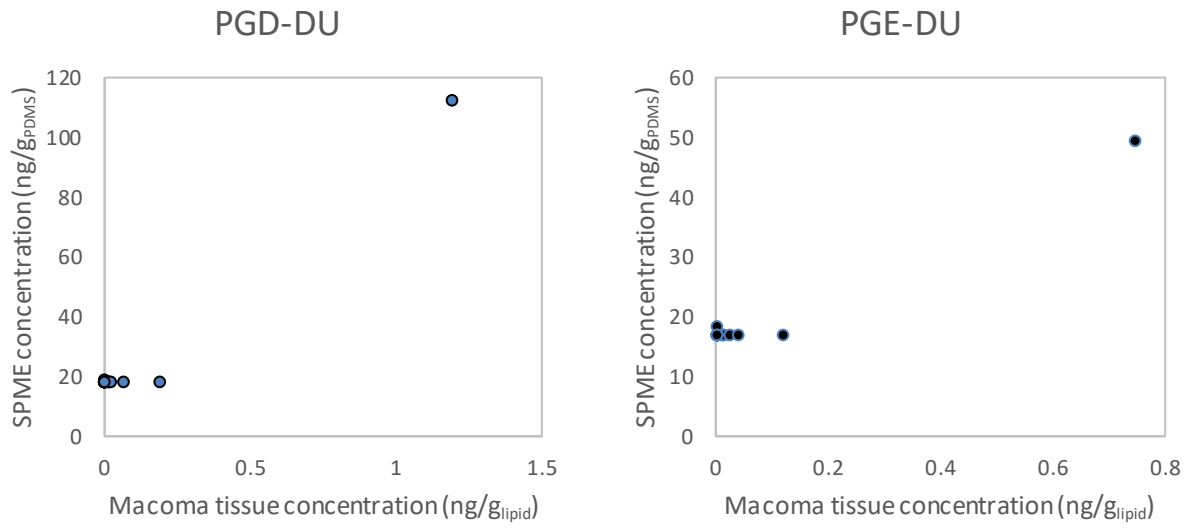


Figure 7. Comparison of Dioxin/Furan Concentrations in SPME Fibers versus *M. nasuta* Tissue Concentrations After Exposure to PGD-DU and PGE-DU Sediments. Each data point represents an individual Dioxin/Furan congener.

The relationship between contaminant concentrations in SPME and that in *M. nasuta* tissues can be calculated for PCBs because there was an observable increase in concentrations in both SPME fibers and *M. nasuta* tissue after exposure to each of the sediments. Figure 8 shows the relationship between PCB concentrations in SPME fiber extracts and that in *M. nasuta* tissues after exposure to the PGD-DU and PGE-DU sediments. Linear regressions of each dataset (not forcing the regression through the origin) are shown in the dashed line. The regression equation includes the standard error for the slope and intercept.

