Supplementary Materials

Evaluation of Metal(loids) Concentrations in Soils of Selected Rice Paddy Fields in Malawi

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Tables

Table S1. ICP-MS (ICP-MS/MS) optimal conditions

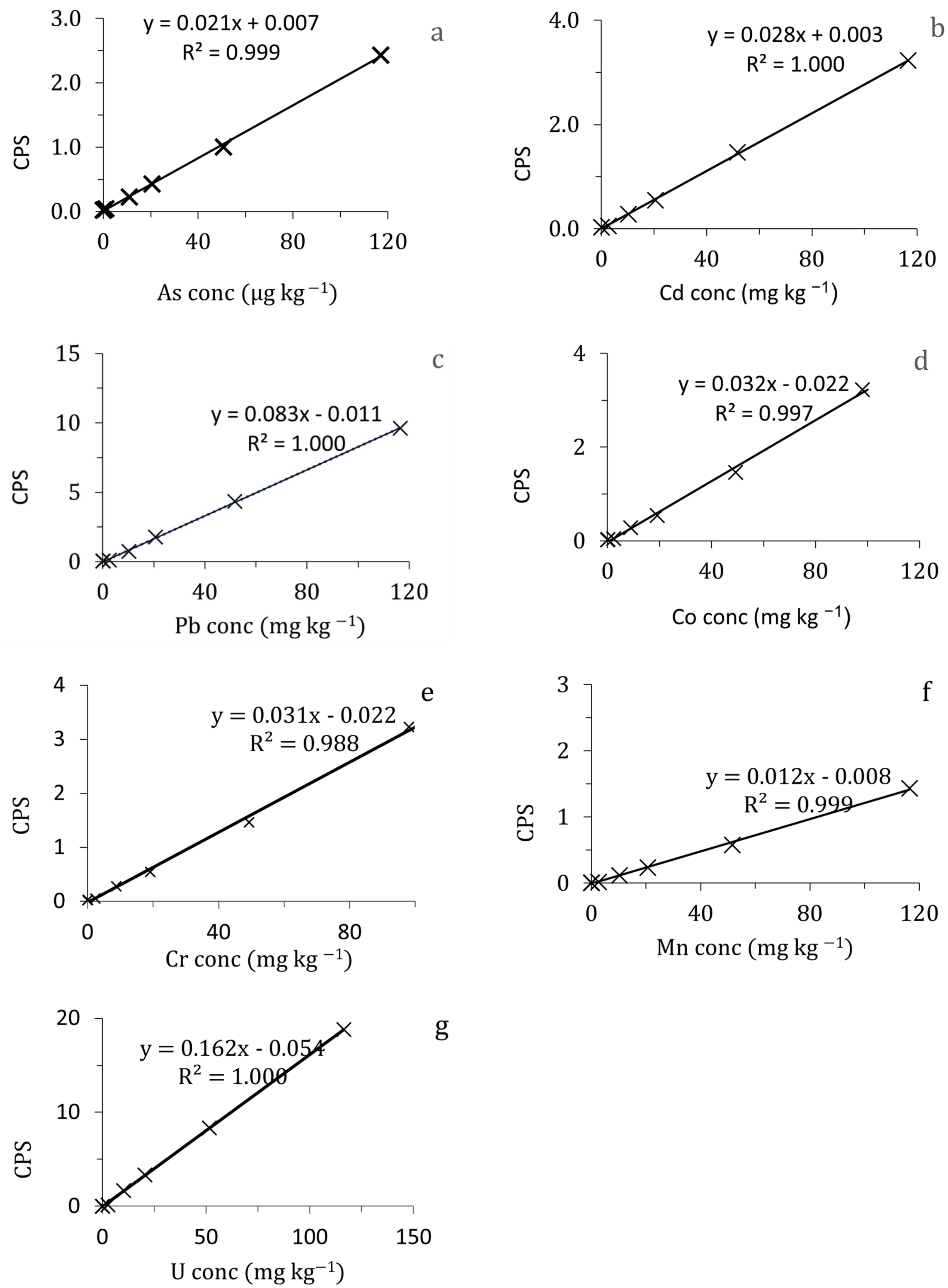
Parameter	Value
RF power	1550 W
RF matching	1.72 V
Nebulizer gas flow rate	1.1 L/min
Sample depth	9.0 mm
Nebulizer pump	0.10 rps
Auxiliary gas	0.8 L/min
Plasma gas (argon)	15.0 L/min
He gas flow rate	4.0 - 4.2 L/min
H2 gas flow rate	4.0 - 4.2 L/min
Sample introduction	double pass spray chamber
Sample introduction method	micro-mist
Sample flow rate	0.8 - 1 mL/min
Integration time	0.3 - 10 s

Table S2. List of metal(loids) analysed in this study showing Mass charge (m/z) ratio and gas modes.

Element	m/z ratio	Gas mode
As	75	H2
Cd	111	He
Co	59	He
Cr	52	He
Mn	55	He
Pb	208	He
Ga	71	He
U	238	He

Table S3. Descriptive statistics of metal(loids) concentrations (mg kg^{-1}) in soils of various rice fields (n=66). All analyses were performed in triplicates.

