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Figure.S1. Effects of application of mineral based potassium humate (MBPH) on pH (A-C), DOC (D-F), and K (G-I) in soil solution at different growth stages of rice under different soil contaminated levels. DOC, dissolved organic carbon; S-Cd, slightly contaminated soil (1 mg kg⁻¹); M-Cd, moderately contaminated soil (2 mg kg⁻¹); H-Cd, highly contaminated soil (4 mg kg⁻¹). Lowercase letters indicate significant differences in different MBPH levels under the same Cd-contaminated soil; capital letters indicate significant differences among different Cd-contaminated soils at the same level of MBPH application ($p < 0.05$, Duncan test and Kruskal–Wallis test).

Figure.S2. Effects of application of mineral based potassium humate (MBPH) on the antioxidant enzyme activities of rice leaves at tillering stage under different soil contaminated levels. SOD (A), superoxide dismutase; POD (B), peroxidase, CAT (C), catalase; S-Cd, slightly contaminated soil (1 mg kg⁻¹); M-Cd, moderately contaminated soil (2 mg kg⁻¹); H-Cd, highly contaminated soil (4 mg kg⁻¹). Lowercase letters indicate significant differences in different MBPH levels under the same Cd-contaminated soil; capital letters indicate significant differences among different Cd-contaminated soils at the same level of MBPH application ($p < 0.05$, Duncan test and Kruskal–Wallis test).

Figure.S3. Prediction equation validation in S-Cd (A), slightly contaminated soil (1 mg kg⁻¹); M-Cd (B), moderately contaminated soil (2 mg kg⁻¹); H-Cd (C), highly contaminated soil (4 mg kg⁻¹); All the data (D).

Figure.S4. Spearman correlation matrix for Cd concentration in brown rice and agronomic traits of rice. Diagonal shows the variable distribution diagram; the top right of the diagonal shows the Spearman correlation coefficient the level of significance ($p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***). S-Cd (A), slightly contaminated soil (1 mg kg⁻¹); M-Cd (B), moderately contaminated soil (2 mg kg⁻¹); H-Cd (C), highly contaminated soil (4 mg kg⁻¹); All the data (D). Cd, Cd concentration in brown rice; PH, Plant height; SL, spike length; TKW, thousand kernel weight; SDW, stem dry weight; OLDW, ordinary leaves dry weight; FLDW, flag leaves dry weight; ADMA, dry matter accumulation of aboveground; RDW, root dry weight.

Table S1 FTIR spectroscopic functional group attribution of mineral based potassium humate (MBPH) and soils.

Peaks (cm ⁻¹)	Tentative assignments of functional groups	References
3686, 3619, 3616	O-H stretching vibration of alcohols, phenols and clay	[90,91]
3189	O-H and N-H stretching vibration of alcohols, phenols and amine	[91,92]
1637	C=O stretching vibration of aromatic series	[91,93]
1564	Amide II band in organic matter	[94]
1434, 1372	-COOH stretching vibration of carboxylate	[95]
1008	C-O stretch of cellulose	[90]
981	C-O stretch of polysaccharide	[96]
912	O-H bend of carboxylic acids	[97]
879, 872	CO ₃ ²⁻	[98,99]
778	C-H, CO ₃ ²⁻	[99]
754	C-H bending aromatic CH out-of-plane deformation	[100]
694	C-H groups of aromatic series	[93]
666	O-H libration	[101]
530, 514, 464	Si-O bending vibration	[102,103]

Table S2 Effects of application of mineral based potassium humate (MBPH) on the growth of rice (*Oryza sativa* L.) under different soil contaminated levels.

Soil Cd contaminated level	MBPH dose	PH	SL	TKW	SDW	OLDW	FLDW	ADMA ^a	RDW
		cm		g					
S-Cd	0% (CK)	81.97±3.61	14.61±0.45Ab	25.50±1.12Ab	13.93±1.06Ab	4.92±0.80Aa	0.52±0.04Ac	19.37±1.81Ab	3.18±0.22Ab
	0.25%	79.93±1.01	15.93±0.24Aa	26.84±1.12Aab	15.57±0.32Aab	5.19±0.52Aa	0.67±0.09Ab	21.43±0.82Aab	3.82±0.58Aab
	0.5%	83.07±2.06	15.67±0.54ABa	25.09±1.00Bb	17.12±2.50Aa	5.78±0.50Aa	1.31±0.06Aa	24.21±2.98Aa	4.33±0.68Aa
	1%	79.93±2.20	16.44±0.56Aa	28.29±1.60Aa	13.52±1.48Bb	5.09±0.79Aa	0.57±0.06Abc	19.18±2.27Ab	3.67±0.40Aab
M-Cd	0% (CK)	85.93±4.14	15.53±1.07Aa	25.25±0.38Aa	13.09±0.39Ab	4.86±0.51Aa	0.42±0.05Ba	18.36±0.71Ab	3.29±0.30Ab
	0.25%	86.07±4.05	16.01±0.41Aa	24.57±0.82Ba	15.02±1.02Aab	4.74±0.32Aa	0.39±0.05Ba	20.15±1.26Aab	3.49±0.15Ab
	0.5%	81.47±3.39	14.77±0.28Ba	25.81±0.58ABa	16.29±1.39Aa	4.68±1.09ABa	0.40±0.15Aa	21.37±2.29ABab	4.17±0.03Aa
	1%	82.20±2.31	15.12±0.39Ba	25.49±1.12Ba	16.64±1.31Aa	5.46±0.58Aa	0.64±0.26Aa	22.73±2.15Aa	4.20±0.48Aa
H-Cd	0% (CK)	80.83±1.82	14.33±0.80Ab	25.22±0.93Aa	12.64±0.43Ab	4.61±0.16Aa	0.28±0.02Ca	17.53±0.47Ac	3.00±0.35Ab
	0.25%	81.87±0.81	16.30±0.42Aa	26.48±1.23ABa	12.81±0.57Bb	4.72±0.56Aa	0.34±0.11Ba	17.87±1.00Bc	3.41±0.28Aab
	0.5%	81.17±3.74	16.01±0.80Aa	27.01±0.19Aa	14.71±0.71Aa	4.14±0.17Ba	0.37±0.02Aa	19.22±0.75Bb	3.26±0.17Bab
	1%	81.57±0.97	15.26±0.62Bab	25.84±1.12ABa	15.78±0.55ABa	4.72±0.48Aa	0.41±0.09Aa	20.91±0.20Aa	3.68±0.34Aa

^a ADMA = SDW+OLDW+FLDW. S-Cd, slightly contaminated soil (1 mg kg⁻¹); M-Cd, moderately contaminated soil (2 mg kg⁻¹); H-Cd, highly contaminated soil (4 mg kg⁻¹). PH, Plant height; SL, spike length; TKW, thousand kernel weight; SDW, stem dry weight; OLDW, ordinary leaves dry weight; FLDW, flag leaves dry weight; ADMA, dry matter accumulation of aboveground; RDW, root dry weight. Lowercase letters indicate significant differences in different MBPH levels under the same Cd-contaminated soil; capital letters indicate significant differences among different Cd-contaminated soils at the same level of MBPH ($p<0.05$, Duncan test and Kruskal–Wallis test).

Table S3 Effects of application of mineral based potassium humate (MBPH) on photosynthetic parameters and SPAD under different soil contaminated levels.

Soil Cd contaminated level		S-Cd				M-Cd				H-Cd			
MBPH dose		0% (CK)	0.25%	0.5%	1%	0% (CK)	0.25%	0.5%	1%	0% (CK)	0.25%	0.5%	1%
Pn	Tilling	17.1±0.41	19.6±1.53	21.1±2.13	20.3±1.96	20.2±2.84	21.3±3.47	19.7±2.76	21.6±1.35	14.6±2.58	21.1±2.23	18.9±1.64	19.5±0.14
		ABb	Aab	Aa	Aa	Aa	Aa	Aa	Aa	Bb	Aa	Aa	Aa
	Filling	7.93±0.585	7.98±2.17	11.0±3.27	7.87±1.59	6.52±1.30	12.1±2.64	13.8±0.92	9.74±0.2	7.12±0.42	9.55±3.67	11.7±1.10	11.1±2.89
		Aa	Aa	Aa	Aa	Ab	Aab	Aa	Aab	Aa	Aa	Aa	Aa
	Maturity	1.27±0.0161	1.65±0.78	2.57±0.47	2.37±0.68	0.9±0.18	1.89±0.29	1.33±0.0094	2.42±0.71	0.85±0.049	3.03±0.001	1.97±0.1	2.48±0.43
		Aa	Aa	Aa	Aa	Bb	Aa	Ca	Aa	Bc	Aa	Bb	Ab
Tr	Tilling (10 ⁻³)	5.39±0.754	4.97±0.87	5.38±0.37	3.99±1.15	5.55±1.04	5.69±0.26	4.24±1.85	5.82±0.48	3.6±0.3	5.23±0.75	4.89±0.83	4.86±0.21
		ABa	Aa	Aa	ABa	Aa	Aa	Aa	Aa	Bb	Aa	Aa	Ba
	Filling (10 ⁻³)	2.09±1.12	2.28±0.96	3.72±1.47	3.56±2.09	1.86±1.05	3.87±0.81	3.57±0.41	2.66±0.53	2.52±0.2	3.21±2.02	2.82±1.03	2.69±0.27
		Aa	Aa	Aa	Aa	Ab	Aa	Aa	Aab	Aa	Aa	Aa	Aa
	Maturity (10 ⁻⁴)	3.12±1.15	6.41±2.26	9.4±5.74	5.68±0.91	4.45±2.84	10.4±3.09	4.72±1.88	4.12±2.01	1.18±0.15	7.42±0.88	3.47±0.34	7.56±0.79
		Aa	Aa	Aa	ABa	Ab	Aa	Ab	Bb	Ac	Aa	Ab	Aa
Ci	Tilling	309±2.79	317±6.00	315±7.20	308±22.3	317±0.85	318±13.0	294±32.3	316±1.15	316±17.9	310±0.85	311±4.76	310±0.87
		Aa	Aa	Aa	Aa	Aa	Aa	Aa	Aa	Aa	Aa	Aa	Aa
	Filling	257±83.5	278±14.2	292±19.0	300±59.6	266±50.9	295±14.1	269±15.5	278±24.7	304±13.8	293±21.1	256±41.3	260±44.1
		Aa	Aa	Aa	Aa	Aa	Aa	Aa	Aa	Aa	Aa	Aa	Aa
	Maturity	279±38.9	327±10.1	298±60.0	286±16.5	322±38.5	338±23.2	306±44.7	214±92.9	206±34.9	284±13.0	306±56.7	318±30.2
		ABa	Aa	Aa	Aa	Aab	Aa	Aab	Ab	Bb	Ba	Aa	Aa

Continued Table S3.

