Supplementary materials

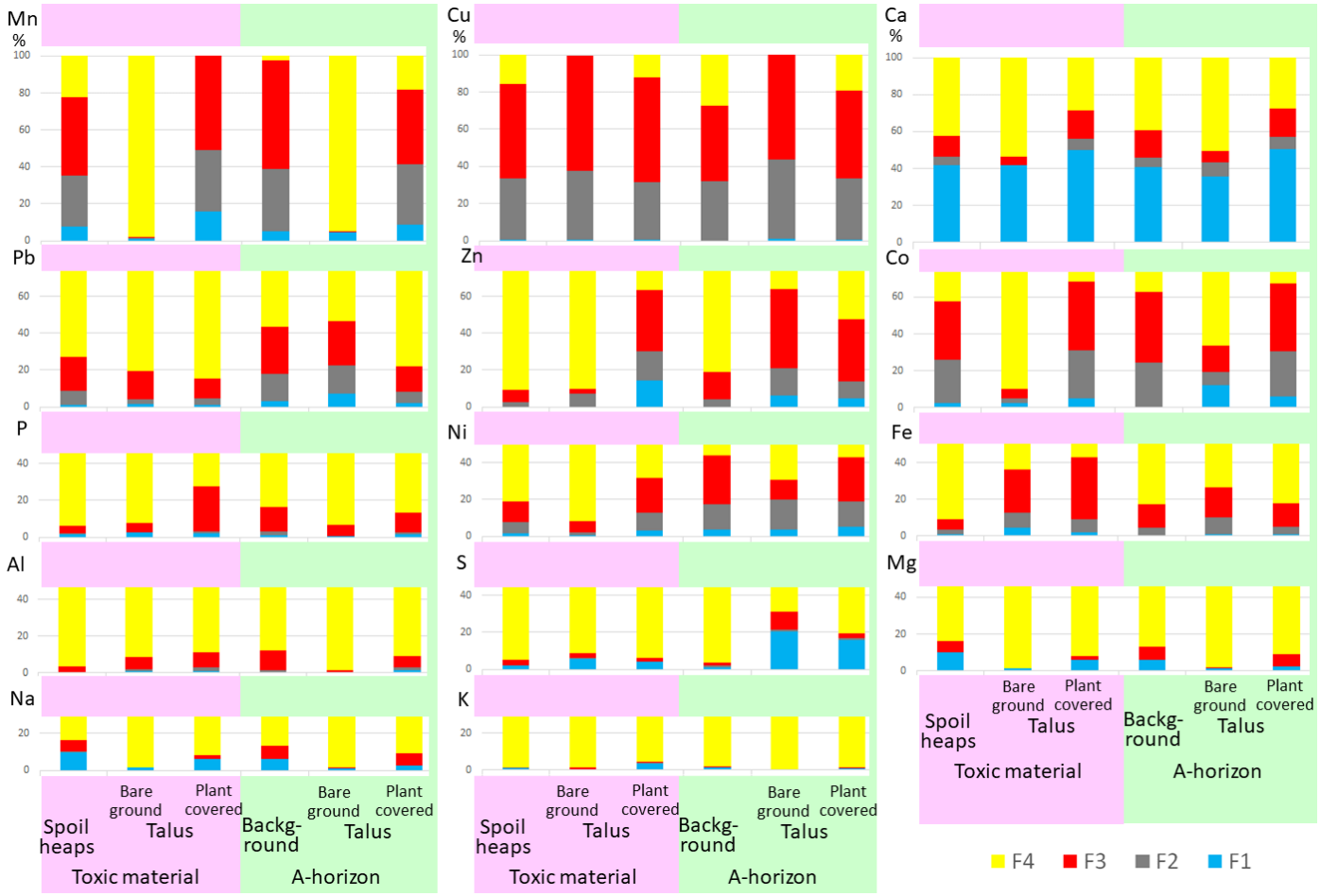

Figure S1. Chemical element speciation (average percentage) in the Spolic A-horizons studied.

Table S1. Main morphological features of soils studied in the Kireevskii and Uzlovskii districts of the Tula region [26–28,39]

Location	Soil	Horizon [41], depth, cm	Munsell color moist	Texture	Structure	Roots	Boundary	
							Shape	Distinctness
Spoil heaps	Spolic Technosols (Arenic/Loamic, Dystric, Sulfidic, Phytotoxic) on toxic technogenic materials	Chu, 0–100	5Y2.5/2	S/L	no			
	Spolic Technosols (Loamic, Eutric, Phytotoxic) on toxic technogenic materials	Cu, 0–40	2.5Y2.5/1	L	no		Wavy	Abrupt
		Chu, 40–120	5Y2.5/1	L	no			
	Technosols (Dystric, Loamic, Molic, Organotransportic)	O, 0–4	10YR2/1	CL	crumby	f3	Wavy	Abrupt
		Ak, 4–28	10YR2/1	CL	crumby	f2	Wavy	Abrupt
		Cox, 28–47	10YR5/4	CL	massive		Wavy	Abrupt
		Ckh, 47–65	10YR5/(3-4)	CL/L	massive			
Talus	Dystric Colluvic Stagnic Regosols (Loamic, Lamellic, Loaminovic, Sulfidic, Phytotoxic) on toxic materials of deluvial fans	Chu, 0–100	2.5/N	Ls	blocky	f1	Wavy	Abrupt
		Ab, 100–130	2.5/N	CL	crumby	f2	Wavy	Abrupt
		Bwgb,130–180	10YR4/5	CL	SAB	f2	Wavy	Abrupt
		C, 180–220	10YR5/6	CL	blocky	f1		
	Dystric Colluvic Stagnic Regosols (Loamic, Lamellic, Loaminovic) on non-toxic materials of proluvial fans	Bs, 0–65	2.5/N	L/ CL	no	m2	Wavy	Abrupt
		Arb, 65–150	2.5/5PB	CL	crumby	m2	Wavy	Abrupt
		Bwrb, 150–175	10YR5/4	CL	blocky	f1	Wavy	Abrupt
		Cr, 175–200	10YR6/4	CL/ C	blocky	f1		
	Chernic Phaeozems (Loamic, Loaminovic, Phytotoxic) on carbonated loess like loams	C, 0–35	7.5YR2.5/1	L/ CL	no	f2	Smooth	Abrupt
		Ab, 35–125	2.5Y2.5/1	CL	massive	f1	Wavy	Abrupt
		Bwrb,130–185	10YR5/6	CL	blocky		Wavy	Abrupt
		C, 185–210	10YR6/4	CL	blocky			
	Eutric Regosols (Loamic, Technic, Phytotoxic) on toxic technogenic materials	O, 0–4	10YR4/1	L	no	f2	Wavy	Abrupt
		Bs, 4–16	5YR6/8	L	no	f1	Smooth	Abrupt
		C, 16–35	2.5Y3/2	CL	massive	f1		
Unpolluted area	Haplic Chernozems (Aric, Loamic) on carbonated loess like loams	A, 0–50	10YR3/2	CL	grainy	m3	Wavy	Abrupt
		Bw, 50–90	10YR5/6	CL	blocky	f2	Wavy	Abrupt
		Ck, 90–210	7.5YR4/6	CL	blocky			
	Chernic Phaeozems (Loamic) on carbonated loess like loams	A, 0–140	5Y2.5/1	CL	grainy	c3	Wavy	Abrupt
		Ckg, 140–180	10YR5/4	CL	massive	f2	Wavy	Abrupt

Cr,180–210	10YR5/6	CL/L	massive	

Texture classes: CL – Clay loam, L – Loam, S – sand. Structure: M – massive, SBC – fine subangular blocky-crumb, SB – subangular blocky, SAB – subangular-angular blocky, P – coarse blocky-prismatic. Roots: f – fine, m – medium, c – coarse, 1 – single, 2 – few, 3 – many.