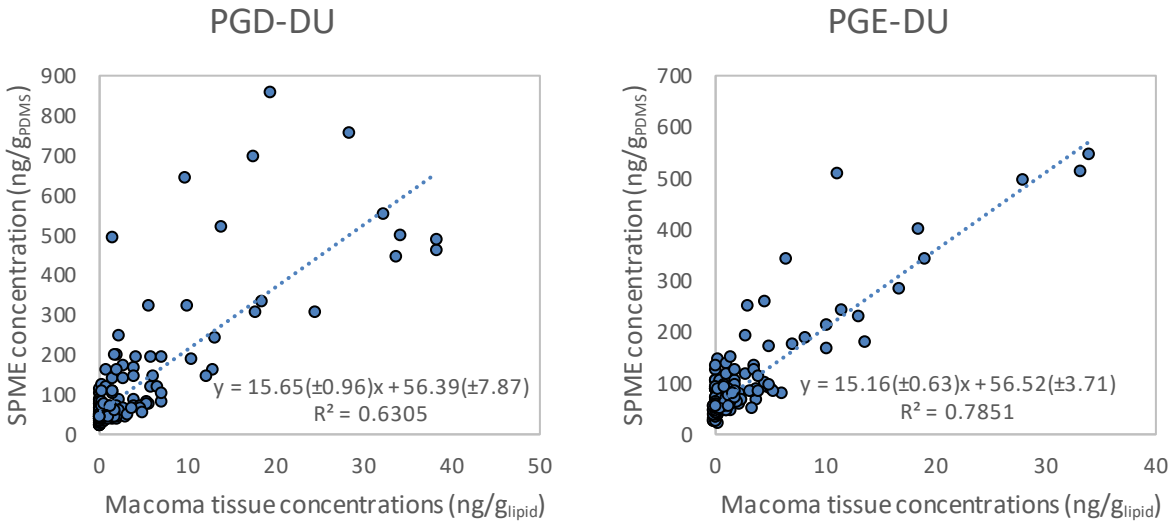


Figure 8. Comparison of PCB Concentrations in SPME Fibers versus *M. nasuta* Tissue Concentrations After Exposure to PGD-DU and PGE-DU Sediments. Each data point represents an individual PCB congener.

The comparison using PCB congener data contained significant amount of spread in the data, particularly for congeners detected at relatively low concentrations and non-detects represented by values of ½ the DL (i.e., for those data closer to the origin). To simplify this relationship, a similar comparison can be made expressing the data based on PCB level of chlorination (LOC). Each LOC value is the sum of all PCBs with a given number of chlorine atoms: LOC1 is the sum of all PCB congeners with one chlorine, LOC2 is the sum of all PCB congeners with two chlorines, etc. Figure 9 shows PCB LOC concentrations in SPME fiber extracts versus that in *M. nasuta* tissues after exposure to the PGD-DU and PGE-DU sediments. Linear regressions of each dataset (not forcing the regression through the origin) are shown in the dashed line. The regression equation included the standard error for the slope and intercept.

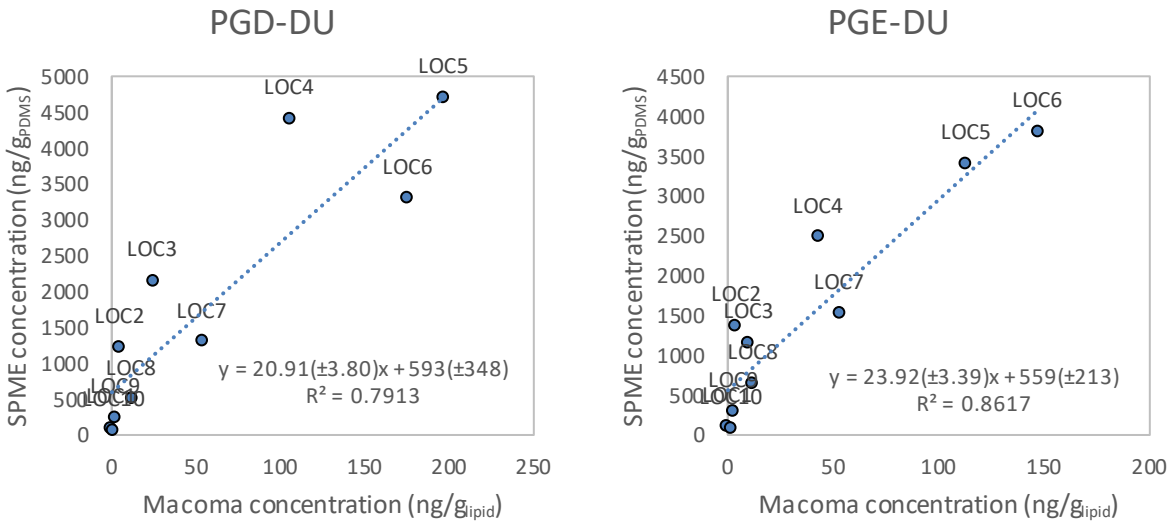


Figure 9. Comparison of PCB Concentrations in SPME Fibers versus *M. nasuta* Tissue Concentrations After Exposure to PGD-DU and PGE-DU Sediments. Each Data Point Represents the Sum of Different LOC PCBs.

