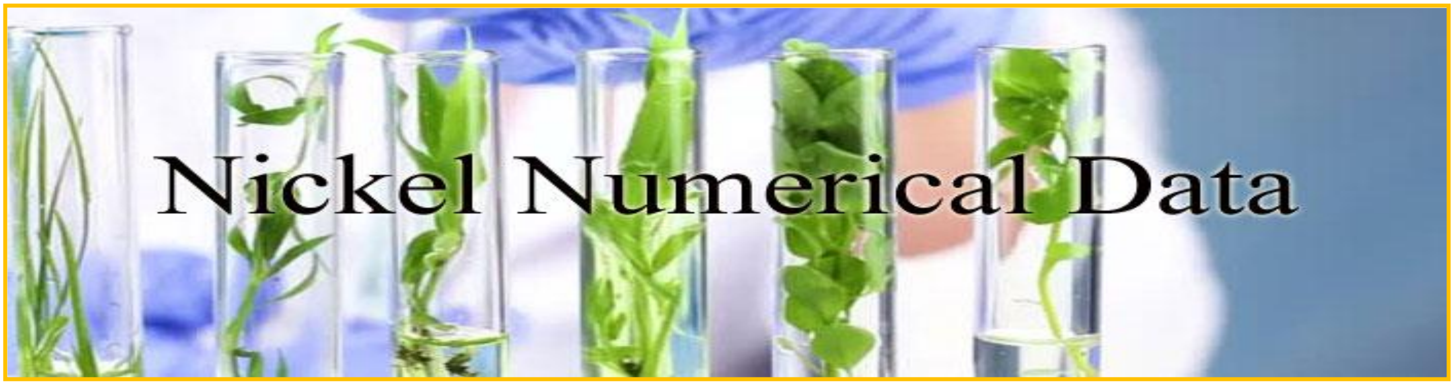

Establishing Critical Limits for Nickel in Soil and Plant for Predicting the Response of Spinach (Spinacia oleracea) (2021)

Table 1: Initial pH, EC and DTPA-Ni content in soil.

Soil No.	**Ni status in soil**	**pH (1:2.5)**	**EC (dS m^{-1})**	**Ni (mg kg^{-1})**
1*	Low	8.19	0.035	0.04
2		8.88	0.069	0.07
3		8.76	0.115	0.12
4		8.06	1.340	0.15
5		8.51	0.096	0.16
6		7.92	0.587	0.30
7		8.04	0.541	0.32
8		8.11	0.060	0.34
9		8.17	0.074	0.37
10		8.20	0.030	0.42
11	Medium	7.98	0.123	0.51
12		7.99	0.156	0.52
13		8.07	0.084	0.52
14		7.77	0.046	0.56
15		8.06	0.150	0.61
16		7.43	0.054	0.63
17	High	6.66	1.260	1.02
18		8.26	0.190	1.10
19		7.68	1.090	1.21
20		7.09	0.088	1.27
Mean		8.01	0.293	0.45
Range		6.66-9.14	0.030-1.340	0.04-1.27

*Low soil Ni group (soil no. 1–10): Medium soil Ni group (soil no. 11–16): High soil Ni group (soil no. 17–20).

Table 2: The DMP of spinach as affected by different levels of Ni application in soil (g pot^{-1})

Soil No.	Ni status in soil	Nickel (mg kg^{-1})						Mean	% Brays yield
		0	2.0	4.0	6.0	8.0	10.0		
1*	Low	8.31±1.0	9.92±1.4	10.19±1.3	9.99±1.9	9.19±0.9	9.98±1.9	9.60	81.5
2		10.90±0.6	12.79±0.3	14.06±1.5	11.13±0.8	11.79±0.5	10.96±0.6	11.94	77.4
3		7.62±1.1	12.45±0.2	12.38±1.1	11.75±0.4	12.53±0.9	10.21±1.1	11.16	60.8
4		8.93±1.0	11.83±1.4	9.50±1.2	12.33±1.3	9.70±1.0	9.86±0.9	10.36	72.3
5		9.54±1.2	11.67±1.6	9.80±0.7	11.01±1.8	11.81±1.1	10.25±1.2	10.68	80.7
6		10.67±1.7	10.55±1.5	11.24±0.2	12.19±1.1	12.58±1.3	12.14±0.8	11.56	84.8
7		9.89±1.4	11.16±0.6	13.06±0.5	11.43±1.9	9.91±1.3	10.76±2.2	11.03	75.7
8		10.55±1.1	12.27±0.8	13.42±1.4	13.06±1.3	12.67±1.8	12.37±0.7	12.39	78.6
9		10.08±1.4	10.01±0.4	11.17±0.9	12.13±1.0	12.03±0.6	11.38±0.2	11.13	83.0
10		9.60±1.5	11.20±1.3	11.25±1.3	9.99±1.6	9.59±1.3	12.20±0.8	10.64	78.6
11	Medium	11.09±1.7	10.84±1.0	12.57±1.1	12.17±0.4	12.48±1.6	11.15±1.8	11.72	88.2
12		12.25±1.5	13.26±1.3	14.21±0.6	12.65±1.0	12.44±0.5	13.40±0.1	13.04	86.1
13		11.33±1.0	11.65±0.6	12.24±1.0	11.69±1.6	11.79±1.3	11.46±1.1	11.69	92.5
14		10.18±0.4	11.31±0.2	10.76±0.9	10.80±1.4	10.42±1.0	11.23±1.1	10.78	90.0
15		11.74±0.4	13.92±0.9	13.30±0.7	13.53±0.8	12.98±1.9	13.00±0.8	13.08	84.3
16		9.78±0.3	10.01±0.0	11.01±0.5	10.10±0.4	9.84±2.0	10.12±0.4	10.15	88.8
17	High	12.89±1.1	12.68±0.5	13.59±1.7	12.46±0.7	11.92±1.6	11.62±1.2	12.53	94.8
18		9.72±0.4	10.75±0.5	10.88±1.6	9.80±0.2	10.54±1.2	9.74±0.3	10.24	89.3
19		9.89±0.3	12.74±0.9	14.42±0.7	14.09±1.8	12.02±0.8	13.72±1.8	12.81	68.5
20		11.07±0.5	12.36±1.9	12.42±1.0	11.19±1.0	11.68±1.6	12.18±0.3	11.82	89.1
Mean		10.30	11.67	12.07	11.68	11.40	11.39	11.42	82.3
Range		7.62-12.89	9.92-13.92	9.50-14.42	9.80-14.09	9.19-12.98	9.74-13.72		60.8-94.8

