Airborne radionuclides and heavy metals in High Arctic terrestrial environment as the indicators of sources and transfers of contamination

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Tab. S1. Coordinates and selected morphology properties of cryoconite holes on Waldemarbreen.

N	GPS coordinates UTM 33N (m)		Altitude a.s.l. (m)	Area (cm^2)	Depth (cm)
2	435222.3	8735590	223	165	29
3	435869.9	8735874	308	156	10
4	436175.5	8736001	357	476	28
5	435295.8	8735921	255	80	9
6	435512.6	8734906	201	12.3	1
7	435954.4	8735202	233	25	2.5
8	435668.5	8735657	264	121	5.5
9	434772.3	8735363	165	340	4
10	434772.3	8735363	165	380	7
11	435668.5	8735657	264	20	8
12	436175.5	8736001	357	170	7
13	436858.6	8735885	423	1200	16

Tab. S2. Activity concentrations of anthropogenic radionuclides (^{137}Cs, Pu isotopes, ^{241}Am) expressed in Bq kg^{-1} and radionuclide activity ratios and mass ratios in soil profiles. All data were corrected for August 2014, the sampling date.

Soil	Depth (cm)	^{238}Pu (Bq/kg)	$^{239+240}Pu$ (Bq/kg)	^{241}Am (Bq/kg)	^{137}Cs (Bq/kg)	$^{238}Pu/^{239+240}Pu$	$^{241}Am/^{239+240}Pu$	$^{239+240}Pu/^{137}Cs$	^{238}Pu (Bq/m^2)	$^{239+240}Pu$ (Bq/m^2)	^{241}Am (Bq/m^2)	^{137}Cs (Bq/m^2)	LOI (%)
S1-1	2	<0.03	<0.03	<0.1	31 ± 4	-	-	-	-	-	-	340 ± 41	15
S1-2	4	<0.05	1.07 ± 0.08	0.59 ± 0.11	<5	-	0.55 ± 0.11	-	-	25.7 ± 1.9	14.2 ± 2.6	120 ± 24	8
S1-3	6	<0.03	0.08 ± 0.01	<0.1	<5	-	-	-	-	1.8 ± 0.2	-	44 ± 22	8
S1-4	9	<0.07	<0.07	<0.03	<2	-	-	-	-	-	-		9
S1-5	13	<0.08	<0.08	<0.08	<2	-	-	-	-	-	-		8
Inventory (Bq m^{-2})									-	**28 ± 2**	**14 ± 3**	**500 ± 90**	
S3-1	2	<0.03	0.32 ± 0.03	0.09 ± 0.01	8 ± 2	-	0.28 ± 0.04	0.042 ± 0.013	-	6.8 ± 0.6	1.9 ± 0.2	148 ± 42	8
S3-2	4.5	<0.03	<0.03	<0.03	<4			-	-	-	-	-	9
S3-3	8	<0.03	<0.03	<0.03	<5			-	-	-	-	-	8
S3-4	12.5	<0.03	<0.03	<0.03	<5			-	-	-	-	-	10
Inventory (Bq m^{-2})									-	**6.8 ± 0.6**	**1.9 ± 0.2**	**150 ± 40**	
S4-1	1	0.08 ±0.01	2.13 ± 0.16	0.90 ± 0.06	63 ± 7	0.038 ± 0.005	0.39 ± 0.03	0.034 ± 0.004	0.58 ± 0.1	15.6 ± 1.2	6.1 ± 0.2	475 ± 51	7
S4-2	4	<0.04	0.56 ± 0.04	0.30 ± 0.03	16 ± 7	-	0.48 ± 0.06	0.034 ± 0.006	0.35 ± 0.1	5.0 ± 0.4	2.4 ± 0.3	150 ± 27	8
S4-3	8	<0.02	0.08 ± 0.01	<0.03	2 ± 1	-	-	0.041 ± 0.021	-	1.9 ± 0.2		47 ± 24	9
S4-4	12	<0.03	<0.03		<4	-	-		-			-	9
Inventory (Bq m^{-2})									**0.94 ± 0.2**	**22 ± 2**	**9 ± 1**	**670 ± 100**	
S5-1	2	<0.04	0.51 ± 0.04	0.25 ± 0.03	9 ± 1	-	0.49 ± 0.07	0.059 ± 0.009	-	15.6 ± 1.1	5.0 ± 0.6	238 ± 20	8
S5-2	4	0.03 ± 0.01	1.04 ± 0.08	0.47 ± 0.06	18 ± 1	0.029 ± 0.010	0.45 ± 0.07	0.056 ± 0.005	1.2 ± 0.4	5.0 ± 0.4	18.6 ± 2.4	174 ± 15	9
S5-3	7	<0.03	<0.03	<0.06	<2	-	-	-	-	1.9 ± 0.2	-	-	8
S5-4	12	<0.02	<0.02		<2	-	-	-	-	-	-	-	9
Inventory (Bq m^{-2})									**1.2 ± 0.4**	**22 ± 2**	**24 ± 3**	**400 ± 30**	
S6-1	2	0.03 ± 0.01	0.58 ± 0.05	0.28 ± 0.03	23 ± 1	0.052 ± 0.018	0.045 ± 0.05	0.025 ± 0.003	-	15.3 ± 1.3	6.9 ± 0.6	449 ± 26	8
S6-2	5	<0.03	<0.03	<0.03	<2	-	-	-	-	-	-	-	9
S6-3	10	<0.02	<0.02	<0.03	<2	-	-	-	-	-	-	-	9
S6-4	17	<0.06	<0.06	<0.03	<3	-	-	-	-	-	-	-	8
Inventory (Bq m^{-2})									-	**15 ± 1**	**7 ± 1**	**450 ± 30**	

