

Supplementary Information

Heavy metals in sediments and greater flamingo tissues from a protected saline wetland in Central Spain

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Table S1

Results of the chemical analyses in sediment samples (concentrations in mg/kg dry weight). Organic matter content (OM, %). M_(Cu, Pb, Zn): method used for Cu, Pb and Zn determination. nd: not determined. BLD: below limit of detection.

Sample	Core	Depth	Control Point	Zone	Date	Cd	Hg	Cu	Pb	Zn	M _(Cu, Pb, Zn)	OM(%)
AA-5	AA	0-5	2648	Lake	25/09/2014	0.018	BLD	2.24	8.0	19.2	ICP-OES	3.76
AA-10	AA	5-10	2648	Lake	25/09/2014	0.062	0.031	4.15	10.2	24.9	ICP-OES	4.76
AA-15	AA	10-15	2648	Lake	25/09/2014	0.087	0.043	8.07	56.0	32.4	ICP-OES	20.3
AA-20	AA	15-20	2648	Lake	25/09/2014	0.030	BLD	2.99	15.0	19.7	ICP-OES	6.55
AA-25	AA	20-25	2648	Lake	25/09/2014	0.033	0.013	2.74	10.7	33.4	ICP-OES	5.39
AB-5	AB	0-5	2648	Lake	25/09/2014	0.021	BLD	6.69	9.1	26.8	ICP-OES	6.50
AB-10	AB	5-10	2648	Lake	25/09/2014	0.076	0.030	7.48	53.5	44.5	ICP-OES	11.8
AB-15	AB	10-15	2648	Lake	25/09/2014	0.039	0.047	9.59	50.2	43.6	ICP-OES	21.4
AB-20	AB	15-20	2648	Lake	25/09/2014	0.033	0.011	2.98	10.7	26.6	ICP-OES	5.39
AB-25	AB	20-25	2648	Lake	25/09/2014	nd	0.040	10.46	69.8	39.6	ICP-OES	15.0
AC-5	AC	0-5	2648	Lake	25/09/2014	0.025	BLD	1.77	4.9	11.6	ICP-OES	3.05
AC-10	AC	5-10	2648	Lake	25/09/2014	0.028	BLD	2.50	10.5	11.3	ICP-OES	4.10
AC-15	AC	10-15	2648	Lake	25/09/2014	0.087	0.026	9.62	79.4	45.4	ICP-OES	13.8
AC-20	AC	15-20	2648	Lake	25/09/2014	0.064	0.039	11.98	86.0	45.3	ICP-OES	17.6
AC-25	AC	20-25	2648	Lake	25/09/2014	0.044	0.054	9.54	58.2	33.4	ICP-OES	20.4
AD-5	AD	0-5	2648	Lake	25/09/2014	0.032	0.008	4.59	8.8	28.7	ICP-OES	3.19
AD-10	AD	5-10	2648	Lake	25/09/2014	0.023	0.030	7.97	48.5	33.0	ICP-OES	12.8
AD-15	AD	10-15	2648	Lake	25/09/2014	0.034	0.041	9.35	74.3	28.5	ICP-OES	16.3
AD-20	AD	15-20	2648	Lake	25/09/2014	0.027	0.028	6.68	44.8	24.9	ICP-OES	12.7
AD-25	AD	20-25	2648	Lake	25/09/2014	0.033	0.018	6.21	38.2	30.9	ICP-OES	6.56
AE-5	AE	0-5	2648	Lake	25/09/2014	0.056	0.045	13.97	85.9	38.3	ICP-OES	19.0
AE-10	AE	5-10	2648	Lake	25/09/2014	0.046	0.017	6.84	27.2	24.4	ICP-OES	7.71
AE-15	AE	10-15	2648	Lake	25/09/2014	0.025	0.031	6.37	34.0	21.1	ICP-OES	12.1
AE-20	AE	15-20	2648	Lake	25/09/2014	0.061	0.028	7.30	71.0	29.1	ICP-OES	12.3
AE-25	AE	20-25	2648	Lake	25/09/2014	0.022	0.009	2.36	15.1	17.8	ICP-OES	4.48
AF-5	AF	0-5	2648	Lake	18/12/2014	0.063	0.018	6.01	26.3	25.7	ICP-OES	13.9
AF-10	AF	5-10	2648	Lake	18/12/2014	0.068	0.022	8.00	35.1	30.1	ICP-OES	12.0
AF-15	AF	10-15	2648	Lake	18/12/2014	0.068	0.017	12.78	22.6	161.5	ICP-OES	7.86
AF-20	AF	15-20	2648	Lake	18/12/2014	0.029	0.011	4.49	23.7	28.0	ICP-OES	7.11
AF-25	AF	20-25	2648	Lake	18/12/2014	0.072	0.026	8.41	40.7	28.6	ICP-OES	10.2
AF-30	AF	25-30	2648	Lake	18/12/2014	0.043	0.017	6.68	33.2	27.2	ICP-OES	9.47
AG-5	AG	0-5	2648	Lake	18/12/2014	0.026	BLD	2.01	9.2	17.3	ICP-OES	3.92
AG-10	AG	5-10	2648	Lake	18/12/2014	0.029	BLD	2.73	14.6	16.6	ICP-OES	5.34
AG-15	AG	10-15	2648	Lake	18/12/2014	0.064	0.015	6.75	30.0	23.7	ICP-OES	10.2
AG-20	AG	15-20	2648	Lake	18/12/2014	0.067	0.018	7.29	53.7	27.5	ICP-OES	15.9

