

Limnological Characteristics Reveal Metal Pollution Legacy in Lakes near Canada's Northernmost Mine, Little Cornwallis Island, Nunavut

Branaavan Sivarajah,^{1,2} Neal Michelutti,¹ Xiaowa Wang,³ Christopher Grooms¹ and John P. Smol¹

APPENDIX 1

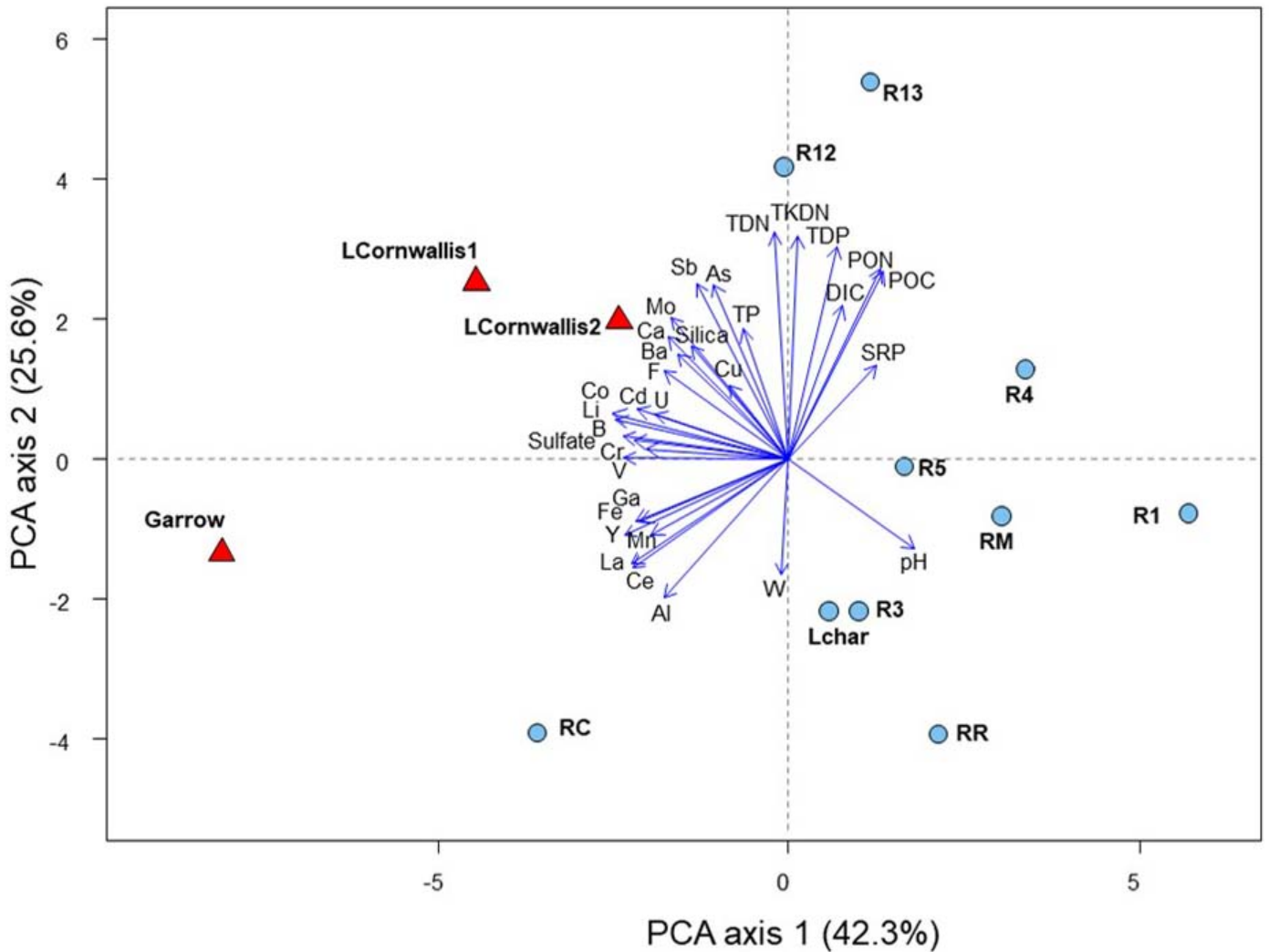


FIG. S1. A principal component analysis biplot with all 33 normal(ized) variables of the 13 sites from Little Cornwallis Island and Cornwallis Island (Nunavut, Canada). RM = Meretta Lake, RR = Resolute Lake, RC = Char Lake, and Lchar = Little Char Lake.