Soil Cd contaminated level		S-Cd				M-Cd				H-Cd			
MBPH dose		0% (CK)	0.25%	0.5%	1%	0% (CK)	0.25%	0.5%	1%	0% (CK)	0.25%	0.5%	1%
gs	Tilling	0.95±0.28	1.03±0.39	1.02±0.14	0.65±0.24	1.14±0.4	1.25±0.17	0.77±0.46	1.21±0.19	0.54±0.067	0.94±0.22	0.8±0.24	0.79±0.012
		ABa	Aa	Aa	ABa	Aa	Aa	Aa	Aa	Bb	Aa	Aab	Bab
	Filling	0.15±0.11	0.137±0.059	0.22±0.09	0.234±0.15	0.11±0.059	0.24±0.062	0.22±0.028	0.17±0.039	0.15±0.016	0.21±0.15	0.17±0.079	0.16±0.017
		Aa	Aa	Aa	Aa	Ab	Aa	Aa	Aab	Aa	Aa	Aa	Aa
	Maturity (10 ⁻²)	2.1±0.76	4.24±1.7	6.1±3.8	3.7±0.65	2.8±1.7	7±2.3	3±1.3	2.7±1.3	0.75±0.1	4.8±0.61	2.2±0.24	6.2±2.3
		Aa	Aa	Aa	ABa	Ab	Aa	Ab	Bb	Ab	Aa	Aa	Aa
SPAD	Tilling	50.1±0.15	50.5±0.4	53.6±0.3	51.8±0.5	49±0.7	51.1±1.21	50.6±1.57	49.6±0.25	46.3±0.78	50.4±1.06	48.9±1.3	48.9±0.71
		Ac	Ac	Aa	Ab	Aa	Aa	Ba	Ba	Bb	Aa	Ba	Ba
	Filling	49.5±0.35	50.8±0.35	53.2±0.31	51.7±0.84	48±0.4	53.8±0.4	54.4±0.21	56±1.24	45±0.76	49.5±0.058	52.1±0.36	54.5±0.45
		Ad	Bc	Ba	Bb	Bc	Ab	Aab	Aa	Cd	Cc	Cb	Aa
	Maturity	18.5±1.08	21.7±1.94	26.7±0.57	23.9±0.25	15.4±2.47	21.1±1.93	22.8±1.05	22.5±1.80	9.23±1.89	12.1±0.87	18±0.85	21.9±1.59
		Ad	Ac	Aa	Ab	Ab	Aa	Ba	Aa	Bd	Bc	Cb	Aa
F _v /F _m	Tilling	0.69±0.016	0.72±0.013	0.73±0.012	0.72±0.011	0.64±0.0081	0.72±0.0024	0.73±0.0049	0.74±0.003	0.62±0.005	0.71±0.013	0.71±0.022	0.70±0.012
		Ab	Aa	Aa	ABa	Bd	Ac	Ab	Aa	Cb	Aa	Aa	Ba
	Filling	0.75±0.0035	0.75±0.017	0.75±0.0078	0.78±0.0081	0.72±0.0066	0.78±0.0085	0.79±0.0026	0.80±0.0042	0.70±0.0051	0.75±0.014	0.78±0.011	0.77±0.0074
		Ab	Bb	Bb	Ba	Bc	Ab	Aab	Aa	Cc	Bb	Aa	Bab
	Maturity	0.47±0.054	0.43±0.077	0.48±0.023	0.45±0.04	0.39±0.034	0.38±0.05	0.36±0.056	0.46±0.035	0.34±0.058	0.49±0.033	0.52±0.1	0.56±0.091
		Aa	Aa	ABa	Aa	ABab	Ab	Bb	Aa	Bb	Aa	Aa	Aa

S-Cd, slightly contaminated soil (1 mg kg⁻¹); M-Cd, moderately contaminated soil (2 mg kg⁻¹); H-Cd, highly contaminated soil (4 mg kg⁻¹). Pn, net photosynthetic rate (μmol mol⁻¹); Tr, transpiration rate (μmol mol⁻¹); Ci, substomatal CO₂ concentration (mol m⁻² s⁻¹); gs, stomatal conductance (mol m⁻² s⁻¹); SPAD, soil and plant analysis development; F_v/F_m, maximal photochemical efficiency of PS II. Lowercase letters indicate significant differences in different MBPH levels under the same Cd-contaminated soil; capital letters indicate significant differences among different Cd-contaminated soils at the same level of MBPH ($p < 0.05$, Duncan test and Kruskal–Wallis test).

Table S4 Effects of application of mineral based potassium humate (MBPH) on transfer factors (TFs) of Cd between different organs of rice under different soil contaminated levels.

Soil Cd contaminated level	MBPH dose	TF _{root-stem}	TF _{stem-ordinary leaf}	TF _{stem-flag leaf}	TF _{stem-brown rice}	TF _{ordinary leaf-brown rice}	TF _{flag leaf-brown rice}
S-Cd	0% (CK)	0.21±0.054ABb	0.37±0.12Aa	0.22±0.047Ba	0.29±0.064Aa	0.78±0.066Aa	1.31±0.15Aa
	0.25%	0.27±0.024Bab	0.26±0.019Ba	0.22±0.045Ba	0.17±0.018Ba	0.66±0.056Abc	0.78±0.11Abc
	0.50%	0.6±0.17Aa	0.31±0.016Ba	0.25±0.016Ba	0.18±0.005Ba	0.59±0.023Bc	0.73±0.07A1c
	1%	0.5±0.049Aa	0.28±0.066Ba	0.21±0.064Ba	0.21±0.054Ba	0.72±0.046Bab	1.01±0.19Ab
M-Cd	0% (CK)	0.29±0.039Ab	0.33±0.02Aa	0.24±0.017Ba	0.20±0.022Ba	0.61±0.037Bb	0.85±0.093Ba
	0.25%	0.36±0.041Aa	0.28±0.05Bab	0.19±0.040Bab	0.12±0.021Cb	0.44±0.035Bc	0.66±0.091Ab
	0.50%	0.28±0.01Ab	0.18±0.008Cb	0.20±0.005Cab	0.14±0.019Cb	0.74±0.072Aa	0.68±0.094Ab
	1%	0.35±0.027Ba	0.18±0.003Cb	0.16±0.004Bb	0.15±0.011Cb	0.82±0.051Aa	0.93±0.061Aa
H-Cd	0% (CK)	0.20±0.013Bc	0.35±0.027Ac	0.30±0.025Ac	0.23±0.011ABc	0.64±0.027Ba	0.74±0.053Ba
	0.25%	0.25±0.038Bbc	0.43±0.03Ab	0.38±0.016Ab	0.25±0.012Abc	0.59±0.035Aab	0.67±0.044Aab
	0.50%	0.28±0.052Ab	0.48±0.023Aab	0.46±0.013Aa	0.27±0.019Aab	0.56±0.032Bb	0.59±0.03Ab
	1%	0.44±0.033Aa	0.53±0.045Aa	0.48±0.041Aa	0.29±0.013Aa	0.54±0.024Cb	0.60±0.027Bb

S-Cd, slightly contaminated soil (1 mg kg⁻¹); M-Cd, moderately contaminated soil (2 mg kg⁻¹); H-Cd, highly contaminated soil (4 mg kg⁻¹). Lowercase letters indicate significant differences in different MBPH levels under the same Cd-contaminated soil; capital letters indicate significant differences among different Cd-contaminated soils at the same level of MBPH ($p < 0.05$, Duncan test and Kruskal–Wallis test).

Table S5 Spearman correlation among soil solution chemistry, minerals in brown rice, photosynthetic and chlorophyll fluorescence characteristics, enzyme activity of leaves, soil DTPA-Cd and Cd in brown rice under S-Cd soils.

	TpH	FpH	MpH	TDOC	FDOC	MDOC	TK	FK	MK	Fe in brown rice	Mn in brown rice	Cu in brown rice	Zn in brown rice	K in brown rice
Cd in brown rice	-0.354	-0.860***	-0.713**	-0.874***	-0.406	-0.706*	-0.958***	-0.853***	-0.860***	0.531	-0.021	-0.811**	-0.783**	-0.860***
TpH	1	0.473	0.035	0.277	0.382	0.263	0.487	0.48	0.242	-0.263	-0.088	0.347	0.256	0.333
FpH		1	0.755**	0.650*	0.413	0.552	0.818**	0.797**	0.692*	-0.601*	-0.028	0.657*	0.657*	0.713**
MpH			1	0.615*	0.399	0.587*	0.650*	0.524	0.734**	-0.455	-0.07	0.385	0.685*	0.678*
TDOC				1	0.413	0.629*	0.839***	0.650*	0.839***	-0.273	0.196	0.615*	0.783**	0.944***
FDOC					1	0.497	0.497	0.357	0.413	0.091	0.483	0.105	0.531	0.503
MDOC						1	0.790**	0.462	0.629*	-0.657*	-0.259	0.469	0.720**	0.622*
TK							1	0.818**	0.867***	-0.545	-0.007	0.797**	0.804**	0.846***
FK								1	0.811**	-0.392	0.154	0.755**	0.615*	0.566
MK									1	-0.329	0.161	0.629*	0.762**	0.769**
Fe in brown rice										1	0.678*	-0.483	-0.322	-0.315
Mn in brown rice											1	0.021	0.231	0.147
Cu in brown rice												1	0.706*	0.580*
Zn in brown rice													1	0.741**
K in brown rice														1
	TF _{root-stem}	TF _{stem} -ordinary leaf	TF _{stem} -flag leaf	TF _{stem} -brown rice	TF _{ordinary} leaf-brown rice	TF _{flag} leaf-brown rice	TPn	FPn	MPn	TTr	FTr	MTr	TCi	FCi
Cd in brown rice	-0.776**	0.28	-0.049	0.378	0.238	0.294	-0.552	-0.14	-0.643*	-0.503	-0.413	-0.594*	-0.056	-0.238
TpH	0.259	-0.361	0.14	-0.368	-0.102	-0.326	0.424	0.193	0.361	0.116	0.221	0.609*	-0.294	0.077
FpH	0.650*	-0.294	-0.119	-0.448	-0.105	-0.168	0.343	0.182	0.755**	0.238	0.329	0.601*	0.028	0.21

Continued Table S5.

	TF _{root-stem}	TF _{stem} -ordinary leaf	TF _{stem} -flag leaf	TF _{stem} -brown rice	TF _{ordinary} leaf-brown rice	TF _{flag} leaf-brown rice	TPn	FPn	MPn	TTr	FTr	MTr	TCi	FCi
MpH	0.678*	0.014	-0.252	-0.252	-0.189	0.098	0.266	0.203	0.503	0.21	0.42	0.133	-0.014	0.49
TDOC	0.853***	-0.294	0.091	-0.371	-0.371	-0.35	0.636*	0.042	0.427	0.671*	0.378	0.406	0.056	0.28
FDOC	0.629*	-0.329	-0.035	-0.706*	-0.678*	-0.622*	0.517	0.392	0.399	0.266	0.273	0.608*	-0.231	0.014
MDOC	0.762**	0.042	0.021	-0.154	-0.196	-0.098	0.427	0.42	0.434	0.462	0.51	0.371	0.014	0.287
TK	0.797**	-0.238	0.175	-0.315	-0.231	-0.378	0.685*	0.154	0.594*	0.559	0.427	0.615*	0	0.238
FK	0.448	-0.469	0.07	-0.399	-0.014	-0.28	0.462	0.077	0.399	0.462	0.259	0.629*	0.217	0.105
MK	0.678*	-0.266	0.119	-0.203	-0.098	-0.231	0.636*	-0.063	0.259	0.664*	0.287	0.294	0.21	0.294
Fe in brown rice	-0.28	-0.301	-0.021	-0.238	-0.245	-0.315	-0.007	-0.175	-0.517	0.049	-0.224	-0.175	0.07	-0.098
Mn in brown rice	0.154	-0.35	0.259	-0.469	-0.497	-0.720**	0.413	-0.028	-0.147	0.364	-0.056	0.315	0.119	-0.203
Cu in brown rice	0.51	-0.049	0.448	-0.098	-0.091	-0.392	0.629*	0.189	0.462	0.49	0.503	0.622*	0.063	0.252
Zn in brown rice	0.867***	-0.049	0.231	-0.336	-0.35	-0.385	0.713**	0.497	0.35	0.706*	0.762**	0.503	0.112	0.559
K in brown rice	0.888***	-0.196	0.091	-0.392	-0.503	-0.413	0.657*	0.028	0.629*	0.476	0.336	0.448	-0.189	0.231
TF _{root-stem}	1	-0.189	-0.014	-0.49	-0.49	-0.392	0.615*	0.371	0.559	0.601*	0.601*	0.49	-0.014	0.441
TF _{stem-ordinary leaf}		1	0.455	0.734**	-0.049	0.231	-0.014	0.091	-0.119	-0.343	0.098	-0.441	-0.434	0.07
TF _{stem-flag leaf}			1	0.441	-0.189	-0.559	0.678*	-0.112	-0.161	0.266	0.056	0.154	-0.259	-0.168
TF _{stem-brown rice}				1	0.503	0.434	-0.133	-0.406	-0.469	-0.175	-0.273	-0.692*	-0.021	-0.077
TF _{ordinary leaf- brown rice}					1	0.671*	-0.469	-0.301	-0.42	0	-0.231	-0.448	0.629*	0.084
TF _{flag leaf-brown rice}						1	-0.755**	-0.07	-0.266	-0.364	-0.098	-0.692*	0.252	0.259
TPn							1	0.07	0.175	0.636*	0.385	0.476	-0.203	0.196
FPn								1	0.196	0.119	0.832**	0.441	-0.042	0.517
MPn									1	-0.175	0.189	0.636*	-0.399	-0.049

Continued Table S5.