*Low soil Ni group (soil no. 1–10): Medium soil Ni group (soil no. 11–16): High soil Ni group (soil no. 17–20),

** standard error of mean of three replications

Table 3: The DMP of spinach, Ni content and uptake by the crop under control (Without Ni Application)

Soil No.	Ni Status in soil	DMP (g pot^{-1})	Ni concentration (mg kg^{-1}) in plant	Ni uptake (μg pot^{-1}) by plant
1	Low	8.31±1.0	1.28±0.2	10.6±2.9
2		10.90±0.6	1.85±0.1	20.2±0.5
3		7.62±1.1	2.17±0.1	16.5±3.2
4		8.93±1.0	2.42±0.1	21.6±3.3
5		9.54±1.2	1.77±0.2	16.9±3.9
6		10.67±1.7	1.86±0.2	19.9±2.0
7		9.89±1.4	2.07±0.4	20.5±4.8
8		10.55±1.1	1.75±0.3	18.5±5.2
9		10.08±1.4	2.34±0.2	23.6±4.7
10		9.60±1.5	2.03±0.1	19.5±3.1

11	Medium	11.09±1.7	2.52±0.2	27.9±4.4
12		12.25±1.5	2.42±0.1	29.6±4.8
13		11.33±1.0	1.75±0.2	19.8±3.9
14		10.18±0.4	2.01±0.0	20.5±1.1
15		11.74±0.4	2.11±0.3	24.8±2.3
16		9.78±0.3	2.01±0.3	19.7±3.3
17	High	12.89±1.1	2.89±0.3	37.3±6.2
18		9.72±0.4	2.26±0.1	22.0±1.7
19		9.89±0.3	2.74±0.1	27.1±0.7
20		11.07±0.5	2.60±0.1	28.7±2.2
Mean		10.30	2.14	22.25
Range		7.62-12.89	1.28-2.89	10.65-37.25

*Low soil Ni group (soil no. 1–10): Medium soil Ni group (soil no. 11–16): High soil Ni group (soil no. 17–20), ** standard error of mean of three replications

Table 4: Statistical method for computation of critical limit of deficiency of nickel content (mg kg^{-1}) in soil and spinach plant

Soil No.	Ni content in soil (mg kg^{-1})	Ni content in spinach (mg kg^{-1})	% Bray's yield of spinach	r^2 for soil	r^2 for plant
1	0.04	1.28	81.5	0.167	0.169
2	0.07	1.85	77.4	0.189	0.179
3	0.12	2.17	60.8	0.403	0.343
4	0.15	2.42	72.3	0.517	0.428
5	0.16	1.77	80.7	0.511	0.409
6	0.30	1.86	84.8	0.462	0.356
7	0.32	2.07	75.7	0.546	0.411
8	0.34	1.75	78.6	0.602	0.440
9	0.37	2.34	83.0	0.601	0.423
10	0.42	2.03	78.6	0.675*	0.462*
11	0.51	2.52	88.2	0.615	0.398
12	0.52	2.42	86.1	0.596	0.364
13	0.52	1.75	92.5	0.495	0.281
14	0.56	2.01	90.0	0.440	0.234
15	0.61	2.11	84.3	0.467	0.228
16	0.63	2.01	88.8	0.444	0.199
17	1.02	12.89	94.8	0.345	0.168
18	1.10	2.26	89.3	0.252	0.184
19	1.21	2.74	68.5		
20	1.27	2.60	89.1		

Critical limit for plant = (2.03 + 2.52)/2 = 2.27
Critical limit for soil = (0.42+0.51)/2 = 0.46
*Critical limit is computed as the mean value of Ni content in soil having maximum value of R2 and that in succeeding soil and plant as well.

Source:https://www.researchgate.net/publication/351228642_Establishing_Critical_Limits_for_Nickel_in_Soil_and_Plant_for_Predicting_the_Response_of_Spinach_Spinacia_oleracea

Organic and inorganic amendments for the remediation of nickel contaminated soil and its improvement on Brassica napus growth and oxidative defense (2021)

Table 1: The effect of different amendments on plant biomass production, chlorophyll and heavy metals contents in plant parts and post-harvest soil DTPA-Ni (mg kg^{-1}) in the Brassica napus under Ni polluted soil.

Treatment	Root DW (g)	Shoot DW (g)	Ch-a (mg g^{-1} FW)	Ch-b (mg g^{-1} FW)	RWC (%)	DTPA-Ni mg kg^{-1}	Ni in root mg kg^{-1}	Ni in shoot mg kg^{-1}
Control	1.34±0.05c-e	6.17 ± 0.2d	5.87±0.2de	4.07±0.14fg	74.7± 2.3c-e	0.077±0.003 i	0.11±0.003 h	0.06±0.003 h
LS	1.42±0.06bd	7.03±0.23bc	6.47 ± 0.2c	4.6±0.17 cd	79.7± 3.3a-c	0.097±0.003 i	0.14±0.006 h	0.097±0.003 h
BC	1.67 ± 0.07a	8.4 ± 0.29a	7.67± 0.26a	5.4 ± 0.2a	85.3 ± 3.7a	0.063±0.003 i	0.21±0.009 h	1.07 ± 0.004 h
ZE	1.34±0.05c-e	6.47± 0.2 cd	6.17±0.2 cd	4.37±0.14d-f	77.7±2.3bd	0.053±0.003 i	0.11±0.003 h	0.06 ± 0.003 h
MS	1.5 ± 0.06b	7.87 ± 0.26a	7.23±0.23ab	5.2± 0.17ab	82.7 ± 2.3ab	0.063±0.003 i	0.12±0.003 h	0.077±0.003 h
Ni (50 mg kg^{-1})	0.9 ± 0.04e	4.07±0.14 g	4.9±0.17 g-i	3.2 ± 0.11i	63 ± 1.7 g-i	1.74±0.07cd	45.4 ± 1.6e	27.4 ± 1.1b
LS+Ni (50 mg kg^{1})	1.29±0.05de	5.9 ± 0.2de	5.53±0.18ef	4.17±0.14e-g	69.3 ± 2e-g	1.54± 0.06ef	37.8 ± 1.4 f	17.1 ± 0.7e
BC+Ni (50 mg kg^{-1})	1.47±0.06bc	7.1 ± 0.23b	6.7 ± 0.23bc	4.8± 0.17bc	73.3 ± 2c-e	1.2 ± 0.05 h	31.6± 1.1 g	12.47± 0.5 g
ZE+Ni (50 mg kg^{1})	1.25 ± 0.05e	5.3 ± 0.17 f	5.2 ± 0.17 f-h	3.9 ± 0.14 g	66.3 ± 2 f-h	1.397±0.06fg	35.4±1.3fg	14.8 ± 0.6 f
MS+Ni (50 mg kg^{-1})	1.38±0.05be	6.47± 0.2 cd	6.37± 0.2 cd	4.5 ± 0.17c-e	71.3 ± 2.4d-f	1.28±0.05gh	34± 1.2fg	13.53±0.5fg
Ni (100 mg kg-1)	0.76 ± 0.03 g	2.87 ± 0.09	3.5 ± 0.11 g	2.23± 0.09k	55.3 ± 1j	2.69 ± 0.11a	86.5 ± 3.1a	41 ± 1.6a
LS+Ni (100 mg kg-1)	0.99 ± 0.04e	4.7 ± 0.14 h	4.37± 0.14ij	3.2 ± 0.11i	61.7±1.8hj	1.96 ± 0.08b	67 ± 2.4b	26.97 ± 1b
BC+Ni (100 mg kg-1)	1.29± 0.05de	5.5 ± 0.18ef	5.3 ± 0.17fg	3.83±0.14gh	68.3 ± 2e-g	1.69± 0.07c-e	53.6±1.9 cd	22.9± 0.9 cd
ZE+Ni (100 mg kg-1)	1.08 ± 0.04e	3.9 ± 0.12 g	4.17 ± 0.14j	2.77 ± 0.09j	56.7 ± 1.8ij	1.83±0.07bc	57.4 ± 2.1c	24.6 ± 0.9c
MS+Ni (100 mg kg-1)	1.24 ± 0.05e	5 ± 0.17 f	4.67±0.14 h-j	3.5 ± 0.11hi	58.7 ± 1.8ij	1.61±0.07de	50.9 ± 1.8d	21.17 ± 0.8d
LSD0.05	0.15	0.57	0.56	0.42	6.5	0.17	4.5	2.2

