

Supplementary materials for the work:

Metabolic and oxidative changes in the fern *Adiantum raddianum* upon foliar application of metals

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Supplementary Table S1. Amount of selected macronutrients and micronutrients **in the soil** at the end of the experiment with foliar application of Ni or Cd on the leaves of *Adiantum raddianum* during 30 days (1 μ M solution). nd – not determined. Data are means $\pm$ SDs shown as bars ($n = 3$) from three individual pots. Values within rows, followed by the same letter, are not significantly different according to Tukey's test (at $P < 0.05$ level).

	control	Ni	Cd
Ni (μ g/g DW)	11.8 $\pm$ 2.90 a	12.4 $\pm$ 3.56 a	nd
Cd (μ g/g DW)	0.47 $\pm$ 0.06 a	nd	0.51 $\pm$ 0.09 a
K (mg/g DW)	3.52 $\pm$ 0.38 a	3.61 $\pm$ 0.27 a	3.75 $\pm$ 0.29 a
Ca (mg/g DW)	2.61 $\pm$ 0.27 a	2.79 $\pm$ 0.34 a	2.87 $\pm$ 0.24 a
Mg (mg/g DW)	4.57 $\pm$ 0.18 a	4.33 $\pm$ 0.15 a	4.26 $\pm$ 0.20 a
Fe (μ g/g DW)	10549 $\pm$ 767 a	11301 $\pm$ 1019 a	11099 $\pm$ 359 a
Cu (μ g/g DW)	18.6 $\pm$ 1.36 a	20.1 $\pm$ 1.81 a	18.7 $\pm$ 1.33 a
Mn (μ g/g DW)	911.0 $\pm$ 72.8 a	934.9 $\pm$ 34.2 a	976.5 $\pm$ 78.3 a

Supplementary Table S2. *Translocation factor* (TF, ratio of metal content in young or mature leaf to rhizome) and *bioaccumulation factor* of the leaves (BAF, ratio of metal content in young or mature leaf to soil metal content) for the quantified elements in the present study. Data are means ($n = 3$) and for the lucidity of table, SD values are not shown. Values within rows (separately for young or mature leaves) followed by the same letter, are not significantly different according to Tukey's test (at $P < 0.05$ level). Although Ni and Cd were applied as a foliar spray, TF and BAF values are comparable at least in control treatments with other species and other elements in all treatments. nd – not determined.

	young leaf			mature leaf		
<i>translocation factor</i>	control	Ni	Cd	control	Ni	Cd
Cd	0.424 b	nd	1.384 a	0.433 b	nd	2.091 a
Ni	0.049 b	0.094 a	nd	0.045 b	0.092 a	nd
K	3.535 a	4.162 a	3.814 a	2.349 a	2.807 a	2.258 a
Ca	0.264 a	0.265 a	0.253 a	1.472 a	1.601 a	1.525 a
Mg	0.291 a	0.317 a	0.369 a	0.974 b	0.961 b	1.345 a
Fe	0.022 a	0.021 a	0.016 a	0.031 a	0.029 a	0.030 a
Cu	1.059 a	1.024 a	0.973 a	0.485 a	0.341 b	0.261 b
Mn	0.083 a	0.077 a	0.081 a	0.119 a	0.084 a	0.092 a
<i>bioaccumulation factor</i>						
Cd	0.847 b	nd	9.302 a	0.873 b	nd	10.09 a
Ni	0.117 b	0.429 a	nd	0.108 b	0.427 a	nd
K	9.678 a	9.712 a	9.004 a	6.428 a	6.553 a	5.327 b
Ca	0.265 a	0.251 a	0.230 a	1.479 a	1.512 a	1.386 a
Mg	0.438 a	0.515 a	0.449 a	1.454 a	1.562 a	1.639 a
Fe	0.0038 a	0.0036 a	0.0025 b	0.0053 a	0.0051 a	0.0049 a
Cu	0.669 a	0.672 a	0.746 a	0.309 a	0.225 b	0.200 b
Mn	0.025 a	0.022 a	0.023 a	0.036 a	0.024 b	0.026 b

Supplementary Table S3. Accumulation of selected macronutrients and micronutrients in the fern *Adiantum raddianum* after 30 days of foliar application of exogenous Cd or Ni (1 μ M solution). Data are means $\pm$ SDs shown as bars ($n = 3$). Values within column for each organ, followed by the same letter(s), are not significantly different according to Tukey's test (at $P < 0.05$ level).

