

Supporting information

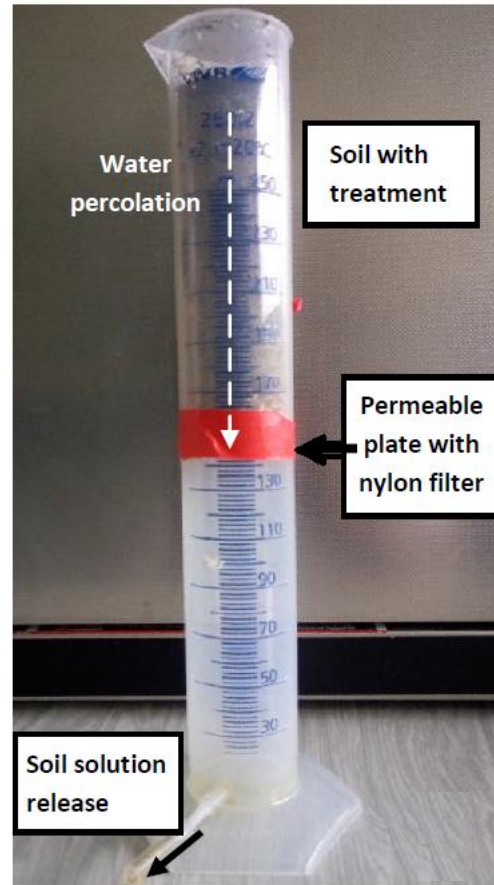


Figure S1: Experimental set-up of soil columns in a 250 mL measuring cylinder (VWR).

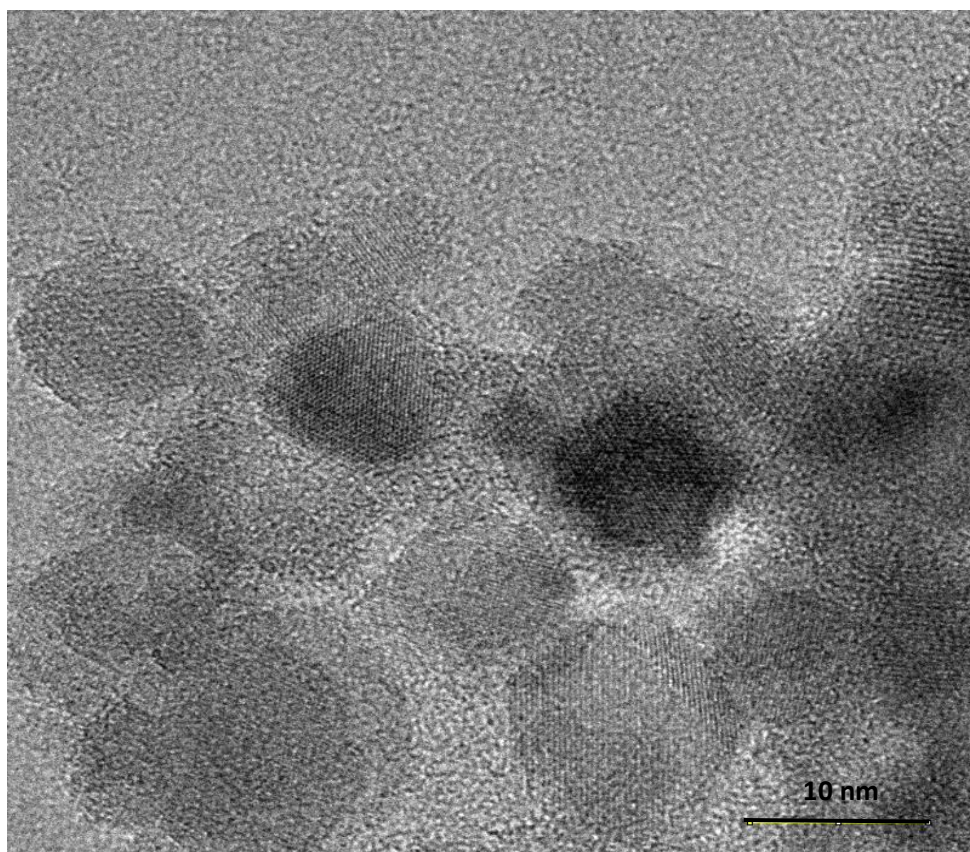
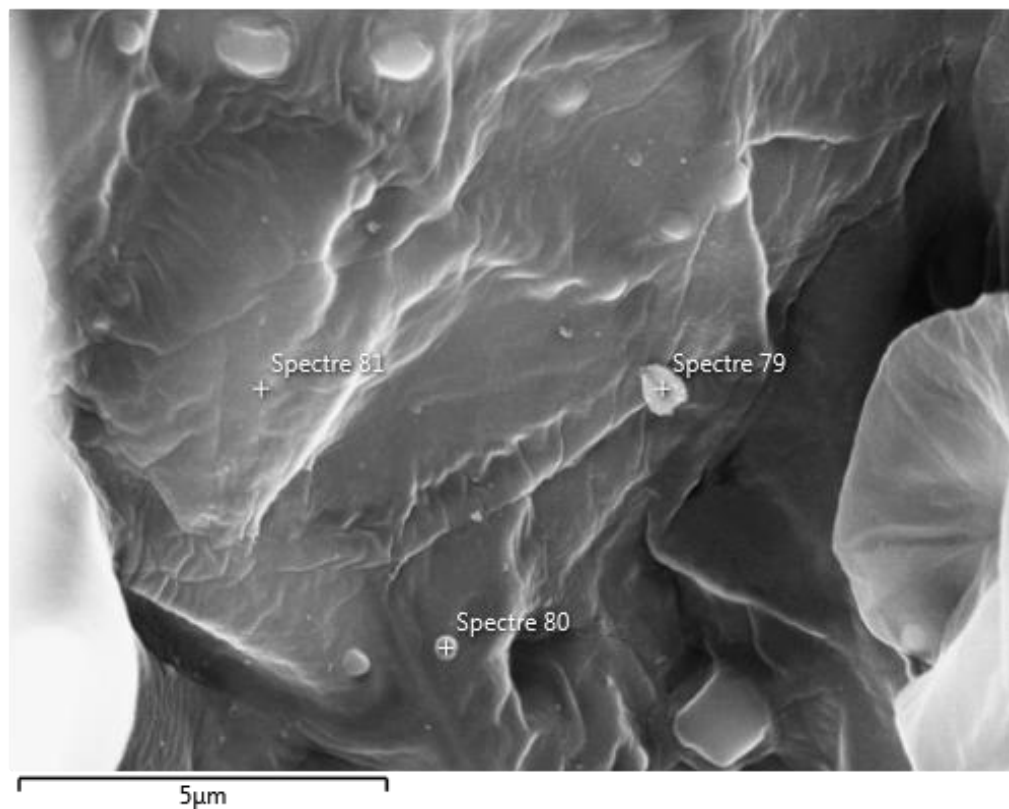