Table S2. The number of soil samples collected at the sites studied

Parent materials	Soil horizons	Site 1		Site 2	Site 3	Site 4
		Spoil heaps	Talus	Spoil heaps	Spoil heaps	Unpolluted area
Coal bearing rocks riched in sulfur compounds	A	1	5	2	0	0
	B	0	1	1	0	0
	C	5	15	8	3	0
Loess like loams	A	0	21	0	1	7
	Bk	0	15	0	1	3
	Ck	0	6	0	0	3

Table S3. The number of surface water samples collected at the sites studied

Date of sampling	Site 1		Site 2		Site 3			Site 4
	Spoil heaps	Talus	Spoil heaps	Talus	Talus	Nearer tailing pond	Farther tailing pond	Unpolluted pond
12.12.2019	1	1	0	1	1	1	1	1
16.06.2020	1	2	0	2	1	1	1	2
16.07.2020	0	3	1	2	2	1	1	1
22.08.2020	1	1	0	1	1	0	0	1
12.11.2020	2	1	0	0	1	1	1	1

Table S4. The root-mean-square deviation values (relative percentage, %) for the X-Ray fluorescence data on the elemental composition of the soils studied

Concentration, %	Na_2O	MgO	Al_2O_3	K_2O	CaO	MnO	Fe_2O_3	P_2O_5	S	Co,Ni,Cu, Zn	Pb
40–50	na	0.9	0.8	na	0.7	0.5	**0.5**	na	0.4	na	na
30–40	na	0.9	1.1	na	0.9	0.6	**0.6**	0.6	0.5	na	na
20–30	na	1.3	**1.4**	na	1.1	0.7	**0.7**	0.8	0.6	0.7	na
10–20	1.8	1.7	**1.8**	1.8	1.6	1.1	**1.1**	1.4	0.8	1.1	1.1
5–10	2.7	2.3	**2.7**	2.7	**2.5**	2.2	**2.2**	1.6	1.7	1.4	1.4
2–5	4.0	3.3	4.0	**4.0**	**3.4**	3.5	**3.5**	2.5	**2.7**	2.3	2.4
1–2	5.0	4.5	5.5	**5.0**	**4.7**	5.0	**5.0**	2.2	**3.8**	3.4	3.4
0.5–1	**6.0**	**6.5**	7.5	**6.0**	**6.0**	6.5	6.5	**3.0**	**5.0**	4.5	4.5
0.2–0.5	**8.0**	**8.0**	10.0	**8.0**	**8.5**	8.5	8.5	**4.1**	**6.0**	5.5	5.5
0.1–0.2	**10.0**	**10.5**	12.5	10.0	**10.5**	**10.5**	10.5	**4.7**	**7.0**	7.0	7.0
$(1000–500)\times10^{-4}$	12.0	13.5	14.0	12.0	13.5	**12.5**	12.5	**6.0**	**8.5**	9.0	**8.5**
$(500–200)\times10^{-4}$	14.0	15.0	15.0	14.0	15.0	**14.0**	14.0	**8.0**	**10.5**	**10.5**	**10.5**
$(200–100)\times10^{-4}$	15.0	15.0	15.0	15.0	15.0	**15.0**	15.0	10.5	**13.0**	**12.5**	**12.5**
$(100–50)\times10^{-4}$	na	na	na	na	15.0	**15.0**	15.0	12.0	na	**13.5**	**15.0**
$(50–20)\times10^{-4}$	na	na	na	na	na	**15.0**	na	12.5	na	**15.0**	**15.0**
$(20–10)\times10^{-4}$	na	na	na	na	na	**15.0**	na	na	na	**20.0**	**15.0**

na – not available. The root-mean-square deviation values for concentration of chemical elements in samples analyzed are in bold.

Table S5. Lower detection limits and the quality of the analysis and quality control for plant and water samples.

ChEs	Plants														Water
	Lower detection limit, mg/kg	Analyzed samples, mg/kg								Control samples, mg/kg					Lower detected limit, µg/l
		Sample #1		Sample #2		Sample #3		Sample #4		COOMET CRM 0067-2008-RU		INCT-OBTL-5		INCT-PVTL-6	
		1	2	1	2	1	2	1	2	Measured concentration	Certified value	Measured concentration	Certified value	Measured concentration	Certified value
Na	2	24.7	24.4	27.3	16.5	18.9	21.0	19.7	21.9	55.3	180 ± 30	232	435	23.2	62.4	8
Mg	1	3723	3652	1906	1962	1998	2089	1179	1195	4406	4400 ± 300	8846	8530 ± 340	2436	2410 ± 90	5
Al	2	105	103	280	297	107	127	42.8	41.0	734	830 ± 100	2150	1980 ± 280	231	252 ± 49	2
P	6	2667	2629	1731	1784	2015	2088	1646	1661	1513	1540 ± 60	1787	1700 ± 120	2534	2420 ± 150	17
K	2	7976	8029	10581	11415	10741	11331	10105	9921	7421	7100 ± 400	23061	22710 ± 760	24891	26400 ± 900	7
Ca	1	10021	9961	7362	7380	7484	7831	3348	3633	15906	16000 ± 900	40687	39960 ± 1420	22887	22970 ± 780	7
Mn	0.1	952	929	95	99	1681	1751	324	329	945	930 ± 70	185	180 ± 6	138	136 ± 5	0.3
Fe	1.4	152	223	159	162	248	317	59	60	743	730 ± 70	1610	1490	282	258	7
Co	0.04	1.3	1.3	0.65	0.64	2.84	2.87	1.82	1.90	0.79	0.79 ± 0.06	0.87	0.98 ± 0.07	0.13	0.15 ± 0.01	0.6
Ni	0.2	4.1	4.4	4.9	4.9	8.6	9.0	4.1	4.4	6.6	5.8 ± 0.8	8.2	8.5 ± 0.49	1.1	1.49 ± 0.1	1
Cu	0.2	5.0	5.1	7.9	8.0	6.9	7.0	3.9	4.1	6.6	7.3 ± 0.6	9.7	10.1 ± 0.4	4.7	5.12 ± 0.2	2
Zn	0.2	153	153	189	202	184	188	191	202	98.2	93.7 ± 15	50.4	52.4 ± 1.8	41.6	43.6 ± 1.4	3
Pb	0.02	0.35	0.35	0.29	0.31	0.28	0.29	0.12	0.13	3.6	3.7 ± 0.5	2.3	2.0 ± 0.3	0.74	0.97 ± 0.15	4

Table S6. Lower detection limits (LDLs) and the quality of the analysis and quality control for liquid samples of soil extracts.

ChEs	Nitric acid, μg/dm³													
	LDLs	Blank	Analyzed samples											
			Sample no. 1		Sample no. 2		Sample no. 3		Sample no. 4		Sample no. 5		Sample no. 6	
			1	2	1	2	1	2	1	2	1	2	1	2
Na	74	1460	5643	4890	2374	2539	2673	2786	3111	3501	4516	4295	2718	2977
Mg	68	2012	6241	6366	4507	4700	8886	8467	89838	94035	105913	103372	41770	42530
Al	47	1117	2126570	2244937	86046	91706	51042	50132	415963	440317	478820	462221	203991	205351
P	223	<LDL	2804	2521	1208	1367	3741	3587	5692	5724	1959	1949	<LDL	<LDL
K	52	385	31680	32386	2950	3259	6527	6632	21645	22856	22381	21873	8743	8800
Ca	82	11120	77245	79817	406175	405257	402501	400663	367287	382597	356722	349067	208823	214641
Mn	7	44	170	169	118	142	1985	1910	40119	40932	10419	10358	1910	1977
Fe	103	1829	208756	212349	376971	406135	325138	313665	215805	223131	189405	187884	62962	62790
Co	10	<LDL	49	51	97	111	325	316	1108	1143	253	242	140	147
Ni	10	<LDL	159	167	284	314	435	426	1015	1050	452	433	293	316
Cu	7	16	408	414	403	433	747	716	299	314	317	319	248	250
Zn	6	289	1230	1307	779	863	3333	3290	814	891	744	837	349	291
Pb	44	<LDL	356	381	226	267	643	634	640	699	389	410	<LDL	62
ChEs							NH_4Ac							
Na	101	1556	3003	2904	2607	2883	2505	2835	2627	3111	3897	3821	7014	2561
Mg	93	2080	3519	3541	4559	4763	6953	7047	38994	40238	49523	49824	30715	26976
Al	46	329	171104	171761	18292	18916	5834	5931	22612	23260	24558	26736	13397	11862
P	216	<LDL	<LDL	413	372	313	313	478	514	367	465	567	487	282
K	106	<LDL	14399	13981	1270	1785	4297	4224	16292	17609	17318	18176	6139	5229
Ca	101	12261	77983	70067	299585	326971	344373	339666	334103	316273	297445	297873	187472	160228
Mn	14	87	124	123	163	153	1831	1758	22935	23035	663	672	285	253
Fe	68	223	13368	13986	73780	71324	21483	21633	4463	4467	2879	3112	1139	839
Co	15	<LDL	<LDL	17	35	38	147	146	553	563	<LDL	<LDL	<LDL	<LDL
Ni	13	<LDL	<LDL	57	25	36	116	112	435	435	87	99	79	64
Cu	8	9.4	48.6	55.8	<LDL	<LDL	19.6	19.6	<LDL	10.9	16.7	13.8	15.2	10.9
Zn	8	437	261.1	413.5	283.1	338	869.3	770.3	89.7	63.0	<LDL	<LDL	36.3	36.3