¹ Paleocological Environmental Assessment and Research Laboratory, Department of Biology, Queen's University, Kingston, Ontario K7L 3N6, Canada

² Corresponding author: branaavan.sivarajah@queensu.ca

³ Aquatic Contaminants Research Division, Environment and Climate Change Canada, Burlington, Ontario L7S 1A1, Canada

TABLE S1. A Pearson correlation matrix of the 33 water chemistry variables. POC = Particulate organic carbon, PON = Particulate organic nitrogen, LogF = Log transformed fluoride, LogSulfate = Log transformed sulfate, TDN = Total dissolved nitrogen, SQRTTKDN = Square-root transformed total Kjeldahl dissolved nitrogen, SRP = Soluble reactive phosphorus, SQRTTP = Square-root transformed total phosphorus, LogTDP = Log transformed total dissolved phosphorus, DIC = Dissolved inorganic carbon, LogCa = Log transformed calcium, LogAl = Log transformed aluminum, LogSb = Log transformed antimony, SQRTAs = Square-root transformed arsenic, LogBa = Log transformed barium, LogB = Log transformed boron, LogCd = Log transformed cadmium, LogCe = Log transformed cerium, LogCr = Log transformed chromium, LogCo = Log transformed cobalt, LogCu = Log transformed copper, LogGa = Log transformed gallium, LogFe = Log transformed iron, LogLa = Log transformed lanthanum, LogLi = Log transformed lithium, LogMn = Log transformed manganese, LogMo = Log transformed molybdenum, LogW = Log transformed tin, LogU = Log transformed uranium, LogV = Log transformed vanadium, LogY = Log transformed yttrium.