Sample	Core	Depth	Control Point	Zone	Date	Cd	Hg	Cu	Pb	Zn	M _(Cu, Pb, Zn)	OC(%)
AG-25	AG	20-25	2648	Lake	18/12/2014	0.032	BLD	5.26	14.0	22.6	ICP-OES	6.88
AG-30	AG	25-30	2648	Lake	18/12/2014	0.050	0.015	5.90	30.4	33.0	ICP-OES	8.79
AH-5	AH	0-5	2648	Lake	18/12/2014	0.047	BLD	2.79	19.3	18.1	ICP-OES	5.33
AH-10	AH	5-10	2648	Lake	18/12/2014	0.039	0.014	5.12	40.7	26.6	ICP-OES	10.4
AH-15	AH	10-15	2648	Lake	18/12/2014	0.032	0.050	7.80	43.2	29.3	ICP-OES	19.9
AH-20	AH	15-20	2648	Lake	18/12/2014	0.053	0.032	6.54	26.6	29.7	ICP-OES	16.0
AH-25	AH	20-25	2648	Lake	18/12/2014	0.041	0.015	4.16	28.5	18.8	ICP-OES	10.1
AI-5	AI	0-5	2648	Lake	18/12/2014	0.045	BLD	3.00	16.9	18.2	ICP-OES	5.91
AI-10	AI	5-10	2648	Lake	18/12/2014	0.079	0.031	11.74	91.4	40.8	ICP-OES	18.2
AI-15	AI	10-15	2648	Lake	18/12/2014	0.089	0.038	11.18	97.8	49.6	ICP-OES	15.0
AI-20	AI	15-20	2648	Lake	18/12/2014	0.055	0.088	4.45	19.9	15.1	ICP-OES	5.05
AJ-5	AJ	0-5	2648	Lake	07/04/2015	0.021	BLD	0.64	6.8	6.2	ICP-OES	5.00
AJ-10	AJ	5-10	2648	Lake	07/04/2015	0.043	0.008	1.95	19.2	7.4	ICP-OES	5.51
AJ-15	AJ	10-15	2648	Lake	07/04/2015	0.056	0.015	4.13	28.7	12.5	ICP-OES	11.4
AJ-20	AJ	15-20	2648	Lake	07/04/2015	0.072	0.021	5.49	45.0	17.7	ICP-OES	14.6
AJ-25	AJ	20-25	2648	Lake	07/04/2015	0.070	0.025	4.68	37.2	16.1	ICP-OES	11.9
AK-5	AK	0-5	2649	Lake	07/04/2015	0.014	BLD	1.20	17.2	7.4	ICP-OES	4.68
AK-10	AK	5-10	2649	Lake	07/04/2015	0.038	0.010	2.96	30.6	9.7	ICP-OES	7.26
AK-15	AK	10-15	2649	Lake	07/04/2015	0.031	0.009	2.30	24.9	8.7	ICP-OES	8.77
AK-20	AK	15-20	2649	Lake	07/04/2015	0.036	0.012	3.46	31.6	11.2	ICP-OES	9.16
AL-5	AL	0-5	2650	Lake	07/04/2015	0.174	0.177	24.78	110.9	97.9	ICP-OES	17.3
AL-10	AL	5-10	2650	Lake	07/04/2015	0.283	0.251	29.63	84.2	118.0	ICP-OES	18.3
AL-15	AL	10-15	2650	Lake	07/04/2015	0.151	0.179	17.90	94.4	60.7	ICP-OES	10.4
AL-20	AL	15-20	2650	Lake	07/04/2015	0.118	0.232	14.57	68.4	41.0	ICP-OES	7.24
AM-5	AM	0-5	2651	Lake	07/04/2015	0.030	0.008	1.06	12.1	4.6	ICP-OES	9.10
AM-10	AM	5-10	2651	Lake	07/04/2015	0.032	BLD	0.64	10.2	4.5	ICP-OES	5.01
AM-15	AM	10-15	2651	Lake	07/04/2015	0.026	BLD	1.17	6.7	7.2	ICP-OES	4.32
AM-20	AM	15-20	2651	Lake	07/04/2015	0.036	BLD	0.89	5.7	7.5	ICP-OES	4.00
AM-25	AM	20-25	2651	Lake	07/04/2015	0.041	BLD	1.58	6.4	9.6	ICP-OES	4.96
AN-5	AN	0-5	2652	Lake	07/04/2015	0.057	0.029	5.01	49.2	14.7	ICP-OES	10.0
AN-10	AN	5-10	2652	Lake	07/04/2015	0.089	0.022	7.41	74.3	21.8	ICP-OES	11.2
AN-15	AN	10-15	2652	Lake	07/04/2015	0.189	0.047	16.15	202.4	49.3	ICP-OES	11.9
AO-5	AO	0-5	2554	Dryland	24/07/2015	0.086	0.012	3.49	16.3	17.9	TXRF	17.2
AP-5	AP	0-5	2602	Irrigation	24/07/2015	0.084	0.030	8.80	15.2	22.8	TXRF	10.6
AQ-5	AQ	0-5	2571	Irrigation	24/07/2015	0.141	0.012	5.17	11.0	21.1	TXRF	6.02
AR-5	AR	0-5	2641	Wastewaters	24/07/2015	0.047	0.032	4.95	16.3	31.7	TXRF	8.01
AS-5	AS	0-5	2635	Lake	27/07/2015	0.022	BLD	2.87	3.1	9.4	TXRF	14.6

