Supporting Information

Role of Fe-based nanoparticles introduced into soil–plant systems or contaminated soil–plant systems: Toxic substance or remediation agent?

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Table S1 Result of Heterogeneity test of meta-analysis in soil–plant systems.

Factors		N	Q	*p*
Plant morphological characteristics	Length	60	3308.4	<0.05
	DW	127	3216.5	<0.05
	FW	85	3817.2	<0.05
Plant physiology characteristics	Pigment	47	2755.4	<0.05
	MDA	40	256.04	<0.05
	Antioxidant enzyme	101	2524.9	<0.05
	Fe in plant	167	7513.5	<0.05

N: sample number of the collected studies.

Q: between-group variability.

p: *p* value of χ^2 test.

FW: Fresh weight; DW: Dry weight; MDA: malondialdehyde.

Table S2 Result of Heterogeneity test in meta-analysis in contaminated soil–plant systems.

Factors		N	Q	*p*
Plant morphological characteristics	Length	93	13525.7628	<0.05
	DW	172	2584.0881	<0.05
	FW	64	2505.22	<0.05
Plant physiology characteristics	Pigment	138	7963.6067	<0.05
	Oxidative stress	102	11080.2281	<0.05
	Antioxidant system	206	55286.8744	<0.05
	Pollutant in plant	423	66646.2984	<0.05
	Fe in plant	112	4828.9301	<0.05

N: sample number of the collected studies.

Q: between-group variability.

p: *p* value of χ^2 test.

FW: Fresh weight; DW: Dry weight.

Table S3 The Heterogeneity test of sub meta-analysis in soil–plant systems.

Factors	N	Q	*p*	Factors	N	Q	*p*	Factors	N	Q	*p*
Length	60	3308.45	<0.05	DW	127	3216.5	<0.05	FW	85	3817.18	<0.05
Fe-NPs type											
nZVI	34	3193.629	<0.05	FeOOH	8	19.5519	<0.05	FeOOH	8	185.0723	<0.05
Fe_2O_3	24	110.189	<0.05	nZVI	43	1815.953	<0.05	nZVI	30	569.1504	<0.05
Fe_3O_4	2	0.17	<0.05	Fe_2O_3	45	717.0273	<0.05	Fe_2O_3	26	808.0766	<0.05
				Fe_3O_4	31	246.1679	<0.05	Fe_3O_4	21	1220.33	<0.05
Fe-NPs dose(mg/kg)											
(0,10]	5	0.1077	0.99	(0,10]	19	105.2823	<0.05	(0,10]	4	212.0702	<0.05
(10,100]	4	109.7913	<0.05	(10,100]	40	291.0789	<0.05	(10,100]	32	1367.441	<0.05
(100,500]	16	73.1889	<0.05	(100,500]	43	639.1471	<0.05	(100,500]	39	1583.081	<0.05
(500,1000]	18	1032.513	<0.05	(500,1000]	19	1038.433	<0.05	(500,1000]	10	32.5709	<0.05
(1000,5000]	8	2048.2725	<0.05	(1000,5000]	6	767.1092	<0.05				
Plant organ											
Root	26	259.5948	<0.05	Root	60	863.6362	<0.05	Root	42	1625.333	<0.05
Shoot	34	2971.333	<0.05	Shoot	64	2105.997	<0.05	Shoot	43	1191.041	<0.05
Plant type											
Herbaceous plant	4	10.5581	<0.05	Herbaceous plant	5	27.3393	<0.05	Legumes plant	4	0.4327	0.9334
Legumes plant	16	64.8501	<0.05	Legumes plant	22	33.5203	<0.05	Maize	2	0.2258	0.6346
Maize	14	2511.841	<0.05	Maize	27	1279.181	<0.05	Rice	22	91.2839	<0.05
Rice	22	319.5869	<0.05	Rice	22	279.3626	<0.05	Vegetable	51	2457.678	<0.05
Wheat	4	7.5749	0.0557	Wheat	51	716.1092	<0.05	Wheat	4	55.571	<0.05
Soil initial pH											
pH>7.5	28	2542.358	<0.05	pH>7.5	44	1348.484	<0.05	pH>7.5	8	57.0401	<0.05
6.5≤pH≤7.5	8	23.4	<0.05	6.5≤pH≤7.5	12	26.6058	<0.05				
pH<6.5	24	333.8533	<0.05					pH<6.5	3	15.2129	<0.05