	TF _{root-stem}	TF _{stem} -ordinary leaf	TF _{stem} -flag leaf	TF _{stem} -brown rice	TF _{ordinary} leaf-brown rice	TF _{flag} leaf-brown rice	TPn	FPn	MPn	TTr	FTr	MTr	TCi	FCi
TTr										1	0.441	0.252	0.559	0.385
FTr											1	0.371	0.042	0.825**
MTr												1	-0.119	-0.077
TCi													1	0.182
FCi														1
	MCi	Tgs	Fgs	Mgs	TSPAD	FSPAD	MSPAD	TF _v /F _m	FF _v /F _m	MF _v /F _m	TSOD	TPOD	TCAT	Soil DTPA-Cd
Cd in brown rice	0	-0.455	-0.392	-0.594*	-0.743**	-0.755**	-0.720**	-0.51	-0.716**	0.186	-0.294	-0.448	0.399	0.594*
TpH	0.256	0.137	0.189	0.609*	0.188	0.2	0.228	0.298	0.541	0.402	-0.161	0.41	-0.158	0.053
FpH	-0.014	0.217	0.322	0.601*	0.578*	0.566	0.441	0.196	0.878***	-0.025	0.007	0.441	-0.413	-0.476
MpH	-0.385	0.196	0.462	0.133	0.473	0.497	0.385	-0.035	0.667*	-0.182	0.014	0.35	-0.357	-0.594*
TDOC	-0.147	0.615*	0.343	0.406	0.799**	0.769**	0.839**	0.622*	0.579*	-0.095	0.378	0.385	-0.231	-0.615*
FDOC	0.315	0.231	0.196	0.608*	0.354	0.678*	0.573	0.497	0.247	-0.06	0.196	0.517	0.364	-0.545
MDOC	-0.133	0.357	0.483	0.371	0.487	0.727**	0.608*	0.413	0.571	-0.112	0.357	0.126	-0.469	-0.427
TK	0.049	0.524	0.406	0.615*	0.701*	0.776**	0.734**	0.524	0.723**	-0.063	0.322	0.538	-0.378	-0.559
FK	0.287	0.476	0.259	0.629*	0.438	0.469	0.42	0.385	0.547	-0.319	0.007	0.643*	-0.238	-0.413
MK	-0.084	0.685*	0.315	0.294	0.536	0.587*	0.580*	0.336	0.54	-0.284	0.189	0.678*	-0.252	-0.566
Fe in brown rice	0.308	0.112	-0.238	-0.175	-0.294	-0.259	-0.126	0.021	-0.660*	-0.137	-0.175	0.119	0.874***	0.042
Mn in brown rice	0.566	0.399	-0.126	0.315	0.256	0.315	0.343	0.42	-0.342	-0.123	0.175	0.51	0.853***	-0.531
Cu in brown rice	0.315	0.469	0.483	0.622*	0.715**	0.608*	0.594*	0.469	0.497	0.042	0.308	0.427	-0.28	-0.573
Zn in brown rice	0.14	0.650*	0.734**	0.503	0.746**	0.818**	0.748**	0.462	0.536	-0.021	0.238	0.448	-0.056	-0.846**
K in brown rice	-0.21	0.427	0.294	0.448	0.851***	0.811**	0.860**	0.573	0.667*	0.091	0.441	0.406	-0.245	-0.636*
TF _{root-stem}	-0.091	0.51	0.552	0.49	0.771**	0.888***	0.846**	0.524	0.653*	0.004	0.322	0.28	-0.126	-0.713**

Continued Table S5

	MCi	Tgs	Fgs	Mgs	TSPAD	FSPAD	MSPAD	TF _v /F _m	FF _v /F _m	MF _v /F _m	TSOD	TPOD	TCAT	Soil DTPA-Cd
TF _{stem-ordinary leaf}	-0.301	-0.35	0.112	-0.441	0.081	-0.077	-0.098	-0.238	-0.243	0.497	0.392	-0.301	-0.196	-0.112
TF _{stem-flag leaf}	0.385	0.315	0.014	0.154	0.396	0.252	0.336	0.385	-0.247	0.529	0.587*	0.378	0.196	-0.343
TF _{stem-brown rice}	-0.364	-0.112	-0.196	-0.692*	-0.263	-0.455	-0.399	-0.427	-0.314	0.277	0.182	-0.231	-0.35	0.329
TF _{ordinary leaf- brown rice}	-0.182	0.07	-0.112	-0.448	-0.609*	-0.664*	-0.713**	-0.671*	0.063	-0.228	-0.566	-0.175	-0.434	0.615*
TF _{flag leaf-brown rice}	-0.657*	-0.364	0.014	-0.692*	-0.56	-0.643*	-0.678*	-0.741**	0.056	-0.231	-0.517	-0.566	-0.580*	0.566
TPn	0.308	0.664*	0.343	0.476	0.680*	0.692*	0.762**	0.608*	0.229	0.301	0.476	0.720**	0.203	-0.671*
FPn	0.336	0	0.776**	0.441	0.189	0.378	0.224	0.189	0.162	0.011	-0.14	-0.189	0.112	-0.392
MPn	-0.056	-0.252	0.126	0.636*	0.606*	0.594*	0.497	0.315	0.709**	0.179	0.28	0.077	-0.364	-0.343
TTr	0.224	0.979***	0.434	0.252	0.41	0.524	0.559	0.455	0.201	-0.256	0.133	0.406	0.119	-0.483
FTr	0.168	0.357	0.986***	0.371	0.441	0.497	0.434	0.217	0.363	0.056	-0.091	0.028	-0.028	-0.573
MTr	0.664*	0.189	0.266	1.000***	0.536	0.664*	0.580*	0.664*	0.402	0.035	0.189	0.378	0.133	-0.448
TCi	0.14	0.559	0.098	-0.119	-0.263	-0.14	-0.224	-0.203	0.011	-0.648*	-0.399	-0.014	0.007	0.07
FCi	-0.21	0.371	0.895***	-0.077	0.154	0.126	0.119	-0.217	0.381	-0.011	-0.413	0.028	-0.126	-0.322
MCi	1	0.231	0.091	0.664*	0.046	0.196	0.126	0.406	-0.286	-0.077	0.014	0.357	0.608*	-0.245
Tgs		1	0.371	0.189	0.333	0.42	0.469	0.357	0.169	-0.231	0.063	0.531	0.161	-0.441
Fgs			1	0.266	0.357	0.399	0.336	0.084	0.381	0.018	-0.189	0.049	-0.084	-0.517
Mgs				1	0.536	0.664*	0.580*	0.664*	0.402	0.035	0.189	0.378	0.133	-0.448
TSPAD					1	0.865***	0.904***	0.687*	0.445	0.275	0.644*	0.256	-0.091	-0.795**
FSPAD						1	0.944***	0.762**	0.416	0.028	0.622*	0.308	0.021	-0.811**
MSPAD							1	0.853***	0.328	0.102	0.678*	0.308	0.049	-0.748**
TF _v /F _m								1	0.021	0.018	0.671*	0.203	0.189	-0.483
FF _v /F _m									1	0.141	-0.131	0.201	-0.607*	-0.212
MF _v /F _m										1	0.238	-0.014	-0.032	-0.021

Continued Table S5.

	MCi	Tgs	Fgs	Mgs	TSPAD	FSPAD	MSPAD	TF _v /F _m	FF _v /F _m	MF _v /F _m	TSOD	TPOD	TCAT	Soil DTPA-Cd
TSOD											1	0.035	-0.021	-0.441
TPOD												1	0.28	-0.448
TCAT													1	-0.273
Soil DTPA Cd														1

S-Cd, slightly contaminated soil (1 mg kg⁻¹); T, Tillering stage; F, Filling stage; M, Maturity stage; pH value, DOC and K concentrations of soil solution; TF, transfer factors (TF) of Cd between different rice organs; Pn, net photosynthetic rate; Tr, transpiration rate; Ci, substomatal CO₂ concentration; gs, stomatal conductance; SPAD, soil and plant analysis development; F_v/F_m, chlorophyll fluorescence parameter; SOD, superoxide dismutase; POD, peroxidase, CAT, catalase; **p*<0.05, ***p*<0.01, ****p*<0.001.

Table S6 Spearman correlation among soil solution chemistry, minerals in brown rice, photosynthetic and chlorophyll fluorescence characteristics, enzyme activity of leaves, soil DTPA-Cd and Cd in brown rice under M-Cd soils.

	TpH	FpH	MpH	TDOC	FDOC	MDOC	TK	FK	MK	Fe in brown rice	Mn in brown rice	Cu in brown rice	Zn in brown rice	K in brown rice
Cd in brown rice	-0.41	-0.169	-0.692*	-0.909***	-0.762**	-0.594*	-0.888***	-0.881***	-0.371	-0.559	-0.699*	-0.762**	-0.559	-0.867** *
TpH	1	-0.063	0.378	0.357	0.743**	0.606*	0.581*	0.466	-0.014	0.501	0.284	0.529	0.371	0.49
FpH		1	0.095	0.186	0.218	-0.292	0.116	0.243	0.671*	0.278	-0.077	-0.06	0.517	0.112
MpH			1	0.811**	0.790**	0.741**	0.839**	0.629*	0.133	0.476	0.35	0.769**	0.650*	0.811**
TDOC				1	0.727**	0.608*	0.923***	0.811**	0.42	0.664*	0.594*	0.748**	0.664*	0.923***
FDOC					1	0.804**	0.860***	0.755**	0.224	0.497	0.392	0.699*	0.699*	0.734**
MDOC						1	0.755**	0.650*	-0.028	0.266	0.434	0.713**	0.503	0.601*
TK							1	0.888***	0.413	0.727**	0.622*	0.797**	0.678*	0.937***
FK								1	0.594*	0.615*	0.671*	0.762**	0.629*	0.769**
MK									1	0.622*	0.245	0.154	0.538	0.322
Fe in brown rice										1	0.469	0.580*	0.615*	0.748**
Mn in brown rice											1	0.629*	0.49	0.720**
Cu in brown rice												1	0.594*	0.783**
Zn in brown rice													1	0.664*
K in brown rice														1
	TF _{root-stem}	TF _{stem} -ordinary leaf	TF _{stem} -flag leaf	TF _{stem} -brown rice	TF _{ordinary} leaf-brown rice	TF _{flag} leaf-brown rice	TPn	FPn	MPn	TTr	FTr	MTr	TCi	FCi
Cd in brown rice	-0.168	0.965***	0.664*	0.573	-0.594*	0.049	0.147	-0.517	-0.51	0.196	-0.399	-0.035	0.455	0.014
TpH	-0.004	-0.417	-0.406	-0.056	0.487	0.207	-0.025	0.116	0.249	-0.529	-0.249	-0.396	-0.634*	-0.186
FpH	0.127	-0.207	-0.401	-0.703*	-0.271	-0.745**	0.453	0.657*	0.348	-0.039	0.689*	0.446	-0.439	0.109

Continued Table S6.