Pb	49	<LDL	<LDL	<LDL	54	65	176	124	71	80	73	74	<LDL	<LDL
ChEs							NH_4Ac + 1% EDTA							
Na	120	1326431	1350849	1327716	1286591	1320005	1353419	1343138	1330287	1353419	1337997	1291603	1316150	1299443
Mg	120	1896	2931	4174	4220	3860	6979	6610	40214	39193	27001	46103	46270	27555
Al	40	562	177673	186935	53537	50561	18971	18958	52668	50785	73420	49100	48389	23382
P	271	434	306	402	412	<LDL	509	538	878	943	1206	678	666	<LDL
K	130	271	17776	18652	3296	2713	7020	6995	20798	19826	17495	19463	19165	8528
Ca	91	9635	70273	82855	371022	366379	407236	403367	357403	346879	454594	298129	297355	177879
Mn	9	13.6	58	66	117	102	1796	1823	24223	23607	23745	9599	9387	1896
Fe	75	246	21754	22679	330740	320225	179491	180031	30138	28631	47331	23887	23227	9048
Co	8	<LDL	<LDL	9.6	78.7	80.1	232	229	637	625	330.2	287.4	281.9	169.9
Ni	11	<LDL	30	44	192	211	288	909	699	651	651.4	196.3	191.8	129.5
Cu	15	<LDL	133.8	140.6	261.4	237.0	530.1	539.6	180.0	175.9	440.6	169.1	167.8	139.3
Zn	13	29.2	275	262	570	586	1413.8	1268.7	148.6	119.3	187.7	34.2	169.4	141.0
Pb	59	<LDL	<LDL	<LDL	143	142	450	476	271	255	444	271	232	73

LDL – lower detectable level

Table S7. Characteristics (m ± SD) of the studied surface waters sampled at the different locations.

Proxies	Spoil heaps, n=6	Talus, n=21	Tailing ponds		Unpolluted pond, n=7
			nearer, n=4	farther, n=4	
pH	**3.7±0.3**	**4.0±0.6**	5.1±1.5	**5.8±0.7**	7.1±0.6
EC, mS/cm	**3.5±1.4**	**3.2±1.4**	**1.8±0.2**	**1.4±0.2**	0.5±0.2
Cl^-, mg/dm³	5.5±2.5	7.3±4.0	12.4±5.5	16.7±14.7	19.3±13.0
NO_3^-, mg/dm³	2.9±3.3	9.4±19.0	1.2±0.8	1.6±1.0	3.1±2.6
SO_4^{2-}, mg/dm³	**2882±1362**	**1938±1241**	**883±120**	**761±275**	68±68
Na, mg/dm³	8.3±4.1	11.3±6.3	13.6±5.7	12.0±5.0	9.8±5.7
Mg, mg/dm³	**92±44**	**76±47**	**48.2±8.6**	**36.8±6.7**	12.1±5.3
Al, mg/dm³	**279±132**	**135±182**	6.4±5.5	0.4±0.5	0.2±0.2
P, µg/dm³	**30±33**	**38±35**	37±40	32±29	81±58
S, mg/dm³	**1032±464**	**789±452**	**354±65**	**259±49**	19±9
K, mg/dm³	2.2±0.7	3.9±3.5	7.6±6.3	12.9±20.3	2.9±0.6
Ca, mg/dm³	**387±173**	**373±141**	**310±67**	**241±57**	67±28
Mn, mg/dm³	**3.3±1.5**	**7.1±5.9**	**4.1±3.2**	**1.7±0.6**	0.19±0.30
Fe, mg/dm³	**24±23**	**118±160**	**2.9±1.5**	1.1±1.9	0.3±0.3
Co, µg/dm³	**278±134**	**294±198**	**91±12**	**34±15**	0.8±0.3
Ni, µg/dm³	**452±222**	**335±243**	**95±22**	**38±21**	2.1±1.8
Cu, µg/dm³	**32±8**	**43±53**	8.1±4.9	5.8±2.6	4.3±1.7
Zn, µg/dm³	**2609±1238**	**2087±1718**	**881±218**	**287±203**	10±4
Pb, µg/ dm³	11±11	**20±19**	12±13	4.3±0.2	8.1±10.4

m – mean, SD – standard deviation. Values significantly different from the unpolluted are marked in bold, with increased values shown in red and decreased – in blue.

Table S8. The spatial differentiation of the studied surface waters

Location	Lower values (depletion) (L <0.8)	Unsubstantial differences (L = 0.8 – 1.3)	Higher values (accumulation) (L >1.3)
Spoil heaps	$Cl_{0.3}$ **$P_{0.4}$** $K_{0.8}$	$Na_{0.8}$	**$EC_{7.6}$ $SO_4^{2-}{}_{42.1}$ $Mg_{7.6}$ $Al_{1187.8}$ $S_{53.4}$ $Ca_{5.8}$ $Mn_{17.4}$ $Fe_{92.1}$ $Co_{338.1}$ $Ni_{216.5}$ $Cu_{7.4}$ $Zn_{267.9}$ $Pb_{1.3}$**
Talus	$Cl_{0.4}$ **$pH_{0.6}$ $P_{0.5}$**	$Na_{1.2}$ $K_{1.3}$	**$EC_{6.9}$ $SO_4^{2-}{}_{28.3}$ $Mg_{6.3}$ $Al_{575.9}$ $S_{40.8}$ $Ca_{5.6}$ $Mn_{37.3}$ $Fe_{464.4}$ $Co_{357.1}$ $Ni_{160.5}$ $Cu_{10.0}$ $Zn_{214.3}$ $Pb_{2.4}$**
Nearest tailing pond	$Cl_{0.6}$ $pH_{0.7}$ $P_{0.5}$	-	**$EC_{3.9}$ $SO_4^{2-}{}_{12.9}$** $Na_{1.4}$ **$Mg_{4.0}$** $Al_{27.2}$ **$S_{18.3}$** $K_{2.6}$ **$Ca_{4.6}$ $Mn_{21.3}$ $Fe_{11.5}$ $Co_{111.0}$ $Ni_{45.6}$** $Cu_{1.9}$ **$Zn_{90.4}$** $Pb_{1.4}$
Farther tailing pond	$P_{0.4}$ $Pb_{0.5}$	$Cl_{0.9}$ **$pH_{0.8}$** $Na_{1.2}$	**$EC_{3.0}$ $SO_4^{2-}{}_{11.1}$ $Mg_{3.0}$** $Al_{1.9}$ **$S_{13.4}$** $K_{4.4}$ **$Ca_{3.6}$ $Mn_{9.1}$** $Fe_{4.3}$ **$Co_{41.2}$ $Ni_{18.2}$** $Cu_{1.3}$ **$Zn_{29.4}$**

Numbers in brackets: L-values (an average content of a chemical element in a sampling location to the average content of the same ChE in the background area). Significantly ($p<0.05$) different proxies are in bold.

Table S9. Characteristics (m±SD) of the studied soil horizons.