N: sample number of the collected studies. Q: between-group variability. *p*: *p* value of χ^2 test.

Table. S4 The Heterogeneity test of sub meta-analysis in contaminated soil–plant systems.

Factors	N	Q	*p*	Factors	N	Q	*p*	Factors	N	Q	*p*
Length	93	13525.76	<0.05	DW	172	2584.088	<0.05	FW	64	2505.22	<0.05
Fe-NPs type											
IONP	32	2737.94	<0.05	IONP	39	466.0724	<0.05	IONP	9	326.6721	<0.05
nZVI	61	10760.26	<0.05	nZVI	133	1670.074	<0.05	nZVI	55	1789.283	<0.05
Fe-NPs dose(mg/kg)											
(1000,5000]	4	317.9078	<0.05	(1000,5000]	8	152.5227	<0.05	(1000,5000]	16	480.1605	<0.05
(500,1000]	12	2455.225	<0.05	(500,1000]	26	675.5847	<0.05	(500,1000]	16	689.3093	<0.05
(100,500]	36	1792.858	<0.05	(100,500]	65	425.912	<0.05	(100,500]	6	108.2227	<0.05
(10,100]	37	2919.919	<0.05	(10,100]	64	748.0488	<0.05	(10,100]	22	538.0117	<0.05
(0,10]	4	14.5774	<0.05	(0,10]	8	51.5244	<0.05	(0,10]	4	1.4185	0.7012
Plant type											
Barely	3	160.2542	<0.05	Barely	4	172.2366	<0.05				
Fruit	3	351.929	<0.05	Herbaceous plant	63	523.8627	<0.05	Herbaceous plant	17	699.2392	<0.05
Herbaceous plant	53	10277.02	<0.05	Legumes plant	14	528.258	<0.05	Legumes plant	8	249.1045	<0.05
Maize	2	17.7775	<0.05	Maize	12	95.1339	<0.05	Maize	14	168.0155	<0.05
Wheat	23	351.929	<0.05	Wheat	33	387.2087	<0.05	Wheat	3	178.2267	<0.05
Rice	6	109.3236	<0.05	Rice	6	47.0052	<0.05	Rice	21	393.4141	<0.05
				Sorghum	40	47.2893	<0.05				
Plant organ											
Total	27	3126.651	<0.05	Total	37	1112.173	<0.05	Total	23	480.7665	<0.05
Root	27	2227.711	<0.05	Root	57	830.406	<0.05	Root	15	310.1244	<0.05
Shoot	29	8008.404	<0.05	Shoot	72	502.2615	<0.05	Shoot	20	550.8955	<0.05
Spike	10	52.2911,	<0.05	Grain/Fruit	6	35.0007	<0.05	Grain/Fruit	6	25.6161	<0.05
Soil initial pH											
pH>7.5	68	10339.02	<0.05	pH>7.5	82	735.9134	<0.05	pH>7.5	12	561.7259	<0.05

6.5≤pH≤7.5	14	583.3331	<0.05	6.5≤pH≤7.5	34	1363.193	<0.05	6.5≤pH≤7.5	18	828.8321	<0.05
				pH<6.5	56	314.7366	<0.05	pH<6.5	16	496.756	<0.05

N: sample number of the collected studies.

Q: between-group variability.

p: *p* value of χ^2 test.

Table S5 The results of publication bias for each group used in the meta-analysis in soil–plant systems.