Means sharing same letter(s) in a column for each parameter do not differ significantly at P = 0.05. Data is average of 3 replicates ± SE

Table 2: The effect of different amendments on the bioactive compound in fresh plant leaves of Brassica napus grown under Ni polluted soil.

Treatments	**Protein (mg g^{-1})**	**Amino acid(mg g^{-1})**	**Carotenoid (mg g^{-1})**	**Ascorbic acid (mg g^{-1})**	**Phenolic (µ mole g^{-1})**
Control	17.4 ± 0.5de	27.9 ± 0.9d-f	1.31 ± 0.06fg	0.32 ± 0.09ef	3.4 ± 0.14 g-i
LS	19.9 ± 0.5c	33.1 ± 1c	1.75 ± 0.09c	0.4 ± 0.12bc	2.9 ± 0.11j-l
BC	23.6 ± 0.7a	39.3 ± 1.2a	2.41 ± 0.1a	0.49 ± 0.11a	2.5 ± 0.09 l
ZE	18 ± 0.5d	29.8 ± 0.9d	1.41 ± 0.06ef	0.36 ± 0.08de	3.1 ± 0.11i-k
MS	21.8 ± 0.6b	36.5 ± 1.1b	2.17 ± 0.09b	0.44 ± 0.17b	2.7 ± 0.11kj
Ni (50 mg kg^{-1})	14.3 ± 0.4 h	22.4 ± 0.7hi	0.097 ± 0.03i	0.22 ± 0.09hi	5.4 ± 0.2b
LS+Ni (50 mg kg^{-1})	15.9 ± 0.4fg	26.1 ± 0.8fg	1.2 ± 0.06gh	0.34 ± 0.014e	3.9 ± 0.14fg
BC+Ni (50 mg kg^{-1})	17.7 ± 0.5de	29.1 ± 0.9de	1.62 ± 0.06 cd	0.42 ± 0.18bc	3.3 ± 0.11 h-j
ZE+Ni (50 mg kg^{-1})	14.8 ± 0.4gh	24.1 ± 0.7gh	1.31 ± 0.06fg	0.29 ± 0.14fg	4.2 ± 0.17ef
MS+Ni (50 mg kg^{-1})	16.5 ± 0.5ef	27.4 ± 0.8ef	1.51 ± 0.06de	0.38 ± 0.20 cd	3.6 ± 0.14gh
Ni (100 mg kg^{-1})	11.8 ± 0.3i	18.3 ± 0.5k	0.07 ± 0.03i	0.15 ± 0.08j	6.8 ± 0.26a
LS+Ni (100 mg kg^{-1})	14 ± 0.4 h	21.3 ± 0.7ij	0.097 ± 0.03i	0.23 ± 0.13hi	4.7 ± 0.17 cd
BC+Ni (100 mg kg^{-1})	15.7 ± 0.4fg	24.6 ± 0.7gh	1.2 ± 0.06gh	0.29 ± 0.15fg	4.1 ± 0.15ef
ZE+Ni (100 mg kg^{-1})	12.5 ± 0.3i	19.97 ± 0.6jk	0.087 ± 0.03i	0.196 ± 0.08i	5.1 ± 0.2bc
MS+Ni (100 mg kg^{-1})	14.9 ± 0.4gh	22.9 ± 0.7hi	1.1 ± 0.06 h	0.25 ± 0.11gh	4.4 ± 0.17de

Means sharing same letter(s) in a column for each parameter do not differ significantly at P = 0.05. Data is average of 3 replicates ± SE

Table 3: The effect of different amendments on superoxide dismutase (SOD), catalase (CAT), peroxidase (POD), ascorbate peroxidase (APX), glutathione reductase (GR), monodehydroascorbate reductase (MDHAR), Dehydroascorbate reductase (DHAR) and malondialdehyde (MDA), hydrogen peroxide (H_2O_2), superoxide radical (O_2) of Brassica napus grown under Ni polluted soil.