Sample	Core	Depth	Control Point	Zone	Date	Cd	Hg	Cu	Pb	Zn	M _(Cu, Pb, Zn)	OC(%)
AT-5	AT	0-5	2643	Lake	27/07/2015	0.022	BLD	2.77	8.0	16.6	TXRF	8.20
AU-5	AU	0-5	2648	Lake	27/07/2015	0.019	0.012	3.09	4.1	5.5	TXRF	13.7
AV-5	AV	0-5	2649	Lake	27/07/2015	0.026	0.030	5.04	5.0	25.3	TXRF	30.4
AW-5	AW	0-5	2652	Lake	27/07/2015	0.075	0.033	8.03	16.7	32.0	TXRF	14.3
AX-5	AX	0-5	2651	Lake	27/07/2015	0.022	BLD	2.74	4.9	14.0	TXRF	6.67
AX-10	AX	5-10	2651	Lake	27/07/2015	0.054	0.025	8.08	9.8	31.0	TXRF	20.5
AX-15	AX	10-15	2651	Lake	27/07/2015	0.037	0.025	5.45	9.5	17.6	TXRF	19.7
AX-20	AX	15-20	2651	Lake	27/07/2015	0.037	0.016	3.66	5.0	11.9	TXRF	13.1
AY-5	AY	0-5	2651	Lake	27/07/2015	BLD	BLD	4.01	4.1	3.9	TXRF	10.7
AY-10	AY	5-10	2651	Lake	27/07/2015	0.024	BLD	2.89	6.7	17.6	TXRF	8.07
AY-15	AY	10-15	2651	Lake	27/07/2015	0.069	0.032	7.91	18.0	27.5	TXRF	23.2
AY-20	AY	15-20	2651	Lake	27/07/2015	0.043	0.020	6.09	11.1	31.6	TXRF	19.4
AZ-5	AZ	0-5	2651	Lake	27/07/2015	0.018	BLD	2.83	1.9	21.8	TXRF	8.09
AZ-10	AZ	5-10	2651	Lake	27/07/2015	0.055	0.029	7.49	10.8	30.4	TXRF	20.3
AZ-15	AZ	10-15	2651	Lake	27/07/2015	0.028	0.026	5.86	5.2	16.9	TXRF	21.1
AZ-20	AZ	15-20	2651	Lake	27/07/2015	0.035	0.023	4.73	6.7	17.2	TXRF	15.4
BA-5	BA	0-5	2554	Dryland	14/01/2016	0.051	BLD	2.10	3.3	8.8	TXRF	5.30
BB-5	BB	0-5	2571	Irrigation	14/01/2016	0.130	0.016	6.69	10.5	26.0	TXRF	8.39
BC-5	BC	0-5	2575	Wastewaters	14/01/2016	0.097	0.025	8.46	22.9	24.1	TXRF	4.50
BD-5	BD	0-5	2602	Irrigation	14/01/2016	0.213	0.030	15.40	19.2	50.7	TXRF	7.67
BE-5	BE	0-5	2640	Dryland	14/01/2016	0.134	0.026	12.03	12.1	36.6	TXRF	10.5
BF-5	BF	0-5	2641	Wastewaters	14/01/2016	0.084	0.054	9.57	19.1	32.0	TXRF	15.2
BG-5	BG	0-5	2642	Dryland	14/01/2016	0.127	0.026	11.57	16.9	42.0	TXRF	8.81
BH-5	BH	0-5	2635	Lake	14/01/2016	0.023	BLD	2.06	5.7	11.1	TXRF	7.69
BI-5	BI	0-5	2643	Lake	14/01/2016	0.021	0.010	2.47	2.7	8.2	TXRF	12.4
BJ-5	BJ	0-5	2648	Lake	14/01/2016	0.029	0.011	3.02	5.1	11.0	TXRF	8.81
BK-5	BK	0-5	2649	Lake	14/01/2016	0.018	0.011	2.28	2.9	16.5	TXRF	11.0
BL-5	BL	0-5	2650	Lake	14/01/2016	0.160	0.058	17.48	21.1	89.5	TXRF	21.9
BM-5	BM	0-5	2651	Lake	14/01/2016	0.020	BLD	0.95	0.9	4.2	TXRF	3.38
BN-5	BN	0-5	2652	Lake	14/01/2016	0.025	BLD	2.05	4.2	10.0	TXRF	4.05