Tab. S3. Activity concentrations of natural radionuclides (^{210}Pb, $^{234,238}U$, $^{230,232}Th$) expressed in Bq kg^{-1} and activity ratio of $^{234}U/^{238}U$ in soil profiles. Data for ^{210}Pb were corrected for August 2014, the sampling date.

soil	Depth (cm)	^{210}Pb (Bq/kg)	^{234}U (Bq/kg)	^{238}U (Bq/kg)	$^{234}U/^{238}U$	^{230}Th (Bq/kg)	^{232}Th (Bq/kg)
S1-1	2	65±2	23±2	22±2	1.0±0.1	17±1	32±3
S1-2	4	43±1	21±1	22±2	0.9±0.1	22±2	42±3
S1-3	6	15±1	22±2	23±2	1.0±0.1	9±1	8±1
S1-4	9	17±1	21±1	22±1	1.0±0.1	12±2	14±2
S1-5	13	15±1	21±1	22±1	1.0±0.1	-	-
S3-1	2	37±5	16±1	16±1	1.0±0.1	9±1	17±2
S3-2	4.5	15±4	16±1	15±1	1.1±0.1	10±1	18±2
S3-3	8	17±4	15±1	14±1	1.0±0.1	11±1	20±2
S3-4	12.5	16±4	17±1	14±1	1.2±0.1	10±1	19±1
S4-1	1	173±4	21±1	20±1	1.1±0.1	10±1	21±2
S4-2	4	31±1	20±1	18±1	1.1±0.2	10±1	27±2
S4-3	8	29±2	19±1	18±1	1.1±0.1	11±1	29±2
S4-4	12	27±3	21±1	20±1	1.0±0.1	10±1	29±2
S5-1	2	83±7	23±2	21±1	1.1±0.1	11±1	19±1
S5-2	4	57±8	28±2	30±2	0.9±0.1	15±1	34±3
S5-3	7	21±2	17±1	17±1	1.0±0.1	10±1	15±1
S5-4	12	18±2	15±1	16±1	1.0±0.1	10±1	20±2
S6-1	2	82±6	24±2	22±2	1.1±0.1	11±1	16±1
S6-2	5	21±4	14±1	13±1	1.0±0.1	10±1	17±1
S6-3	10	18±2	19±1	19±1	1.0±0.1	10±1	21±2
S6-4	17	19±2	13±1	12±1	1.1±0.1	9±1	13±1