		K (mg/g DW)	Ca (mg/g DW)	Mg (mg/g DW)	Fe (μ g/g DW)	Cu (μ g/g DW)	Mn (μ g/g DW)
young leaf	control	34.1 $\pm$ 3.27 a	0.68 $\pm$ 0.041 a	1.99 $\pm$ 0.41 a	40.4 $\pm$ 3.20 a	12.4 $\pm$ 1.76 a	22.9 $\pm$ 2.45 a
	Ni	35.0 $\pm$ 2.58 a	0.69 $\pm$ 0.026 a	2.23 $\pm$ 0.17 a	40.9 $\pm$ 4.08 a	13.8 $\pm$ 2.16 a	20.7 $\pm$ 3.02 a
	Cd	33.6 $\pm$ 2.44 a	0.66 $\pm$ 0.054 a	1.91 $\pm$ 0.23 a	28.7 $\pm$ 3.55 b	13.2 $\pm$ 1.51 a	22.3 $\pm$ 3.74 a
mature leaf	control	22.6 $\pm$ 3.35 a	3.84 $\pm$ 0.32 a	6.63 $\pm$ 0.50 a	56.3 $\pm$ 3.79 a	5.77 $\pm$ 0.20 a	32.8 $\pm$ 3.12 a
	Ni	23.7 $\pm$ 2.53 a	4.18 $\pm$ 0.17 a	6.76 $\pm$ 0.51 a	57.6 $\pm$ 3.27 a	4.53 $\pm$ 0.32 b	22.6 $\pm$ 2.86 b
	Cd	20.0 $\pm$ 1.48 a	3.96 $\pm$ 0.15 a	6.97 $\pm$ 0.34 a	54.9 $\pm$ 5.32 a	3.72 $\pm$ 0.39 b	25.0 $\pm$ 3.35 ab
rhizome	control	9.65 $\pm$ 0.81 a	2.63 $\pm$ 0.45 a	6.81 $\pm$ 0.50 a	1832.8 $\pm$ 277.7 a	12.0 $\pm$ 1.60 a	277.3 $\pm$ 34.2 a
	Ni	8.47 $\pm$ 1.13 a	2.67 $\pm$ 0.26 a	7.03 $\pm$ 0.26 a	1948.0 $\pm$ 257.5 a	13.4 $\pm$ 1.91 a	268.2 $\pm$ 22.0 a
	Cd	8.95 $\pm$ 0.97 a	2.61 $\pm$ 0.23 a	5.18 $\pm$ 0.22 b	1816.4 $\pm$ 273.9 a	14.5 $\pm$ 1.52 a	276.6 $\pm$ 30.3 a

Supplementary Table S4. Pearson's correlation analysis between parameters in the **young leaves** of the fern *Adiantum raddianum* after 30 days of foliar application of exogenous Cd or Ni (1 μ M solution). * The corresponding correlation in R is considered significant as an off-diagonal element of P was smaller than the significance level of 0.05. Green and red numbers indicate significantly positive or negative values, respectively.