	TF _{root-stem}	TF _{stem} -ordinary leaf	TF _{stem} -flag leaf	TF _{stem} -brown rice	TF _{ordinary} leaf-brown rice	TF _{flag} leaf-brown rice	TPn	FPn	MPn	TTr	FTr	MTr	TCi	FCi
MpH	0.063	-0.678*	-0.357	-0.091	0.811**	0.14	-0.063	0.434	0.503	-0.07	0.07	-0.364	-0.112	-0.301
TDOC	0.294	-0.867***	-0.685*	-0.455	0.685*	0.091	-0.098	0.559	0.594*	-0.168	0.336	-0.105	-0.315	-0.126
FDOC	0.042	-0.783**	-0.524	-0.357	0.671*	-0.028	-0.07	0.517	0.427	-0.378	0.175	-0.329	-0.566	-0.168
MDOC	0.028	-0.643*	-0.308	-0.014	0.741**	0.371	-0.301	0.182	0.238	-0.196	-0.196	-0.580*	-0.084	-0.252
TK	0.336	-0.853***	-0.692*	-0.385	0.692*	0.14	-0.042	0.399	0.685*	-0.189	0.175	-0.196	-0.399	-0.133
FK	0.266	-0.916***	-0.748**	-0.657*	0.392	-0.105	-0.07	0.42	0.629*	-0.154	0.35	0.091	-0.35	0.063
MK	0.629*	-0.364	-0.706*	-0.804**	-0.28	-0.42	0.301	0.469	0.720**	0.077	0.629*	0.552	-0.224	0.273
Fe in brown rice	0.664*	-0.455	-0.818**	-0.357	0.329	0.154	0.364	0.301	0.902***	-0.014	0.196	0.14	-0.42	0.077
Mn in brown rice	0.399	-0.678*	-0.692*	-0.287	0.497	0.35	0.266	0.028	0.476	0.329	-0.028	-0.126	-0.245	-0.049
Cu in brown rice	0.049	-0.776**	-0.566	-0.203	0.699*	0.245	-0.042	0.329	0.517	-0.014	0.014	-0.14	-0.119	-0.077
Zn in brown rice	0.427	-0.587*	-0.762**	-0.448	0.49	0.014	0.462	0.629*	0.643*	0.175	0.287	-0.182	-0.329	-0.112
K in brown rice	0.357	-0.790**	-0.685*	-0.287	0.762**	0.224	0.112	0.364	0.678*	-0.042	0.091	-0.217	-0.392	-0.252
TF _{root-stem}	1	-0.049	-0.636*	-0.203	0.007	0.315	0.517	-0.014	0.755**	0.441	0.147	0.112	-0.098	0.21
TF _{stem-ordinary leaf}		1	0.657*	0.608*	-0.559	0.098	0.168	-0.517	-0.427	0.217	-0.413	0	0.42	-0.035
TF _{stem-flag leaf}			1	0.615*	-0.28	-0.084	-0.427	-0.399	-0.776**	-0.098	-0.413	-0.147	0.497	-0.273
TF _{stem-brown rice}				1	0.231	0.664*	-0.014	-0.685*	-0.371	0.21	-0.797**	-0.594*	0.441	-0.259
TF _{ordinary leaf- brown rice}					1	0.545	-0.049	0.175	0.231	-0.042	-0.252	-0.685*	-0.182	-0.378
TF _{flag leaf-brown rice}						1	0.091	-0.517	0.084	0.315	-0.636*	-0.636*	0.245	-0.084
TPn							1	-0.063	0.49	0.636*	0.021	0.035	-0.224	0.126
FPn								1	0.217	-0.287	0.650*	0.224	-0.322	-0.119
MPn									1	0.28	0.294	0.224	-0.245	0.21

Continued Table S6.

	TF _{root-stem}	TF _{stem} -ordinary leaf	TF _{stem} -flag leaf	TF _{stem} -brown rice	TF _{ordinary} leaf-brown rice	TF _{flag} leaf-brown rice	TPn	FPn	MPn	TTr	FTr	MTr	TCi	FCi
TTr										1	-0.105	0.049	0.469	0.14
FTr											1	0.664*	-0.322	0.566
MTr												1	-0.007	0.545
TCi													1	-0.091
FCi														1
	MCi	Tgs	Fgs	Mgs	TSPAD	FSPAD	MSPAD	TF _v /F _m	FF _v /F _m	MF _v /F _m	TSOD	TPOD	TCAT	Soil DTPA-Cd
Cd in brown rice	0.287	0.217	-0.399	-0.035	-0.214	-0.909***	-0.699*	-0.839**	-0.820**	-0.182	-0.573	-0.697*	-0.497	0.853***
TpH	-0.683*	-0.578*	-0.249	-0.396	0.132	0.620*	0.301	0.637*	0.623*	0.018	0.088	0.512	0.137	-0.529
FpH	0.183	0.025	0.689*	0.446	0.697*	0.058	0.531	0.134	0.15	-0.422	0.07	0.486	0.541	-0.292
MpH	-0.615*	-0.084	0.07	-0.364	0.077	0.733**	0.594*	0.776**	0.757**	0.483	0.545	0.641*	0.811**	-0.783**
TDOC	-0.455	-0.189	0.336	-0.105	0.235	0.891***	0.818**	0.874***	0.865***	0.287	0.399	0.655*	0.664*	-0.846**
FDOC	-0.636*	-0.385	0.175	-0.329	0.406	0.811**	0.643*	0.853***	0.830**	0.105	0.545	0.799**	0.594*	-0.895***
MDOC	-0.706*	-0.217	-0.196	-0.580*	0.137	0.649*	0.42	0.727**	0.704*	0.427	0.517	0.347	0.371	-0.748**
TK	-0.622*	-0.21	0.175	-0.196	0.242	0.944***	0.706*	0.923***	0.907***	0.371	0.49	0.669*	0.622*	-0.888***
FK	-0.336	-0.161	0.35	0.091	0.406	0.800**	0.727**	0.790**	0.778**	0.231	0.601*	0.515	0.517	-0.881***
MK	0.07	0.154	0.629*	0.552	0.676*	0.33	0.587*	0.35	0.371	0.014	0.161	0.228	0.476	-0.413
Fe in brown rice	-0.469	-0.028	0.196	0.14	0.161	0.768**	0.580*	0.755**	0.771**	0.364	0.049	0.452	0.552	-0.559
Mn in brown rice	-0.357	0.252	-0.028	-0.126	-0.084	0.649*	0.455	0.671*	0.676*	0.364	0.189	0.165	0.133	-0.594*
Cu in brown rice	-0.469	-0.07	0.014	-0.14	-0.088	0.779**	0.587*	0.832**	0.823**	0.538	0.517	0.413	0.594*	-0.797**
Zn in brown rice	-0.545	0.182	0.287	-0.182	0.508	0.600*	0.825**	0.811**	0.830**	0.231	0.224	0.501	0.783**	-0.818**
K in brown rice	-0.601*	-0.084	0.091	-0.217	0.035	0.933***	0.671*	0.909***	0.900***	0.42	0.301	0.651*	0.601*	-0.790**
TF _{root-stem}	-0.294	0.462	0.147	0.112	0.207	0.351	0.266	0.378	0.41	0.364	-0.168	-0.053	0.196	-0.189

Continued Table S6.

	MCi	Tgs	Fgs	Mgs	TSPAD	FSPAD	MSPAD	TF _v /F _m	FF _v /F _m	MF _v /F _m	TSOD	TPOD	TCAT	Soil DTPA-Cd
TF _{stem-ordinary leaf}	0.287	0.252	-0.413	0	-0.315	-0.818**	-0.762**	-0.797**	-0.778**	-0.091	-0.636*	-0.641*	-0.497	0.909***
TF _{stem-flag leaf}	0.378	-0.056	-0.413	-0.147	-0.431	-0.702*	-0.804**	-0.776**	-0.799**	-0.105	-0.147	-0.378	-0.462	0.741**
TF _{stem-brown rice}	-0.287	0.14	-0.797**	-0.594*	-0.732**	-0.368	-0.636*	-0.35	-0.354	0.322	-0.336	-0.441	-0.343	0.51
TF _{ordinary leaf- brown rice}	-0.755**	-0.126	-0.252	-0.685*	-0.228	0.695*	0.427	0.748**	0.732**	0.42	0.245	0.487	0.434	-0.636*
TF _{flag leaf-brown rice}	-0.608*	0.203	-0.636*	-0.636*	-0.543	0.179	-0.105	0.245	0.256	0.531	-0.252	-0.35	-0.189	-0.014
TPn	-0.217	0.594*	0.021	0.035	0.067	-0.032	0.154	0.126	0.165	0.07	-0.294	-0.025	0.231	-0.049
FPn	0.063	-0.196	0.650*	0.224	0.592*	0.414	0.699*	0.497	0.501	-0.161	0.245	.648*	0.678*	-0.552
MPn	-0.385	0.28	0.294	0.224	0.21	0.653*	0.524	0.657*	0.673*	0.469	0.259	0.347	0.636*	-0.559
TTr	0.056	0.979***	-0.105	0.049	-0.291	-0.218	-0.126	-0.084	-0.053	0.497	-0.049	-0.487	0.084	0.126
FTr	0.427	-0.056	1.000**	0.664*	0.634*	0.189	0.531	0.147	0.151	-0.413	0.427	0.42	0.399	-0.357
MTr	0.783**	0.119	0.664*	1.000**	0.179	-0.119	-0.007	-0.252	-0.242	-0.189	0.168	-0.046	0.028	0.175
TCi	0.273	0.503	-0.322	-0.007	-0.406	-0.516	-0.385	-0.448	-0.438	0.517	-0.035	-0.743**	-0.077	0.427
FCi	0.322	0.084	0.566	0.545	0.203	-0.091	0.077	-0.133	-0.123	-0.266	0.329	-0.168	-0.098	-0.042
MCi	1	0.133	0.427	0.783**	-0.028	-0.54	-0.364	-0.657*	-0.655*	-0.343	0.007	-0.315	-0.329	0.538
Tgs		1	-0.056	0.119	-0.214	-0.242	-0.154	-0.112	-0.081	0.51	-0.042	-0.473	0.119	0.161
Fgs			1	0.664*	0.634*	0.189	0.531	0.147	0.151	-0.413	0.427	0.42	0.399	-0.357
Mgs				1	0.179	-0.119	-0.007	-0.252	-0.242	-0.189	0.168	-0.046	0.028	0.175
TSPAD					1	0.114	0.585*	0.217	0.225	-0.48	0.203	0.361	0.336	-0.448
FSPAD						1	0.625*	0.937***	0.923***	0.333	0.396	0.710**	0.512	-0.807**
MSPAD							1	0.748**	0.760**	-0.049	0.266	0.55	0.699*	-0.853***
TF _v /F _m								1	0.998***	0.371	0.343	0.637*	0.629*	-0.895***
FF _v /F _m									1	0.375	0.308	0.612*	0.634*	-0.886***
MF _v /F _m										1	0.175	-0.186	0.343	-0.161

Continued Table S6.

	M _{Ci}	T _{gs}	F _{gs}	M _{gs}	TSPAD	FSPAD	MSPAD	TF _v /F _m	FF _v /F _m	MF _v /F _m	TSOD	TPOD	TCAT	Soil DTPA-Cd
TSOD											1	0.385	0.427	-0.594*
TPOD												1	0.574	-0.648*
TCAT													1	-0.678*
Soil DTPA Cd														1

M-Cd, moderately contaminated soil (2 mg kg⁻¹); T, Tillering stage; F, Filling stage; M, Maturity stage; pH value, DOC and K concentrations of soil solution; TF, transfer factors (TF) of Cd between different rice organs; Pn, net photosynthetic rate; Tr, transpiration rate; Ci, substomatal CO₂ concentration; gs, stomatal conductance; SPAD, soil and plant analysis development; F_v/F_m, chlorophyll fluorescence parameter; SOD, superoxide dismutase; POD, peroxidase, CAT, catalase; **p*<0.05, ***p*<0.01, ****p*<0.001.

Table S7 Spearman correlation among soil solution chemistry, minerals in brown rice, photosynthetic and chlorophyll fluorescence characteristics, enzyme activity of leaves, soil DTPA-Cd and Cd in brown rice under H-Cd soils.

	TpH	FpH	MpH	TDOC	FDOC	MDOC	TK	FK	MK	Fe in brown rice	Mn in brown rice	Cu in brown rice	Zn in brown rice	K in brown rice
Cd in brown rice	-0.51	-0.860***	-0.832**	-0.797**	-0.776**	-0.860***	-0.916***	-0.916***	-0.853***	-0.545	-0.699*	-0.881***	-0.825**	-0.839**
TpH	1	0.428	0.586*	0.224	0.601*	0.441	0.476	0.462	0.434	-0.07	-0.035	0.615*	0.559	0.287
FpH		1	0.775**	0.754**	0.730**	0.695*	0.874***	0.937***	0.905***	0.284	0.586*	0.800**	0.649*	0.768**
MpH			1	0.705*	0.635*	0.842**	0.874***	0.807**	0.698*	0.2	0.512	0.884***	0.765**	0.853***
TDOC				1	0.650*	0.832**	0.909***	0.888***	0.692*	0.483	0.762**	0.671*	0.790**	0.853***
FDOC					1	0.776**	0.818**	0.783**	0.762**	0.203	0.406	0.748**	0.538	0.573
MDOC						1	0.902***	0.860***	0.699*	0.483	0.664*	0.811**	0.741**	0.881***
TK							1	0.944***	0.832**	0.385	0.713**	0.818**	0.818**	0.874***
FK								1	0.881***	0.441	0.692*	0.811**	0.776**	0.867***
MK									1	0.224	0.455	0.762**	0.566	0.615*
Fe in brown rice										1	0.783**	0.266	0.517	0.587*
Mn in brown rice											1	0.385	0.706*	0.811**
Cu in brown rice												1	0.678*	0.762**
Zn in brown rice													1	0.769**
K in brown rice														1
	TF _{root-stem}	TF _{stem} -ordinary leaf	TF _{stem} -flag leaf	TF _{stem} -brown rice	TF _{ordinary} leaf-brown rice	TF _{flag} leaf-brown rice	TPn	FPn	MPn	TTr	FTr	MTr	TCi	FCi
Cd in brown rice	-0.762**	-0.902***	-0.937***	-0.804**	0.825**	0.923***	-0.392	-0.664*	-0.385	-0.427	-0.098	-0.566	0.084	0.552
TpH	0.552	0.545	0.503	0.371	-0.748**	-0.462	0.734**	0.713**	0.601*	0.776**	0.168	0.559	0.105	-0.315
FpH	0.723**	0.779**	0.786**	0.768**	-0.695*	-0.747**	0.467	0.47	0.467	0.474	-0.116	0.807**	-0.26	-0.635*

Continued Table S7.

