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Distribution and mobility of heavy elements in floodplain agricultural soils along the Ibar River (Southern Serbia and Northern Kosovo). Chemometric investigation of pollutant sources and ecological risk assessment

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Supplementary Material B

Content

Table B1 Pseudo total HEs concentrations (mg kg^{-1}) in soil samples with respect to the Ibar River flows

Floods	River Flow*		As	Cd	Cr	Cu	Ni	Pb	Sb	Zn
BF *n* = 25	Middle (S1 – S14)	Mean±*SD*	61±38	2.4±1.6	68±31	49±26	137±64	550±560	6.8±3.7	25±106
		Median (Range)	51 (23–165)	2.4 (0.40–5.1)	64 (25–129)	43 (24–132)	135 (50–259)	246 (144–2078)	5.7 (2.8–15)	206 (134–477)
	Lower (S15 – 25)	Mean±*SD*	28±17	1.5±1.5	127±43	35±12	270±140	93±38	4.1±1.8	177±147
		Median (Range)	32 (9.4–59)	0.33 (0.13–4.1)	132 (72–189)	29 (23–64)	240 (130–546)	91 (50–157)	4.1 (<*LOD*–6.8)	137 (55–538)
	Mann–Whitney *U* test		*U* = 3 p ≤ *0.01*	*U* = 44 *p* ≤ *0.01*	*U* = 20 *p* ≤ *0.01*	*U* = 42 *p* = 0.055	*U* = 28 *p* ≤ *0.01*	*U* = 1 *p* ≤ *0.001*	*U* = 44 *p* = 0.075	*U* = 32 *p* ≤ *0.01*
AF *n* = 25	Middle (S1 – S14)	Mean±*SD*	202 ±102	6.2±3.1	81±28	64±20	154±54	557±46	12±6.6	793±374
		Median (Range)	185 (84.6–474)	5.6 (1.8–12)	85 (25–115)	57 (42–95)	158 (49–247)	402 (204–1320)	8.7 (5.1–26)	703 (351–1374)
	Lower (S15 – 25)	Mean±*SD*	36±25	1.7±1.7	131±39	35±7.0	271±154	105±46	4.2±1.5	196±109
		Median (Range)	28 (15–101)	1.2 (0.13–4.9)	126 (67–219)	36 (25–49)	222 (114–687)	82 (50–203)	3.4 (2.7–7.7)	192 (50–410)
	Mann–Whitney *U* test		*U* = 1.0 *p* ≤ *0.001*	*U* = 1.0 *p* ≤ *0.001*	*U* = 15 *p* ≤ *0.001*	*U* = 4.0 *p* ≤ *0.001*	*U* = 22 *p* ≤ *0.01*	*U* = 0.0 *p* ≤ *0.001*	*U* = 9.0 *p* ≤ *0.001*	*U* = 3.0 *p* ≤ *0.001*

BF – Before the floods; AF – After the floods; *LOD* – Limit of Detection; *n* – Number of analyzed soil samples; *Middle flow of the Ibar River stretches from the K. Mitrovica to the Raška city *ie* between sampling sites S1 – S14; Lower flow of the Ibar River stretches from the Raška to the Kraljevo city *ie* between sampling sites S15 – S25 (see Fig. 1).

Table B2 Environmental risk assessment of the studied agricultural soils by Contamination Factors (C_f^i)

Sampling sites	C_f^i As		C_f^i Cd		C_f^i Cu		C_f^i Pb		C_f^i Sb		C_f^i Zn	
	The high-magnitude flood event (May 2014)											
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
S1	3.4	14	8.8	14	2.0	3.2	25	16	6.5	8.8	3.2	9.1
S2	2.3	8.7	5.1	19	2.0	2.6	15	13	3.5	7.9	1.4	8.4
S3	2.1	11	8.8	16	4.4	2.6	10	14	3.6	7.8	2.3	4.6
S4	1.3	8.4	3.0	10	1.5	1.8	4.9	7.2	2.0	3.9	1.4	4.3
S5	2.6	6.2	2.1	8.0	1.3	1.4	2.7	4.1	1.9	3.1	1.6	4.8
S6	1.9	3.5	0.8	3.9	1.3	1.7	2.1	3.1	1.7	2.2	1.2	2.4
S7	6.9	20	10	24	1.7	3.1	3.1	8.0	4.0	11	2.8	9.2
S8	1.4	7.0	0.90	8.7	0.90	2.4	2.7	4.7	1.3	2.8	1.4	5.4
S9	2.2	9.2	5.7	12	1.1	2.0	2.4	3.8	2.3	4.6	1.4	4.1
S10	1.9	9.2	2.5	22	1.3	3.0	2.0	6.1	1.2	3.9	1.4	8.0
S11	2.2	4.9	6.7	8.2	1.4	1.4	1.7	3.0	2.5	3.4	1.1	2.3
S12	1.0	4.7	0.90	3.5	0.80	1.5	1.9	2.8	1.2	2.1	0.90	2.4
S13	5.0	5.9	4.4	14	1.7	1.8	9.1	4.9	3.1	3.1	2.6	5.9
S14	1.6	5.6	6.9	9.8	1.6	1.4	8.5	2.4	4.8	3.3	1.4	3.0
S15	1.4	2.6	5.1	6.3	0.90	1.3	1.9	1.7	2.3	2.4	1.1	1.4
S16	1.3	2.0	0.70	2.4	1.2	1.2	1.6	1.7	1.2	1.2	0.90	1.5
S17	0.7	0.60	0.30	0.30	1.0	0.80	0.70	0.60	1.7	1.1	0.4	0.30
S18	2.2	4.2	5.9	10	1.5	1.2	1.6	2.4	2.3	3.2	1.4	2.7
S19	0.4	1.1	0.60	0.50	0.80	1.6	0.6	1.1	1.5	1.4	0.60	1.3
S20	0.5	1.0	0.40	0.40	0.90	0.90	1.1	1.0	1.2	1.5	0.6	0.7
S21	2.5	1.2	8.2	7.5	2.1	1.3	1.4	1.8	2.9	1.4	2.4	1.7
S22	0.6	0.80	0.50	0.60	0.90	0.90	0.70	0.90	1.3	1.3	0.50	0.80
S23	0.4	0.70	0.30	0.50	0.90	1.1	0.60	0.90	0.0	1.4	0.50	0.80
S24	1.7	1.3	5.3	5.3	1.1	1.2	1.1	0.90	2.2	2.3	1.1	2.3
S25	1.4	1.2	5.2	4.6	1.4	1.3	0.90	0.80	2.1	1.9	3.6	0.90
Mean	2.0	5.4	4.0	8.5	1.4	1.71	4.2	4.3	2.3	3.5	1.5	3.5
SD	1.4	4.8	3.2	6.8	0.73	0.70	5.6	4.3	1.5	2.6	0.86	2.8
Median	1.7	4.7	4.4	8.0	1.3	1.4	1.9	2.8	2.1	2.8	1.4	2.4
Range	0.39–6.9	0.62–20	0.26–10	0.26–24	0.78–4.4	0.85–3.2	0.60–25	0.59–16	0.0–6.5	1.2–11	0.37–3.6	0.34–9.2
Wilcoxon Signed Rank Test	$Z = -3.8$ $p \leq 0.001$		$Z = -3.7$ $p \leq 0.001$		$Z = -1.9$ $p \leq 0.05$		$Z = -1.4$ $p = 0.154$		$Z = -2.8$ $p \leq 0.01$		$Z = -3.7$ $p \leq 0.001$	