Treatments	**Reactive oxygen species**			**Antioxidant Enzymes**					
	MDA (n mole mg^{-1} protein)	H_2O_2 (n mole mg^{-1} fw)	O_2(n mole $min^{-1}g^{-1}$ fw)	SOD (U min^{-1} mg^{-1} protein)	APx (µ mole min^{-1} mg^{-1} protein)	CAT (µ mole min^{-1} mg^{-1} protein)	GR (µ mole min^{-1} mg^{-1} protein)	MDHAR (µ mole min^{-1} mg^{-1} protein)	DHAR (µ mole min^{-1} mg^{-1} protein)
Control	13.7± 0.4 h	11.7±0.3 h	10.4±0.29 h	24.8 ± 0.7j	0.55±0.02j	21.2± 0.6 l	11.26±0.70k	2.5± 0.37k	17.5± 0.33 m
LS	11.5 ± 0.3 h	10.3±0.3 hi	8.3±0.23 hi	29.5±0.9 hj	0.71± 0.03 hj	26.2±0.7jk	15.63±0.49j	4.36± 0.27j	27.23± 0.53k
BC	10.3 ± 0.3 h	8.5± 0.3i	7.3±0.2i	35.8±1.1gh	0.86±0.04gh	31.7±0.9hi	24.66± 0.53 h	11.5± 0.23 g	46.26± 0.50 f
ZE	11.96±0.3 h	10.8±0.3 hi	8.7±0.23ji	27± 0.8ij	0.66± 0.03ij	23.4±0.6kl	14.9± 0.53j	4.86± 0.10j	24.06± 0.14 l
MS	10.93±0.3 h	8.97± 0.3i	7.6±0.2hi	32.5±1hi	0.77±0.03 gi	27.3±0.7jk	18.73±0.57i	7.43± 0.20i	40.93± 0.14 h
Ni (50 mg kg^{-1})	79.17±2.1 b	34.87±1.1 bc	48.4± 1.4c	45.1±1.4 f	0.95± 0.04 g	35.7±1 h	28.3± 0.67 g	12.53± 0.17 f	2.66± 1.02e
LS+Ni (50 mg kg^{-1})	60.13±1.6 ef	29.8±0.9 ef	32.96±0.9e	92.9±2.9c	1.72± 0.06d	65.2±1.8d	42.5± 0.67d	15.2± 0.31e	60.93± 0.73d
BC+Ni	51.73±1.3	24.7±0.7	25.7±0.7	124.6±3.8a	2.92± 0.12a	77.8±2.2a	57.73±0.	24.33±0.	91.66 ± 2.14a

(50 mg kg^{-1})	g	g	g				84a	37a	
ZE+Ni (50 mg kg^{-1})	67.6 ± 1.7d	31.6±0.9 de	35.6 ± 1e	84.5± 2.6d	1.41± 0.06e	60.9±1.7e	36.4± 0.57e	16.6± 0.20d	64± 0.67c
MS+Ni (50 mg kg^{-1})	55.9±1.5f g	27.3± 0.8 f	28.9 ± 0.8 f	107.8±3.3b	2.58± 0.09b	71.5 ± 2b	51.16±0.44c	18.56±0.23c	74.33 ± 1.02b
Ni (100 mg kg^{-1})	96.97±2.7a	52.7± 1.6a	70.5 ± 2a	42.2±1.3fg	0.69 ± 0.03 h j	29.2±0.8ij	18.6 ± 0.55i	7.2 ± 0.13i	32.73 ± 0.47j
LS+Ni (100 mg kg^{-1})	72.8 ± 1.9c	34.8±1.1 bc	50.2 ± 1.4bc	80.1±2.4de	1.51± 0.06e	48.4 ± 1.4 f	37.4± 0.67e	9.33 ± 0.17 h	37± 0.67i
BC+Ni (100 mg kg^{-1})	58.1±1.5 f	30.4±0.9 de	41.9 ± 1.2d	105.4±3.2b	2.41± 0.11b	69.3±1.9 bc	59.1± 0.64a	19.56±0.41b	51.03 ± 0.71e
ZE+Ni (100 mg kg^{-1})	77.1±2 bc	36.6± 1.1b	52.8 ± 1.5b	74.1± 2.3e	1.2 ± 0.06 f	42.96±1.2 g	32.7± 0.88 f	11.43± 0.28 g	34± 0.67j
MS+Ni (100 mg kg^{-1})	63.3±1.7 de	32.6±0.9 cd	43.8 ± 1.2d	96 ± 2.9c	1.96± 0.09c	65.43±1.8 cd	53.76±0.98b	15.73±0.57e	44± 1.33 g

Means sharing same letter(s) in a column for each parameter do not differ significantly at P = 0.05. Data is average of three replicates ± SE.

Table 4: The effect of different amendments on soil enzyme activities of control and Ni polluted soil.

Treatments	β-glucosidase (mole PNF g^{-1} h^{-1})	Phosphomonoesterase (mole PNF g^{-1} h^{-1})	Urease [mg N-N (H4 kg^{-1} h^{-1})]	Catalase (vol. of 0.1 M KMnO4 g^{-1} of soil)	Acid phosphatase (mg p-NP g^{-1} 24 h^{-1})
Control	2.7 ± 0.11d-f	0.73 ± 0.03 f	1.45 ± 0.05e-g	0.19 ± 0.009fg	25.6 ± 0.8ef
LS	3.3 ± 0.14c	0.97 ± 0.04c	1.83 ± 0.09d	0.28 ± 0.01c	30.4 ± 0.9bc
BC	4.2 ± 0.17a	1.25 ± 0.05a	2.6 ± 0.1a	0.38 ± 0.01a	34.5 ± 1a
ZE	2.8 ± 0.11de	0.83 ± 0.03de	1.6 ± 0.06e	0.23 ± 0.009de	28.2 ± 0.9 cd
MS	3.7 ± 0.14b	1.08 ± 0.05b	2.27 ± 0.09bc	0.34 ± 0.01b	31.9 ± 1b
Ni	2.4 ± 0.09 f-h	0.53 ± 0.02hi	1.1 ± 0.03ij	0.16 ± 0.006 h	22.3 ± 0.7gh
LS+Ni (50 mg kg^{-1})	2.9 ± 0.11d	0.75 ± 0.03ef	1.5 ± 0.06ef	0.22 ± 0.009de	26.6 ± 0.8de
BC+Ni (50 mg kg^{-1})	3.7 ± 0.14b	0.99 ± 0.04bc	2.37 ± 0.09b	0.33 ± 0.01b	31.1 ± 0.9b
ZE+Ni (50 mg kg^{-1})	2.6 ± 0.11d-g	0.68 ± 0.03fg	1.4 ± 0.06fg	0.2 ± 0.009ef	23.6 ± 0.7fg
MS+Ni (50 mg kg^{-1})	3.5 ± 0.14bc	0.9 ± 0.04 cd	2.17 ± 0.09c	0.3 ± 0.01c	28.6 ± 0.9 cd
Ni (100 mg kg^{-1})	1.9 ± 0.09i	0.36 ± 0.03k	0.95 ± 0.03j	0.11 ± 0.003i	19.3 ± 0.6i
LS+Ni (100 mg kg^{-1})	2.3 ± 0.09gh	0.49 ± 0.04ij	1.2 ± 0.06hi	0.17 ± 0.006gh	22.5 ± 0.7gh
BC+Ni (100 mg kg^{-1})	2.7 ± 0.11d-f	0.66 ± 0.01fg	1.4 ± 0.06fg	0.22 ± 0.009de	25.1 ± 0.7ef
ZE+Ni (100 mg kg^{-1})	2.1 ± 0.09hi	0.4 ± 0.02jk	1.06 ± 0.04ij	0.15 ± 0.006 h	21.1 ± 0.6hi
MS+Ni (100 mg kg^{-1})	2.5 ± 0.11e-g	0.59 ± 0.03gh	1.3 ± 0.06gh	0.2 ± 0.009ef	23.5 ± 0.7fg
$LSD_{0.05}$	0.35	0.099	0.19	0.03	2.3

Means sharing same letter(s) in a column for each parameter do not differ significantly at P = 0.05. Data is average of three replicates ± SE.