Tab. S4. Activity concentrations of anthropogenic radionuclides (^{137}Cs, Pu isotopes, ^{241}Am) expressed in Bq kg^{-1} and radionuclide activity ratios and mass ratios in all cryoconite samples. All data were corrected for August 2014, the sampling date.

No.	^{137}Cs (Bq/kg)	$^{239+240}$Pu (Bq/kg)	^{238}Pu (Bq/kg)	^{241}Am (Bq/kg)	^{238}Pu/$^{239±240}$Pu	$^{239±240}$Pu/^{137}Cs	^{241}Am/$^{239±240}$Pu	^{240}Pu/^{239}Pu
KW2	642 ± 84	16.73 ± 1.12	0.80 ± 0.10	7.56 ± 0.54	0.048±0.007	0.026±0.004	0.45±0.04	0.159±0.002
KW3	1021 ± 136	16.93 ± 1.15	0.59 ± 0.08	7.52 ± 0.57	0.035±0.005	0.017±0.002	0.44± 0.05	0.145±0.001
KW4	2030 ± 257	33.54 ± 2.30	2.09 ± 0.22	18.77 ± 1.27	0.062±0.008	0.017±0.002	0.56±0.05	0.141±0.001
KW5	109 ± 22	1.59 ± 0.16	0.08 ± 0.02	1.04 ± 0.16	0.050±0.013	0.015±0.003	0.65±0.12	0.196±0.019
KW6	<3	0.09 ± 0.02	<0.03	<0.25	-	-	-	-
KW7	17 ± 7	0.12 ± 0.02	<0.02	<0.20	-	0.007±0.003	-	-
KW8	440 ± 58	7.20 ± 0.57	0.45 ± 0.07	3.02 ± 0.26	0.063±0.011	0.016±0.003	0.42±0.05	0.161±0.004
KW9	13 ± 3	0.47 ± 0.07	<0.04	0.25 ± 0.06	-	0.035±0.010	0.53±0.16	0.121±0.039
KW10	76 ± 13	2.88 ± 0.27	0.15 ± 0.06	1.45 ± 0.20	0.052±0.022	0.038±0.008	0.50±0.08	0.131±0.015
KW11	513 ± 88	7.40 ± 0.54	0.23 ± 0.04	1.80 ± 0.36	0.031±0.006	0.014±0.003	0.24±0.05	0.137±0.004
KW12	1886 ± 264	33.64 ± 2.33	2.08 ± 0.23	18.13 ± 1.24	0.062±0.008	0.018±0.003	0.54±0.05	0.140±0.001
KW13	1905 ± 266	42.77 ± 2.81	2.10 ± 0.20	24.48 ± 1.47	0.049±0.006	0.022±0.003	0.57±0.05	0.143±0.001

Tab. S5. Activity concentrations of natural radionuclides (^{210}Pb, ^{234,238}U, ^{230,232}Th) expressed in Bq kg^{-1} and activity ratio of ^{234}U/^{238}U in all cryoconite samples. Data for ^{210}Pb were corrected for August 2014, the sampling date.