Proxy	Spolic Technosols (Arenic/Loamic, Dystric, Sulfidic, Phytotoxic) of the bare ground at the summits and slopes of the spoil heaps			Dystric Colluvic Stagnic Regosols (Arenic/Loamic, Lamellic, Areninovic, Sulfidic, Phytotoxic) of the bare ground at the talus					Colluvic Brunic Stagnic FolicRegosols (Arenic/Loamic, Lamellic, Areninovic, Toxic) over Phaeozems (Loamic) of meadows and forests at the talus						Un polluted Calcic Chernozems (Aric, Loamic) of meadows		
	Arju, n=3	Bru, n=2	Cru, n=10-15	Arju, n=1	Cru, n=4-9	2Aygb, n=1-3	2Bgb, n=2-4	2Cg, n=1	Ag, n=4	Bg, n=1	Cg, n=4-6	2Ayb, n=8-18	2Bb, n=6-11	2Ck, n=5	A, n=5-8	Bk, n=1-4	Ck, n=3
pH	6.1±2.2	6.1±1.1	5.2±1.6	5.0	4.2±1.1	5.0±1.7	5.9±1.4	4.9	5.1±0.5	5.6	4.8±0.3	5.3±0.8	6.5±1.0	7.1±1.2	6.5±0.3	6.7±0.5	6.6±0.4
EC, µS/cm	179±225	209±270	1023±733	243	541±423	614±473	293±79	133	191±109	163	409±239	421±485	258±194	293±229	30±15	21±15	13±2
TOC, %	3.5±3.1	1.1±0.5	7.6±6.1	2.0	8.4±3.6	5.8±3.7	1.1±0.8	0.4	9.5±3.3	6.8	8.0±3.5	5.3±2.8	1.1±0.4	0.67±0.37	3.9±2.3	1.8±0.5	1.2±0.2
Sand, %	38.8±12.3	14.9±17.5	17.2±19.8	47.8	31.2±20.4	6.6±11.4	<0.01	<0.01	20.9±19.5	1.3	26.2±18.7	0.0±0.1	<0.01	0.2±0.4	<0.01	<0.01	<0.01
Silt, %	49.5±10.4	72.0±19.2	66.9±17.6	43.9	57.5±17.1	77.9±9.7	81.1±0.7	81.1	68.1±16.7	82.5	62.3±14.7	80.5±1.8	78.6±1.7	77.8±4.1	81.6±3.8	78.1±0.4	72.7±7.1
Clay, %	11.8±2.1	13.2±1.8	15.9±4.0	8.3	11.3±4.0	15.5±2.6	18.6±1.0	18.9	11.0±4.1	16.2	11.5±4.5	19.5±1.8	21.4±1.7	22.0±4.5	18.4±3.8	21.9±0.4	27.3±7.1
Fine silt, %	32.6±7.5	44.5±4.9	44.3±12.4	24.9	34.8±11.4	51.8±8.0	56.2±3.7	56.9	42.0±15.1	49.4	38.0±14.4	60.0±3.6	58.6±3.5	54.0±6.8	65.2±2.4	62.6±1.2	59.2±3.0
Coarse silt, %	16.8±2.9	27.5±14.3	22.6±9.5	19.0	22.8±8.1	26.1±1.8	25.0±3.6	24.2	26.1±8.3	33.1	24.3±6.7	20.5±5.1	20.0±4.4	23.8±10.3	16.4±2.6	15.6±1.4	13.5±4.4
Very fine sand, %	6.6±2.7	2.2±0.5	5.2±6.7	16.1	11.8±7.8	4.6±7.9	0.3±0.4	<0.01	12.8±11.5	1.3	13.4±6.9	0.03±0.06	0.02±0.04	0.20±0.45	<0.01	<0.01	<0.01
Fine sand, %	11.5±1.2	5.5±7.7	3.8±5.0	13.2	9.8±7.8	1.9±3.3	<0.01	<0.01	4.6±5.1	<0.01	6.3±5.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Medium sand, %	20.7±10.7	7.3±10.3	8.1±14.6	15.5	8.2±6.7	0.1±0.2	<0.01	<0.01	3.4±6.7	<0.01	6.5±10.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Coarse sand, %	<0.01	<0.01	0.05±0.12	2.40	1.19±2.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03±0.08	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Very coarse sand, %	<0.01	<0.01	<0.01	0.60	0.26±0.51	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Al, %	3.3±0.3	6.0±3.7	4.2±1.7	3.0	4.8±1.7	4.6±1.5	4.2±0.0	4.4	5.0±1.2	3.2	5.4±1.0	5.5±1.7	4.3±0.2	4.4±0.2	3.7±0.4	4.6	4.4±0.4
Al1, g/kg	0.06±0.03	0.88±1.17	0.13±0.08	0.37	0.35±0.39	0.06	0.18±0.07	0.13	0.61±0.26	0.69	0.80±0.21	0.78±0.35	0.36±0.62	0.23±0.29	0.13±0.05	0.25	0.18±0.05
Al2, g/kg	0.13±0.05	0.14±0.05	0.32±0.31	0.25	0.43±0.31	0.13	0.2±0.06	0.17	0.78±0.23	0.43	0.91±0.25	0.91±0.26	0.18±0.09	0.15±0.07	0.47±0.16	0.23	0.17±0.05
Al3, g/kg	1.1±0.7	11.1±12.7	0.8±0.5	2.1	2.0±1.8	0.4	4.2±0.2	4.0	4.2±1.5	5.6	4.2±2.4	3.4±1.0	4.1±0.4	3.9±0.6	3.9±0.3	4.4	3.3±1.3
Ca, %	0.43±0.31	0.39±0.31	0.39±0.22	0.10	0.23±0.26	0.92±0.52	0.76±0.08	0.84	0.29±0.25	0.19	0.18±0.04	0.50±0.37	1.35±1.40	1.63±0.88	0.89±0.09	0.63	0.56±0.13
Ca^{2+}, mg/100g	7±3	23±26	71±57	19	55±70	73±73	26±10	10	13±10	10	36±27	46±65	24±19	26±21	3±1	3±2	3±1
Ca1, g/kg	1.81±1.42	1.61±1.40	2.42±1.23	0.42	1.83±2.63	3.30	3.42±0.41	3.90	1.43±1.69	0.98	0.65±0.22	2.52±2.21	8.21±11.88	10.55±6.84	3.61±0.54	2.85	2.53±0.81
Ca2, g/kg	0.18±0.28	0.22±0.24	0.34±0.24	0.00	0.21±0.34	0.66	0.31±0.02	0.31	0.18±0.28	0.08	0.13±0.09	0.33±0.40	0.37±0.36	0.39±0.29	0.44±0.14	0.03	0.16±0.05
Ca3, g/kg	0.50±0.47	0.37±0.45	0.65±0.35	0.05	0.39±0.65	0.61	0.41±0.14	0.34	0.43±0.60	0.20	0.22±0.18	0.78±0.79	0.82±0.79	1.00±0.76	1.32±0.45	0.56	0.42±0.05
Co, mg/kg	9.3±5.5	11.5±3.5	6.1±3.0	3.0	8.5±6.6	12.0±4.2	18.53.5	15.0	11.5±9.0	150.0	7.3±3.4	13.5±6.6	15.5±2.6	15.0±2.4	13.2±2.3	15.0	14.0±10.5
Co1, mg/kg	0.24±0.19	0.10±0.03	0.78±1.26	0.08	0.33±0.39	1.47	2.83±3.89	0.08	0.59±0.69	10.18	0.37±0.15	0.84±1.16	0.15±0.17	0.16±0.20	0.08±0.00	0.08	0.08±0.00
Co2, mg/kg	2.2±1.8	1.9±2.7	0.8±1.0	0.1	1.2±1.6	0.8	0.9±0.3	3.2	3.0±5.4	17.6	0.4±0.2	3.3±3.5	3.5±1.3	3.7±0.5	3.2±1.0	2.8	3.8±2.2
Co3, mg/kg	3.0±2.4	1.9±2.2	1.3±1.4	0.2	2.0±2.7	1.7	3.9±2.6	1.9	4.3±6.9	51.2	1.3±0.8	4.9±4.0	3.1±1.1	2.8±0.5	5.1±1.4	2.4	1.7±0.3
Cu, mg/kg	16.3±17.3	18.3±19.3	20.3±21.3	22.3	23.3±24.3	25.3±26.3	27.3±28.3	29.3	30.3±31.3	32.3	33.3±34.3	35.3±36.3	37.3±38.3	39.3±40.3	41.3±42.3	43.3±44.3	45.3±46.3
Cu1, mg/kg	0.12±0.09	0.22±0.31	0.09±0.15	0.02	0.01±0.01	0.11	0.03±0.03	0.13	0.14±0.10	1.43	0.08±0.02	0.08±0.13	0.14±0.09	0.19±0.14	0.03±0.04	0.07	0.32±0.36
Cu2, mg/kg	5.3±4.1	1.7±1.0	5.1±3.5	2.5	3.6±0.8	5.2	2.0±0.4	1.9	6.1±2.5	13.1	5.2±1.4	6.5±3.0	2.1±0.8	2.8±0.9	5.6±1.3	1.6	1.5±0.7
Cu3, mg/kg	8.3±7.1	3.5±0.1	7.1±4.9	4.3	5.8±2.2	7.0	3.2±0.5	3.7	11.0±2.4	19.8	9.7±2.9	9.4±4.4	3.9±1.0	5.1±1.3	7.1±1.1	3.0	2.8±1.0
Fe, %	3.1±1.5	2.9±1.6	1.9±1.9	0.8	1.6±0.6	1.8±1.0	2.8±0.0	3.1	2.6±2.0	29.6	1.6±0.7	2.6±0.9	2.9±0.2	3.0±0.3	2.60.2	5.3	8.5±8.0
Fe1, %	0.022±0.037	0.007±0.009	0.043±0.030	0.035	0.042±0.039	0.021	0.003±0.002	0.002	0.055±0.027	0.358	0.039±0.020	0.030±0.020	0.003±0.003	0.002±0.002	0.017±0.017	0.003	0.004±0.002
Fe2, %	0.086±0.100	0.016±0.010	0.179±0.082	0.063	0.129±0.099	0.158	0.023±0.003	0.027	0.179±0.142	0.769	0.111±0.046	0.101±0.033	0.026±0.009	0.020±0.007	0.102±0.050	0.021	0.023±0.012
Fe3, %	0.18±0.13	0.16±0.05	0.33±0.20	0.18	0.25±0.13	0.30	0.22±0.01	0.25	0.88±1.13	10.56	0.28±0.09	0.32±0.16	0.26±0.03	0.27±0.02	0.33±0.14	0.18	0.16±0.09
K, %	0.92±0.37	1.14±0.26	0.56±0.24	0.37	0.93±0.57	1.32±0.70	2.07±0.00	2.03	0.75±0.22	0.39	0.83±0.29	1.41±0.41	2.00±0.12	1.87±0.07	1.86±0.13	1.87	1.47±0.66
K^+, mg/100g	0.57±0.29	0.67±0.57	0.68±0.67	0.89	0.84±0.45	1.97±1.37	1.13±0.79	0.56	3.13±2.68	5.20	1.53±1.06	1.06±0.86	0.53±0.55	0.52±0.52	0.39±0.61	0.18	0.10±0.06
K1, mg/kg	100±86	106±50	26±30	7	40±45	43	167±3	166	281±335	199	93±69	118±103	161±9	141±26	236±198	177	106±43
K2, mg/kg	15±14	34±5	14±7	10	13±8	25	23±11	30	29±16	40	31±13	27±9	26±12	23±15	37±19	13	31±2
K3, mg/kg	32±12	112±89	21±14	37	28±16	19	41±12	41	45±32	25	45±29	37±28	61±25	56±22	54±8	40	25±3
Mg, %	0.28±0.15	0.29±0.20	0.14±0.08	0.09	0.23±0.19	0.38±0.27	0.76±0.01	0.81	0.15±0.03	0.07	0.17±0.07	0.38±0.18	0.83±0.06	0.82±0.11	0.59±0.08	0.80	0.60±0.24