Factors		p_E	Existence of bias	p_{E-A}	Existence of bias after adjusted	Does bias affect the trend
Plant morphological characteristics	Length	0.0047	Yes	0.9087	No	-
	DW	0.0013	Yes	0.0013	Yes	No
	FW	0.0027	Yes	0.0534	No	-
Plant physiology characteristics	Pigment	<0.0001	Yes	<0.0001	Yes	No
	MDA	0.2789	No	-	-	-
	Antioxidant enzyme	0.631	No	-	-	-
	Fe in plant	0.0142	yes	0.8462	No	No

p_E: *p*-value of Egger's test, the publication bias did not affect the results when the value of p_E >0.05.

p_{E-A}: *p*-value of Egger's test after adjusted by using trim-and fill method.

FW: Fresh weight; DW: Dry weight; MDA: malondialdehyde.

Table S6 The results of publication bias for each group used in meta-analysis in contaminated soil–plant systems.

Factors		p_E	Existence of bias	p_{E-A}	Existence of bias after adjusted	Does bias affect the trend
Plant morphological characteristics	Length	0.1028	No	-	-	-
	DW	0.104	No	-	-	-
	FW	0.0035	Yes	0.0035	Yes	No
Plant physiology characteristics	Pigment	0.2891	No	-	-	-
	Oxidative stress	0.7447	No	-	-	-
	Antioxidant system	0.1654	No	-	-	-
	Pollutant in plant	0.0129	Yes	0.0129	Yes	No
	Fe in plant	0.004	Yes	0.004	Yes	No

p_E: *p*-value of Egger's test, the publication bias did not affect the results when the value of p_E >0.05.

p_{E-A}: *p*-value of Egger's test after adjusted by using trim-and fill method. FW: Fresh weight; DW: Dry weight.

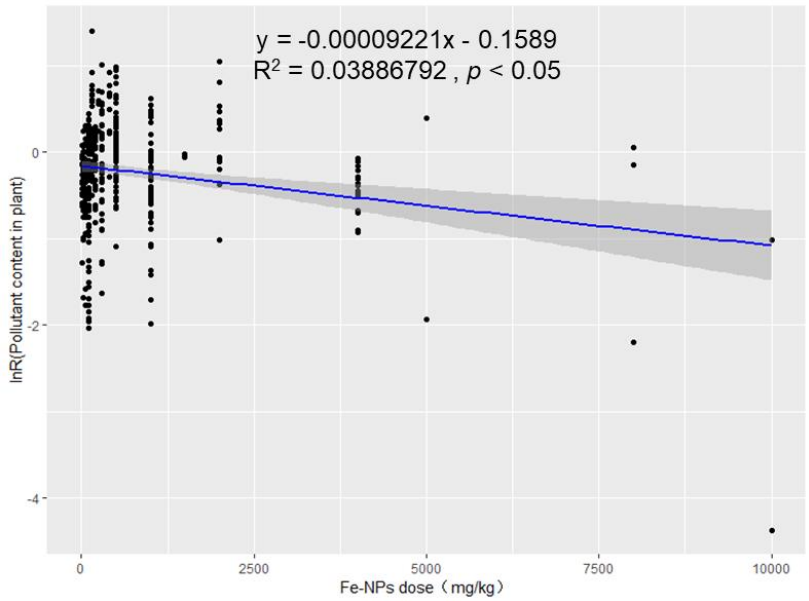

Fig. S1 The linear relationship between Fe-NPs dose (mg/kg) and the response variables (pollutant content in plant) calculated by the mixed-effects model.