Source: https://doi.org/10.1016/j.jhazmat.2021.12592

Biotransfer, bioaccumulation and detoxification of nickel along the soil - faba bean - aphid - ladybird food chain (2021)

Table 1: Chemical properties and Ni concentrations (total and extractable) of soil treated with different doses of Ni (mean ± SE, n = 4). Values with different small superscript letters in each group are significantly different from each other at $p < 0.05$ as per DMRT.

Parameters	T0	T1	T2	T3	T4
pH	7.81 ± 0.04^a	7.77 ± 0.03^a	7.74 ± 0.05^a	7.74 ± 0.04^a	7.72 ± 0.03^a
Organic C (%)	0.72 ± 0.04^a	0.71 ± 0.03^a	0.71 ± 0.03^a	0.73 ± 0.03^a	0.74 ± 0.03^a
Total N (%)	0.17 ± 0.02^b	0.19 ± 0.02^b	0.22 ± 0.02^{ab}	0.24 ± 0.02^{ab}	0.28 ± 0.03^a
Total nickel in soil (mg kg^{-1}) Ni	12.36 ± 0.44^e	36.82 ± 1.64^d	59.78 ± 2.05^c	82.23 ± 3.07^b	106.35 ± 9.51^a
DTPA extractable nickel in soil (mg kg^{-1}) Ni	2.12 ± 0.08^e	6.36 ± 0.21^d	10.58 ± 0.34^c	14.36 ± 0.40^b	18.65 ± 0.44^a

- T0: control soil; T1: 25 mg kg^{-1}; T2: 50 mg kg^{-1}; T3: 75 mg kg^{-1}; T4: 100 mg kg^{-1} Ni treatments.

Table 2: Transfer coefficients of Ni concentrations between various components of the soil – plant –aphid – ladybird food chain on amendment of soil with various levels of Ni.

Food chain components	T0	T1	T2	T3	T4
Total soil to root	1.62	1.65	1.78	1.86	1.96
Extractable soil to root	9.44	9.55	10.06	10.65	11.18
Root to Shoot	0.58	0.65	0.71	0.74	0.77
Shoot to aphid	1.23	1.31	1.39	1.36	1.34
Aphid to ladybird	0.61	0.63	0.67	0.68	0.68

T0: control soil; T1: 25 mg kg^{-1}; T2: 50 mg kg^{-1}; T3: 75 mg kg^{-1}; T4: 100 mg kg^{-1} Ni treatments.

Table 3: Ni content (mg kg^{-1} dry weight) excreted via honeydew of aphids and in pupal exuviae of predatory ladybirds exposed to varying levels of Ni concentration (mean ± SE; n = 4).Values with different superscript letters in each group are significantly different from eachother at $p < 0.05$ as per DMRT.

Treatments	Honeydew	Pupal exuviae
T0	2.42 ± 0.38^e (0.17)	10.43 ± 1.54^e (14.25)
T1	9.82 ± 0.98^d (0.19)	37.76 ± 1.91^d (14.12)
T2	22.05 ± 1.38^c (0.21)	78.75 ± 3.76^c (13.87)
T3	38.48 ± 1.75^b (0.25)	112.36 ± 5.85^b (13.29)
T4	58.07 ± 2.58^a (0.27)	148.40 ± 9.45^a (12.67)

- T0: control soil; T1: 25 mg kg^{-1}; T2: 50 mg kg^{-1}; T3: 75 mg kg^{-1}; T4: 100 mg kg^{-1} Ni treatments.
- Values within parenthesis in honeydew columns are the ratios of Ni content in honeydew vs Ni content in aphids.
- Values within parenthesis in exuviae columns are percentages of total Ni content lost via exuviae.

Table 4: Variation in fresh and dry mass (mg individual^{-1}) of aphids and newly emerged adult ladybirds exposed to various application rates of Ni (mean ± SE; n = 4). Values with dif ferent superscript letters in each group are significantly different from each other at $p < 0.05$ as per DMRT.

Amendments	Fresh mass (mg)		Dry mass (mg)	
	Aphid	Adult ladybird	Aphid	Adult ladybird
T0	0.22 ± 0.02^a	33.15 ± 1.37^a	0.033 ± 0.003^a	6.91 ± 0.28^a
T1	0.22 ± 0.02^a	32.25 ± 1.29^a	0.033 ± 0.002^a	6.79 ± 0.23^a
T2	0.21 ± 0.01^a	31.68 ± 1.18^a	0.032 ± 0.003^a	6.68 ± 0.20^a
T3	0.19 ± 0.02^a	30.65 ± 1.02^a	0.030 ± 0.002^a	6.52 ± 0.17^a
T4	0.19 ± 0.01^a	30.15 ± 0.94^a	0.030 ± 0.001^a	6.49 ± 0.19^a

- T0: control soil; T1: 25 mg kg^{-1}; T2: 50 mg kg^{-1}; T3: 75 mg kg^{-1}; T4: 100 mg kg^{-1} Ni treatments.

Source: https://doi.org/10.1016/j.scitotenv.2021.147226

Growth and Physiology of Maize (Zea mays L.) in a Nickel-Contaminated Soil and Phytoremediation Efficiency Using EDTA (2020)

Table 1: Physico-chemical characteristics of the experimental soil

Soil Characterstic	Value/Characterization
Soil texture	Sandy loam
EC_e (dS m^{-1})	0.70–0.96
pH	7.6–7.9
OM (%)	0.38–0.63
Saturation (%)	39.5
CO_3^{2-} (meq L^{-1})	Nil
HCO_3^- (meq/L^{-1})	4.0–4.2
Cl^- (meq/L^{-1})	0.60
Ca+Mg (meq L^{-1})	2.7
Soluble K^+ (mg kg^{-1})	102–200
Nickel (Ni) (mg kg^{-1})	0.28

OM organic matter

Source: https://link.springer.com/content/pdf/10.1007/s00344-020-10132-1.pdf

Phytoremediation Potential of Crop Plants in Countering Nickel Contamination in Carbonation Lime Coming from the Sugar Industry (2020)

Table 1: Translocation factor for Ni in plants growing in the greenhouse experiment (reported values are the medians of nine replicates and interquartile range).