Mg^{2+}, mg/100g	0.81±0.38	0.67±0.24	2.07±1.86	0.88	1.17±0.63	2.01±0.37	2.19±0.79	0.85	0.93±0.35	1.13	1.37±0.48	2.07±2.54	2.22±1.97	3.36±4.46	0.3±70.13	0.29±0.17	0.29±0.02
Mg1, mg/kg	281±275	144±183	85±139	15	48±71	49	463±124	533	92±127	92	29±9	98±88	572±501	585±137	361±57	476	350±74
Mg2, mg/kg	5.2±6.8	1.0±1.5	<0.1	<0.1	0.5±1.1	<0.1	1.4±1.9	6.9	<0.1	6.3	0.4±0.8	0.6±1.8	6.1±12.2	2.9±5.5	0.5±1.1	<0.1	5.2±8.1
Mg3, mg/kg	173±175	149±171	20±42	0	150±235	17	586±88	757	30±15	<0.1	42±57	251±236	926±349	813±215	422±64	550	391±236
Mn, mg/kg	256±177	244±279	63±73	54	147±202	387±427	666±99	589	395±587	937	85±44	400±414	598±25	595±24	640±238	519	421±186
Mn1, mg/kg	20±20	6±8	6±9	1	10±13	17	117±158	6	82±128	104	5.0±3.3	34±52	14±8	23±24	33±17	5.8	3.5±2.1
Mn2, mg/kg	70±71	78±110	8±26	<0.1	40±70	0.9	32±30	181	160±296	116	1.2±0.8	131±191	210±85	226±46	217±124	89	71±49
Mn3, mg/kg	109±99	83±117	11±33	<0.1	75±115	2.0	143±46	91	234±426	490	14±15	161±187	143±41	139±30	376±205	98	44±34
Na, %	0.24±0.09	0.24±0.14	0.13±0.05	0.16	0.22±0.17	0.33±0.27	0.63±0.03	0.68	0.13±0.03	0.08	0.15±0.02	0.32±0.20	0.64±0.03	0.59±0.04	0.57±0.04	0.53	0.45±0.24
Na^{+}, mg/100g	0.78±0.45	0.62±0.31	0.97±0.63	0.60	0.73±0.49	1.52±0.77	1.40±0.90	0.75	1.21±0.48	1.23	0.92±0.29	1.30±0.36	1.41±0.38	1.56±0.45	2.12±2.27	0.59±0.09	0.56±0.16
Na1, mg/kg	10.5±3.3	14.0±0.1	11.5±3.8	10.6	11.5±5.0	11.1	18.7±7.9	55.7	10.9±2.7	11.7	8.8±2.0	18.4±13.3	29.2±20.1	27.6±6.7	22.3±11.6	23.0	28.3±4.6
Na2, mg/kg	3.6±6.3	57±81	22.4±70.9	<0.1	87±143	207	380±337	548	45±90	515	56±65	110±189	149±357	175±364	265±209	<0.1	305±291
Na3, mg/kg	0.42±0.73	12±17	1.6±2.6	<0.1	0.49±0.77	1.56	3.3±2.8	0.0	27±37	80	6.8±2.1	3.3±3.6	6.1±3.0	12.1±5.4	9.7±3.1	6.4	6.1±5.4
Ni, mg/kg	24±9	31±7	22±7	10	20±8	30±10	39±4	38	25±11	46	24±7	39±16	38±3	41±5	34±2	44	49±14
Ni1, mg/kg	0.37±0.27	0.43±0.16	0.77±1.04	0.07	0.48±0.52	1.14	2.50±2.62	0.49	0.72±0.80	5.85	0.51±0.20	1.99±2.11	0.84±0.39	1.38±1.98	1.18±0.40	0.93	0.98±0.24
Ni2, mg/kg	1.5±1.1	1.5±2.1	1.8±1.6	0.1	2.0±2.4	4.8	2.0±0.6	0.9	2.5±3.4	5.7	1.6±0.8	5.3±3.9	2.3±1.5	3.8±2.6	4.8±0.5	1.0	0.7±0.3
Ni3, mg/kg	2.8±1.9	3.2±2.7	3.0±2.5	0.6	4.1±4.3	3.2	5.4±0.8	4.0	4.6±4.2	9.0	3.8±1.4	9.2±6.1	5.4±2.0	6.5±2.1	9.0±1.0	3.5	2.5±0.6
P, mg/kg	538±240	458±340	210±134	131	371±364	568±432	415±31	349	480±353	306	306±123	540±264	378±66	314±57	830±260	655	1019±1048
P1, mg/kg	8.9±2.4	3.5±1.3	3.2±1.7	3.3	6.6.2	4.0	3.5±1.3	4.1	10.2±7.1	8.5	6.1±5.8	8.3±4.9	5.9±7.6	2.6±0.9	9.8±5.0	5.2±0.0	3.5±1.0
P2, mg/kg	1.2±2.1	<0.1	0.19±0.61	<0.1	4.6±8.7	<0.1	0.18±0.25	<0.1	4.5±5.3	<0.1	3.4±6.9	5.7±7.0	1.2±3.0	<0.1	18.2±14.8	<0.1	<0.1
P3, mg/kg	23±12	18±8	15±11	7	42±48	33	56±5	68	119±159	123	40±36	59±31	63±38	40±21	110±61	14±0	3±3
Pb, mg/kg	25±14	36±27	97±190	17	31±10	21±5	25±1	28	60±42	28	46±30	48±23	26±3	23±3	29±3	29	27±2
Pb1, mg/kg	0.25±0.00	0.25±0.00	2.02±1.84	0.25	0.66±0.43	1.50	0.68±0.10	0.93	0.56±0.36	0.25	0.67±0.42	1.01±0.66	1.05±0.59	0.93±0.42	0.93±0.55	0.74	0.83±0.52
Pb2, mg/kg	1.9±0.7	1.5±2.0	4.1±3.1	0.4	2.1±1.1	3.1	1.7±0.2	2.3	2.3±2.8	1.2	0.9±0.8	3.1±1.5	2.5±0.8	2.4±0.6	4.3±0.6	1.8	1.2±0.9
Pb3, mg/kg	4.5±0.9	4.0±0.9	10.3±12.8	2.7	4.3±1.4	4.9	5.2±1.0	4.8	6.4±4.7	14.1	3.8±2.2	6.6±1.6	5.3±0.6	5.2±0.7	7.4±0.9	3.3	2.8±2.5
S, %	0.51±0.61	0.73±0.93	1.88±0.91	0.81	1.09±0.62	0.84±0.78	0.09±0.04	0.07	1.22±0.49	1.30	1.40±0.34	0.71±0.49	0.11±0.10	0.10±0.12	0.08±0.04	0.03	0.03±0.04
SO_4^{2-}, mg/100g	18±24	73±101	274±238	51	182±292	254±310	67±24	24	35±32	29	101±79	158±252	55±50	52±59	4±4	2±1	1±0
S1, mg/kg	102±146	917±1290	1977±1092	468	634±544	1715	383±304	168	486±420	3134	718230	1138±1692	468±536	437±651	9±5	5	7±4
S2, mg/kg	16±23	1.6±2.3	18±33	14	36±49	84	<0.1	<0.1	22±26	105	57±14	66±165	16±36	23±48	5.5±3.9	2.5	3.7±2.5
S3, mg/kg	156±266	286±404	715±554	231	128±90	794	9±12	<0.1	256±141	0	214±76	178±204	<0.1	95±213	12.2±6.7	<0.1	0.0±0.0
Zn, mg/kg	70±34	78±25	46±36	24	52±49	62±10	60±3	62	102±122	451	46±17	97±53	67±8	62±8	68±5	85	95±44
Zn1, mg/kg	<0.1	<0.1	3.8±9.4	<0.1	0.3±0.7	3.8	<0.1	<0.1	15±29	27	<0.1	4.6±10.4	<0.1	<0.1	<0.1	<0.1	0.0±0.0
Zn2, mg/kg	2.0±0.7	2.3±0.1	6.3±4.8	1.8	4.5±3.1	9.3	0.9±0.2	0.1	16±22	19	5.3±2.0	8.7±5.4	0.8±0.8	0.6±0.2	3.0±2.0	0.7	1.0±0.3
Zn3, mg/kg	4.5±4.3	11.1±1.8	13.0±22.1	0.6	13.4±21.8	26.4	5.6±0.0	6.7	34±50	90	11.7±6.0	33.0±25.7	10.6±6.8	9.1±2.6	9.9±3.6	5.0	3.7±3.0