No.	^{210}Pb (Bq/kg)	^{234}U (Bq/kg)	^{238}U (Bq/kg)	^{234}U/^{238}U	^{230}Th (Bq/kg)	^{232}Th (Bq/kg)	LOI (%)
KW2	3577±196	18±2	18±2	1.0±0.2	18±1	16±1	6
KW3	4460± 230	43±4	37±4	1.2±0.2	54±4	50±4	6
KW4	12269±634	34±3	36±4	0.9±0.1	45±3	48±4	11
KW5	1028±73	25±2	25±3	1.0±0.1	33±2	57±4	2
KW6	485±56	16±2	12±2	1.4±0.3	25±2	56±4	3
KW7	497±35	12±1	10±1	1.2±0.2	16±1	35±3	3
KW8	4443±224	22±2	23±2	1.0±0.1	27±2	51±4	8
KW9	1744±95	26±2	24±2	1.1±0.1	27±2	58±4	6
KW10	2739±142	20±2	20±2	1.0±0.1	27±2	54±4	7

KW11	5053±292	23±2	24±2	1.0±0.1	34±2	50±4	8
KW12	5081±259	39±3	31±3	1.3±0.2	47±4	47±4	11
KW13	5236±263	36±3	33±2	1.1±0.1	41±3	48±4	11

Table S6. Concentrations of measured metals in soil samples, together with $^{206}Pb/^{207}Pb$ and $^{208}Pb/^{206}Pb$ ratios. The calculated anthropogenic metal enrichment factors (EF) results are also given after normalization for Fe and Al content ($_{Fe\ norm}$ or $_{Al\ norm}$).

	Pb (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Cd (mg/kg)	Fe (g/kg)	Al (g/kg)	Cr (mg/kg)	Co (mg/kg)	Ni (mg/kg)	Mn (mg/kg)	$^{206}Pb/^{207}Pb$	$^{208}Pb/^{206}Pb$	EF Pb $_{Fe\ norm}$	EF Pb $_{Al\ norm}$	EF Zn $_{Fe\ norm}$	EF Zn $_{Al\ norm}$	EF Cu $_{Fe\ norm}$	EF Cu $_{Al\ norm}$	EF Cd $_{Fe\ norm}$	EF Cd $_{Al\ norm}$
SO1-1	20.75	66.56	22.93	0.12	38.02	51.79	55.26	11.12	30.25	0.67	1.205	2.046	1.6	1.3	1.0	0.9	1.4	1.2	1.1	0.7
SO1-2	21.13	75.26	26.57	0.05	42.91	64.47	61.20	12.37	32.22	0.83	1.205	2.035	1.4	1.1	1.0	0.8	1.4	1.1	0.4	0.4
SO1-3	20.94	71.30	25.95	0.09	44.18	62.30	52.20	12.46	30.63	0.78	1.205	2.036	1.4	1.1	0.9	0.8	1.4	1.1	0.7	0.4
SO1-4	19.19	65.67	23.88	0.60	39.95	58.99	53.61	11.74	28.16	0.87	1.203	2.048	1.4	1.1	1.0	0.7	1.4	1.1	5.3	3.1
SO1-5	18.92	66.04	24.55	0.07	39.72	62.58	50.27	11.60	28.61	0.72	1.208	2.036	1.4	1.0	1.0	0.7	1.4	1.0	0.6	0.4