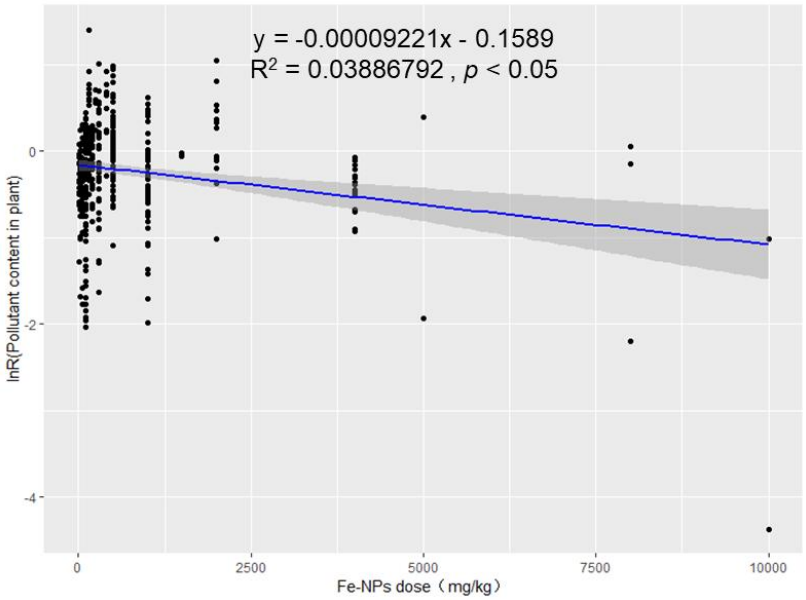

Fig. S2 The linear relationship between Fe-NPs dose (mg/kg) and the response variables (pollutant content in soil) calculated by the mixed-effects model.

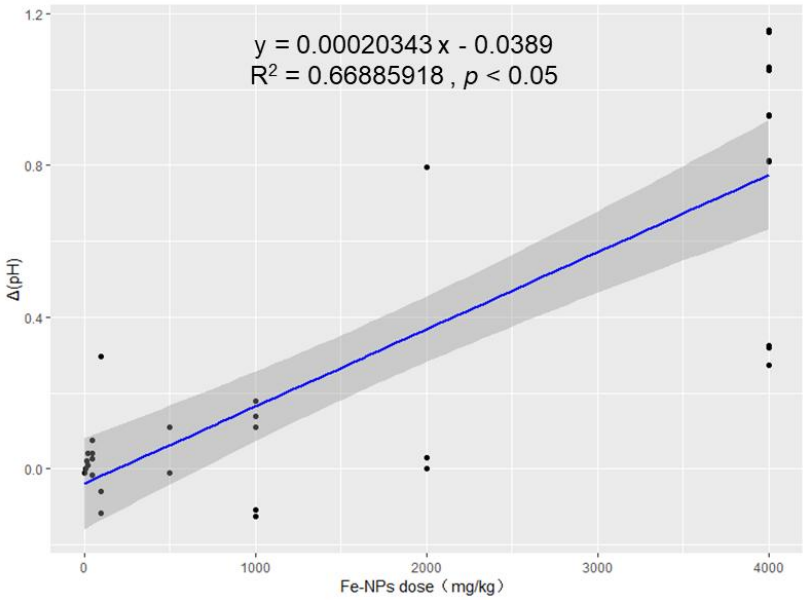

Fig. S3 The linear relationship between Fe-NPs dose (mg/kg) and the change of soil pH in polluted–soil system.

Texts

Text 1: The collected papers about the normal soil–plant system (N = 23).

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[13] Wang Y, Chen S, Deng C, Shi X, Cota-Ruiz K, White J C, Zhao L, Gardea-Torresdey J L. Metabolomic analysis reveals dose-dependent alteration of maize (Zea mays L.) metabolites and mineral nutrient profiles upon exposure to zerovalent iron nanoparticles [J]. NanoImpact, 2021, 23: 100336.

[14] Wang Y, Jiang F, Ma C, Rui Y, Tsang D C W, Xing B. Effect of metal oxide nanoparticles on amino acids in wheat grains (Triticum aestivum) in a life cycle study [J]. Journal of Environmental Management, 2019, 241: 319-327.

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Text 2: The collected papers about the contaminated soil–plant system (N = 38).

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