

Supplementary Online Information

Pan-Arctic River Fluxes of Polychlorinated Biphenyls

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Table S1. Physiographic, hydrological and geochemical characteristics of the Great Arctic Rivers.

Rivers	Ob	Yenisey	Lena	Indigirka	Kolyma	Mackenzie
Geological and Physiographic regions	West Siberian Lowlands	West Siberian Lowlands	Central Siberian Plateau	East Siberian Highlands	East Siberian Highlands	North America Cordillera
Basin area (10 ⁶ km ²) ^a	2.54-2.99	2.44-2.59	2.43-2.49	0.36	0.65-0.66	1.68
Latitude; longitude	72 ⁰ 65'N/ 73 ⁰ 44'E	72 ⁰ 61'N/ 79 ⁰ 86'E	71 ⁰ 96'N/ 129 ⁰ 54'E	71 ⁰ 02'N/ 150 ⁰ 46'E	70 ⁰ 00'N/ 163 ⁰ 53'E	67 ⁰ 26'N/ 130 ⁰ 45'W
Water discharge (km ³ /year) ^b	411.5	569.5	528.5	50	84.5	291.5
DOC (mg/L) ^c	9.1	8.5	6.6	4.8	4.6	5.2
POC (mg/L) ^c	0.9	0.3	1.1	3.5	3.1	7.2
(POC/DOC+POC)	0.09	0.03	0.14	0.42	0.40	0.58
δ ¹³ C, ‰ ^a	-27.4	-26.5	-25.0	-26.6	-26.7	-27.06
POC (ton/year)	3.7 x 10 ⁵	1.7 x 10 ⁵	5.8 x 10 ⁵	1.7 x 10 ⁵	2.6 x 10 ⁵	2.1 x 10 ⁶
DOC (ton/year)	3.7 x 10 ⁶	4.8 x 10 ⁶	3.4 x 10 ⁶	2.4 x 10 ⁵	3.8 x 10 ⁵	1.5 x 10 ⁶
SOC* (mgOC/gdw) ^d	9.2	19.4	5.7	18.1	19.2	20.2

9 soc*: sedimentary organic carbon

10 ^a: van Dongen, *et al.* 2008.

11 ^b: Dittmar and Kattner, 2003.

12 ^c: Stein and Macdonald, 2004.

13 ^d: Elmquist *et al.* 2008.

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15 **Table S2.** Sediment PCB concentrations (ng/g OC) in the GARs.

PCBs	Ob	Yenisey	Lena	Indigirka	Kolyma	Mackenzie
PCB#18	0.11	0.14	0.36	0.08	0.17	2.05
PCB#28	0.75	1.32	1.18	0.31	0.44	4.76
PCB#52	0.79	1.29	1.42	0.54	0.70	2.43
PCB#70	0.58	1.18	1.14	0.47	0.62	1.16
PCB#101	2.74	3.96	10.47	2.62	3.77	1.17
PCB#110	1.11	2.03	4.08	0.97	1.57	0.54
PCB#118	1.30	3.28	4.19	1.17	1.62	0.33
PCB#105	0.35	1.06	1.00	0.33	0.42	0.20
PCB#149	2.61	3.89	12.41	2.46	4.37	0.85
PCB#153	3.05	4.93	13.17	3.08	4.63	0.88
PCB#138	2.37	4.58	14.79	3.43	4.83	0.99
PCB#180	1.25	2.12	3.15	0.69	1.12	0.22
PCB#199	0.14	0.02	0.07	0.01	0.03	0.00
Total PCB	17.16	29.81	67.43	16.17	24.30	15.57

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18 **Table S3.** Estimated Total Fluxes of PCBs (kg/yr) in the GARs (mean±sd).

PCBs	Ob	Yenisey	Lena	Indigirka	Kolyma	Mackenzie
PCB#18	1.31	0.24	0.39	0.02	0.07	5.24
PCB#28	10.23	2.59	1.07	0.06	0.18	14.61
PCB#52	12.03	2.80	1.93	0.12	0.38	16.82
PCB#70	7.55	2.25	2.00	0.12	0.43	6.23
PCB#101	55.98	11.47	14.40	0.59	1.76	3.87
PCB#110	17.19	4.51	7.06	0.25	0.73	1.61
PCB#118	6.40	2.54	6.06	0.38	0.59	0.95
PCB#105	2.51	1.15	2.16	0.09	0.16	0.55
PCB#149	12.38	2.93	22.80	0.51	1.64	2.22
PCB#153	22.54	5.51	20.97	0.73	1.78	3.10
PCB#138	16.57	4.86	27.26	0.84	1.85	3.60
PCB#180	15.55	3.82	6.35	0.17	0.38	0.90
PCB#199	3.18	0.05	0.10	0.00	0.01	0.01
Total PCB	183.43±18.1	44.72±4.1	112.57±8.84	3.88±0.33	9.98±0.81	59.70±4.84

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21 **Table S4.** Estimated fluxes of dissolved PCBs (kg/yr) in the GARs (mean±sd).