	pH	POC	PON	LogF	LogSulfate	TDN	SQRTTKDN	SRP	SQRTTP	LogTDP	DIC
pH	1.00										
POC	0.02	1.00									
PON	0.15	0.89	1.00								
LogF	-0.38	-0.16	0.02	1.00							
LogSulfate	-0.62	-0.37	-0.32	0.79	1.00						
TDN	-0.44	0.70	0.68	0.35	0.21	1.00					
SQRTTKDN	-0.36	0.78	0.72	0.22	0.09	0.97	1.00				
SRP	0.22	0.37	0.58	0.11	-0.32	0.18	0.20	1.00			
SQRTTP	-0.29	0.24	0.20	0.08	-0.12	0.49	0.42	-0.06	1.00		
LogTDP	-0.12	0.75	0.77	0.26	-0.14	0.74	0.71	0.58	0.49	1.00	
DIC	0.01	0.70	0.58	0.03	-0.39	0.48	0.58	0.42	0.35	0.65	1.00
LogCa	-0.77	0.09	0.01	0.74	0.70	0.52	0.44	-0.04	0.21	0.37	0.29
Silica	-0.22	0.06	0.21	0.81	0.46	0.35	0.30	0.29	0.25	0.33	0.35
LogAl	-0.25	-0.71	-0.81	0.12	0.34	-0.55	-0.56	-0.53	-0.04	-0.66	-0.28
LogSb	-0.53	0.35	0.40	0.43	0.27	0.69	0.60	-0.08	0.77	0.49	0.30
SQRTAs	-0.39	0.30	0.29	0.56	0.32	0.73	0.64	-0.04	0.74	0.67	0.39
LogBa	-0.70	0.11	0.15	0.27	0.39	0.47	0.44	-0.16	0.41	0.06	0.07
LogB	-0.67	-0.46	-0.45	0.77	0.92	0.21	0.06	-0.32	0.15	-0.07	-0.33
LogCd	-0.85	-0.16	-0.22	0.41	0.68	0.28	0.16	-0.50	0.35	-0.06	-0.25
LogCe	-0.27	-0.73	-0.68	0.46	0.70	-0.35	-0.43	-0.55	-0.13	-0.63	-0.56
LogCr	-0.44	-0.33	-0.29	0.52	0.48	0.01	-0.04	-0.25	0.25	-0.25	0.02
LogCo	-0.67	-0.32	-0.34	0.79	0.81	0.24	0.12	-0.34	0.27	-0.03	-0.02
LogCu	-0.18	0.15	0.17	0.35	0.02	0.16	0.12	0.20	0.33	0.19	0.48
LogGa	-0.50	-0.57	-0.65	0.36	0.52	-0.22	-0.28	-0.35	0.08	-0.39	-0.16
LogFe	-0.33	-0.65	-0.63	0.44	0.43	-0.27	-0.35	-0.44	0.30	-0.38	-0.12
LogLa	-0.29	-0.71	-0.67	0.44	0.68	-0.33	-0.42	-0.54	-0.10	-0.64	-0.53
LogLi	-0.73	-0.41	-0.37	0.75	0.89	0.27	0.13	-0.30	0.27	-0.05	-0.30
LogMn	-0.22	-0.72	-0.64	0.41	0.45	-0.29	-0.38	-0.47	0.22	-0.38	-0.29
LogMo	-0.65	0.14	0.18	0.53	0.62	0.68	0.57	-0.24	0.55	0.31	-0.11
LogW	0.08	-0.30	-0.47	-0.29	-0.08	-0.38	-0.42	-0.64	0.02	-0.39	-0.30
LogU	-0.68	-0.14	-0.17	0.53	0.88	0.38	0.31	-0.51	-0.02	-0.15	-0.38
LogV	-0.51	-0.50	-0.38	0.51	0.55	0.02	-0.11	-0.39	0.48	-0.19	-0.24
LogY	-0.42	-0.66	-0.60	0.47	0.70	-0.22	-0.33	-0.46	0.01	-0.54	-0.51

TABLE S1 continued:

	LogCa	Silica	LogAl	LogSb	SQRTAs	LogBa	LogB	LogCd	LogCe	LogCr	LogCo
LogCa	1.00										
Silica	0.54	1.00									
LogAl	0.20	0.14	1.00								
LogSb	0.51	0.53	-0.05	1.00							
SQRTAs	0.63	0.51	-0.11	0.75	1.00						
LogBa	0.48	0.37	0.23	0.76	0.34	1.00					
LogB	0.70	0.49	0.42	0.34	0.48	0.35	1.00				
LogCd	0.64	0.22	0.38	0.65	0.39	0.74	0.68	1.00			
LogCe	0.27	0.32	0.80	0.08	-0.02	0.30	0.67	0.53	1.00		
LogCr	0.40	0.67	0.54	0.47	0.19	0.53	0.56	0.54	0.60	1.00	
LogCo	0.80	0.66	0.54	0.54	0.54	0.51	0.88	0.73	0.69	0.75	1.00
LogCu	0.33	0.64	0.20	0.52	0.21	0.38	0.09	0.22	0.19	0.60	0.48
LogGa	0.50	0.33	0.87	0.17	0.12	0.42	0.62	0.53	0.79	0.55	0.75
LogFe	0.36	0.45	0.83	0.30	0.25	0.34	0.60	0.49	0.73	0.79	0.76
LogLa	0.27	0.33	0.81	0.12	-0.03	0.35	0.65	0.55	0.99	0.64	0.70
LogLi	0.70	0.52	0.43	0.49	0.51	0.53	0.97	0.77	0.69	0.62	0.88
LogMn	0.26	0.30	0.74	0.20	0.28	0.23	0.61	0.39	0.69	0.55	0.64
LogMo	0.53	0.44	-0.04	0.81	0.70	0.70	0.65	0.75	0.28	0.40	0.59
LogW	-0.15	-0.54	0.26	-0.20	-0.15	-0.29	-0.05	0.19	0.18	-0.06	-0.04
LogU	0.58	0.26	0.20	0.39	0.32	0.56	0.76	0.77	0.56	0.41	0.65
LogV	0.44	0.44	0.62	0.61	0.43	0.64	0.66	0.74	0.69	0.72	0.76
LogY	0.33	0.36	0.75	0.24	0.03	0.48	0.69	0.65	0.96	0.66	0.73