3.6 Comparison of SPME and A. virens Data

The relationship between contaminant concentrations in SPME and that in *A. virens* tissues could not be calculated for dioxins/furans. Like the *M. nasuta* comparison (see previous section), most of the dioxins/furans were not detected in the SPME sample exposed to both PGD-DU and PGE-DU sediments. The plot of SPME concentration versus *A. virens* tissue concentration (Figure 10) yielded a relationship that was not linear and was heavily biased by values that were ½ the DL of the SPME measurements. This relationship may be further complicated by the fact that *A. virens* had a higher body burden of dioxins/furans before exposure to the sediment.

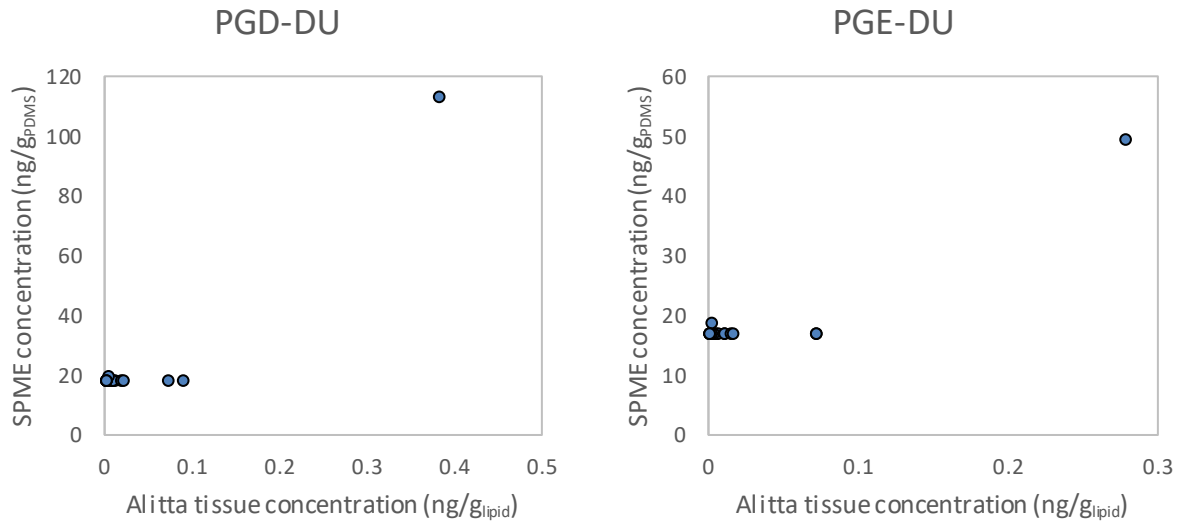


Figure 10. Comparison of Dioxin/Furan Concentrations in SPME Fibers versus *M. nasuta* Tissue Concentrations After Exposure to PGD-DU and PGE-DU Sediments. Each Data Point Represents an Individual Dioxin/Furan Congener.

The relationship between contaminant concentrations in SPME and that in *A. virens* tissues could be calculated for PCBs, though the relationship was not strong given that there was only a marginal increase in PCB concentrations in *A. virens* tissue after exposure to sediments (see previous discussion of *A. virens* dioxin/furan concentrations). Figure 11 shows the relationship between PCB concentrations in SPME fiber extracts and that in *A. virens* tissues after exposure to the PGD-DU and PGE-DU sediments. Linear regressions of each dataset (not forcing the regression through the origin) are shown in the dashed line. The regression equation includes the standard error for the slope and intercept.

