The red mud accident in Ajka (Hungary): plant toxicity and trace metal bioavailability in red mud contaminated soil

Supporting information

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1 Table SI 1: Elemental composition in 0.01 M $CaCl_2$ extracts of red mud and NaOH amended soils. The Exchangeable Sodium
2 Percentage (ESP) in soil at conditions as in the pot trial is estimated by an ion exchange equation and the Ca, Mg and Na
3 concentrations (see text). Linear regression analysis to the nominal dose is used to identify significant effects.

	Red mud dose (%)	**pH**	**DOC** (mg L^{-1})	**ESP** (%)	**Ca**	**K**	**Mg** (mg L^{-1})	**Na**	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe** (µg L^{-1})	**Mn**	**Ni**	**Pb**	**Zn**
Without leaching	**0**	6.8	3.1	0.5	270	4.6	19	2.1	0.22	14	<1.0	<1.0	<1.0	13	110	4.0	16	<5	17
	0.1	6.9	3.7	2	270	5.1	19	7.5	0.15	14	<1.0	<1.0	<1.0	6.2	76	0.95	3.5	<5	13
	0.5	7.3	4.5	4	270	4.4	18	18	0.19	14	<1.0	<1.0	<1.0	5.0	99	1.4	2.4	<5	23
	1.4	7.6	3.6	6	260	4.1	17	29	0.15	16	<1.0	<1.0	<1.0	3.2	79	<1.0	2.3	<5	56
	4.9	8.0	3.5	12	250	4.4	14	55	0.12	16	<1.0	<1.0	<1.0	2.7	65	3.4	17	<5	27
	16.5	8.3	3.0	30	210	7.3	8.7	136	0.12	16	<1.0	<1.0	<1.0	2.3	<10	<1.0	1.2	<5	14
	p	***	**NS**	***	***	***	***	***	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**	**NS**	**NS**	**NS**	**NS**
With leaching	**0**	6.8	2.6	0.5	270	5.8	19	2.0	<0.01	10	<1.0	<1.0	<1.0	<1.0	<10	<1.0	3.3	<5	13
	0.1	7.0	4.1	1.7	270	11	19	7.7	<0.01	16	<1.0	<1.0	<1.0	<1.0	<10	<1.0	2.0	<5	42
	0.5	7.3	4.2	3.9	280	6.6	20	21	<0.01	13	<1.0	<1.0	<1.0	<1.0	<10	<1.0	4.7	<5	24
	1.4	7.7	3.4	6.4	260	6.3	17	30	0.01	14	<1.0	<1.0	<1.0	<1.0	<10	<1.0	2.0	<5	47
	4.9	8.0	4.5	11	250	5.6	14	56	0.04	15	<1.0	<1.0	<1.0	<1.0	<10	<1.0	1.9	<5	18
	16.5	8.3	3.7	26	220	8.8	7.7	114	0.10	14	<1.0	<1.0	<1.0	<1.0	<10	<1.0	1.2	<5	26
	p	**	**NS**	***	***	**NS**	***	***	***	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

	NaOH dose (mmol kg^{-1})	**pH**	**DOC** (mg L^{-1})	**ESP** (%)	**Ca**	**K**	**Mg** (mg L^{-1})	**Na**	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe** (µg L^{-1})	**Mn**	**Ni**	**Pb**	**Zn**
NaOHref	**0**	6.8	3.1	0.5	270	4.6	19	2.1	0.22	14	<1.0	<1.0	<1.0	13	110	4.0	16	<5	17
	12	7.4	3.8	4.1	266	5.2	19	20	<0.01	13	<1.0	<1.0	<1.0	<1.0	<10	<1.0	1.8	<5	26
	21	7.6	4.2	6.5	257	6.1	17	31	<0.01	15	<1.0	<1.0	<1.0	<1.0	<10	<1.0	6.7	<5	15
	49	8.0	6.6	15	234	6.5	15	79	<0.01	12	<1.0	<1.0	<1.0	<1.0	<10	<1.0	2.5	<5	20
	p	***	**	***	***	**NS**	***	***	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