Note: Mobile fractions are shown by digits after the chemical elements as follows: 1 – exchangeable, 2 – complex, 3 – specifically adsorbed. na – not available. TOC – total organic carbon. Soil horizons are named according to [41].

Table S10. Spatial differentiation of the horizons of Regosols on talus at the footslope of spoil heaps.

Location	Proxy	Lower values (depletion) (L <0.8)	Unsubstantial differences (L = 0.8 – 1.3)	Higher values (accumulation) (L >1.3)
Waste-rocks	Physico–chemical properties* and F0	$Ca_{0.7}$ $EC_{0.5}$ **$Clay_{0.8}$** $MS_{0.7}$ $Mg_{0.7}$ $S_{0.5}$	$FSI_{0.9}$ $CSI_{1.1}$ $Na_{1.0}$ $silt_{0.9}$ $TOC_{1.3}$	$CS_{18.6}$ **$VFS_{2.4}$** $FSA_{1.5}$ **$K_{2.5}$** $sand_{1.3}$
	Total content	$Ca_{0.6}$ $Pb_{0.6}$	$Al_{1.1}$ $K_{1.1}$ $Mg_{0.3}$ $Na_{1.0}$ $Ni_{1.0}$ $P_{1.2}$ $S_{0.8}$	$Co_{2.5}$ $Cu_{1.5}$ $Fe1._{7}$ $Mn_{2.1}$ $Zn_{1.7}$
	F1	**$Ca_{0.6}$** $Mg_{0.4}$ $Pb_{0.4}$ $S_{0.5}$	$Na_{0.9}$	**$Al_{2.5}$** $Co_{1.7}$ $Cu_{1.3}$ $Fe_{1.9}$ $K_{1.3}$ $Mn_{3.6}$ $Ni_{1.3}$ $P_{1.6}$ $Zn_{2.2}$
	F2	$Ca_{0.5}$ $Mg_{0.6}$ $Pb_{0.5}$	$Cu_{1.1}$ $Fe_{1.2}$ $Ni_{1.3}$	**$Al_{2.5}$** $Co_{2.0}$ $K_{1.4}$ $Mn_{2.1}$ $Na_{3.9}$ $P_{10.0}$ $S_{2.7}$ $Zn_{1.7}$
	F3	**$Ca_{0.6}$** $Pb_{0.6}$	$Cu_{1.3}$ $K_{1.0}$ $Mg_{1.3}$	**$Al_{1.5}$** $Co_{3.1}$ $Fe_{3.8}$ $Mn_{3.0}$ $Na_{4.9}$ $Ni_{1.4}$ $P_{3.8}$ $S_{20.2}$ $Zn_{2.0}$
	Extractability	$Co_{0.8}$ $Pb_{0.7}$	$Ca_{0.9}$ $Cu_{1.1}$ $Fe_{1.2}$ $Mg_{0.8}$ $Ni_{1.2}$ $S_{0.9}$ $Zn_{1.0}$	**$Al_{2.2}$** $K_{2.2}$ $Mn_{1.3}$ $Na_{3.8}$ $P_{1.9}$
Ab–horizon	Physico–chemical properties* and F0	$Na_{0.6}$	$Clay_{1.0}$ **$FSI_{0.9}$** $silt_{1.0}$	**$Ca_{14.0}$** **$EC_{13.9}$** **$CSI_{1.3}$** **$K_{2.7}$** **$Mg_{5.4}$** **$S_{39.4}$** $TOC_{1.4}$
	Total content	$Ca_{0.7}$ **$K_{0.7}$** **$Mg_{0.6}$** $Mn_{0.6}$ **$Na_{0.6}$** $P_{0.7}$	$Co_{1.0}$ $Cu_{1.0}$ $Fe_{0.9}$ $Ni_{1.1}$	**$Al_{1.4}$** $Pb_{1.5}$ **$S_{9.4}$** $Zn_{1.3}$
	F1**	$Ca_{0.7}$ $K_{0.5}$ **$Mg_{0.3}$** $Na_{0.8}$ $P_{0.8}$	$Mn_{1.0}$ $Pb_{1.1}$	$Al_{5.2}$ **$Co_{12.2}$** $Cu_{2.7}$ $Fe_{1.7}$ $Ni_{1.6}$ **$S_{128.8}$**
	F2	$K_{0.7}$ $Mn_{0.5}$ $Na_{0.5}$ $P_{0.3}$ $Pb_{0.7}$	$Ca_{0.8}$ $Co_{1.0}$ $Cu_{1.1}$ $Fe_{1.1}$ $Mg_{1.2}$ $Ni_{1.1}$	$Al_{1.7}$ $S_{12.3}$ **$Zn_{2.9}$**
	F3	$Al_{0.8}$ $Ca_{0.6}$ $K_{0.7}$ $Mg_{0.5}$ **$Mn_{0.4}$** **$Na_{0.3}$** $P_{0.5}$	$Co_{0.9}$ $Cu_{1.3}$ $Fe_{1.0}$ $Ni_{0.9}$ $Pb_{0.9}$	$S_{20.2}$ $Zn_{3.3}$
	Extractability	$Al_{0.7}$ $K_{0.7}$ **$Mg_{0.5}$** $Mn_{0.6}$ $P_{0.7}$ **$Pb_{0.7}$**	$Ca_{1.0}$ $Co_{0.8}$ $Cu_{1.1}$ $Fe_{1.2}$ $Na_{0.9}$ $Ni_{0.9}$	$S_{3.8}$ **$Zn_{2.5}$**
Bb–horizon	Physico–chemical properties* and F0	$TOC_{0.6}$	$Clay_{1.0}$ **$FSI_{0.9}$** $silt_{1.0}$	**$Ca_{7.8}$** **$EC_{13.5}$** **$CSI_{1.4}$** **$K_{4.4}$** **$Mg_{7.9}$** **$Na_{2.3}$** **$S_{37.6}$**
	Total content	$Cu_{0.8}$ $Fe_{0.5}$ $P_{0.6}$ $Zn_{0.8}$	$Al_{0.9}$ $Co_{1.1}$ $K_{1.1}$ $Mg_{1.0}$ $Mn_{1.2}$ $Na_{1.2}$ $Ni_{0.9}$ $Pb_{0.9}$	$Ca_{1.9}$ $S_{3.4}$
	F1**	–	$Al_{1.2}$ $Fe_{1.1}$ $K_{0.9}$ $Mg_{1.1}$ $Na_{1.2}$ $P_{1.0}$	$Ca_{2.5}$ $Co_{10.9}$ $Cu_{1.7}$ $Mn_{6.9}$ $Ni_{1.3}$ $Pb_{1.3}$ $S_{98.8}$
	F2***	–	$Al_{0.9}$ $Co_{1.0}$ $Cu_{1.3}$ $Fe_{1.2}$ $Pb_{1.3}$ $Zn_{1.1}$	$Ca_{13.1}$ $K_{1.9}$ $Mn_{1.9}$ $Ni_{2.2}$ $S_{4.8}$