Table S2 Concentrations of Cu, Pb, and Zn found in the chemical speciation fractions F1-F6 for the sediment samples. All concentrations are given in mg/kg dry weight. F1: exchangeable fraction. F2: fraction bound to carbonates. F3: fraction bound to Mn oxides. F4: fraction bound to organic matter. F5: fraction bound to Fe oxides. F6: residual fraction. BLD: below limit of detection.

Control Point	2554	2571	2575	2602	2640	2641	2642	2635	2643	2648	2649	2650	2651	2652	
Sample	BA-5	BB-5	BC-5	BD-5	BE-5	BF-5	BG-5	BH-5	BI-5	BJ-5	BK-5	BL-5	BM-5	BN-5	
F1	Cu	BLD	BLD	BLD	BLD	BLD	2.50	BLD	BLD	BLD	BLD	3.81	BLD	BLD	BLD
	Pb	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
	Zn	BLD	1.01	1.19	1.29	1.86	3.62	1.48	2.64	BLD	2.20	4.83	3.07	BLD	3.58
F2	Cu	BLD	BLD	2.08	1.37	BLD	BLD	1.13	1.83	1.45	0.64	1.06	BLD	BLD	BLD
	Pb	BLD	BLD	2.00	1.53	2.44	BLD	3.32	BLD	BLD	1.20	BLD	BLD	BLD	BLD
	Zn	1.12	2.09	7.53	3.31	3.09	2.92	3.08	4.38	1.77	1.36	3.09	22.7	16.9	2.49
F3	Cu	0.40	1.61	2.32	2.18	BLD	0.89	0.57	BLD	0.48	0.48	5.44	0.78	BLD	0.80
	Pb	BLD	1.77	2.72	4.03	BLD	2.68	2.19	BLD	0.97	BLD	0.49	1.91	BLD	BLD
	Zn	4.30	3.62	2.48	6.29	17.1	6.74	9.56	1.99	18.2	2.48	8.69	11.8	1.39	1.69
F4	Cu	BLD	0.89	0.80	1.37	1.30	BLD	BLD	BLD	BLD	BLD	BLD	0.50	BLD	BLD
	Pb	BLD	BLD	BLD	BLD	0.57	3.33	BLD	1.03	1.21	BLD	0.89	4.03	BLD	1.04
	Zn	1.04	2.25	12.5	2.26	1.63	1.70	2.67	0.80	0.64	1.12	2.52	12.7	BLD	1.61
F5	Cu	BLD	BLD	BLD	1.29	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
	Pb	BLD	BLD	BLD	0.24	0.33	0.81	BLD	0.48	0.40	BLD	0.57	2.41	BLD	BLD
	Zn	5.42	6.52	7.13	11.45	5.29	6.33	6.24	9.79	6.52	6.65	7.88	19.9	6.45	6.02
F6	Cu	0.75	6.42	4.80	7.81	7.82	5.50	7.02	1.30	1.45	1.72	0.63	10.4	0.56	1.03
	Pb	0.82	9.25	5.77	5.39	6.77	189	7.99	0.61	1.93	1.65	BLD	14.3	BLD	0.48