	TF _{root-stem}	TF _{stem} -ordinary leaf	TF _{stem} -flag leaf	TF _{stem} -brown rice	TF _{ordinary} leaf-brown rice	TF _{flag} leaf-brown rice	TPn	FPn	MPn	TTr	FTr	MTr	TCi	FCi
MpH	0.807**	0.726**	0.747**	0.737**	-0.582*	-0.621*	0.533	0.796**	0.46	0.639*	0.298	0.688*	0.063	-0.414
TDOC	0.769**	0.755**	0.727**	0.790**	-0.51	-0.643*	0.259	0.441	0.084	0.294	0.287	0.413	-0.119	-0.385
FDOC	0.678*	0.713**	0.685*	0.594*	-0.825**	-0.692*	0.308	0.427	0.329	0.364	0.112	0.531	0.035	-0.434
MDOC	0.783**	0.748**	0.727**	0.706*	-0.650*	-0.706*	0.21	0.664*	0.161	0.315	0.245	0.441	0.063	-0.497
TK	0.860***	0.846**	0.846**	0.860***	-0.685*	-0.769**	0.42	0.594*	0.357	0.503	0.238	0.615*	-0.056	-0.448
FK	0.818**	0.853***	0.825**	0.825**	-0.741**	-0.790**	0.378	0.552	0.357	0.413	-0.021	0.685*	-0.196	-0.671*
MK	0.713**	0.713**	0.720**	0.713**	-0.699*	-0.727**	0.42	0.336	0.622*	0.322	-0.154	0.797**	-0.448	-0.503
Fe in brown rice	0.168	0.51	0.559	0.371	-0.392	-0.720**	-0.224	0.378	-0.343	-0.112	-0.077	-0.231	0.028	-0.483
Mn in brown rice	0.573	0.741**	0.762**	0.783**	-0.406	-0.713**	-0.049	0.364	-0.112	0.147	0.07	0.119	0.147	-0.462
Cu in brown rice	0.657*	0.706*	0.741**	0.566	-0.748**	-0.727**	0.517	0.762**	0.371	0.503	0.231	0.643*	-0.063	-0.462
Zn in brown rice	0.839**	0.909***	0.888***	0.860***	-0.692*	-0.748**	0.573	0.734**	0.273	0.657*	0.385	0.42	0.14	-0.35
K in brown rice	0.685*	0.741**	0.762**	0.734**	-0.517	-0.720**	0.189	0.706*	0.077	0.357	0.154	0.42	0.049	-0.608*
TF _{root-stem}	1	0.860***	0.776**	0.923***	-0.650*	-0.552	0.552	0.51	0.469	0.608*	0.28	0.685*	0.112	-0.336
TF _{stem-ordinary leaf}		1	0.972***	0.916***	-0.853***	-0.846**	0.462	.594*	0.343	0.545	0.14	0.524	0.154	-0.517
TF _{stem-flag leaf}			1	0.881***	-0.825**	-0.909***	0.441	.629*	0.357	0.531	0.154	0.483	0.119	-0.476
TF _{stem-brown rice}				1	-0.615*	-0.678*	0.434	0.434	0.413	0.531	0.161	0.587*	0.084	-0.385
TF _{ordinary leaf- brown rice}					1	0.839**	-0.476	-0.594*	-0.392	-0.49	0.014	-0.517	-0.07	0.573
TF _{flag leaf-brown rice}						1	-0.294	-0.615*	-0.266	-0.357	0.035	-0.364	0.077	0.580*
TPn							1	0.524	0.615*	0.902***	0.357	0.671*	-0.077	0.021
FPn								1	0.217	0.678*	0.336	0.343	0.238	-0.42
MPn									1	0.517	-0.182	0.769**	-0.378	-0.14

Continued Table S7.

	TF _{root-stem}	TF _{stem} -ordinary leaf	TF _{stem} -flag leaf	TF _{stem} -brown rice	TF _{ordinary} leaf-brown rice	TF _{flag} leaf-brown rice	TPn	FPn	MPn	TTr	FTr	MTr	TCi	FCi
TTr										1	0.399	0.587*	0.217	-0.091
FTr											1	-0.161	0.462	0.594*
MTr												1	-0.322	-0.434
TCi													1	0.14
FCi														1
	MCi	Tgs	Fgs	Mgs	TSPAD	FSPAD	MSPAD	TF _v /F _m	FF _v /F _m	MF _v /F _m	TSOD	TPOD	TCAT	Soil DTPA-Cd
Cd in brown rice	-0.587*	-0.385	-0.056	-0.622*	-0.34	-0.900***	-0.944***	-0.413	-0.734**	-0.706*	-0.224	-0.566	-0.371	0.902***
TpH	0.636*	0.804**	0.14	0.559	0.680*	0.592*	0.476	0.776**	0.622*	0.818**	0.559	0.601*	0.664*	-0.462
FpH	0.684*	0.414	-0.081	0.821***	0.33	0.838**	0.846**	0.354	0.575	0.537	0.305	0.632*	0.47	-0.930***
MpH	0.646*	0.625*	0.277	0.751**	0.301	0.898**	0.821**	0.54	0.663*	0.779**	0.291	0.488	0.456	-0.789**
TDOC	0.566	0.189	0.217	0.455	0.091	0.844**	0.881***	0.224	0.580*	0.552	-0.091	0.524	0.175	-0.881***
FDOC	0.448	0.364	0.07	0.524	0.322	0.792**	0.818**	0.252	0.573	0.566	0.007	0.615*	0.406	-0.846**
MDOC	0.497	0.252	0.133	0.49	0.238	0.876***	0.888***	0.21	0.664*	0.713**	-0.049	0.517	0.224	-0.818**
TK	0.636*	0.434	0.196	0.643*	0.291	0.949***	0.965***	0.406	0.706*	0.664*	0.154	0.657*	0.406	-0.972***
FK	0.706*	0.329	-0.063	0.720**	0.368	0.914***	0.944***	0.329	0.685*	0.685*	0.189	0.650*	0.406	-0.958***
MK	0.469	0.322	-0.126	0.790**	0.529	0.725**	0.853***	0.259	0.476	0.559	0.315	0.573	0.622*	-0.874***
Fe in brown rice	0.21	-0.294	-0.217	-0.175	-0.053	0.368	0.441	-0.049	0.559	0.182	-0.091	0.315	-0.385	-0.357
Mn in brown rice	0.476	-0.021	-0.014	0.182	-0.074	0.690*	0.727**	0.133	0.594*	0.266	-0.021	0.378	-0.105	-0.699*
Cu in brown rice	0.531	0.517	0.217	0.692*	0.256	0.834**	0.783**	0.406	0.601*	0.741**	0.14	0.497	0.364	-0.776**
Zn in brown rice	0.790**	0.559	0.315	0.476	0.322	0.879***	0.818**	0.685*	0.734**	0.769**	0.315	0.566	0.364	-0.776**
K in brown rice	0.608*	0.238	0.07	0.503	0.067	0.876***	0.839**	0.266	0.741**	0.608*	0.042	0.497	0.063	-0.804**
TF _{root-stem}	0.762**	0.580*	0.252	0.713**	0.417	0.893***	0.860***	0.552	0.503	0.748**	0.266	0.476	0.622*	-0.846**

Continued Table S7.

	MCi	Tgs	Fgs	Mgs	TSPAD	FSPAD	MSPAD	TF _v /F _m	FF _v /F _m	MF _v /F _m	TSOD	TPOD	TCAT	Soil DTPA-Cd
TF _{stem-ordinary leaf}	0.776**	0.483	0.098	0.580*	0.333	0.914***	0.895***	0.566	0.685*	0.699*	0.28	0.524	0.42	-0.874***
TF _{stem-flag leaf}	0.685*	0.476	0.126	0.545	0.28	0.890***	0.888***	0.566	0.727**	0.643*	0.308	0.517	0.364	-0.860***
TF _{stem-brown rice}	0.741**	0.462	0.147	0.629*	0.315	0.872***	0.881***	0.524	0.566	0.587*	0.315	0.469	0.497	-0.874***
TF _{ordinary leaf- brown rice}	-0.636*	-0.476	0.056	-0.538	-0.48	-0.764**	-0.748**	-0.497	-0.650*	-0.706*	-0.287	-0.587*	-0.455	0.741**
TF _{flag leaf-brown rice}	-0.51	-0.266	0.091	-0.399	-0.333	-0.753**	-0.811**	-0.378	-0.783**	-0.545	-0.28	-0.636*	-0.217	0.783**
TPn	0.664*	0.909***	0.441	0.622*	0.504	0.48	0.329	0.846**	0.301	0.566	0.636*	0.538	0.720**	-0.434
FPn	0.622*	0.615*	0.252	0.413	0.284	0.711**	0.545	0.643*	0.783**	0.790**	0.343	0.517	0.196	-0.483
MPn	0.343	0.629*	-0.084	0.755**	0.795**	0.326	0.406	0.587*	0.273	0.51	0.783**	0.322	0.937***	-0.385
TTr	0.776**	0.958***	0.441	0.566	0.417	0.613*	0.399	0.923***	0.517	0.594*	0.643*	0.608*	0.601*	-0.49
FTr	0.07	0.42	0.972***	-0.154	-0.315	0.266	0.119	0.35	0.056	0.196	-0.259	0.021	-0.056	-0.112
MTr	0.636*	0.622*	-0.063	0.979***	0.574	0.609*	0.580*	0.462	0.273	0.559	0.538	0.469	0.811**	-0.671*
TCi	0.154	0.224	0.406	-0.259	-0.438	0.165	-0.07	0.196	0.042	0.021	-0.259	-0.245	-0.287	0.098
FCi	-0.559	0.014	0.664*	-0.497	-0.333	-0.518	-0.517	-0.056	-0.580*	-0.462	-0.217	-0.413	-0.098	0.503
MCi	1	0.664*	0.056	0.664*	0.392	0.781**	0.608*	0.720**	0.601*	0.685*	0.483	0.594*	0.476	-0.678*
Tgs		1	0.49	0.615*	0.424	0.553	0.357	0.916***	0.399	0.608*	0.622*	0.441	0.692*	-0.42
Fgs			1	-0.07	-0.329	0.217	0.063	0.378	-0.056	0.112	-0.189	-0.021	0.028	-0.098
Mgs				1	0.529	0.669*	0.636*	0.483	0.336	0.636*	0.51	0.385	0.769**	-0.685*
TSPAD					1	0.26	0.361	0.494	0.413	0.602*	0.764**	0.539	0.813**	-0.305
FSPAD						1	0.932***	0.539	0.739**	0.764**	0.186	0.585*	0.396	-0.928***
MSPAD							1	0.385	0.720**	0.713**	0.168	0.559	0.434	-0.951***
TF _v /F _m								1	0.559	0.650*	0.727**	0.469	0.622*	-0.392
FF _v /F _m									1	0.692*	0.399	0.713**	0.203	-0.650*
MF _v /F _m										1	0.385	0.448	0.566	-0.594*

Continued Table S7.

	MCi	Tgs	Fgs	Mgs	TSPAD	FSPAD	MSPAD	TF _v /F _m	FF _v /F _m	MF _v /F _m	TSOD	TPOD	TCAT	Soil DTPA-Cd
TSOD											1	0.455	0.706*	-0.182
TPOD												1	0.385	-0.671*
TCAT													1	-0.448
Soil DTPA Cd														1

H-Cd, highly contaminated soil (4 mg kg⁻¹); T, Tillering stage; F, Filling stage; M, Maturity stage; pH value, DOC and K concentrations of soil solution; TF, transfer factors (TF) of Cd between different rice organs; Pn, net photosynthetic rate; Tr, transpiration rate; Ci, substomatal CO₂ concentration; gs, stomatal conductance; SPAD, soil and plant analysis development; F_v/F_m, chlorophyll fluorescence parameter; SOD, superoxide dismutase; POD, peroxidase, CAT, catalase; **p*<0.05, ***p*<0.01, ****p*<0.001.