	F3****	–	$Al_{0.9}$ $Ca_{1.3}$ $Cu_{1.3}$ $Na_{0.8}$	$Co_{1.4}$ $Fe_{1.3}$ $K_{1.4}$ $Mg_{1.5}$ $Mn_{1.5}$ $Ni_{1.6}$ $P_{4.3}$ $Pb_{1.6}$ $Zn_{1.9}$
	Extractability	–	$Al_{1.0}$ $Ca_{1.0}$ $Co_{1.2}$ $K_{1.0}$ $Mg_{1.3}$	$Cu_{1.6}$ $Fe_{2.5}$ $Mn_{1.5}$ $Na_{6.7}$ $Ni_{1.9}$ $P_{5.7}$ $Pb_{1.7}$ $S_{17.5}$ $Zn_{2.2}$
C–horizon	Physico–chemical properties and F0	$Clay_{0.8}$ $TOC_{0.5}$	$FSI_{0.9}$ $silt_{1.1}$	**$Ca_{8.8}$** **$EC_{20.5}$** $CSI_{1.8}$ $K_{5.4}$ **$Mg_{10.2}$** **$Na_{2.5}$** **$S_{46.7}$**
	Total content	**$Fe_{0.4}$** $P_{0.3}$ **$Zn_{0.7}$**	$Al_{1.0}$ $Co_{1.1}$ $Cu_{0.8}$ $K_{1.3}$ $Ni_{0.8}$ $Pb_{0.9}$	$Ca_{2.7}$ $Mg_{1.4}$ $Mn_{1.4}$ $Na_{1.3}$ $S_{2.9}$
	F1**	$Cu_{0.6}$ $Fe_{0.5}$	$Al_{1.2}$ $Na_{1.1}$ $Ni_{1.3}$ $P_{0.8}$ $Pb_{1.1}$	**$Ca_{3.7}$** $Co_{2.0}$ $K_{1.4}$ $Mg_{1.6}$ **$Mn_{5.9}$** **$S_{53.8}$**
	F2***	$K_{0.8}$ $Mg_{0.7}$ $Na_{0.8}$ $Zn_{0.5}$	$Al_{0.9}$ $Co_{1.0}$ $Fe_{0.9}$	$Ca_{2.3}$ $Cu_{1.8}$ **$Mn_{3.1}$** $Ni_{4.8}$ **$Pb_{1.9}$** $S_{5.2}$
	F3****	–	$Al_{1.2}$	$Ca_{2.1}$ **$Co_{1.5}$** $Cu_{1.7}$ **$Fe_{1.7}$** **$K_{2.2}$** **$Mg_{2.1}$** **$Mn_{3.0}$** $Na_{1.6}$ **$Ni_{2.4}$** **$P_{14.0}$** $Pb_{1.8}$ **$Zn_{2.3}$**
	Extractability	$Co_{0.8}$ $Na_{0.4}$	$Al_{1.2}$ $Ca_{1.2}$ $K_{1.0}$	**$Cu_{1.9}$** **$Fe_{2.2}$** **$Mg_{1.3}$** **$Mn_{2.4}$** **$Ni_{2.8}$** **$P_{10.0}$** $Pb_{1.9}$ **$S_{6.2}$** **$Zn_{2.4}$**

Numbers in brackets: L-index values. Significantly ($p<0.05$) differed proxies are in bold. * The content of some particle-size fraction is below 0.01%. ** The content of exchangeable Zn is below the detection limit in most samples from the A horizon in both compared datasets. *** The content of the F2 of Mg (only in the B horizon), Na (only in the B-horizon), and P are below the detection limit in most samples from the A horizon in both compared datasets. **** The content of the F3 of S is below the detection limit in most samples from the A horizon in both compared datasets. CS – coarse sand, CSI – coarse silt, EC – electrical conductivity, FSA – fine sand, FSI – fine silt, MS – medium sand, TOC – total organic carbon, VFS – very fine sand

Table S11. Characteristics (m ± SD) of the studied aerial tissues of a birch

Elements	Plant tissue	Spoil heaps, n=3	Talus, n=7	Unpolluted area, n=1	Units (dry weight)
Ash	L	11.2±8.0	9.2±3.9	7.0	%
Ash	B	3.2±0.9	2.91.0	3.9	%
Al	L	**158±106**	**124±64**	192	mg/kg
Al	B	46±10	32±12	43	mg/kg
Ca	L	**8.4±1.4**	**7.2±1.7**	5.1	g/kg
Ca	B	5.6±1.0	5.1±1.8	3.3	g/kg
Co	L	1.2±0.5	2.3±1.4	4.5	mg/kg
Co	B	0.63±0.22	0.94±0.53	1.82	mg/kg
Cu	L	6.2±1.5	7.1±1.4	5.1	mg/kg
Cu	B	6.4±2.3	6.6±1.0	3.9	mg/kg
Fe	L	**165±20**	**161±44**	207	mg/kg
Fe	B	62±12	60±15	59	mg/kg
K	L	**8.9±1.4**	**11.9±2.8**	12.3	g/kg
K	B	5.0±0.2	7.6±2.8	10.1	g/kg
Mg	L	**3.0±0.9**	**2.5±0.4**	2.9	g/kg
Mg	B	0.8±90.12	0.95±0.13	1.18	g/kg
Mn	L	0.53±0.42	**0.82±0.54**	1.04	g/kg
Mn	B	0.13±0.09	0.27±0.18	0.32	g/kg
Na	L	24±4	27±13	22	mg/kg
Na	B	35±10	39±16	20	mg/kg
Ni	L	**4.5±0.4**	**8.6±1.7**	7.1	mg/kg
Ni	B	2.8±0.6	4.7±1.6	4.1	mg/kg
P	L	**2.2±0.5**	2.5±0.6	2.4	g/kg
P	B	1.3±0.0	1.5±0.2	1.6	g/kg
Pb	L	0.31±0.03	**0.24±0.03**	0.18	mg/kg
Pb	B	0.44±0.44	0.12±0.06	0.12	mg/kg
S	L	**2.44±1.05**	**2.23±0.51**	2.40	g/kg
S	B	0.71±0.18	0.75±0.08	0.88	g/kg
Zn	L	0.16±0.02	0.17±0.07	0.23	g/kg
Zn	B	0.15±0.02±	0.14±0.04	0.19	g/kg