Table B3 Environmental risk assessment of the studied agricultural soils by the potential ecological risk factor (E_r^i) and potential ecological risk index (RI)

Sampling sites	Before the floods						After the floods					
	E_r^i As	E_r^i Cd	E_r^i Cu	E_r^i Pb	E_r^i Zn	RI (Risk Ranges*)	E_r^i As	E_r^i Cd	E_r^i Cu	E_r^i Pb	E_r^i Zn	RI (Risk Ranges)
S1	34	260	9.8	120	3.2	Considerable	140	430	156	79	9.1	Very high
S2	22	150	9.9	77	1.4	Moderate	86	560	13	64	8.4	Very high
S3	21	260	22	52	2.3	Considerable	110	490	13	72	4.6	Very high
S4	13	89	7.5	23	1.4	Low	84	310	9.0	36	4.3	Considerable
S5	26	64	6.4	14	1.6	Low	62	240	7.0	20	4.8	Considerable
S6	19	24	6.7	11	1.2	Low	35	120	8.4	16	2.4	Moderate
S7	69	310	8.3	16	2.8	Considerable	197	730	16	40	9.2	Very high
S8	13	26	4.5	14	1.4	Low	70	260	12	24	5.4	Considerable
S9	22	170	5.4	12	1.4	Moderate	92	360	10	19	4.1	Considerable
S10	19	76	6.7	10	1.4	Low	92	660	15	30	8.0	Very high
S11	22	202	6.8	8.6	1.1	Moderate	49	240	7.0	15	2.3	Considerable
S12	9.7	26	4.0	9.6	0.90	Low	47	110	7.5	14	2.4	Moderate
S13	50	130	8.5	46	2.6	Moderate	59	420	8.9	24	5.9	Considerable
S14	16	210	7.9	42	1.4	Moderate	56	290	7.2	12	3.0	Considerable
S15	14	150	4.5	9.4	1.1	Moderate	25	190	6.7	8.4	1.4	Moderate
S16	13	20	5.9	7.8	0.90	Low	20	71	6.0	8.4	1.5	Low
S17	7	7.8	4.9	3.4	0.40	Low	6.2	7.8	4.2	3.0	0.34	Low
S18	22	180	7.5	8.0	1.4	Moderate	42	298	5.8	12	2.7	Considerable
S19	3.9	17	3.9	3.0	0.6	Low	11	16	8.2	5.6	1.3	Low
S20	5.3	12	4.3	5.6	0.6	Low	9.8	12	4.8	4.9	0.72	Low
S21	24	250	11	7.1	2.4	Moderate	12	230	6.4	9.0	1.7	Moderate
S22	5.8	14	4.7	3.3	0.50	Low	8.1	17	4.3	4.6	0.77	Low
S23	3.9	9.6	4.7	3.1	0.50	Low	6.8	14	5.6	4.6	0.77	Low
S24	17	160	5.6	5.4	1.1	Moderate	13	160	6.2	4.6	2.3	Moderate
S25	14	160	6.8	4.4	3.6	Moderate	12	140	6.7	4.1	0.87	Moderate
Mean	20	120	7.1	21	1.5	170	54	250	8.5	21	3.5	340
SD	14	95	3.7	28	0.9	120	48	210	3.5	21	2.8	270
Median	17	130	6.7	9.6	1.4	180	47	240	7.2	14	2.4	320
Range	3.9–69	7.8–310	3.9–22	3.0–120	0.4–3.6	22–430	6.2–197	7.8–730	4.3–16	3.0–79	0.30–9.2	22–990

Underlined values represent a very high ecological risk ($E_r^i \geq 320$); * Risk Ranges defined by Hakånson (1980).