SO5-1	14.73	58.41	16.90	0.10	26.18	47.41	33.24	8.86	60.27	0.49	1.206	2.036	1.6	1.0	1.3	0.8	1.5	1.0	1.3	0.6
SO5-2	16.67	49.83	16.50	0.08	26.61	49.60	43.43	8.76	21.46	0.45	1.196	2.019	1.8	1.1	1.1	0.7	1.4	0.9	1.0	0.5
SO5-3	9.59	45.80	12.24	0.27	27.46	37.19	28.85	6.13	18.70	0.39	1.211	2.039	1.0	0.9	1.0	0.8	1.0	0.9	3.4	2.2
SO5-4	20.24	62.94	20.61	0.36	32.45	54.91	46.49	10.55	27.31	0.38	1.208	2.040	1.8	1.2	1.1	0.8	1.5	1.0	3.9	2.0
SO6-1	10.07	48.05	12.95	0.21	35.62	42.22	32.47	7.23	23.86	0.35	1.209	2.030	0.8	0.8	0.8	0.8	0.8	0.8	2.1	1.5
SO6-2	12.70	47.45	14.71	0.60	27.41	41.18	34.42	6.98	24.13	0.34	1.197	2.057	1.4	1.0	1.0	0.8	1.3	1.0	7.7	4.4
SO6-3	15.51	50.78	26.18	0.50	28.58	38.52	46.85	10.67	28.86	0.52	1.217	2.050	1.6	1.3	1.0	0.9	2.1	1.8	6.2	3.9
SO6-4	15.80	53.17	22.52	0.60	28.87	43.24	42.65	10.87	28.41	0.57	1.208	2.042	1.6	1.2	1.1	0.8	1.8	1.4	7.3	4.2
SO4-1	25.91	76.89	19.59	0.34	28.72	47.41	38.47	8.53	21.83	0.40	1.190	2.027	2.6	1.8	1.6	1.1	1.6	1.1	4.2	2.2
SO4-2	17.98	58.44	21.44	0.16	28.82	53.22	52.43	10.90	26.34	0.38	1.195	2.053	1.8	1.1	1.2	0.7	1.7	1.1	1.9	0.9
SO4-3	17.14	53.07	20.73	0.14	28.91	59.96	62.65	10.86	26.23	0.46	1.196	2.036	1.7	1.0	1.1	0.6	1.7	0.9	1.6	0.7
SO4-4	19.36	53.42	22.40	0.16	34.00	58.64	30.21	11.58	29.12	0.48	1.203	2.033	1.7	1.1	0.9	0.6	1.5	1.0	1.6	0.8
SO3-1	11.57	45.09	11.83	0.22	20.85	40.20	36.12	5.37	15.01	0.35	1.190	2.025	1.6	1.0	1.3	0.7	1.3	0.8	3.6	1.6
SO3-2	11.34	51.80	12.92	0.17	30.56	43.56	37.21	6.94	18.46	0.53	1.197	2.038	1.1	0.9	1.0	0.8	1.0	0.8	2.0	1.2
SO3-3	12.91	59.38	14.37	0.15	30.32	38.73	33.39	6.79	20.99	0.57	1.200	2.014	1.2	1.1	1.1	1.0	1.1	1.0	1.8	1.2
SO3-4	12.82	56.62	14.42	0.18	27.89	45.30	30.11	7.26	20.32	0.74	1.204	2.022	1.3	0.9	1.2	0.8	1.2	0.8	2.2	1.2