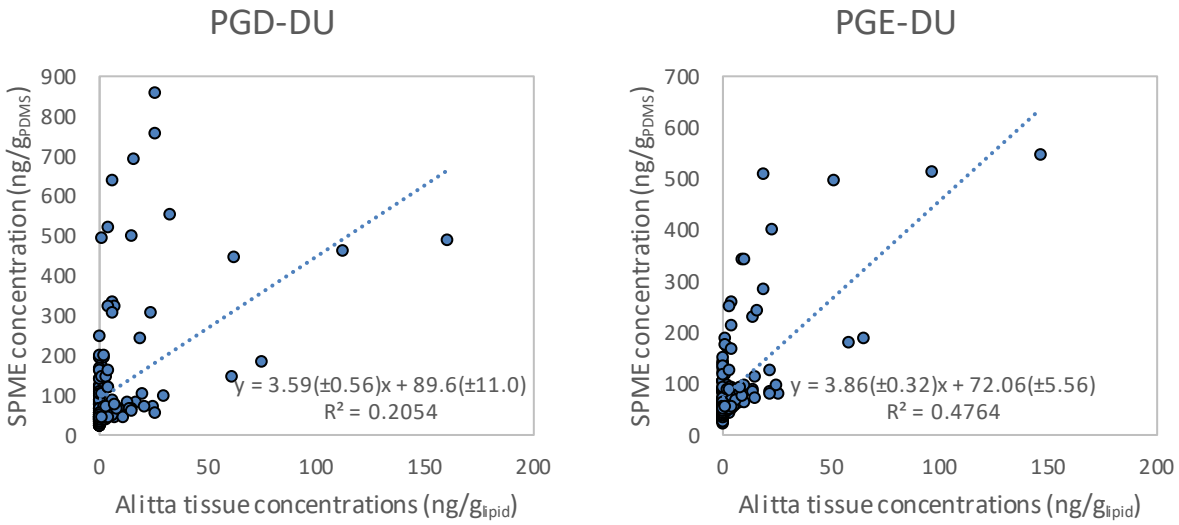


Figure 11. Comparison of PCB Concentrations in SPME Fibers versus *A. virens* Tissue Concentrations After Exposure to PGD-DU and PGE-DU Sediments. Each Data Point Represents an Individual PCB Congener.

The comparison using PCB congener data contained significant amount of spread in the data, particularly for congeners detected at relatively low concentrations and non-detects represented by values of ½ the DL (i.e., for those data closer to the origin). To simplify this relationship, a similar comparison can be made expressing the data using PCB level of chlorination (LOC). Each LOC value is the sum of all PCBs with a given number of chlorine atoms: LOC1 is the sum of all PCB congeners with one chlorine, LOC2 is the sum of all PCB congeners with two chlorines, etc.). Figure 12 shows PCB LOC concentrations in SPME fiber extracts versus that in *A. virens* tissues after exposure to the PGD-DU and PGE-DU sediments. Linear regressions of each dataset (not forcing the regression through the origin) are shown in the dashed line. The regression equation includes the standard error for the slope and intercept.