Table S8 Spearman correlation among soil solution chemistry, minerals in brown rice, photosynthetic and chlorophyll fluorescence characteristics, enzyme activity of leaves, soil DTPA-Cd and Cd in brown rice using all the data.

	TpH	FpH	MpH	TDOC	FDOC	MDOC	TK	FK	MK	Fe in brown rice	Mn in brown rice	Cu in brown rice	Zn in brown rice	K in brown rice
Cd in brown rice	-0.079	-0.281	-0.432**	-0.666***	-0.133	-0.333*	-0.425**	-0.739***	-0.636***	-0.580***	-0.743***	-0.878***	-0.880***	-0.740***
TpH	1	0.235	0.354*	0.188	0.550**	0.487**	0.527**	0.436**	0.227	-0.011	-0.001	0.188	0.177	0.319
FpH		1	0.443**	0.639***	0.316	0.192	0.547**	0.534**	0.530**	0.121	0.024	0.126	0.425**	0.446**
MpH			1	0.488**	0.616***	0.715***	0.748***	0.659***	0.561***	0.151	0.306	0.470**	0.571***	0.699***
TDOC				1	0.256	0.392*	0.684***	0.749***	0.544**	0.451**	0.451**	0.579***	0.745***	0.835***
FDOC					1	0.712***	0.719***	0.567***	0.455**	0.067	0.172	0.152	0.318	0.468**
MDOC						1	0.812***	0.637***	0.476**	0.143	0.327	0.445**	0.505**	0.651***
TK							1	0.847***	0.638***	0.19	0.338*	0.474**	0.586***	0.803***
FK								1	0.731***	0.425**	0.601***	0.729***	0.791***	0.850***
MK									1	0.378*	0.444**	0.458**	0.743***	0.618***
Fe in brown rice										1	0.763***	0.582***	0.590***	0.501**
Mn in brown rice											1	0.740***	0.700***	0.667***
Cu in brown rice												1	0.785***	0.753***
Zn in brown rice													1	0.785***
K in brown rice														1
	TF _{root-stem}	TF _{stem} -ordinary leaf	TF _{stem} -flag leaf	TF _{stem} -brown rice	TF _{ordinary} leaf-brown rice	TF _{flag} leaf-brown rice	TPn	FPn	MPn	TTr	FTr	MTr	TCi	FCi
Cd in brown rice	-0.529**	0.674***	0.614***	0.540**	-0.347*	-0.354*	-0.283	-0.125	-0.223	-0.297	-0.228	-0.288	-0.09	-0.023
TpH	0.235	0.051	0.141	0.071	-0.027	-0.209	0.362*	0.321	0.531**	0.086	0.075	0.266	-0.377*	-0.11
FpH	0.474**	-0.203	-0.14	-0.321	-0.281	-0.397*	0.301	0.534**	0.482**	0.223	0.372*	0.523**	-0.217	-0.121

Continued Table S8.

	TF _{root-stem}	TF _{stem} -ordinary leaf	TF _{stem} -flag leaf	TF _{stem} -brown rice	TF _{ordinary} leaf-brown rice	TF _{flag} leaf-brown rice	TPn	FPn	MPn	TTr	FTr	MTr	TCi	FCi
MpH	0.586***	-0.023	-0.028	0.068	0.096	0.065	0.11	0.348*	0.624***	0.08	0.281	0.217	-0.129	-0.025
TDOC	0.680***	-0.551***	-0.482**	-0.541**	0.146	0.016	0.359*	0.427**	0.32	0.367*	0.343*	0.193	-0.019	-0.05
FDOC	0.345*	0.115	0.299	0.134	-0.117	-0.370*	0.012	0.299	0.511**	-0.156	0.109	0.149	-0.351*	-0.15
MDOC	0.540**	0.111	0.194	0.271	0.108	-0.071	0.081	0.325	0.460**	0.067	0.188	0.081	-0.109	-0.125
TK	0.658***	-0.141	0.029	-0.034	0.086	-0.198	0.232	0.378*	0.627***	0.154	0.27	0.271	-0.192	-0.083
FK	0.582***	-0.465**	-0.31	-0.338*	0.227	-0.005	0.271	0.308	0.492**	0.239	0.236	0.328	-0.099	-0.106
MK	0.706***	-0.185	-0.102	-0.19	-0.198	-0.119	0.362*	0.179	0.557***	0.309	0.261	0.546**	-0.055	0.067
Fe in brown rice	0.146	-0.499**	-0.500**	-0.406*	0.262	0.237	0.16	0.191	0.083	0.158	0.018	-0.012	0.07	-0.105
Mn in brown rice	0.303	-0.489**	-0.410*	-0.283	0.384*	0.346*	0.221	-0.014	0.133	0.28	0.002	0.044	0.146	-0.083
Cu in brown rice	0.424**	-0.610***	-0.564***	-0.391*	0.527**	0.465**	0.307	0.125	0.26	0.328	0.158	0.183	0.132	-0.006
Zn in brown rice	0.667***	-0.539**	-0.463**	-0.439**	0.226	0.182	0.431**	0.373*	0.333*	0.446**	0.454**	0.264	0.093	0.094
K in brown rice	0.708***	-0.406*	-0.305	-0.283	0.248	0.115	0.31	0.329	0.454**	0.268	0.197	0.213	-0.066	-0.155
TF _{root-stem}	1	-0.129	-0.147	-0.153	-0.18	0.01	0.440**	0.221	0.519**	0.428**	0.333*	0.444**	0.051	0.092
TF _{stem-ordinary leaf}		1	0.877***	0.893***	-0.528**	-0.345*	-0.215	-0.156	0.053	-0.314	-0.218	-0.085	-0.227	-0.059
TF _{stem-flag leaf}			1	0.814***	-0.463**	-0.583***	-0.145	-0.113	0.107	-0.274	-0.21	-0.02	-0.282	-0.148
TF _{stem-brown rice}				1	-0.15	-0.09	-0.247	-0.275	0.019	-0.313	-0.291	-0.227	-0.119	-0.073
TF _{ordinary leaf- brown rice}					1	0.697***	-0.108	-0.17	-0.222	-0.036	-0.106	-0.486**	0.24	0.005
TF _{flag leaf-brown rice}						1	-0.02	-0.403*	-0.225	0.063	-0.152	-.377*	0.358*	0.187
TPn							1	0.171	0.340*	0.806***	0.233	0.357*	-0.06	0.081
FPn								1	0.262	0.172	0.657***	0.292	-0.178	-0.042
MPn									1	0.184	0.162	0.590***	-0.385*	-0.013

Continued Table S8.

	TF _{root-stem}	TF _{stem} -ordinary leaf	TF _{stem} -flag leaf	TF _{stem} -brown rice	TF _{ordinary} leaf-brown rice	TF _{flag} leaf-brown rice	TPn	Fpn	MPn	TTr	FTr	MTr	TCi	FCi
TTr										1	0.323	0.3	0.434**	0.148
FTr											1	0.284	0.046	0.664***
MTr												1	-0.174	0.018
TCi													1	0.127
FCi														1
	MCi	Tgs	Fgs	Mgs	TSPAD	FSPAD	MSPAD	TF _v /F _m	FF _v /F _m	MF _v /F _m	TSOD	TPOD	TCAT	Soil DTPA-Cd
Cd in brown rice	-0.175	-0.354*	-0.249	-0.278	-0.681***	-0.440**	-0.846***	-0.591***	-0.380*	0.013	-0.578***	-0.412*	-0.155	0.827***
TpH	-0.001	0.055	0.073	0.27	0.121	0.384*	0.17	0.453**	0.499**	0.555***	0.023	0.503**	0.325	-0.07
FpH	0.325	0.238	0.348*	0.528**	0.285	0.672***	0.478**	0.365*	0.666***	-0.025	0.084	0.544**	0.352*	-0.198
MpH	-0.06	0.05	0.287	0.239	0.279	0.492**	0.541**	0.360*	0.488**	0.431**	0.156	0.427**	0.188	-0.560***
TDOC	0.084	0.374*	0.338*	0.196	0.352*	0.820***	0.782***	0.658***	0.780***	0.001	0.245	0.539**	0.234	-0.453**
FDOC	-0.119	-0.218	0.078	0.16	0.128	0.449**	0.381*	0.307	0.327	0.398*	-0.026	0.478**	0.267	-0.337*
MDOC	-0.093	0.014	0.172	0.1	0.222	0.481**	0.535**	0.399*	0.443**	0.574***	0.097	0.343*	0.001	-0.528**
TK	-0.024	0.125	0.261	0.283	0.19	0.749***	0.658***	0.571***	0.683***	0.383*	0.096	0.577***	0.22	-0.457**
FK	0.118	0.253	0.236	0.332*	0.471**	0.707***	0.790***	0.677***	0.660***	0.219	0.354*	0.633***	0.306	-0.663***
MK	0.207	0.326	0.256	0.539**	0.612***	0.447**	0.745***	0.462**	0.340*	0.213	0.28	0.475**	0.293	-0.651***
Fe in brown rice	0.003	0.178	0.046	-0.023	0.348*	0.410*	0.530**	0.447**	0.386*	0.013	0.219	0.391*	0.359*	-0.560***
Mn in brown rice	0.112	0.263	0.019	0.034	0.385*	0.341*	0.624***	0.502**	0.253	0.123	0.419*	0.314	0.181	-0.735***
Cu in brown rice	0.025	0.377*	0.198	0.183	0.505**	0.479**	0.776***	0.616***	0.412*	0.191	0.520**	0.311	0.201	-0.805***
Zn in brown rice	0.174	0.465**	0.458**	0.258	0.666***	0.594***	0.891***	0.722***	0.519**	0.107	0.476**	0.519**	0.289	-0.795***
K in brown rice	0.068	0.248	0.2	0.228	0.328	0.754***	0.844***	0.667***	0.648***	0.278	0.27	0.510**	0.164	-0.689***
TF _{root-stem}	0.201	0.397*	0.329	0.451**	0.373*	0.595***	0.704***	0.441**	0.422*	0.278	0.155	0.244	0.094	-0.508**

Continued Table S8.

	MCi	Tgs	Fgs	Mgs	TSPAD	FSPAD	MSPAD	TF _v /F _m	FF _v /F _m	MF _v /F _m	TSOD	TPOD	TCAT	Soil DTPA-Cd
TF _{stem-ordinary leaf}	-0.045	-0.379*	-0.253	-0.063	-0.344*	-0.374*	-0.477**	-0.504**	-0.411*	0.462**	-0.365*	-0.308	-0.273	0.309
TF _{stem-flag leaf}	0.032	-0.331*	-0.26	0.001	-0.348*	-0.261	-0.375*	-0.318	-0.355*	0.478**	-0.262	-0.101	-0.146	0.301
TF _{stem-brown rice}	-0.146	-0.364*	-0.302	-0.205	-0.311	-0.380*	-0.384*	-0.441**	-0.393*	0.532**	-0.259	-0.252	-0.296	0.108
TF _{ordinary leaf- brown rice}	-0.419*	0.025	-0.051	-0.493**	0.06	-0.009	0.162	0.197	0.129	-0.122	0.217	0.095	-0.039	-0.266
TF _{flag leaf-brown rice}	-0.386*	0.101	-0.084	-0.386*	0.156	-0.245	0.101	-0.068	-0.112	-0.15	0.15	-0.254	-0.244	-0.319
TPn	0.198	0.788***	0.249	0.344*	0.213	0.371*	0.360*	0.546**	0.330*	0.233	0.271	0.365*	0.425**	-0.133
FPn	0.298	0.137	0.620***	0.303	0.154	0.634***	0.311	0.492**	0.649***	0.123	-0.023	0.410*	0.375*	-0.089
MPn	-0.027	0.114	0.169	0.596***	0.338*	0.477**	0.407*	0.526**	0.468**	0.558***	0.314	0.301	0.408*	-0.27
TTr	0.328	0.973***	0.340*	0.291	0.142	0.286	0.299	0.490**	0.276	0.078	0.252	0.132	0.332*	-0.121
FTr	0.225	0.293	0.991***	0.275	0.186	0.330*	0.305	0.327	0.336*	-0.106	0.039	0.188	0.129	-0.167
MTr	0.630***	0.306	0.264	0.996***	0.358*	0.359*	0.353*	0.306	0.179	0.235	0.29	0.185	0.429**	-0.265
TCi	0.175	0.488**	0.064	-0.168	-0.134	-0.169	-0.03	-0.11	-0.154	-0.289	-0.133	-0.338*	-0.099	-0.037
FCi	-0.172	0.135	0.707***	-0.005	0.022	-0.227	-0.025	-0.101	-0.167	-0.187	-0.063	-0.21	-0.139	-0.014
MCi	1	0.339*	0.177	0.640***	0.09	0.217	0.138	0.134	0.034	0.011	0.13	0.155	0.24	-0.141
Tgs		1	0.318	0.298	0.176	0.273	0.322	0.454**	0.269	0.032	0.255	0.154	0.355*	-0.15
Fgs			1	0.254	0.19	0.315	0.307	0.32	0.335*	-0.109	0.048	0.177	0.137	-0.19
Mgs				1	0.334*	0.376*	0.358*	0.305	0.187	0.252	0.276	0.169	0.422*	-0.265
TSPAD					1	0.183	0.638***	0.440**	0.22	0.118	0.654***	0.293	0.248	-0.634***
FSPAD						1	0.672***	0.709***	0.831***	0.202	0.186	0.602***	0.475**	-0.373*
MSPAD							1	0.685***	0.498**	0.127	0.453**	0.434**	0.271	-0.816***
TF _v /F _m								1	0.653***	0.24	0.558***	0.535**	0.507**	-0.411*
FF _v /F _m									1	0.192	0.094	0.614***	0.333*	-0.188
MF _v /F _m										1	0.099	0.144	0.2	-0.251

Continued Table S8.