Table S7. The Pearson's correlation matrix for soil samples. Different heavy metals concentrations, $^{206}Pb/^{207}Pb$ and $^{208}Pb/^{206}Pb$ isotopic ratios, natural and anthropogenic radionuclide activity concentrations and organic matter content (LOI).

Soils	^{234}U	^{238}U	^{230}Th	^{232}Th	Cr	Pb	Cu	Zn	Cd	Co	Ni	Mn	Fe	Al	$^{206/207}Pb$	$^{208/206}Pb$	LOI	^{137}Cs	$^{239+241}Pu$	^{241}Am
^{210}Pb	**0.65**	**0.68**	**0.80**	**0.55**	**0.63**	**0.74**	**0.53**	**0.71**	0.05	**0.45**	**0.40**	**-0.39**	0.41	**0.51**	**-0.70**	0.03	0.32	**0.90**	**0.79**	**0.71**
^{234}U		**0.95**	**0.83**	**0.53**	**0.48**	**0.42**	0.31	**0.60**	-0.22	0.34	**0.42**	-0.14	0.32	0.36	**-0.57**	0.31	0.35	0.20	0.20	0.28
^{238}U			**0.77**	**0.50**	**0.46**	**0.42**	0.31	**0.57**	-0.20	0.32	0.39	-0.12	0.32	0.35	**-0.53**	0.29	0.36	0.08	0.21	0.32
^{230}Th				**0.80**	**0.75**	**0.63**	**0.57**	**0.82**	-0.05	**0.60**	**0.45**	-0.25	**0.56**	**0.64**	**-0.69**	0.22	0.26	-0.09	0.13	0.31
^{232}Th					**0.76**	**0.50**	**0.64**	**0.74**	-0.16	**0.73**	0.36	-0.23	**0.58**	**0.78**	-0.48	0.26	0.19	0.00	0.22	0.39
Cr						**0.73**	**0.86**	**0.88**	0.01	**0.88**	**0.51**	-0.15	**0.80**	**0.89**	**-0.62**	0.26	0.17	-0.33	-0.28	0.29
Pb							**0.82**	**0.71**	0.09	**0.59**	**0.48**	-0.40	**0.53**	**0.59**	**-0.78**	-0.08	0.25	0.46	0.47	**0.90**
Cu								**0.77**	0.11	**0.89**	**0.56**	-0.12	**0.73**	**0.80**	**-0.59**	-0.01	0.07	-0.12	-0.04	0.56
Zn									-0.01	**0.80**	**0.56**	-0.08	**0.75**	**0.84**	**-0.59**	0.21	0.30	0.35	0.41	**0.83**
Cd										0.04	-0.03	-0.08	-0.04	-0.10	-0.03	-0.25	-0.11	**0.74**	0.51	0.30
Co											**0.57**	0.04	**0.84**	**0.91**	-0.43	0.19	-0.04	-0.24	-0.18	0.42
Ni												-0.04	**0.49**	**0.48**	-0.54	-0.02	-0.01	-0.24	-0.16	-0.12
Mn													0.14	-0.09	0.51	0.09	-0.25	-0.30	-0.17	0.34
Fe														**0.82**	-0.45	0.19	-0.12	-0.42	-0.42	-0.03
Al															-0.50	0.31	0.05	-0.40	-0.16	0.42
$^{206/207}Pb$																0.06	-0.12	0.04	-0.02	0.49
$^{208/206}Pb$																	0.12	-0.19	-0.26	-0.08
LOI																		**0.70**	0.45	0.34
137Cs																			**0.72**	**0.74**
239+240Pu																				**0.98**

Table S8. Concentrations of measured metals in cryoconite samples, together with $^{206}Pb/^{207}Pb$ and $^{208}Pb/^{206}Pb$ ratios. The calculated anthropogenic metal enrichment factors (EF) results are also given after normalization for Fe and Al content ($_{Fe\ norm}$ or $_{Al\ norm}$).