Trial	TF
B	0.57 (0.14)
B+	0.51 (0.12)
BC	0.83 (0.07)
S	2.70 (0.99)
S+	1.67 (0.70)
SC	1.52 (0.54)

Table 2: Soluble (µg L^{-1}) and bioavailable (µg Kg^{-1}) Ni concentration in the rhizosphere (reported values are the median of nine replicates and interquartile range). Different letters indicate significant differences (ns: not significant differences), Dunn's Kruskal–Wallis multiple comparisons test (Benjamini–Hochberg p-value adjustment, α-level = 0.05).

Box	Plant	Soluble Ni	Bioavailable Ni
1	Helianthus annuus	10.2 (0.7) ^{ns}	681.2 (74.4) ^{ab}
2	Sorghum vulgare	8.0 (0.6) ^{ns}	637.9 (10.3) ^{a}
3	Helianthus annuus	10.3 (1.7) ^{ns}	692.2 (78.9) ^{ab}
4	Sorghum vulgare	8.4 (1.5)^{ns}	763.1 (15.7) ^{b}

Table 3: Translocation factor for Ni in plants growing in the outdoor experiment (reported values are the medians of six replicates and interquartile range).

Box	TF
1H	1.07 (0.26)
3H	2.04 (0.30)
H	0.84 (0.23)
2S	0.52 (0.13)
4S	0.51 (0.05)
S	0.83 (0.31)

Table 4: Basic properties of the substrate used for the experiments.

Parameter	Values
pH	8.36 ± 0.10 [1]
Organic matter (%)	7.2
Total Ni (mg Kg^{-1})	2.62 ± 0.63 [1]

[1] Reported pH and Ni concentrations are means of sixteen replicates ± standard deviation.

Source:https://www.researchgate.net/publication/341158414_Phytoremediation_Potential_of_Crop_Plants_in_Countering_Nickel_Contamination_in_Carbonation_Lime_Coming_from_the_Sugar_Industry

Impact of chitosan on nickel bioavailability in soil, the accumulation and tolerance of nickel in Calendula tripterocarpa (2020)

Table 1: Characteristics of applied soil in this experiment before applying treatments.

Ni (mg kg^{-1})	$B_{ava.}$ (mg kg^{-1})	$Cu_{ava.}$ (mg kg^{-1})	$Fe_{ava.}$ (mg kg^{-1})	$Mn_{ava.}$ (mg kg^{-1})	$Zn_{ava.}$ (mg kg^{-1})	$K_{ava.}$ (mg kg^{-1})
0.99	2.91	1.77	9.65	14.28	0.96	1000
$P_{ava.}$ (mg kg^{-1})	Total N (%)	T.N.V (%)	O.C (%)	pH of past	E.C. (dS $m^{-1)}$	
66.1	0.124	1.5	0.96	7.8	0.59	

Table 2: Effect of various concentrations of nickel nitrate on seed germination percentage and fresh and dry weights of Calendula tripterocarpa seedlings.

Nickel concentration (mg/kg)	Germination percentage (%)	Fresh weights (mg)	Dry weights (mg)
0	80.55 ± 4.01 b	177.87 ± 10.41 a	8.08 ± 0.23 b
25	83.33 ± 5.71 ab	182.04 ± 6.45 a	8.16 ± 0.21 b
50	94.44 ± 8.11 a	190.63 ± 8.05 a	8.68 ± 0.15 a
75	77.77 ± 6.01 b	179.98 ± 9.32 a	8.29 ± 0.31 ab
100	72.21 ± 8.31 b	140.15 ± 7.26 b	7.47 ± 0.11 c
125	58.33 ± 3.22 c	129.21 ± 5.90 b	6.58 ± 0.40 d
150	41.66 ± 7.16 d	102.03 ± 4.78 c	5.19 ± 0.52 e

Values represent mean ± SE ($n = 3$). The same letters indicate that there is no significant difference between treatments, according to Duncan's multiple range test at $p < 0.05$.

Table 3: Interactive effects of nickel and chitosan on Ni content in plant and soil, bioaccumulation factor (BAF) and transfer factor (TF) of nickel in Calendula tripterocarpa plant.

Nickel (mg/kg)	Chitosan (%)	Ni content in root (mg kg^{-1} D. W)	Ni content in shoot (mg kg^{-1}D. W)	Ni content in soil (mg kg^{-1})	BA (shoot)	BAF (root)	TF
0	0	0.55 ± 0.06 g	0.86 ± 0.03 g	0.99 ± 0.21 h	0.87 ± 0.027 a	0.56 ± 0. 014 a	1.56 ± 0.14 c
	0.125	0.53 ± 0.07 g	0.71 ± 0.03 gh	0.95 ± 0.20 h	0.75 ± 0.050 b	0.56 ± 0. 016 a	1.35 ± 0.13 d
	0.25	0.39 ± 0.04 gh	0.66 ± 0.01 gh	0.83 ± 0.18 h	0.79 ± 0.012 b	0.47 ± 0. 015 b	1.67 ± 0.11 c
	0.5	0.29 ± 0.04 h	0.61 ± 0.01 gh	0.72 ± 0.28 h	0.85 ± 0.025 a	0.40 ± 0. 014 c	2.13 ± 0.06 b
	1	0.25 ± 0.01 h	0.59 ± 0.02 h	0.66 ± 0.25 h	0.89 ± 0.039 a	0.38 ± 0. 015 c	2.33 ± 0.06 a
100	0	3.57 ± 0.30 bc	4.28 ± 0.50 c	86.41 ± 4.01 d	0.05 ± 0.005 c	0.04 ± 0. 003 d	1.19 ± 0.10 de
	0.125	3.45 ± 0.32 c	3.88 ± 0.12 d	72.19 ± 5.35 e	0.05 ± 0.003 c	0.04 ± 0. 005 d	1.13 ± 0.07 e
	0.25	3.08 ± 0.04 de	3.55 ± 0.12 e	69.52 ± 3.31 e	0.05 ± 0.006 c	0.04 ± 0. 003 d	1.15 ± 0.05 e
	0.5	2.84 ± 0.12 ef	3.24 ± 0.06 f	61.7 ± 2.53 f	0.05 ± 0.005 c	0.04 ± 0. 004 d	1.14 ± 0.06 e
	1	2.66 ± 0.12 f	3.02 ± 0.07 f	53.42 ± 4.16 g	0.05 ± 0.004 c	0.05 ± 0. 006 d	1.13 ± 0.06 e
150	0	4.11 ± 0.22 a	5.07 ± 0.25 a	136.39 ± 11.01 a	0.03 ± 0.000 c	0.03 ± 0. 001 d	1.23 ± 0.03 de
	0.125	3.72 ± 0.10 b	4.53 ± 0.06 b	116.28 ± 6.96 b	0.04 ± 0.002 c	0.03 ± 0. 002 d	1.21 ± 0.02 de
	0.25	3.42 ± 0.07 c	4.25 ± 0.09 c	104.86 ± 4.52 c	0.04 ± 0.002 c	0.03 ± 0. 002 d	1.24 ± 0.04 de
	0.5	3.18 ± 0.03 d	3.82 ± 0.09 d	99.05 ± 5.09 c	0.03 ± 0.002 c	0.03 ± 0. 002d	1.20 ± 0.02 de
	1	2.94 ± 0.13 de	3.14 ± 0.07 f	85.25 ± 3.45 d	0.03 ± 0.001 c	0.03 ± 0. 003 d	1.07 ± 0.01 e