	MCi	Tgs	Fgs	Mgs	TSPAD	FSPAD	MSPAD	TF _v /F _m	FF _v /F _m	MF _v /F _m	TSOD	TPOD	TCAT	Soil DTPA-Cd
TSOD											1	0.268	0.319	-0.473**
TPOD												1	0.530**	-0.326
TCAT													1	-0.165
Soil DTPA Cd														1

T, Tillering stage; F, Filling stage; M, Maturity stage; pH value, DOC and K concentrations of soil solution; TF, transfer factors (TF) of Cd between different rice organs; Pn, net photosynthetic rate; Tr, transpiration rate; Ci, substomatal CO₂ concentration; gs, stomatal conductance; SPAD, soil and plant analysis development; F_v/F_m, chlorophyll fluorescence parameter; SOD, superoxide dismutase; POD, peroxidase, CAT, catalase; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

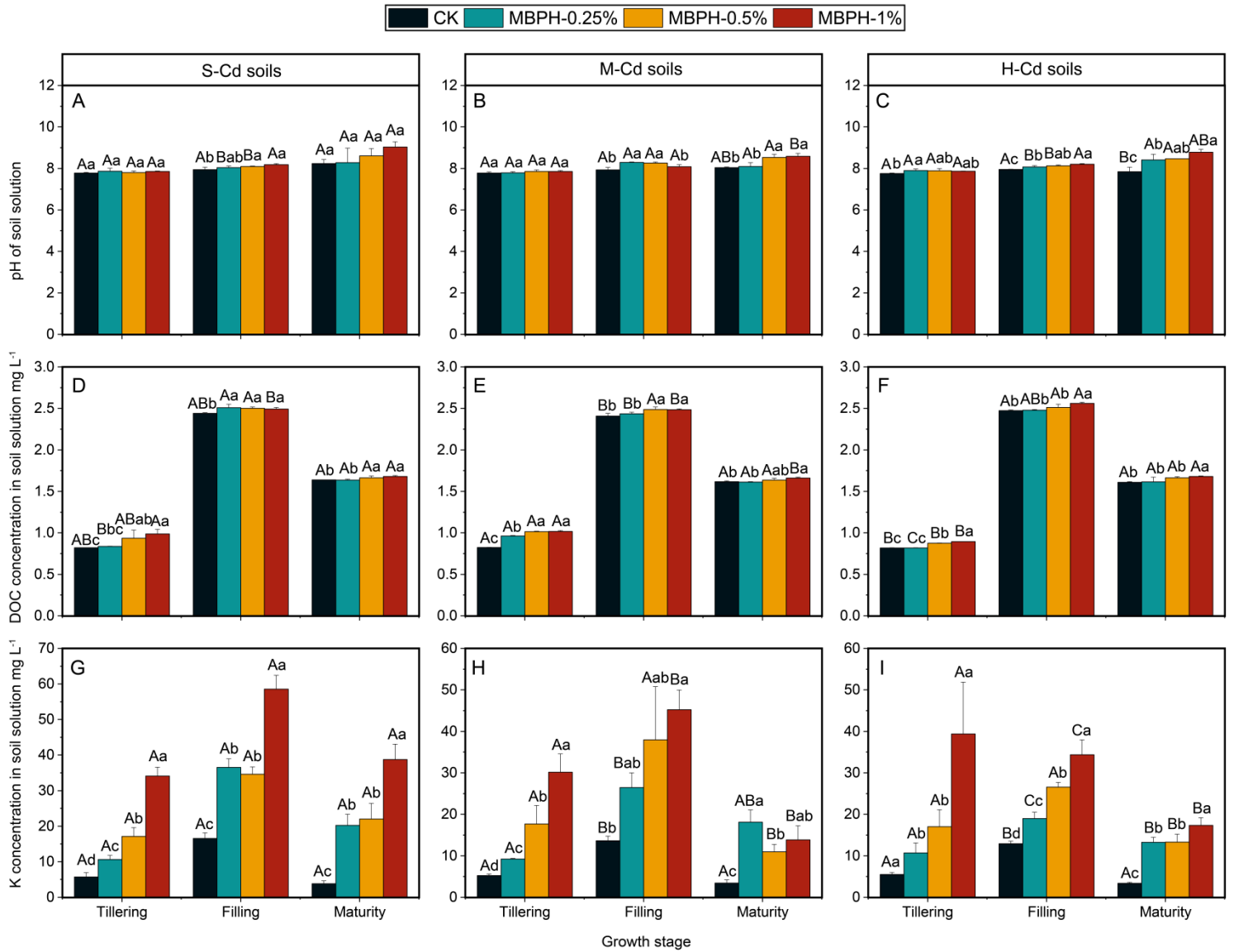


Figure.S1. Effects of application of mineral based potassium humate (MBPH) on pH (A-C), DOC (D-F), and K (G-I) in soil solution at different growth stages of rice under different soil contaminated levels. DOC, dissolved organic carbon; S-Cd, slightly contaminated soil (1 mg kg⁻¹); M-Cd, moderately contaminated soil (2 mg kg⁻¹); H-Cd, highly contaminated soil (4 mg kg⁻¹). Lowercase letters indicate significant differences in different MBPH levels under the same Cd-contaminated soil; capital letters indicate significant differences among different Cd-contaminated soils at the same level of MBPH application ($p < 0.05$, Duncan test and Kruskal–Wallis test).

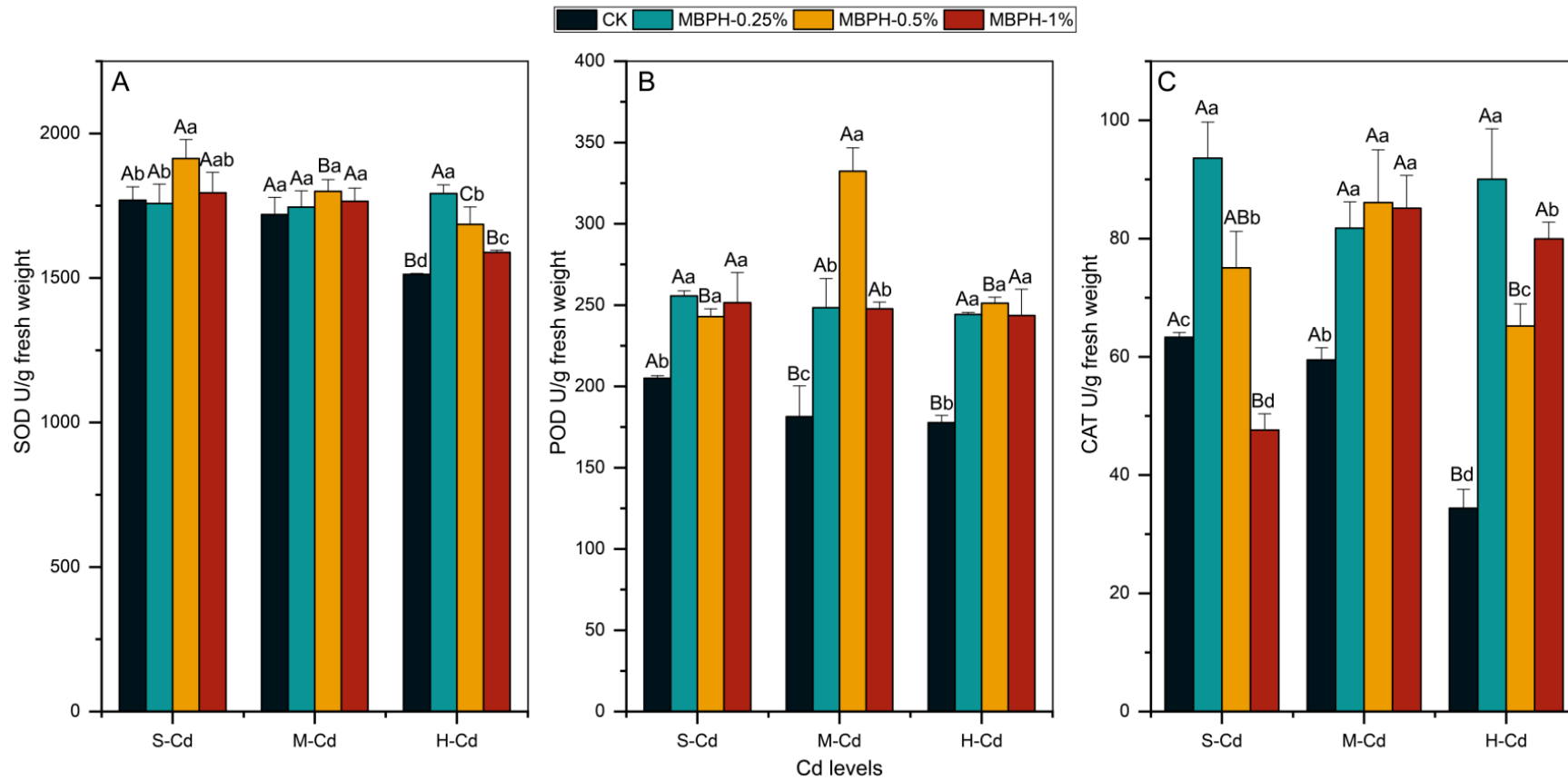


Figure.S2. Effects of application of mineral based potassium humate (MBPH) on the antioxidant enzyme activities of rice leaves at tillering stage under different soil contaminated levels. SOD (A), superoxide dismutase; POD (B), peroxidase, CAT (C), catalase; S-Cd, slightly contaminated soil (1 mg kg^{-1}); M-Cd, moderately contaminated soil (2 mg kg^{-1}); H-Cd, highly contaminated soil (4 mg kg^{-1}). Lowercase letters indicate significant differences in different MBPH levels under the same Cd-contaminated soil; capital letters indicate significant differences among different Cd-contaminated soils at the same level of MBPH application ($p < 0.05$, Duncan test and Kruskal–Wallis test).