PCBs	Ob	Yenisey	Lena	Indigirka	Kolyma	Mackenzie
PCB#18	1.05	0.18	0.12	0.00	0.02	0.78
PCB#28	8.52	2.05	0.18	0.00	0.06	4.26
PCB#52	10.23	2.27	0.86	0.02	0.19	11.54
PCB#70	6.25	1.76	1.14	0.03	0.25	3.71
PCB#101	49.76	9.83	6.48	0.10	0.70	1.33
PCB#110	14.67	3.67	3.98	0.07	0.29	0.44
PCB#118	3.44	1.19	2.89	0.16	0.14	0.23
PCB#105	1.72	0.71	1.40	0.03	0.04	0.11
PCB#149	6.46	1.32	13.42	0.05	0.42	0.37
PCB#153	15.63	3.47	11.01	0.15	0.47	1.18
PCB#138	11.19	2.96	16.07	0.20	0.48	1.45
PCB#180	12.71	2.94	3.97	0.04	0.07	0.43
PCB#199	2.87	0.04	0.05	0.00	0.01	0.01
Total PCB	144.48±17.7	32.39±3.97	61.57±7.54	0.86±0.33	3.14±0.38	25.83±3.16

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27 **Table S5.** Estimated fluxes of DOC-associated PCBs (kg/yr) in the GARs (mean±sd).

PCBs	Ob	Yenisey	Lena	Indigirka	Kolyma	Mackenzie
PCB#18	0.22	0.03	0.06	0.00	0.00	0.16
PCB#28	1.43	0.32	0.21	0.00	0.01	0.36
PCB#52	1.51	0.31	0.25	0.01	0.01	0.18
PCB#70	1.09	0.29	0.20	0.01	0.01	0.09
PCB#101	5.21	0.96	1.83	0.03	0.07	0.09
PCB#110	2.11	0.49	0.71	0.01	0.03	0.04
PCB#118	2.48	0.80	0.73	0.01	0.03	0.02
PCB#105	0.66	0.26	0.18	0.00	0.01	0.02
PCB#149	4.96	0.94	2.17	0.03	0.09	0.06
PCB#153	5.78	1.20	2.31	0.04	0.09	0.07
PCB#138	4.50	1.11	2.59	0.04	0.09	0.08
PCB#180	2.38	0.52	0.55	0.01	0.02	0.02
PCB#199	0.26	0.00	0.01	0.00	0.00	0.00
Total PCB	32.59±4.0	7.24±0.89	11.80±1.45	0.19±0.02	0.47±0.06	1.18±0.15

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29 **Table S6.** Estimated POC-associated fluxes of PCBs (kg/yr) in the GARs (mean±sd).

PCBs	Ob	Yenisey	Lena	Indigirka	Kolyma	Mackenzie
PCB#18	0.04	0.02	0.21	0.01	0.05	4.31
PCB#28	0.28	0.23	0.69	0.05	0.12	9.98
PCB#52	0.29	0.22	0.82	0.09	0.18	5.09
PCB#70	0.21	0.20	0.66	0.08	0.16	2.44
PCB#101	1.02	0.68	6.09	0.46	0.99	2.45
PCB#110	0.41	0.35	2.37	0.17	0.41	1.13
PCB#118	0.48	0.56	2.44	0.21	0.42	0.69
PCB#105	0.13	0.18	0.58	0.06	0.11	0.42
PCB#149	0.97	0.66	7.21	0.43	1.14	1.78
PCB#153	1.13	0.84	7.66	0.54	1.21	1.85
PCB#138	0.88	0.78	8.60	0.60	1.27	2.08
PCB#180	0.46	0.36	1.83	0.12	0.29	0.46
PCB#199	0.05		0.04		0.01	0.01
Total PCB	6.35±0.71	5.09±0.57	39.20±4.38	2.83±0.32	6.36±0.71	32.69±3.97

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31 **Table S7.** Arctic Sediment PCB concentration (ng/g OC) in the GARs and Arctic Seas.