Values represent mean ± SE ($n = 3$). The same letters per each column indicate that there is no significant difference between treatments according to Duncan's multiple range test at $p < 0.05$.

Source: https://www.tandfonline.com/doi/full/10.1080/15226514.2020.1748564

Bacterial community diversity in the rhizosphere of nickel hyperaccumulator plant species from Borneo Island (Malaysia) (2020)

Table 1: Sampled sites, species and codes of the hyperaccumulator plants.

Site number	Site name	Elevation (m)	Hyperaccumulator plants and codes
01	Bukit Kulung	1410	*P. balgooyi* (Phyb-01a, Phyb-01b, Phyb-01c)
02	Pahu	340	*P. rufuschaneyi* (Phyr-02a, Phyr-02b, Phyr-02c), *R.* aff. *Bengalensis* (Rinb-02a, Rinb-02b, Rinb-02c)
03	Monggis	420	*M. sundaicus* (Mis-03), *R.* aff. *Javanica* (Rinj-03), *R.* aff. *Bengalensis* (Rinb-03a, Rinb-03b, Rinb-03c)
04	Wuluh River	780	*F. kinabaluensis* (Fla-04), *M. sundaicus* (Mis-04), *R.* aff. *Javanica* (Rinj-04)
05	Wuluh River Km 7	905	*P. balgooyi* (Phyb-05a, Phyb-05b, Phyb-05c), *P. sarmentosa* (Psy-05)
06	Wuluh River Km 3	680	*F. kinabaluensis* (Fla-06), *M. sundaicus* (Mis-06), *P. sarmentosa* (Psy-06), *R.* aff. *Javanica* (Rinj-06), *R.* aff. *Bengalensis* (Rinb-06a, Rinb-06b, Rinb-06c), *W. pinnata* (Wal-06)
07	Lobou	385	*F. kinabaluensis* (Fla-07), *M. sundaicus* (Mis-07), *R.* aff. *Javanica* (Rinj-07), *W. pinnata* (Wal-07)
08	Panataran River	470	*P. balgooyi* (Phyb-08a, Phyb-08b), *Rinorea* sp. (Rin-08), *M. sundaicus* (Mis-08), *P. sarmentosa* (Psy-08), *F. kinabaluensis* (Fla-08)
09	Bukit Mongilan	750	*F. kinabaluensis* (Fla-09), *M. sundaicus* (Mis-09), *P. balgooyi* (Phyb-09), *P. sarmentosa* (Psy-09), *Rinorea* sp. (Rin-09)
10	Bukit Lompouyu	700	*F. kinabaluensis* (Fla-10), *P. balgooyi* (Phyb-10), *P. rufuschaneyi* (Phyr-10a, Phyr-10b, Phyr-10c), *P. sarmentosa* (Psy-10), *Rinorea* sp. (Rin-10), *W. pinnata* (Wal-10)

The letters a–c correspond to the different plant replicates collected at a same site.

Table 2: pH, total N, C/N ratio and organic C of rhizosphere soils.

Site	*n*	pH	*N* (%)	C/N	C organic (%)
01	3	6.0 [5.8–6.5] de	0.37 [0.19–0.53]	21 [15–28] a	6.3 [2.3–11] ab
02	6	6.8 [6.5–7.1] abc	0.50 [0.43–0.67]	13 [12–16] b	6.4 [5.1–11] ab
03	5	7.0 [6.8–7.3] ab	0.49 [0.42–0.66]	12 [11–13] b	5.7 [5.0–7.6] b
04	3	6.9 [6.4–7.2] abc	0.53 [0.30–0.78]	16 [14–17] ab	8.1 [5.0–12] ab
05	4	6.0 [5.7–6.3] e	0.90 [0.63–1.11]	20 [17–22] a	18 [11–23] a
06	8	6.4 [6.0–6.9] cde	0.60 [0.29–1.03]	13 [10–15] b	7.8 [2.9–16] ab
07	4	7.4 [6.7–7.7] a	0.49 [0.23–0.73]	14 [11–15] b	6.7 [2.5–10] ab
08	6	6.4 [6.2–6.8] bcde	0.81 [0.24–1.92]	15 [12–21] ab	13 [2.9–34] ab
09	5	6.1 [5.7–6.4] de	0.53 [0.42–0.66]	14 [12–17] b	7.3 [4.9–10] ab
10	8	6.7 [6.3–6.9] bcd	0.37 [0.24–0.54]	16 [13–24] ab	5.8 [3.9–12] b

Mean and range are provided, n is the number of soil samples per site. Data followed by different letters are significantly different at $P < 0.05$ (TukeyHSD test).

Table 3: DTPA-extractable elements of rhizosphere soils.