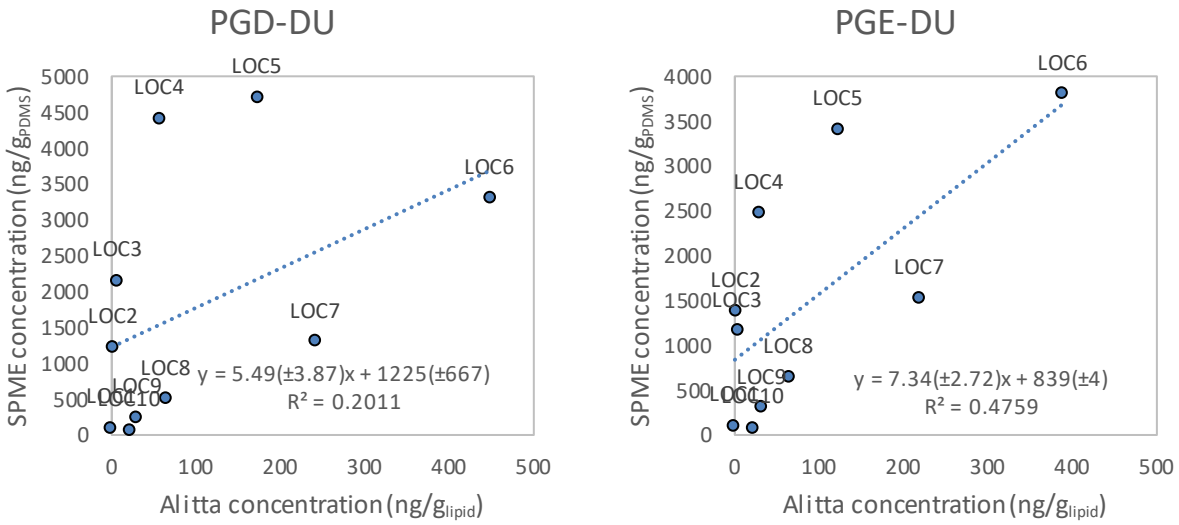


Figure 12. Comparison of PCB Concentrations in SPME Fibers versus *A. virens* Tissue Concentrations After Exposure to PGD-DU and PGE-DU Sediments. Each Data Point Represents the Sum of Different LOC PCBs.

4.0 DISCUSSION

This report represents an initial examination of the relationship between dioxins/furans and PCBs in SPME fibers, sediment, and *M. nasuta* and *A. virens* tissues collected as part of monitoring at the Port Gardner dredged material disposal site. The results from this evaluation highlight both potential benefits and limitations of using SPME data as a proxy for bioaccumulation.

The relationship observed between PCB uptake in SPME fibers and *M. nasuta* tissue could potentially be used to predict tissue uptake. This suggests there may be contexts where SPMEs could be used in place of live organisms to lower cost or used for sediments where survival of organisms may be a concern.

The limitations of using SPME as a proxy for tissues is highlighted by the dioxin/furan data in the SPME themselves, as well as the relationship between PCBs in SPME and *A. virens* tissues. Dioxin/furan concentrations in SPME fibers increased only marginally after exposure to the sediments, although there were measurable (but relatively low) concentrations of dioxins/furans in the sediments. From the PRC data, we know that equilibrium was not reached. Seventy-one percent (71%) of the dioxin PRC ($^{13}C_6$-1,2,3,4-TCDD) remained in the SPME fibers after the 45-day exposure to the PGD-DU sediments, and 63% remained in the SPME fibers after exposure to the PGE-DU sediment. At equilibrium, no PRC would remain. Therefore, if the SPME fibers had been left in the sediment for longer, additional dioxins/furans would have accumulated, perhaps increasing concentrations above the non-detects observed for most congeners.

One of the factors that affects equilibrium time is the thickness of the SPME fiber. The thicker the fiber, the longer it takes to reach equilibrium. Therefore, using a thinner SPME fiber would decrease the amount of time it takes to reach equilibrium. The PCB PRCs indicated that equilibrium was not reached for PCBs. Fifty-three and fifty-eight percent (53 and 58%) of $^{13}C_{12}$-PCB-28 remained in the SPME fibers after exposure to the PGD-DU and PGE-DU sediments, respectively; 76 and 82% of $^{13}C_{12}$-PCB-47; 71 and 77% of $^{13}C_{12}$-PCB-70; 74 and 76% of $^{13}C_{12}$-PCB-80; 88 and 88% of $^{13}C_{12}$-PCB-111; 85 and 90% of $^{13}C_{12}$-PCB-142; and 86 and 88% of $^{13}C_{12}$-PCB-182. Despite this, PCBs were measured in the SPME fibers after exposure, likely reflective of the higher concentrations of PCBs compared to dioxins/furans.

The measurable concentrations of PCBs in the *A. virens* tissues before exposure to either test sediment was another factor that may have confounded the results. The fundamental principle of using passive samplers as a proxy for tissue in contaminant exposure studies is that both systems will accumulate contaminants similarly upon exposure to contaminated sediment. While it is unlikely that either the SPME or the tissue would ever be clean enough to have non-detects for all measured contaminants before exposure, the fact that dioxins/furans and PCB concentrations did not increase significantly after exposure to the sediments meant that the relationship between uptake of contaminants in SPME versus *A. virens* tissue could not be established.