TABLE S1 *continued*:

	LogCu	LogGa	LogFe	LogLa	LogLi	LogMn	LogMo	LogW	LogU	LogV	LogY
LogCu	1.00										
LogGa	0.41	1.00									
LogFe	0.41	0.78	1.00								
LogLa	0.25	0.80	0.75	1.00							
LogLi	0.16	0.63	0.62	0.68	1.00						
LogMn	0.08	0.66	0.90	0.66	0.59	1.00					
LogMo	0.09	0.17	0.23	0.28	0.75	0.26	1.00				
LogW	-0.19	0.02	0.18	0.19	-0.07	0.12	-0.22	1.00			
LogU	-0.11	0.33	0.25	0.55	0.78	0.28	0.77	-0.02	1.00		
LogV	0.33	0.66	0.85	0.71	0.77	0.80	0.59	0.11	0.48	1.00	
LogY	0.31	0.81	0.73	0.98	0.75	0.61	0.38	0.14	0.58	0.77	1.00

TABLE S2. Measured water chemistry variables that were included in the principal component analysis. The median values from the 10 Resolute Bay sites are provided for comparison. RM = Meretta Lake, RR = Resolute Lake, RC = Char Lake, and Lchar = Little Char Lake.

Lake ¹	pH	POC (mg/L)	PON (mg/L)	F (mg/L)	Sulfate (mg/L)	TDN (mg/L)	TKDN (mg/L)	SRP (mg/L)	TP (mg/L)	TDP (mg/L)	DIC (mg/L)
Garrow	7.79	0.127	0.011	0.050	180.00	0.217	0.186	0.0002	0.0116	0.0009	10.3
LCornwallis1	7.77	0.276	0.028	0.080	298.00	0.283	0.262	0.0005	0.0053	0.0045	19.5
LCornwallis2	8.06	0.334	0.039	0.040	51.60	0.280	0.331	0.0005	0.0044	0.0014	18.8
RR	8.79	0.194	0.024	0.030	15.30	0.078	0.077	0.0005	0.0027	0.0010	6.6
RM	8.97	0.256	0.035	0.040	8.06	0.188	0.176	0.0006	0.0061	0.0023	17.4
RC	8.57	0.170	0.017	0.050	34.00	0.092	0.094	0.0003	0.0029	0.0006	20.6
Lchar	8.51	0.195	0.022	0.050	39.40	0.130	0.158	0.0008	0.0013	0.0013	20.6
R1	8.36	0.341	0.032	0.020	1.95	0.161	0.171	0.0008	0.0043	0.0023	22.9
R4	8.44	0.350	0.033	0.030	18.80	0.328	0.397	0.0004	0.0038	0.0021	20.8
R3	8.42	0.239	0.020	0.020	2.51	0.131	0.151	0.0003	0.0102	0.0014	23.3
R5	8.41	0.362	0.030	0.030	17.40	0.216	0.257	0.0002	0.0045	0.0016	21.0
R12 (received sewage)	8.56	0.398	0.040	0.050	11.70	0.304	0.354	0.0007	0.0121	0.0064	29.2
R13 (received sewage)	8.25	0.372	0.044	0.050	9.21	0.346	0.395	0.0008	0.0121	0.0061	28.8
Median Resolute Bay	8.48	0.299	0.031	0.035	13.50	0.175	0.174	0.0006	0.0044	0.0019	20.9