Figure S2: High resolution TEM observation of magnNPs in aqueous suspension



	C	O	Al	P	K	Fe
Point 79	0.00	41.21	6.64	10.88	17.82	23.45
Point 80	0.00	0.00	10.48	0.00	36.73	52.79
Point 81	55.12	33.37	1.80	0.00	4.83	4.87

Figure S3: SEM image showing the deposition of magnNPs aggregates (points 79 and 80) on the surface of the plant roots. EDS of the targeted points (79, 80 and 81) are shown in the table displayed below the SEM picture (weight %).

Table S1: Physico-chemical characteristics of soils sampled in the wetland area of Pleine-Fougères (Brittany, France). The analyses were performed in the ISAE, Analytical laboratory (Combourg, France).

pH	CEC (meq/100g)	MO (%)	C/N	Cd (ppm)	Cr (ppm)	Cu (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)
5.4	15.6	5.75	10.1	0.29	84.30	20.26	30.32	21.95	73.62
SiO ₂ (%)	Al ₂ O ₃ (%)	Fe ₂ O ₃ (%)	MnO (%)	MgO (%)	CaO (%)	Na ₂ O (%)	K ₂ O (%)	TiO ₂ (%)	P ₂ O ₅ (%)
64.89	12.0	4.03	0.03	0.96	0.39	1.0	1.85	0.71	0.15

Table S2: Magnetic susceptibilities ($\text{m}^3 \text{kg}^{-1}$) in the plant samples (stems, leaves, flowers and roots). Data represent mean \pm SEM (n= 4). Sunflower plants were exposed for 57 days to 1% magnNPs and/or Cu (500 mg kg^{-1}) in soil columns.

	roots		stems		leaves		flowers	
	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Control	4.8E-09	2.2E-09	-4.3E-09	2.2E-10	-1.9E-09	7.0E-10	-4.1E-09	8.2E-10
magnNPs	6.5E-07	1.1E-07	4.1E-09	1.9E-09	-4.2E-09	5.7E-10	-2.0E-09	1.3E-09
magnNPs-Cu	5.3E-07	2.9E-07	1.2E-09	1.0E-09	-5.7E-09	1.1E-09	-3.4E-09	1.5E-09
Cu	1.9E-09	1.2E-09	-2.4E-09	7.1E-10	-4.5E-09	4.6E-10	-5.6E-09	3.9E-09

Table S3: Magnetic susceptibilities ($\text{m}^3 \text{kg}^{-1}$) in the plant tissues (roots and aerial parts - stems and leaves -) and in the soil samples (initially 1% wgt magnNPs). Data represent means \pm SEM. Sunflower plants were exposed for 95 days to 1% magnNPs and/or Cu (500 mg kg^{-1}) in soil columns. In each column, three sections (samples) were made regards to the height of the aerial parts (increasing height from AP1 to AP3) and depth (increasing depth from 1 to 3) for roots (R) and soils (S). Values in bold characters highlight significant changes in magnetic susceptibilities, relating to magnNPs occurrence.

		Control		magnNPs		Cu		magnNPs-Cu	
		Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Aerial parts	AP3	-1.0E-08	5.0E-09	-2.8E-08	6.2E-09	-5.8E-09	2.0E-09	-3.3E-08	9.7E-09
	AP2	-7.1E-09	2.4E-09	-1.2E-08	1.0E-08	-4.5E-09	1.4E-09	-5.7E-09	1.9E-09
	AP1	-1.1E-08	6.2E-09	1.4E-08	8.8E-09	-2.4E-09	1.0E-09	-1.5E-09	7.5E-10
Roots	R1	-1.7E-09	1.9E-09	9.3E-07	2.4E-07	6.1E-10	3.7E-10	1.7E-07	3.2E-08
	R2	1.9E-09	5.7E-10	6.3E-07	1.6E-07	1.9E-09	6.1E-10	1.4E-07	6.2E-08
	R3	5.2E-09	2.2E-09	3.9E-07	4.9E-08	4.2E-09	2.0E-09	5.8E-07	1.5E-07
Soil	S1	7.1E-08	1.5E-09	5.9E-06	1.3E-07	6.8E-08	1.2E-09	7.3E-06	1.8E-07
	S2	6.9E-08	1.4E-09	5.5E-06	1.4E-07	6.8E-08	1.5E-09	6.7E-06	1.1E-07
	S3	6.9E-08	1.3E-09	5.8E-06	1.3E-07	6.9E-08	1.1E-09	6.4E-06	1.3E-07