5.0 REFERENCES

Adams, R.G., R. Lohmann, L.A. Fernandez, J.K. MacFarlane, and P.M. Gschwend. 2007. Polyethylene Devices: Passive Samplers for Measuring Dissolved Hydrophobic Organic Compounds in Aquatic Environments. *Environ. Sci. Technol*. 2007, 41, 4, 1317–1323. Publication Date: January 13, 2007.

NewFields. 2021. 2020 Pilot Study: DMMP Monitoring of the Port Gardner Non-Dispersive Unconfined Open-Water Dredged Material Disposal Site. Draft Report. March 29, 2021. Submitted to Washington State Department of Natural Resources, Aquatic Resources Division, Olympia, WA. Submitted by NewFields, Edmonds, WA.

APPENDIX A

Individual PCB Congeners, LogK_{OW}, and the PRC to Correct Non-Equilibrium SPME Data

Table A1: Individual PCB congeners, logK_{OW}, and the PRC used to correct for non-equilibrium in SPME data

PCB Congener	logK_{PDMS}	PRC
PCB-001	4.12	$^{13}C_6$-PCB-28
PCB-002	4.42	$^{13}C_6$-PCB-28
PCB-003	4.35	$^{13}C_6$-PCB-28
PCB-004	4.41	$^{13}C_6$-PCB-28
PCB-005	4.69	$^{13}C_6$-PCB-28
PCB-006	4.77	$^{13}C_6$-PCB-28
PCB-007	4.76	$^{13}C_6$-PCB-28
PCB-008	4.71	$^{13}C_6$-PCB-28
PCB-009	4.78	$^{13}C_6$-PCB-28
PCB-010	4.42	$^{13}C_6$-PCB-28
PCB-011	5.09	$^{13}C_6$-PCB-28
PCB-012/013*	4.98**	$^{13}C_6$-PCB-28
PCB-014	5.12	$^{13}C_6$-PCB-28
PCB-015	4.96	$^{13}C_6$-PCB-28
PCB-016	4.85	$^{13}C_6$-PCB-28
PCB-017	5.03	$^{13}C_6$-PCB-28
PCB-018/030*	5.01**	$^{13}C_6$-PCB-28
PCB-019	4.66	$^{13}C_6$-PCB-28
PCB-020/028*	5.31**	$^{13}C_6$-PCB-28
PCB-021/033*	5.22**	$^{13}C_6$-PCB-28
PCB-022	5.24	$^{13}C_6$-PCB-28
PCB-023	5.33	$^{13}C_6$-PCB-28
PCB-024	4.97	$^{13}C_6$-PCB-28
PCB-025	5.36	$^{13}C_6$-PCB-28
PCB-026/029*	5.35**	$^{13}C_6$-PCB-28
PCB-027	4.91	$^{13}C_6$-PCB-28
PCB-031	5.34	$^{13}C_6$-PCB-28
PCB-032	4.81	$^{13}C_6$-PCB-28
PCB-034	5.42	$^{13}C_6$-PCB-28
PCB-035	5.57	$^{13}C_6$-PCB-47
PCB-036	5.74	$^{13}C_6$-PCB-70
PCB-037	5.52	$^{13}C_6$-PCB-47
PCB-038	5.49	$^{13}C_6$-PCB-47
PCB-039	5.67	$^{13}C_6$-PCB-47
PCB-040/041/071*	5.30**	$^{13}C_6$-PCB-28
PCB-042	5.46	$^{13}C_6$-PCB-47
PCB-043	5.39	$^{13}C_6$-PCB-28
PCB-044/047/065*	5.48**	$^{13}C_6$-PCB-47
PCB-045/051*	5.22**	$^{13}C_6$-PCB-28
PCB-046	5.08	$^{13}C_6$-PCB-28
PCB-048	5.50	$^{13}C_6$-PCB-47
PCB-049/069*	5.53**	$^{13}C_6$-PCB-47
PCB-050/053*	5.21**	$^{13}C_6$-PCB-28