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Region, year	gOC/gdw	∑PCBs (ng/g OC)	ref
Ob river, 2005	0.009	17.2	Present data
Yenisey river, 2005	0.019	29.8	Present data
Lena river, 2004	0.006	67.4	Present data
Indigirka river, 2004	0.018	16.2	Present data
Kolyma river, 2004	0.019	24.3	Present data
Mackenzie river, 2004	0.020	15.6	Present data
Norwegian Sea	0.008	31.0	(a,b)
Kara Sea (Baydaratskaya Gulf), 1993	0.005	53.2	(a,b)
Kara Sea (Baydaratskaya Gulf), 1993	0.015	16.1	(a,b)
Kara Sea (Ob Gulf), 1993	0.009	25.8	(a,b)
Kara Sea (Yenisey Gulf), 1993	0.014	17.1	(a,b)
Chukchi Sea, 1996	0.013	10.5	(a,b)
Bering Sea, 1996	0.003	38.2	(a,b)
Arctic Shelf sediments (44 samples)	nd	60.0	(a,b)

33 nd: no data

34 ^a: AMAP 1998.

35 ^b: Jönsson. *et al*, 2003.

36 **Flux equations**

37 **Equation A (POC associated PCB flux)**

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$$\text{Flux}_{\text{PCB in POC}} = (\text{PCB})_{\text{POC}} * \text{POC (kg/yr)}$$

39 $(\text{PCB})_{\text{POC}}$: kg of PCBs /kg OC

40 POC (kg/yr): annual river POC discharge

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42 **Equation B (DOC associated PCB flux)**

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$$\text{Flux}_{\text{PCB in DOC}} = (\text{PCB})_{\text{seawater}} * \text{water discharge (km}^3\text{/yr)} * f_{\text{(DOC)}}$$

44 $(\text{PCB})_{\text{seawater}}$: kg of PCBs /L

45 Annual river water discharge (Km³/yr)

46 $f_{\text{(DOC)}}$: fraction of PCBs associated with DOC

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48 **Equation C (dissolved associated PCB flux)**

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$$\text{Flux}_{\text{PCB in diss}} = (\text{PCB})_{\text{seawater}} * \text{water discharge (km}^3\text{/yr)} * f_{\text{(diss)}}$$

50 $(\text{PCB})_{\text{seawater}}$: kg of PCBs /L

51 Annual river water discharge (Km³/yr)

52 $f_{\text{(DOC)}}$: fraction of PCBs associated with DOC

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55 **Partitioning coefficient equations. A river-specific K_{POCm} for each PCB congener and each**
56 **river was used based on ambient K_{POC} calculated from data in Carrizo and Gustafsson**
57 **(2011)**

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59 **PCBs associated with the dissolved fraction**

$$60 \quad f_{(diss)} = 1 / (1 + (K_{DOC} * DOC) + (K_{POC m} * POC))$$

61 K_{DOC} : literature-based DOC-water partition coefficient (Burkhard, 2000)

62 DOC: dissolved organic carbon (Kg/L)

63 $K_{POC m}$: observed distribution coefficient between POC and coastal water in the relevant shelf sea (based
64 on Carrizo and Gustafsson, 2011).

65 POC: particulated organic carbon (Kg/L)

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67 **PCBs associated with the DOC fraction**

$$68 \quad f_{(DOC)} = (K_{DOC} * DOC) / (1 + (K_{DOC} * DOC) + (K_{POC m} * POC))$$

69 K_{DOC} : literature-based DOC-water partition coefficient (Burkhard, 2000)

70 DOC: dissolved organic carbon (Kg/L)

71 $K_{POC m}$: observed distribution coefficient between POC and coastal water in the relevant shelf sea (based
72 on Carrizo and Gustafsson, 2011).

73 POC: particulate organic carbon (Kg/L)

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75 **PCBs associated with the POC fraction**

$$76 \quad f_{(POC)} = (K_{POC m} * POC) / (1 + (K_{DOC} * DOC) + (K_{POC m} * POC))$$

77 K_{DOC} : literature-based DOC-water partition coefficient (Burkhard, 2000)

78 DOC: dissolved organic carbon (Kg/L)

79 K_{POC} m: observed distribution coefficient between POC and coastal water in the relevant shelf sea (based
80 on Carrizo and Gustafsson, 2011).

81 POC: particulate organic carbon (Kg/L)

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83 **Supplementary online Information references**

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