TABLE S2 continued

Lake ¹	Ca (mg/L)	Silica (mg/L)	Al (µg/L)	Sb (µg/L)	As (µg/L)	Ba (µg/L)	B (µg/L)	Cd (µg/L)	Ce (µg/L)	Cr (µg/L)	Co (µg/L)
Garrow	44.7	0.57	79.9	0.089	0.18	46.40	244.0	0.132	0.274	0.21	0.094
LCornwallis1	101.0	0.63	16.0	0.078	0.22	24.90	154.0	0.088	0.041	0.07	0.092
LCornwallis2	39.6	0.63	17.9	0.122	0.12	138.00	21.7	0.048	0.052	0.12	0.029
RR	15.1	0.31	10.5	0.015	0.08	8.25	20.5	0.003	0.037	0.05	0.011
RM	22.9	0.36	4.9	0.030	0.15	9.18	10.8	0.002	0.015	0.04	0.011
RC	36.2	0.71	108.0	0.027	0.10	15.40	33.8	0.007	0.215	0.21	0.068
Lchar	37.0	0.71	27.5	0.007	0.10	9.47	39.2	0.001	0.029	0.09	0.022
R1	25.6	0.15	6.6	0.016	0.07	12.50	5.5	0.003	0.004	0.04	0.008
R4	31.6	0.21	3.4	0.020	0.15	12.60	21.9	0.002	0.008	0.03	0.015
R3	27.0	0.18	67.8	0.036	0.15	21.40	11.0	0.006	0.013	0.06	0.016
R5	31.6	0.35	9.5	0.032	0.13	11.80	17.0	0.012	0.014	0.09	0.018
R12 (received sewage)	40.8	0.96	12.3	0.126	0.24	20.70	24.9	0.004	0.021	0.08	0.035
R13 (received sewage)	37.8	0.81	2.1	0.155	0.20	29.10	24.6	0.006	0.003	0.15	0.028
Median Resolute Bay	31.6	0.36	10.0	0.029	0.14	12.55	21.2	0.004	0.015	0.07	0.017

TABLE S2 continued

Lake ¹	Cu (µg/L)	Ga (µg/L)	Fe (µg/L)	La (µg/L)	Li (µg/L)	Mn (µg/L)	Mo (µg/L)	W (µg/L)	U (µg/L)	V (µg/L)	Y (µg/L)
Garrow	0.61	0.033	140.0	0.139	19.70	4.57	1.110	0.006	0.8110	0.726	0.144
LCornwallis1	0.52	0.013	37.2	0.017	7.28	2.20	0.731	0.003	0.6570	0.199	0.024
LCornwallis2	0.88	0.007	22.0	0.030	2.23	0.83	0.806	0.001	0.7010	0.219	0.042
RR	0.16	0.002	15.2	0.015	0.90	1.37	0.328	0.002	0.2020	0.063	0.016
RM	0.27	0.001	16.1	0.008	0.76	0.95	0.281	0.008	0.1340	0.110	0.012
RC	4.81	0.030	148.0	0.101	1.62	3.79	0.188	0.005	0.2020	0.187	0.065
Lchar	0.22	0.006	29.9	0.014	1.85	1.43	0.195	0.001	0.2060	0.061	0.015
R1	1.08	0.003	6.5	0.003	0.35	0.13	0.139	0.004	0.0723	0.025	0.007
R4	0.15	0.002	6.1	0.004	0.92	0.43	0.383	0.002	0.3510	0.023	0.006
R3	0.26	0.009	68.8	0.007	0.66	4.52	0.245	0.005	0.1060	0.175	0.009
R5	0.24	0.001	15.3	0.008	0.91	0.46	0.407	0.011	0.4260	0.050	0.009
R12 (received sewage)	2.58	0.007	26.1	0.011	1.69	0.80	0.594	0.001	0.1670	0.098	0.015
R13 (received sewage)	1.79	0.001	26.9	0.002	1.53	1.00	0.638	0.001	0.1720	0.124	0.005
Median Resolute Bay	0.27	0.003	21.1	0.008	0.92	0.98	0.305	0.003	0.1870	0.081	0.011

¹ Lake depth was not available for all study lakes. Lakes and ponds for which depth (Z_{\max}) is available are Garrow, 49 m; RR, 22.5 m; RM, 9 m; and RC, 27.5 m. R1, R3, R4, R5, R12, R13 are shallow ponds around Resolute Bay where Z_{\max} is less than 2 m.