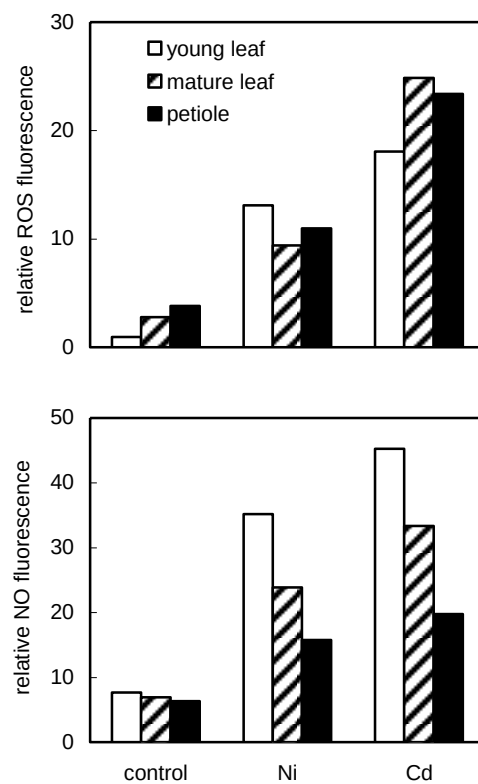
	AsA														
AsA	1	GSH													
GSH	0.725*	1	PC2												
PC2	-0.925*	-0.903*	1	TPC											
TPC	0.112	-0.009	-0.109	1	flav.										
flav.	-0.056	-0.204	0.044	0.772*	1	FAA									
FAA	0.415	0.116	-0.299	0.524	0.445	1	prot.								
prot.	0.220	-0.190	-0.068	0.103	0.030	0.432	1	SOD							
SOD	0.220	-0.190	-0.068	0.103	0.030	0.432	1.000*	1	CAT						
CAT	-0.827*	-0.957*	0.949*	-0.091	0.063	-0.227	0.221	0.221	1	K					
K	0.340	0.020	-0.147	0.401	-0.012	0.016	0.294	0.294	-0.045	1	Ca				
Ca	0.247	0.548	-0.497	0.201	0.276	0.366	0.254	0.254	-0.446	-0.353	1	Mg			
Mg	0.306	0.322	-0.416	-0.007	0.286	0.578	0.327	0.327	-0.341	-0.594	0.790*	1	Fe		
Fe	0.914*	0.771*	-0.860*	0.066	-0.127	0.283	-0.052	-0.052	-0.840*	0.339	0.143	0.115	1	Cu	
Cu	-0.442	-0.411	0.533	0.390	0.260	0.381	-0.217	-0.217	0.370	0.016	-0.286	-0.214	-0.346	1	Mn
Mn	-0.236	0.137	-0.022	0.336	0.072	-0.325	-0.268	-0.268	-0.076	-0.060	0.196	-0.188	-0.237	-0.108	1

Supplementary Table S5. Pearson's correlation analysis between parameters in the **mature leaves** of the fern *Adiantum raddianum* after 30 days of foliar application of exogenous Cd or Ni (1 μ M solution). * The corresponding correlation in R is considered significant as an off-diagonal element of P was smaller than the significance level of 0.05. Green and red numbers indicate significantly positive or negative values, respectively.