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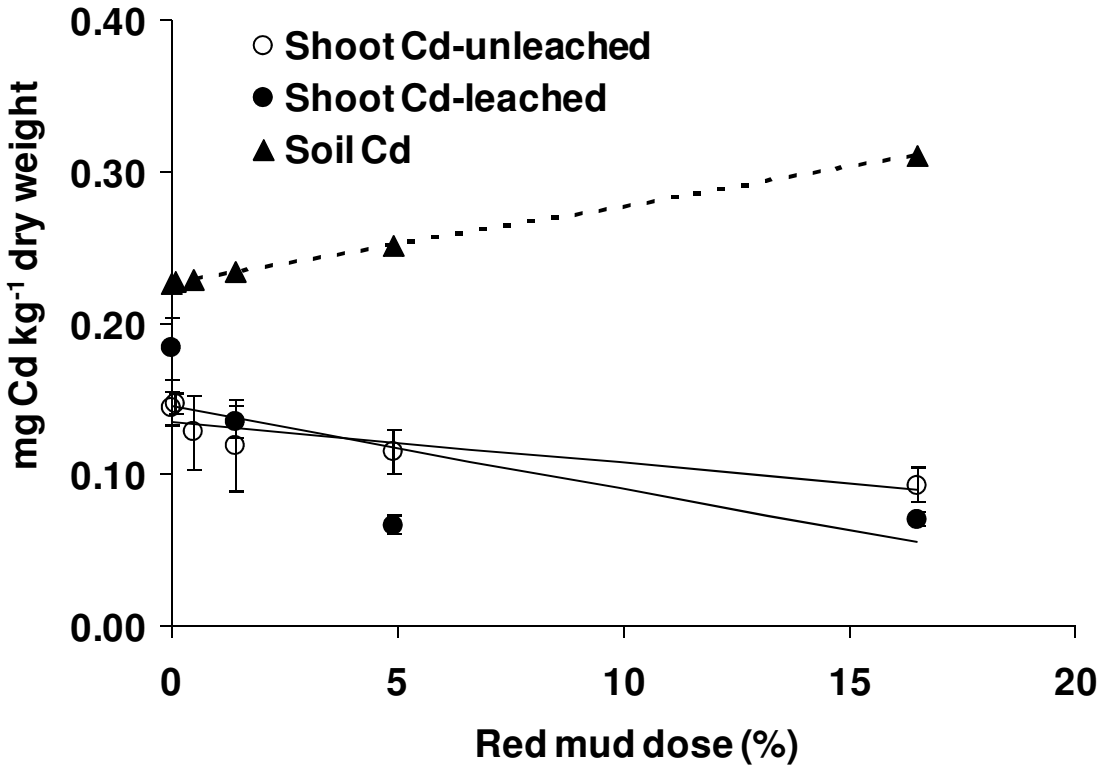
5 NS not significant; * significant at $p<0.05$; ** significant at $p<0.01$; *** significant at $p<0.001$

Table SI 2: Elemental composition plants in plants grown in of red mud and NaOH amended soils. Linear regression analysis to the nominal dose is used to identify significant effects.

	Red mud dose (%)	**Ca**	**K**	**Mg**	**Na**	**P**	**S**	**Al**	**B**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Zn**
		%						mg kg^{-1}									
without leaching	**0**	0.58	4.0	0.17	0.12	0.33	0.088	16	5.1	0.14	1.4	3.4	44	26	0.49	0.49	20
	0.1	0.56	4.5	0.18	0.43	0.27	0.17	32	5.1	0.15	1.5	5.2	79	27	0.60	0.67	17
	0.5	0.50	4.4	0.19	0.77	0.24	0.31	19	4.4	0.13	1.7	5.3	96	30	0.66	0.34	15
	1.4	0.45	4.1	0.19	1.1	0.25	0.37	28	5.1	0.12	1.5	6.2	96	28	0.65	0.31	14
	4.9	0.35	4.2	0.18	1.4	0.24	0.38	29	5.6	0.12	2.9	7.6	100	23	0.76	0.60	15
	16.5	0.20	4.1	0.16	2.4	0.20	0.46	34	7.5	0.09	5.6	8.3	120	26	0.82	0.16	17
	p	***	**NS**	*	***	***	***	**NS**	***	***	***	***	**	**NS**	*	**NS**	**NS**
with leaching	**0**	0.62	4.4	0.21	0.12	0.34	0.085	nd	5.4	0.18	1.7	3.6	75	24	0.79	0.13	23
	0.1	0.47	4.1	0.16	0.18	0.30	0.11	nd	nd	nd	2.4	nd	83	23	0.93	0.16	18
	0.5	0.47	4.4	0.18	0.63	0.26	0.23	nd	nd	nd	2.4	nd	100	24	0.74	0.09	14
	1.4	0.42	4.9	0.19	0.84	0.27	0.32	nd	5.3	0.14	2.7	6.5	100	23	0.91	0.15	13
	4.9	0.34	3.6	0.19	1.2	0.18	0.32	7.6	5.4	0.07	2.0	5.0	82	22	0.37	0.15	10
	16.5	0.18	4.5	0.18	2.1	0.14	0.35	17.6	7.1	0.07	2.4	9.6	99	23	0.35	0.20	14
	p	***	**NS**	**NS**	***	***	***	**-**	***	**	**NS**	***	**NS**	**NS**	**	**NS**	**NS**
	NaOH dose (mmol kg^{-1})	**Ca**	**K**	**Mg**	**Na**	**P**	**S**	**Al**	**B**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Zn**
		%						mg kg^{-1}									
NaOHref	**0**	0.58	4.0	0.17	0.12	0.33	0.088	16	5.1	0.14	1.4	3.4	44	26	0.49	0.49	20
	12	0.51	3.8	0.18	0.80	0.35	0.11	nd	4.6	0.13	7.9	3.6	120	26	0.67	0.18	18
	21	0.43	3.9	0.16	1.09	0.37	0.13	nd	4.9	0.12	10.6	3.9	151	27	0.78	<0.05	16
	49	0.28	3.9	0.14	1.83	0.34	0.15	nd	3.9	0.13	10.4	5.3	149	30	0.77	0.09	15
	p	***	**NS**	*	***	**NS**	***	**-**	**	*	***	***	***	**	***	**NS**	**

9 NS not significant; * significant at $p<0.05$; ** significant at $p<0.01$; *** significant at $p<0.001$



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11 Figure SI 1: Cadmium concentrations in barley shoots and soil amended with red mud
12 before or after leaching soils with artificial rain water. Shoot Cd decreased significantly
13 with increasing red mud dose (R^2=0.43 or 0.51 for unleached and leached soils
14 respectively; $p<0.01$). Data represent average values (± standard deviation; n=4). Soil
15 concentrations are nominal ones based on *aqua regia* soluble metal concentrations in red
16 mud and unamended soil (Table 2).