L – leaves, B – branches. The chemical element concentration in leaves significantly ($p<0.05$) different from those in branches is marked in red bold

Table S12. Spatial differentiation of the chemical composition of the analyzed birch tissues

Tissue	Location	Lower values (depletion) (L <0.8)	Unsubstantial differences (L = 0.8 – 1.3)	Higher values (accumulation) (L >1.3)
Leaves	Spoil heaps	$Co_{0.3}$ $Fe_{0.8}$ $K_{0.7}$ $Mn_{0.5}$ $Ni_{0.6}$ $Zn_{0.7}$	$Al_{0.8}$ $Cu_{1.2}$ $Mg_{1.0}$ $Na_{1.1}$ $P_{0.9}$ $S_{1.0}$	$Ca_{1.6}$ $Pb_{1.8}$
	Talus	$Al_{0.6}$ $Co_{0.5}$ $Fe_{0.8}$ $Mn_{0.8}$ $Zn_{0.7}$	$K_{1.0}$ $Mg_{0.9}$ $Na_{1.2}$ **$Ni_{1.2}$** $P_{1.0}$ $S_{0.9}$	$Ca_{1.4}$ $Cu_{1.4}$ **$Pb_{1.4}$**
Branches	Spoil heaps	$Co_{0.3}$ $K_{0.5}$ $Mg_{0.8}$ $Mn_{0.4}$ $Ni_{0.7}$ $P_{0.8}$	$Al_{1.1}$ $Fe_{1.0}$ $S_{0.8}$ $Zn_{0.8}$	$Ca_{1.7}$ $Cu_{1.6}$ $Na_{1.8}$ $Pb_{3.6}$
	Talus	$Al_{0.8}$ $Co_{0.5}$ $K_{0.7}$ $Zn_{0.7}$	$Fe_{1.0}$ $Mg_{0.8}$ $Mn_{0.8}$ **$Ni_{1.2}$** $P_{0.9}$ $S_{0.9}$	$Ca_{1.5}$ $Cu_{1.7}$ $Na_{2.0}$

Numbers in brackets: L-indices. Proxies are marked in bold in cases of significant differences between ChE content in birch trees grown on the spoil heaps and talus.

Table S13. A comparison of chemical element concentration in the studied surface waters and soils with the water and soil quality standards of the Russian Federation

Chemical elements	Ratio	Surface water				Topsoils (0 – 20 cm)					
						Total content			F1		
		Spoil heaps, n=6	Talus, n=21	Tailing ponds, n=8	Unpolluted area, n=7	Spoil heaps, n=10	Talus, n=14	Unpolluted area, n=5	Spoil heaps, n=10	Talus, n=14	Unpolluted area, n=5
Co	K_{MPC}	**3,8**	**6.3**	**1.1**	<0.1		–		0.1	**2.0**	<0.1
	N_{MPC}	83	81	13	0		–		0	7	0
	MPC*			0,1			–			5.0	
Cu	K_{MPC}	<0.1	0.2	<0.1	<0.1	0.4	0.6	0.3	0.1	0.5	<0.1
	N_{MPC}	0	0	0	0	0	0	0	0	0	0
	MPC*			1.0			66			3.0	
Fe	K_{MPC}	**220**	**1759**	**14**	**3.2**		–			–	
	N_{MPC}	100	95	63	14		–			–	
	MPC*			0.3			–			–	
Mg	K_{MPC}	**2.3**	**3.5**	**1.1**	0.3		–			–	
	N_{MPC}	83	62	25	0		–			–	
	MPC*			50			–			–	
Mn	K_{MPC}	**43**	**222**	**88**	**8.7**	0.3	0.8	0.5	0.7	**4.5**	0.8
	N_{MPC}	100	100	100	57	0	0	0	0	14	0
	MPC*			0.1			1500			60	
Ni	K_{MPC}	**31**	**43**	**5.8**	0.3	0.9	**1.2**	0.9	0.2	**1.5**	0.4
	N_{MPC}	100	100	88	0	0	7	0	0	7	0
	MPC*		0.02				40			4.0	
P	K_{MPC}	**980**	**979**	**979**	**1798**		–			–	
	N_{MPC}	100	100	100	100		–			–	
	MPC*			0.0001			–			–	

Pb	K_{MPC}	**3.2**	**7.8**	**3.2**	**3.2**	**9.8**	**1.6**	0.5	0.4	0.2	0.3
	N_{MPC}	33	52	13	14	10	29	0	0	0	0
	MPC*			0.01			65			6.0	
S	K_{MPC}			–		**209**	**116**	**7.5**		–	
	N_{MPC}			–		100	100	80		–	
	MPC*						160			–	
Zn	K_{MPC}	0.7	**1.0**	0.2	<0.1	**1.0**	**4.1**	0.7	<0.1	**2.5**	<0.1
	N_{MPC}	0	5	0	0	10	14	0	0	14	0
	MPC*			5			110			23	

K_{MPC} is the ratio of the actual maximal concentration of a chemical element to its maximal permissible concentration (MPC) in the Russian Federation. N_{MPC} is the percentage of samples with concentration above the MPC. All values exceeding MPCs are shown in bold. The values exceeding MPCs by multiples of 10 and more are marked in red. * in mg/dm^3 for waters and in mg/kg for soils.

Table S14. Correlation matrix for the elemental composition of topsoil and birch aerial tissues, n = 8

Plant tissues	Elements	Topsoil (0 – 10 cm)						Branches
		Total content	Extractability	F1	F2	F3	F0	
Leaves	Na	0.143	-0.262	-0.024	-0.078	-0.127	-0.476	0.333
	Mg	0.786	0.833	0.738	0.733	0.857	-0.595	0.714
	Al	0.262	0.143	0.357	0.429	0.262	n.d.	0.762
	P	0.810	0.190	0.810	0.546	0.738	n.d.	0.524
	S	0.299	0.881	0.429	-0.076	0.619	0.524	0.881
	K	0.095	0.143	0.381	0.071	-0.190	1.000	0.929
	Ca	-0.238	-0.167	-0.381	-0.168	-0.524	0.000	0.905
	Mn	0.024	0.167	0.262	-0.167	0.071	n.d.	0.952
	Fe	0.048	-0.429	-0.214	0.024	0.071	n.d.	0.548
	Co	0.108	-0.119	-0.252	0.024	0.048	n.d.	0.952
	Ni	-0.119	0.238	0.000	-0.024	0.000	n.d.	0.714
	Cu	0.072	0.599	-0.012	0.333	0.452	n.d.	0.619
	Zn	-0.095	0.405	0.327	0.119	0.119	n.d.	0.167
	Pb	-0.167	0.190	-0.218	0.262	0.119	n.d.	0.571
Branches	Na	0.286	-0.024	-0.500	-0.218	-0.190	-0.429	n.d.
	Mg	0.857	0.690	0.810	0.405	0.905	-0.619	n.d.
	Al	-0.071	-0.381	-0.167	-0.024	-0.286	n.d.	n.d.
	P	0.310	0.714	0.452	0.846	0.619	n.d.	n.d.
	S	0.299	0.952	0.357	-0.203	0.643	0.429	n.d.
	K	0.214	0.095	0.357	-0.024	-0.310	0.929	n.d.
	Ca	-0.524	-0.310	-0.571	-0.228	-0.690	0.048	n.d.
	Mn	-0.228	-0.071	0.000	-0.381	-0.190	n.d.	n.d.
	Fe	0.143	0.071	0.167	0.262	0.310	n.d.	n.d.
	Co	-0.072	-0.286	-0.275	-0.190	-0.143	n.d.	n.d.
	Ni	-0.262	-0.238	-0.310	-0.357	-0.310	n.d.	n.d.
	Cu	-0.072	0.587	-0.048	0.095	0.333	n.d.	n.d.
	Zn	-0.714	-0.262	-0.546	-0.452	-0.571	n.d.	n.d.
	Pb	-0.452	0.048	-0.546	-0.238	-0.452	n.d.	n.d.

The coefficients of correlation between the contents of the same chemical element in different medium are presented. Significant ($p<0.05$) values are marked in red, n.d. – not determined.