	Pb (mg/kg)	**Zn (mg/kg)**	**Cu (mg/kg)**	**Cd (mg/kg)**	**Fe (g/kg)**	**Al (g/kg)**	**Cr (mg/kg)**	**Co (mg/kg)**	**Ni (mg/kg)**	**Mn (mg/kg)**	**$^{206}Pb/^{207}Pb$**	**$^{208}Pb/^{206}Pb$**	**EF Pb $_{Fe\ norm}$**	**EF Pb $_{Al\ norm}$**	**EF Zn $_{Fe\ norm}$**	**EF Zn $_{Al\ norm}$**	**EF Cu $_{Fe\ norm}$**	**EF Cu $_{Al\ norm}$**	**EF Cd $_{Fe\ norm}$**	**EF Cd $_{Al\ norm}$**
2	82.79	85.07	34.3	0.21	49.62	83.03	83.01	13.39	37.19	0.34	1.174	2.042	5.0	3.3	1.0	0.7	1.7	1.1	1.5	0.7
3	23.04	96.89	22.4	0.23	42.56	75.50	77.22	13.16	35.89	0.51	1.183	2.061	1.6	1.0	1.4	0.9	1.3	0.8	1.9	0.9
4	95.53	92.36	34.8	0.24	37.08	69.40	75.57	13.01	36.70	0.30	1.174	2.025	7.7	4.6	1.5	0.9	2.3	1.3	2.4	1.1
5	40.91	74.22	27.5	0.20	42.75	77.55	64.01	13.73	29.15	0.39	1.192	2.035	2.9	1.8	1.0	0.6	1.5	0.9	1.7	0.8
6	36.84	87.32	33.4	0.27	51.27	89.73	80.95	17.74	34.71	0.63	1.199	2.034	2.2	1.4	1.0	0.6	1.6	1.0	1.9	0.9
7	24.02	59.57	25.8	0.24	29.38	63.57	47.55	11.42	22.56	0.40	1.197	2.036	2.5	1.3	1.2	0.6	2.1	1.1	2.9	1.1
8	20.48	86.64	22.2	0.25	41.37	90.20	72.99	13.05	28.99	0.45	1.197	2.048	1.5	0.8	1.3	0.6	1.3	0.7	2.2	0.8
9	57.91	90.04	40.1	0.21	41.38	91.87	83.22	15.21	36.70	0.51	1.181	2.039	4.2	2.1	1.3	0.7	2.3	1.2	1.8	0.7
10	45.57	83.26	34.4	0.19	46.65	79.24	81.29	14.15	33.73	0.25	1.184	2.039	2.9	1.9	1.1	0.7	1.8	1.2	1.4	0.7
11	97.28	97.55	39.6	0.60	48.16	78.80	84.04	15.31	41.80	0.31	1.180	2.038	6.1	4.1	1.2	0.8	2.0	1.3	4.5	2.3
12	97.70	86.80	34.3	0.19	37.93	65.72	76.42	12.95	36.46	0.31	1.169	2.032	7.7	5.0	1.4	0.9	2.2	1.4	1.8	0.9
13	19.87	88.14	21.5	0.26	40.18	85.90	65.98	13.00	35.83	0.46	1.194	2.047	1.5	0.8	1.3	0.7	1.3	0.7	2.3	0.9

Table S9. The Pearson's correlation matrix for cryoconite samples. Different heavy metals concentrations, $^{206}Pb/^{207}Pb$ and $^{208}Pb/^{206}Pb$ isotopic ratios, natural and anthropogenic radionuclide activity concentrations, organic matter content (LOI), and some cryoconite characteristics: localization altitude, area and depth were taken into account.