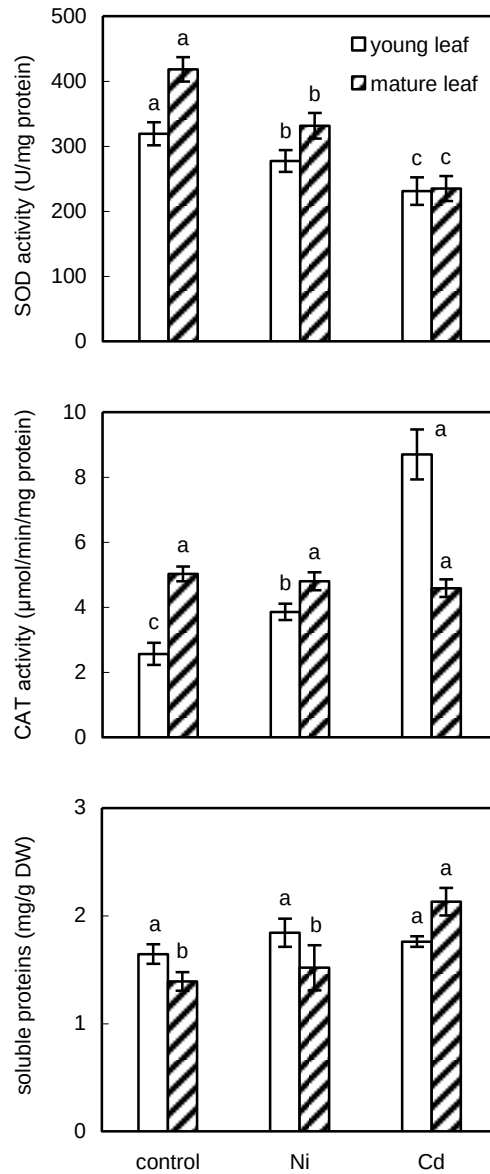
	AsA														
AsA	1	GSH													
GSH	0.957*	1	PC2												
PC2	-0.960*	-0.948*	1	TPC											
TPC	0.315	0.298	-0.300	1	flav.										
flav.	0.435	0.555	-0.386	0.310	1	FAA									
FAA	-0.875*	-0.879*	0.918*	-0.218	-0.257	1	prot.								
prot.	-0.924*	-0.939*	0.899*	-0.539	-0.529	0.778*	1	SOD							
SOD	-0.924*	-0.939*	0.899*	-0.539	-0.529	0.778*	1.000*	1	CAT						
CAT	0.661	0.622	-0.551	0.264	0.720*	-0.513	-0.555	-0.555	1	K					
K	0.654	0.645	-0.493	-0.123	0.461	-0.455	-0.504	-0.504	0.738*	1	Ca				
Ca	0.037	-0.001	-0.102	-0.285	-0.547	0.004	-0.065	-0.065	-0.639	-0.231	1	Mg			
Mg	-0.425	-0.370	0.249	-0.012	-0.401	0.300	0.224	0.224	-0.795*	-0.827*	0.636	1	Fe		
Fe	0.260	0.335	-0.142	0.000	-0.079	-0.235	-0.354	-0.354	-0.134	0.376	0.364	-0.073	1	Cu	
Cu	0.788*	0.769*	-0.721*	0.467	0.581	-0.664	-0.766*	-0.766*	0.568	0.394	-0.177	-0.370	0.174	1	Mn
Mn	0.269	0.255	-0.307	0.537	0.384	-0.441	-0.267	-0.267	0.455	-0.146	-0.605	-0.183	-0.359	0.571	1

Supplementary Table S6. Pearson's correlation analysis between parameters in the **rhizome** of the fern *Adiantum raddianum* after 30 days of foliar application of exogenous Cd or Ni (1 μ M solution). * The corresponding correlation in R is considered significant as an off-diagonal element of P was smaller than the significance level of 0.05. Green and red numbers indicate significantly positive or negative values, respectively.