PCB Congener	logK_{PDMS}	PRC
PCB-052	5.42	$^{13}C_6$-PCB-28
PCB-054	4.99	$^{13}C_6$-PCB-28
PCB-055	5.79	$^{13}C_6$-PCB-70
PCB-056	5.75	$^{13}C_6$-PCB-70
PCB-057	5.90	$^{13}C_6$-PCB-70
PCB-058	5.92	$^{13}C_6$-PCB-70
PCB-059/062/075*	5.52**	$^{13}C_6$-PCB-47
PCB-060	5.73	$^{13}C_6$-PCB-70
PCB-061/070/074/076*	5.81**	$^{13}C_6$-PCB-70
PCB-063	5.86	$^{13}C_6$-PCB-70
PCB-064	5.41	$^{13}C_6$-PCB-28
PCB-066	5.83	$^{13}C_6$-PCB-70
PCB-067	5.89	$^{13}C_6$-PCB-70
PCB-068	5.98	$^{13}C_6$-PCB-70
PCB-072	5.96	$^{13}C_6$-PCB-70
PCB-073	5.32	$^{13}C_6$-PCB-28
PCB-077	6.04	$^{13}C_6$-PCB-70
PCB-078	6.11	$^{13}C_6$-PCB-70
PCB-079	6.19	$^{13}C_6$-PCB-111
PCB-080	6.38	$^{13}C_6$-PCB-80
PCB-081	6.06	$^{13}C_6$-PCB-70
PCB-082	5.73	$^{13}C_6$-PCB-70
PCB-083/099*	5.80**	$^{13}C_6$-PCB-70
PCB-084	5.65	$^{13}C_6$-PCB-47
PCB-085/116/117*	5.95**	$^{13}C_6$-PCB-70
PCB-086/087/097/109/119/125*	5.88**	$^{13}C_6$-PCB-70
PCB-088/091*	6.06**	$^{13}C_6$-PCB-70
PCB-089	5.29	$^{13}C_6$-PCB-28
PCB-090/101/113*	5.84**	$^{13}C_6$-PCB-70
PCB-092	5.83	$^{13}C_6$-PCB-70
PCB-093/095/098/100/102*	5.73**	$^{13}C_6$-PCB-70
PCB-094	5.62	$^{13}C_6$-PCB-47
PCB-096	5.51	$^{13}C_6$-PCB-47
PCB-103	5.73	$^{13}C_6$-PCB-70
PCB-104	5.67	$^{13}C_6$-PCB-47
PCB-105	6.41	$^{13}C_6$-PCB-80
PCB-106	6.30	$^{13}C_6$-PCB-111
PCB-107	6.35	$^{13}C_6$-PCB-80
PCB-108/124*	6.36**	$^{13}C_6$-PCB-80
PCB-110/115*	5.93**	$^{13}C_6$-PCB-70
PCB-111	6.46	$^{13}C_6$-PCB-182
PCB-112	5.98	$^{13}C_6$-PCB-70
PCB-114	6.26	$^{13}C_6$-PCB-111
PCB-118	6.35	$^{13}C_6$-PCB-80
PCB-120	6.47	$^{13}C_6$-PCB-182