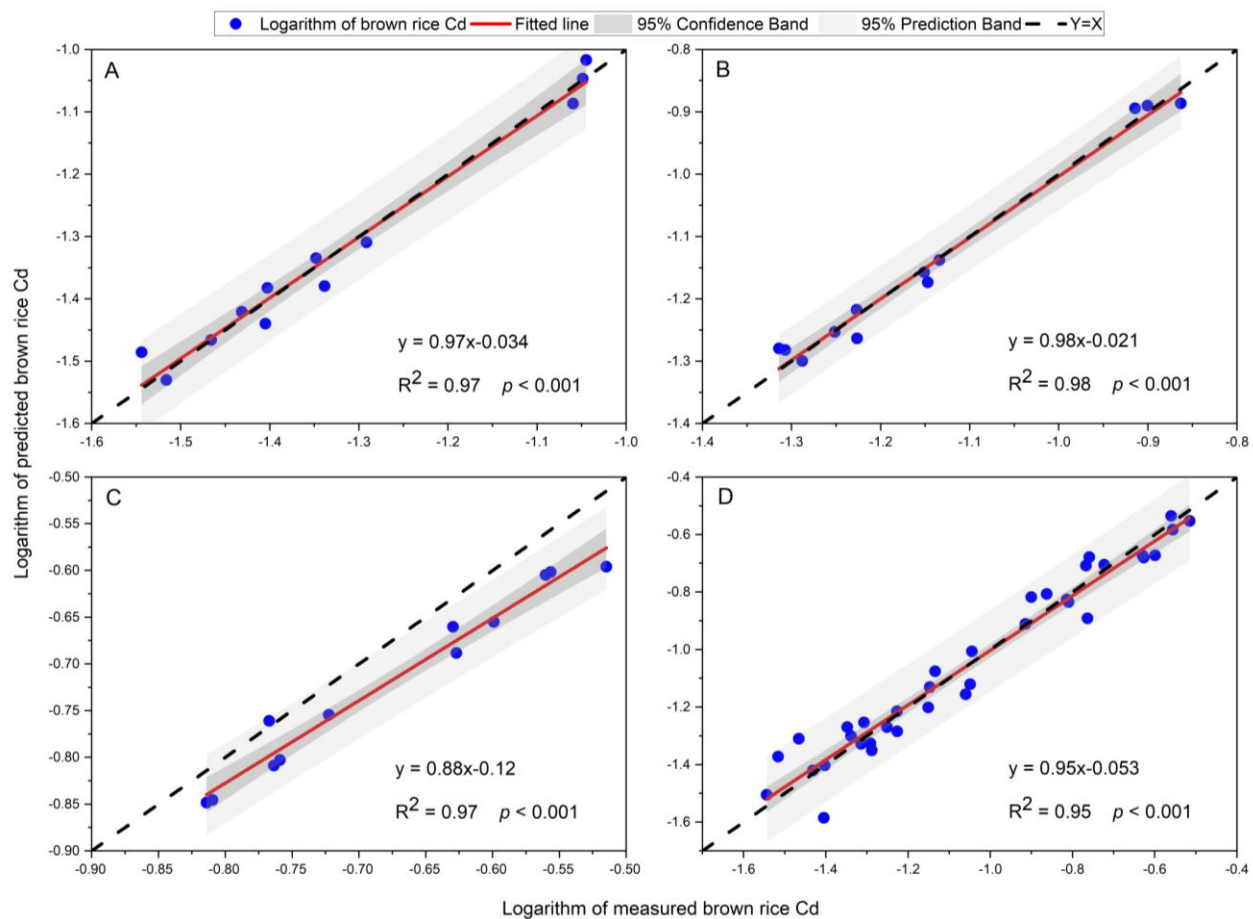


Figure.S3. Prediction equation validation in S-Cd (A), slightly contaminated soil (1 mg kg⁻¹); M-Cd (B), moderately contaminated soil (2 mg kg⁻¹); H-Cd (C), highly contaminated soil (4 mg kg⁻¹); All the data (D).

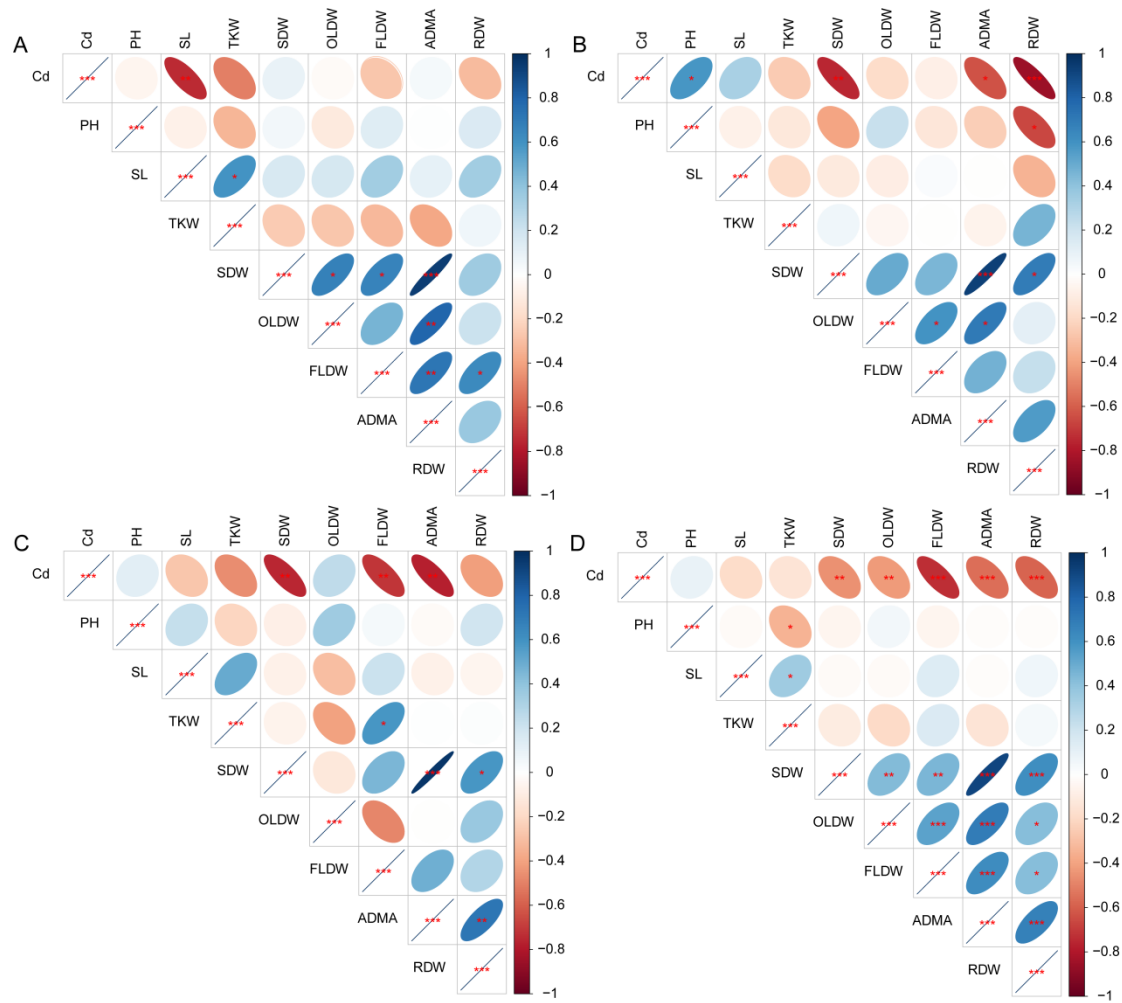


Figure.S4. Spearman correlation matrix for Cd concentration in brown rice and agronomic traits of rice. Diagonal shows the variable distribution diagram; the top right of the diagonal shows the Spearman correlation coefficient the level of significance ($p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***). S-Cd (A), slightly contaminated soil (1 mg kg^{-1}); M-Cd (B), moderately contaminated soil (2 mg kg^{-1}); H-Cd (C), highly contaminated soil (4 mg kg^{-1}); All the data (D). Cd, Cd concentration in brown rice; PH, Plant height; SL, spike length; TKW, thousand kernel weight; SDW, stem dry weight; OLDW, ordinary leaves dry weight; FLDW, flag leaves dry weight; ADMA, dry matter accumulation of aboveground; RDW, root dry weight.

References:

90. Calderon, F.J.; Reeves, J.B.; Collins, H.P.; Paul, E.A. Chemical differences in soil organic matter fractions determined by diffuse-reflectance mid-infrared spectroscopy. *Soil Sci. Soc. Am J* **2011**, *75*, 568-579, <https://doi.org/10.2136/sssaj2009.0375>.
91. Zhao, J.; Huang, X.; Shi, Y.; Song, X.; Qin, Z.; Tang, J. FTIR characteristics of rhizosphere soil of multi-generation continuous Eucalyptus plantation in South Subtropical Region. *Ecol. Environ. Sci.* **2022**, *31*, 688-694 (in Chinese).
92. Ma, F.; Du, C.W.; Zhou, J.M.; Shen, Y.Z. Investigation of soil properties using different techniques of mid-infrared spectroscopy. *Eur. J. Soil Sci.* **2019**, *70*, 96-106, <https://doi.org/10.1111/ejss.12741>.
93. Cui, L.Q.; Pan, G.X.; Li, L.Q.; Bian, R.J.; Liu, X.Y.; Yan, J.L.; Quan, G.X.; Ding, C.; Chen, T.M.; Liu, Y.; et al. Continuous immobilization of cadmium and lead in biochar amended contaminated paddy soil: A five-year field experiment. *Ecol. Eng.* **2016**, *93*, 1-8, <https://doi.org/10.1016/j.ecoleng.2016.05.007>.
94. Janik, L.J.; Skjemstad, J.O.; Shepherd, K.D.; Spouncer, L.R. The prediction of soil carbon fractions using mid-infrared-partial least square analysis. *Aust. J. Soil Res.* **2007**, *45*, 73-81, <https://doi.org/10.1071/Sr06083>.
95. Hall, S.J.; Berhe, A.A.; Thompson, A. Order from disorder: do soil organic matter composition and turnover co-vary with iron phase crystallinity? *Biogeochemistry* **2018**, *140*, 93-110, <https://doi.org/10.1007/s10533-018-0476-4>.
96. Zhang M.Y.; Zhu Z.L.; Li H.H.; Feng C.L.; An, S.S. Comparison and application of different fourier transform infrared spectroscopy to soil spectral characteristics analysis. *Res. Soil Water Conserv.* **2022**, *29*, 121-128, <https://doi.org/10.13869/j.cnki.rswc.20220414.006> (in Chinese).
97. Srivastava, M.; Mishra, A.K. Comparative responses of diazotrophic abundance and community structure to the chemical composition of paddy soil. *Environ. Sci. Pollut. R.* **2018**, *25*, 399-412, <https://doi.org/10.1007/s11356-017-0375-6>.
98. Li T.; Zhao S.W.; Li X.X.; M S. Characters of soil organic matter functional groups in the fields planted with alfalfa (*Medicago sativa*) for different years in hilly regions of South Ningxia , Northwest China. *Chin. J. Appl. Environ. Biol.* **2012**, *23*, 3266-3272, <https://doi.org/10.13287/j.1001-9332.2012.0406> (in Chinese).
99. Li, Z.; Liu, S.; Liu, J.; Li, D.; Liu, F. Characteristics and influencing factors of soil organic carbon functional groups in coastal wetlands with different. *Chin. J. Appl. Ecol.* **2022**, *28*, 276-282, <https://doi.org/10.19675/j.cnki.1006-687x.2020.11047> (in Chinese).
100. Wu, W.X.; Yang, M.; Feng, Q.B.; McGrouther, K.; Wang, H.L.; Lu, H.H.; Chen, Y.X. Chemical characterization of rice straw-derived biochar for soil amendment. *Biomass Bioenerg.* **2012**, *47*, 268-276, <https://doi.org/10.1016/j.biombioe.2012.09.034>.
101. Nkoumbou, C.; Villieras, F.; Barres, O.; Bihannic, I.; Pelletier, M.; Razafitianamaharavo, A.; Metang, V.; Ngoune, C.Y.; Njopwouo, D.; Yvon, J. Physicochemical properties of talc ore from Pout-Kelle and Memel deposits (Central Cameroon). *Clay Miner.* **2008**, *43*, 317-337, <https://doi.org/10.1180/claymin.2008.043.2.11>.
102. Du, C.W.; Zhou, J.M.; Goynes, K.W. Organic and inorganic carbon in paddy soil as evaluated by mid-infrared photoacoustic spectroscopy. *Plos One* **2012**, *7*, <https://doi.org/10.1371/journal.pone.0043368>.
103. Wang, S.; Wang, N.; Yao, K.; Fan, Y.C.; Li, W.H.; Han, W.H.; Yin, X.H.; Chen, D.Y.

Characterization and interpretation of Cd (II) adsorption by different modified rice straws under contrasting conditions. *Scientific Reports* **2019**, *9*, <https://doi.org/10.1038/s41598-019-54337-1>.