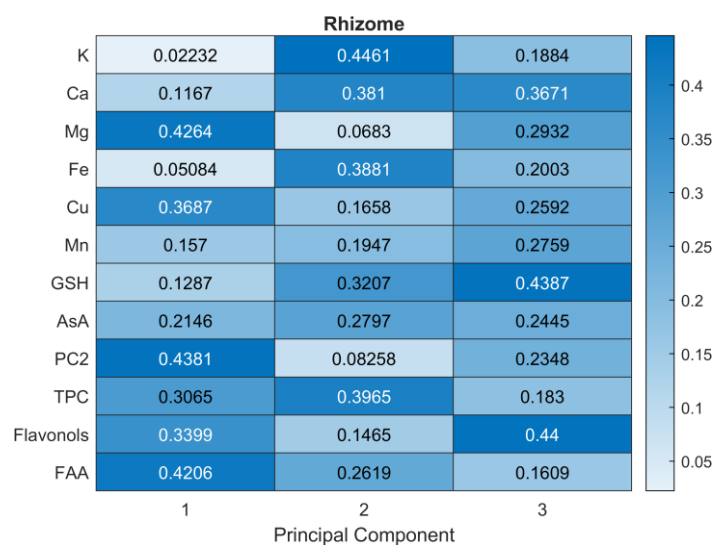
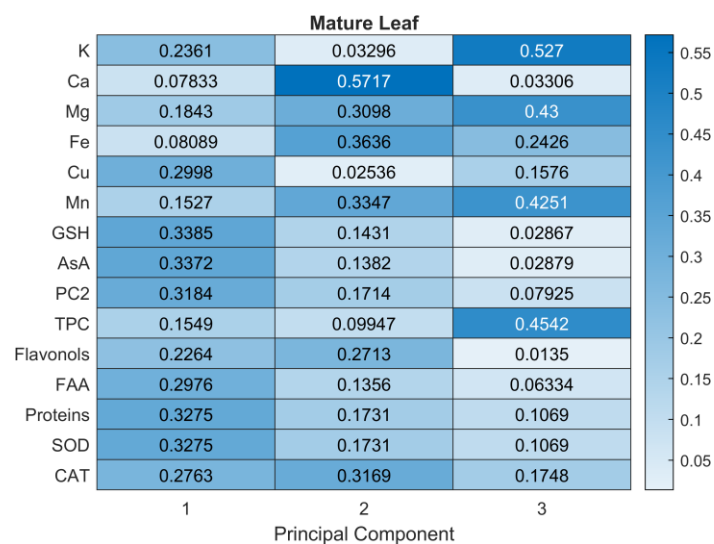
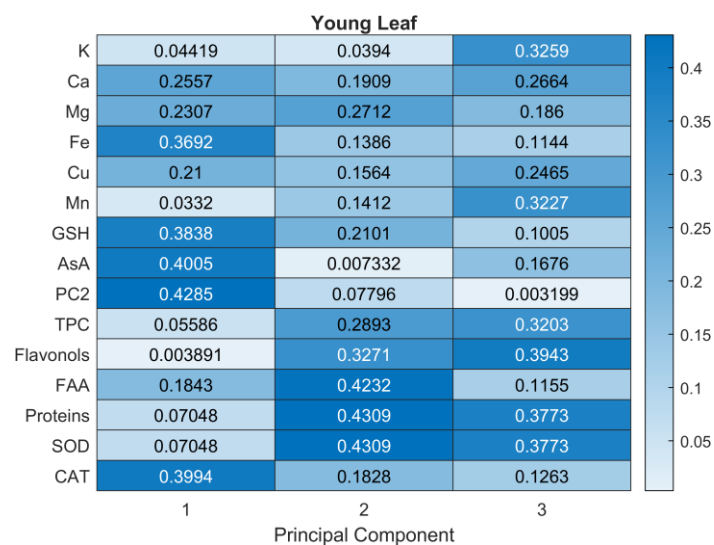
	AsA												
AsA	1	GSH											
GSH	0.586	1	PC2										
PC2	-0.256	-0.282	1	TPC									
TPC	0.086	0.067	-0.647	1	flav.								
flav.	-0.308	0.058	0.292	-0.082	1	FAA							
FAA	-0.031	0.263	0.763*	-0.718*	0.550	1	K						
K	-0.253	-0.480	-0.027	0.596	0.059	-0.455	1	Ca					
Ca	-0.038	-0.234	0.027	0.405	0.593	0.000	0.312	1	Mg				
Mg	0.286	0.432	-0.906*	0.689*	-0.291	-0.646	-0.122	0.047	1	Fe			
Fe	0.441	0.367	-0.204	-0.402	0.086	0.145	-0.435	-0.296	0.015	1	Cu		
Cu	-0.301	0.074	0.513	-0.025	0.801*	0.610	0.259	0.392	-0.438	-0.237	1	Mn	
Mn	-0.290	-0.300	-0.066	-0.083	0.474	0.127	-0.142	0.530	-0.028	-0.085	0.185	1	