	Zn	2.87	25.0	22.4	25.0	34.4	31.7	57.9	6.62	4.76	5.70	3.27	37.4	6.65	4.33

Table S3 Results of the chemical analyses in flamingo tissue samples (concentrations in mg/kg dry weight). BLD: below limit of detection.

Sample	Flamingo	Tissue	Cd	Hg	Cu	Pb	Zn
H-A	A	Liver	0.767	0.634	12.6	0.251	198
H-B	B	Liver	0.288	0.733	9.97	0.143	243
H-C	C	Liver	0.345	0.284	12.9	0.143	248
H-D	D	Liver	0.007	0.206	8.53	0.044	263
H-E	E	Liver	0.007	0.137	17.5	0.087	298
H-F	F	Liver	0.017	0.710	79.5	0.424	608
H-G	G	Liver	0.007	0.089	23.4	0.065	297
H-H	H	Liver	0.006	0.379	12.5	0.065	286
H-I	I	Liver	0.011	0.255	84.9	0.154	263
H-J	J	Liver	1.881	1.805	58.4	0.313	1124
H-L	L	Liver	0.009	0.640	59.9	0.076	378
M-A	A	Muscle	0.029	0.168	41.3	0.052	43.1
M-B	B	Muscle	0.020	0.130	26.4	0.012	51.8
M-C	C	Muscle	0.021	0.048	32.3	0.023	43.8
M-D	D	Muscle	0.003	0.027	6.91	0.038	43.5
M-E	E	Muscle	0.002	0.012	9.27	0.019	33.0
M-F	F	Muscle	0.001	0.113	8.47	0.013	59.3
M-G	G	Muscle	0.004	0.009	5.86	0.026	45.4
M-H	H	Muscle	0.005	0.062	9.12	0.018	51.5
M-I	I	Muscle	0.001	0.066	18.5	0.006	68.7
M-J	J	Muscle	0.329	0.206	78.0	0.048	126
M-K	K	Muscle	0.063	0.137	29.7	0.016	69.9
M-L	L	Muscle	0.005	0.082	22.7	0.025	38.0
F-D	D	Fat	0.007	BLD	BLD	0.127	11.4
F-E	E	Fat	0.002	BLD	BLD	0.033	15.1
F-G	G	Fat	0.007	BLD	BLD	0.036	23.4
F-H	H	Fat	0.016	BLD	3.25	0.129	9.13
F-L	L	Fat	0.005	BLD	BLD	0.049	10.9

Table S4 Pearson correlation analysis among total concentrations of heavy metals and organic matter content in lake sediment samples (n=102) and flamingo tissue samples (n=28).

	Cd	Cu	Hg	Pb	Zn	OM%
Cd	1					
Cu	0.353*	1				
Hg	0.347*	0.649*	1			
Pb	0.515*	0.108	-0.146	1		
Zn	0.232*	0.541*	0.786*	-0.326*	1	
OM%	0.277*	0.629*	0.645*	0.404*	0.439*	1

* Correlations significant at $p < 0.05$.