PCB Congener	logK_{PDMS}	PRC
PCB-121	6.00	$^{13}C_6$-PCB-70
PCB-122	6.27	$^{13}C_6$-PCB-111
PCB-123	6.35	$^{13}C_6$-PCB-80
PCB-126	6.57	$^{13}C_6$-PCB-182
PCB-127	6.72	$^{13}C_6$-PCB-182
PCB-128/166*	6.35**	$^{13}C_6$-PCB-80
PCB-129/138/160/163*	6.34**	$^{13}C_6$-PCB-80
PCB-130	6.90	$^{13}C_6$-PCB-182
PCB-131	6.21	$^{13}C_6$-PCB-111
PCB-132	6.06	$^{13}C_6$-PCB-70
PCB-133	6.34	$^{13}C_6$-PCB-80
PCB-134/143*	6.15**	$^{13}C_6$-PCB-111
PCB-135/151/154*	6.15**	$^{13}C_6$-PCB-111
PCB-136	5.91	$^{13}C_6$-PCB-70
PCB-137	6.39	$^{13}C_6$-PCB-80
PCB-139/140*	6.27**	$^{13}C_6$-PCB-111
PCB-141	6.33	$^{13}C_6$-PCB-80
PCB-142	6.28	$^{13}C_6$-PCB-111
PCB-144	6.20	$^{13}C_6$-PCB-111
PCB-145	6.12	$^{13}C_6$-PCB-111
PCB-146	6.37	$^{13}C_6$-PCB-80
PCB-147/149*	6.20**	$^{13}C_6$-PCB-111
PCB-148	6.46	$^{13}C_6$-PCB-182
PCB-150	6.00	$^{13}C_6$-PCB-70
PCB-152	6.07	$^{13}C_6$-PCB-70
PCB-153/168*	6.38**	$^{13}C_6$-PCB-80
PCB-155	6.25	$^{13}C_6$-PCB-111
PCB-156/157*	6.73**	$^{13}C_6$-PCB-182
PCB-158	6.37	$^{13}C_6$-PCB-80
PCB-159	6.85	$^{13}C_6$-PCB-182
PCB-161	6.45	$^{13}C_6$-PCB-182
PCB-162	6.83	$^{13}C_6$-PCB-182
PCB-164	6.24	$^{13}C_6$-PCB-111
PCB-165	6.44	$^{13}C_6$-PCB-182
PCB-167	6.83	$^{13}C_6$-PCB-182
PCB-169	7.08	$^{13}C_6$-PCB-182
PCB-170	6.68	$^{13}C_6$-PCB-182
PCB-171/173*	6.67**	$^{13}C_6$-PCB-182
PCB-172	6.69	$^{13}C_6$-PCB-182
PCB-174	6.50	$^{13}C_6$-PCB-182
PCB-175	6.62	$^{13}C_6$-PCB-182
PCB-176	6.46	$^{13}C_6$-PCB-182
PCB-177	6.61	$^{13}C_6$-PCB-182
PCB-178	6.62	$^{13}C_6$-PCB-182
PCB-179	6.46	$^{13}C_6$-PCB-182

PCB Congener	logK_{PDMS}	PRC
PCB-180/193*	6.78**	$^{13}C_6$-PCB-182
PCB-181	6.76	$^{13}C_6$-PCB-182
PCB-182	6.58	$^{13}C_6$-PCB-182
PCB-183/185*	6.65**	$^{13}C_6$-PCB-182
PCB-184	6.59	$^{13}C_6$-PCB-182
PCB-186	6.56	$^{13}C_6$-PCB-182
PCB-187	6.65	$^{13}C_6$-PCB-182
PCB-188	6.54	$^{13}C_6$-PCB-182
PCB-189	7.20	$^{13}C_6$-PCB-182
PCB-190	6.81	$^{13}C_6$-PCB-182
PCB-191	6.84	$^{13}C_6$-PCB-182
PCB-192	6.90	$^{13}C_6$-PCB-182
PCB-194	7.12	$^{13}C_6$-PCB-182
PCB-195	7.10	$^{13}C_6$-PCB-182
PCB-196	6.98	$^{13}C_6$-PCB-182
PCB-197/200*	6.91**	$^{13}C_6$-PCB-182
PCB-198/199*	7.05**	$^{13}C_6$-PCB-182
PCB-201	6.87	$^{13}C_6$-PCB-182
PCB-202	6.84	$^{13}C_6$-PCB-182
PCB-203	7.09	$^{13}C_6$-PCB-182
PCB-204	7.03	$^{13}C_6$-PCB-182
PCB-205	7.26	$^{13}C_6$-PCB-182
PCB-206	7.43	$^{13}C_6$-PCB-182
PCB-207	7.34	$^{13}C_6$-PCB-182
PCB-208	7.28	$^{13}C_6$-PCB-182
PCB-209	7.64	$^{13}C_6$-PCB-182

*coeluting PCB congeners

**aggregate logK_{OW} values for coeluting PCB congeners were calculated from the average of logK_{OW} values for each coeluting PCB congener