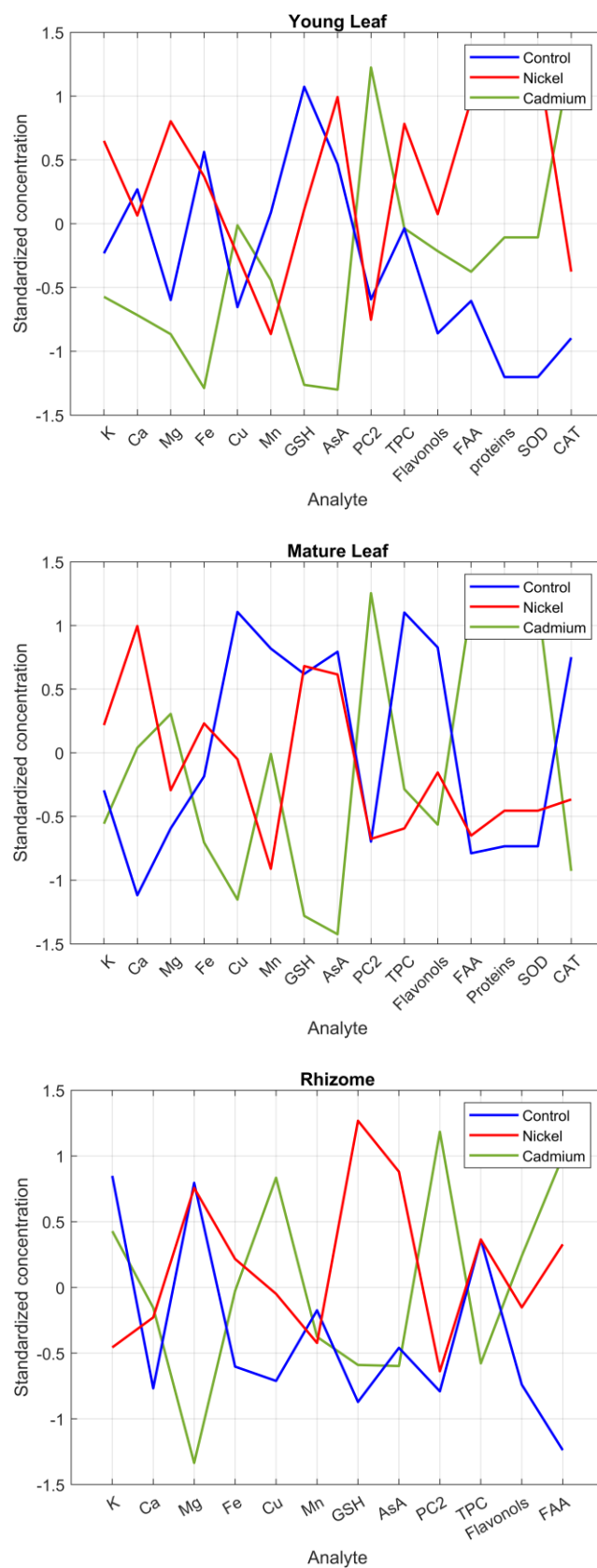
Supplementary Figure S1. Relative ROS and NO fluorescence from photos presented in the Fig. 2 in the main text. Note that the impact of Cd on the ROS formation was higher than the impact of Ni while the impact of Cd and Ni on the NO signal was similar in mature leaf and petiole.



Supplementary Figure S2. Activities of superoxide dismutase (SOD) and catalase (CAT) and amount of soluble proteins in the fern *Adiantum raddianum* after 30 days of foliar application of exogenous Cd or Ni (1 μ M solution). Control means plants without exogenous application of metals. Data are means $\pm$ SDs shown as bars ($n = 3$). Columns for young or mature leaves, followed by the same letter, are not significantly different according to Tukey's test (at $P < 0.05$ level).



Supplementary Figure S3. Heat maps of the analyte loadings on the three components.



Supplementary Figure S4. Median values of standardized concentrations of individual analytes in different plant organs.