Cryoconites	^{234}U	^{238}U	^{230}Th	^{232}Th	Cr	Pb	Cu	Zn	Cd	Co	Ni	Mn	Fe	Al	$^{206/207}Pb$	$^{208/206}Pb$	LOI	^{137}Cs	$^{239+241}Pu$	^{241}Am	^{238}Pu	Altitude	Area	Depth
^{210}Pb	0.56	**0.72**	**0.59**	-0.06	0.21	0.50	0.08	0.53	0.15	-0.29	0.41	-0.41	-0.18	-0.34	-0.55	-0.19	**0.77**	**0.80**	**0.72**	**0.70**	**0.75**	**0.64**	0.38	**0.68**
^{234}U		**0.94**	**0.96**	0.25	0.19	0.13	-0.22	0.57	-0.12	-0.32	0.40	-0.02	-0.19	-0.40	-0.44	0.31	**0.60**	**0.77**	**0.72**	**0.70**	**0.67**	**0.72**	0.43	0.24
^{238}U			**0.92**	0.26	0.19	0.20	-0.18	**0.60**	-0.03	-0.34	0.41	-0.16	-0.18	-0.36	-0.46	0.22	**0.64**	**0.79**	**0.72**	**0.70**	**0.68**	**0.73**	0.47	0.41
^{230}Th				0.36	0.18	0.16	-0.19	**0.58**	0.03	-0.22	0.42	-0.05	-0.15	-0.44	-0.39	0.21	0.53	**0.74**	**0.66**	**0.63**	**0.62**	**0.73**	0.32	0.17
^{232}Th					0.13	-0.23	0.04	0.27	0.09	0.44	0.05	0.27	0.06	0.25	0.27	-0.03	-0.02	-0.12	-0.19	-0.15	-0.17	-0.05	0.07	**-0.58**
Cr						0.52	**0.65**	**0.81**	0.22	**0.62**	**0.90**	-0.03	**0.77**	**0.53**	-0.55	0.03	0.22	0.05	0.04	-0.01	0.02	-0.22	-0.03	0.20
Pb							**0.78**	0.36	0.32	0.12	**0.67**	**-0.58**	0.16	-0.11	**-0.86**	**-0.58**	0.40	0.35	0.27	0.23	0.35	0.09	-0.17	0.44
Cu								0.28	0.30	0.51	**0.62**	-0.30	0.34	0.30	**-0.59**	**-0.59**	0.04	-0.15	-0.20	-0.21	-0.12	-0.43	-0.26	0.06
Zn									0.38	0.39	**0.86**	0.09	0.51	0.30	-0.44	0.26	0.49	0.40	0.36	0.30	0.30	0.25	0.20	0.25
Cd										0.29	0.42	-0.12	0.27	0.06	-0.03	-0.02	0.10	-0.05	-0.09	-0.15	-0.15	0.06	-0.17	0.09
Co											0.41	0.42	**0.74**	**0.78**	0.14	-0.15	-0.36	-0.49	-0.52	-0.53	-0.49	-0.56	-0.41	-0.37
Ni												-0.12	**0.59**	0.20	**-0.69**	-0.01	0.37	0.31	0.27	0.21	0.23	0.08	0.05	0.33
Mn													0.1	0.44	**0.59**	0.37	-0.41	-0.25	-0.22	-0.20	-0.28	-0.12	-0.02	-0.39
Fe														**0.67**	-0.05	0.14	-0.21	-0.29	-0.24	-0.28	-0.30	-0.38	-0.16	0.07
Al															0.24	0.13	-0.32	-0.51	-0.55	-0.55	-0.54	**-0.64**	-0.23	-0.21
$^{206/207}Pb$																0.24	-0.50	-0.48	-0.42	-0.37	-0.46	-0.17	0.01	-0.53
$^{208/206}Pb$																	-0.03	-0.06	-0.01	-0.05	-0.16	0.07	0.11	-0.11
LOI																		**0.82**	**0.81**	**0.79**	**0.83**	**0.67**	**0.60**	0.40
^{137}Cs																			**0.98**	**0.98**	**0.98**	**0.91**	**0.58**	0.57
$^{239+240}Pu$																				**0.99**	**0.98**	**0.90**	**0.69**	**0.60**
^{241}Am																					**0.98**	**0.90**	**0.73**	0.57
^{238}Pu																						**0.87**	**0.63**	**0.58**
Altitude																							0.57	0.40
Area																								0.37

Table S10. Results (H, p values) of Kruskal-Wallis test showing differences in heavy metals concentrations and radionuclide activity concentrations between cryoconites and soils. Statistically significant differences are bolded.

	^{210}Pb	^{137}Cs	$^{239+240}Pu$	^{241}Am	^{234}U	^{238}U	^{230}Th	^{232}Th	Cr	Pb	Cu	Zn	Cd	Co	Ni	Mn	Fe	Al	$^{206/207}Pb$	$^{206/207}Pb$	LOI
H	22.2	8.0	6.3	9.3	4.7	4.6	20.7	16.4	19.8	18.5	13.7	19.2	2.0	19.8	11.3	5.2	12.9	21.9	14.9	0.4	3.2
p	**.00**	**.00**	**.01**	**.00**	**.03**	**.03**	**.00**	**.00**	**.00**	**.00**	**.00**	**.00**	.16	**.00**	**.00**	**.02**	**.00**	**.00**	**.00**	**.05**	.07