Site name	Site #	Abbr.	pH	AS	Cr	Co	Mn	Pb	Cd	U	Ga
Lifuwu	11	LFW (n=4)	8.3	3.3±0.6	87±10	17±1	403±79	16±2	0.033±0.01	2.3±0.3	39±±4
North Rumphi	4	NRU (n=4)	6.58	2.8±1.0	38±33	9±6	225±178	12±4	0.021±0.01	2.3±0.7	17±2
Domasi	17	DOM (n=3)	5.61	2.8±0.2	17± 4	6±1	320±12	13±1	0.034±0.02	2.3±0.2	19±3
Salima	10, 12, 13 14,	SA (n=4)	6.86	2.5±0.5	128±26	28±1	729±14	12±1	0.067±0.06	1.9±0.1	33±6
Balaka	17, 18	BLK (n=6)	5.91	2.4±0.4	127±45	27±6	1097±473	7± 1	0.093±0.04	1.5±0.1	26±4
Hara	3	HAR (n=6)	6.20	2.4±1.2	59±22	14±4	501±179	12±4	0.028±0.03	2.6±0.9	29±5
Bwanje	15, 16a, 16b	BWJ (n=4)	6.13	2.3±0.4	59±7	15±1	429±60	7± 1	0.022±0.10	1.6±0.1	24±2
Nkhate	21, 22	NKT (n=3)	6.82	2.1±0.3	136±30	29±6	776±284	11±2	0.086±0.02	1.7±0.1	26±2
Kasinthula	20	KAS (n=4)	6.82	2.0±0.2	54±9	16±2	511±124	6± 3	0.043±0.01	2.0±0.3	17±2
Lifiliya	1,2	LFY (n=5)	6.56	2.0±0.2	135±40	25±2	855±67	15±3	0.043±0.03	2.8±0.2	29±4
Nkhotakota	7, 8, 9	KK (n=8)	6.15	1.8±0.3	108±47	26±4	611±125	12±3	0.057±0.02	1.9±0.1	30±7
Khanda	19, 19b	KHA (n=6)	6.31	1.7±0.9	44± 25	16±8	426±445	7±3	0.025±0.02	1.5±0.2	20±5
Limphasa	5, 6	LPH (n=10)	4.91	1.2±0.4	30±11	11±3	651±264	16±5	0.011±0.01	2.8±0.5	21±1
Nazolo	21	NAZ (n=4)	6.62	1.2±0.2	71±38	22±4	883±193	5±1	0.050±0.01	1.3±0.1	15±3
		Summary									
		Mean		1.9±0.60	81±42	14±7	601±245	10±4	0.044±0.024	1.3±0.5	24±6
		Median		2.2	65	16	561	12	0.038	1.9	25
		Min		1.2	17	6	225	5	0.011	1.3	15
		Max		3.3	136	29	1097	16	0.093	2.8	35



a
y = 0.021x + 0.007
R² = 0.999
CPS
3.0
2.0
1.0
0.0
0
40
80
120
As conc (µg kg −1)
b
y = 0.028x + 0.003
R² = 1.000
CPS
4.0
2.0
0.0
0
40
80
120
Cd conc (mg kg −1)
c
y = 0.083x - 0.011
R² = 1.000
CPS
15
10
5
0
0
40
80
120
Pb conc (mg kg −1)
d
y = 0.032x - 0.022
R² = 0.997
CPS
4
2
0
0
40
80
120
Co conc (mg kg −1)
e
y = 0.031x - 0.022
R² = 0.988
CPS
4
3
2
1
0
0
40
80
Cr conc (mg kg −1)
f
y = 0.012x - 0.008
R² = 0.999
CPS
3
2
1
0
0
40
80
120
Mn conc (mg kg −1)
g
y = 0.162x - 0.054
R² = 1.000
CPS
20
10
0
0
50
100
150
U conc (mg kg−1)

Figure S1. External calibration using accu-Trace multi-element indicating calibration curve for As (a), Cd (b), Pb (c), Co (d), Cr (e), Mn (f) and U (g). CPS, counts per second. External calibration was carried out using standards prepared from an accu-Trace multi-element standard solution diluted with 5% nitric acid (obtained from Mallinckrodt Chemicals, USA) [1,2]. For each analytical run (batch), mass charge ratios of As (m/z = 75), Cd (m/z = 110), Co (m/z = 59), Cr (m/z =52), Mn (m/z = 51), Pb (m/z = 208), U (m/z = 205), and Ga (m/z = 73) were selected for analyses and a six-point external calibration curve of 0, 1.0, 5.0, 25, 50, and 100 µg kg^{-1} was used [3,4].

1. Sun, G.X.; Williams, P.N.; Carey, A.M.; Zhu, Y.G.; Deacon, C.; Raab, A.; Feldmann, J.; Islam, R.M.; Meharg, A.A. Inorganic Arsenic in Rice Bran and Its Products Are an Order of Magnitude Higher than in Bulk Grain. *Environ. Sci. Technol.* **2008**, *42*, 7542–7546, doi:10.1021/es801238p.
2. Bücker, P.; Raab, A.; P, H. Analytica Chimica Acta Validation and Inter-Laboratory Study of Selective Hydride Generation for Fast Screening of Inorganic Arsenic in Seafood Tursd O. **2018**, doi:10.1016/j.aca.2018.11.036.
3. Mlangeni, A.T.; Lancaster, S.T.; Raab, A.; Krupp, E.M.; Norton, G.J.; Feldmann, J. Impact of Soil-Type , Soil-PH , and Soil-Metal (Loids) on Grain-As and Cd Accumulation in Malawian Rice Grown in Three Regions of Malawi. *Environ. Adv.* **2022**, *7*, 100145, doi:10.1016/j.envadv.2021.100145.
4. Mlangeni, A.T.; Perez, M.; Raab, A.; Krupp, E.M.; Norton, G.J.; Feldmann, J. Simultaneous Stimulation of Arsenic Methylation and Inhibition of Cadmium Bioaccumulation in Rice Grain Using Zero Valent Iron and Alternate Wetting and Drying Water Management. *Sci. Total Environ.* **2020**, *711*, 134696, doi:10.1016/j.scitotenv.2019.134696.