Site	*n*	Mn (mg kg^{-1})	Fe (mg kg^{-1})	Co (mg kg^{-1})	Ni (mg kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})
01	3	68 [61–76] bcd	152 [43–247] b	8.7 [4.2–11] b	110 [78–145]	14 [8.2–22] a	6.1 [4.0–9.4]
02	6	140 [98–172] abc	67 [52–83] b	4.5 [3.1–6.3] b	295 [243–436]	1.6 [1.3–1.8] b	3.3 [2.5–4.0]
03	5	68 [32–108] cd	96 [42–151] b	2.9 [1.0–5.1] b	207 [165–291]	0.6 [0.4–0.8] b	2.9 [1.9–4.7]
04	3	40 [12–72] d	92 [48–161] b	2.6 [0.6–5.7] b	232 [149–318]	0.7 [0.4–1.3] b	2.3 [1.3–3.3]
05	4	97 [23–173] bcd	571 [282–900] a	12 [7.7–20] b	211 [126–334]	1.5 [1.1–1.9] b	4.0 [2.3–6.5]
06	8	101 [45–145] bcd	122 [52–211] b	5.0 [3.0–8.1] b	228 [157–389]	1.1 [0.4–1.9] b	3.8 [1.3–10]
07	4	37 [11–88] d	67 [51–102] b	1.9 [0.3–5.9] b	148 [63–354]	1.0 [0.7–1.6] b	2.1 [0.76–3.9]
08	6	45 [30–55] d	261 [68–757] b	2.7 [1.4–3.6] b	141 [67–252]	2.0 [1.2–2.6] b	7.0 [0.84–22]
09	5	163 [82–216] ab	112 [44–312] b	29 [6.9–46] a	196 [72–513]	1.5 [1.1–1.7] b	3.4 [1.7–6.0]
10	8	186 [109–257] a	37 [23–53] b	7.9 [3.9–14] b	163 [63–239]	1.6 [1.1–3.1] b	2.1 [1.4–2.9]

Mean and range are provided, n is the number of samples. Data followed by different letters are significantly different at $P < 0.05$ (TukeyHSD test).

Table 4: Exchangeable elements of rhizosphere soils.

Site	*n*	CEC ($cmol^{+}$ kg^{-1})	Ca ($cmol^{+}$ kg^{-1})	K ($cmol^{+}$ kg^{-1})	Mg ($cmol^{+}$ kg^{-1})	Mn ($cmol^{+}$ kg^{-1})	Ni ($cmol^{+}$ kg^{-1})
01	3	17 [8.0–31] ab	5.7 [0.49–14]	0.15 [0.08–0.22] b	7.9 [5.5–12] bcd	0.40 [0.16–0.58]	0.19 [0.12–0.27]
02	6	27 [22–37] ab	11 [5.5–23]	0.28 [0.18–0.45] ab	12 [10–16] bcd	0.18 [0.11–0.28]	0.20 [0.09–0.50]
03	5	25 [22–30] ab	3.6 [1.9–6.4]	0.25 [0.21–0.30] ab	18 [15–20] bcd	0.11 [0.03–0.19]	0.07 [0.02–0.10]
04	3	33 [18–49] ab	11 [1.1–28]	0.26 [0.07–0.44] ab	18 [13–23] abcd	0.13 [0.02–0.33]	0.08 [0.03–0.17]
05	4	43 [36–53] a	1.0 [0.59–1.7]	0.60 [0.45–0.73] a	35 [27–47] a	0.33 [0.18–0.50]	0.16 [0.06–0.30]
06	8	30 [18–42] ab	5.8 [0.62–17]	0.37 [0.13–0.60] ab	19 [14–29] b	0.31 [0.09–0.80]	0.16 [0.05–0.25]
07	4	30 [24–43] ab	5.0 [2.1–7.7]	0.25 [0.17–0.33] ab	21 [15–30] abc	0.06 [0.01–0.22]	0.05 [0.01–0.16]
08	6	40 [18–76] a	14 [3.2–28]	0.35 [0.09–0.86] ab	20 [7.8–40] b	0.07 [0.01–0.11]	0.05 [0.02–0.09]
09	5	12 [6.9–24] b	2.7 [1.0–5.9]	0.15 [0.07–0.28] b	5.2 [2.3–13] cd	0.33 [0.02–1.29]	0.21 [0.08–0.45]
10	8	17 [8.7–33] b	8.2 [5.0–23]	0.15 [0.09–0.25] b	5.0 [1.0–7.9] d	0.06 [0.01–0.11]	0.13 [0.03–0.25]

Mean and range are provided, n is the number of samples. Data followed by different letters are significantly different at $P < 0.05$ (TukeyHSD test).

Table 5: Nickel concentrations in soils ([Ni] soils), leaves ([Ni]leaves) and roots ([Ni]roots) and bioconcentration (BCF) and translocation (TF) factors from Ni hyperaccumulator plant species.

Plant	***n***	**$[Ni]_{soils}$ ($mg\ g^{-1}$)**	**$[Ni]_{leaves}$ ($mg\ g^{-1}$)**	**$[Ni]_{roots}$ ($mg\ g^{-1}$)**	**BCF**	**TF**
F. kinabaluensis	6	1.9 [0.6–3.4] ab	5.2 [2.2–8.1] c	0.7 [0.2–1.3] cd	27 [8.8–44] ab	9.3 [3.3–16] a
M. sundaicus	6	2.0 [0.4–3.5] ab	2.2 [0.6–3.6] c	0.2 [0.08–0.4] d	16 [7.4–34] b	9.6 [8.2–15] a
P. balgooyi	10	1.8 [1.1–3.4] b	5.0 [1.8–11] c	2.8 [0.6–6.3] abc	44 [15–146] ab	2.0 [0.8–3.3] b
P. rufuschaneyi	6	3.4 [3.1–3.7] a	19 [6.9–34] a	4.9 [2.8–6.4] a	95 [16–195] a	3.7 [2.2–6.4] b
P. sarmentosa	5	1.8 [0.5–2.8] b	12 [0.04–21] abc	3.8 [0.2–6.8] ab	62 [0.7–98] ab	2.8 [0.2–5.2] b
***Rinorea* sp.**	3	2.3 [0.8–3.0] ab	7.5 [3.9–14] abc	1.9 [1.1–2.6] abcd	79 [32–137] ab	3.7 [2.1–5.4] b
R.* aff. *bengalensis	9	2.7 [1.9–3.7] ab	16 [6.1–30] ab	5.1 [2.5–7.6] a	63 [21–111] ab	3.1 [1.7–4.5] b
R.* aff. *javanica	4	2.4 [1.2–3.8] ab	15 [10–21] abc	3.1 [1.4–5.1] abcd	66 [33–101] ab	5.5 [3.5–7.8] ab
W. pinnata	3	2.5 [2.2–2.8] ab	3.1 [1.8–4.1] bc	0.3 [0.1–0.5] bcd	18 [16–21] ab	11 [8.4–17] a

Mean and range deviation are provided, n is the number of samples. Data followed by different letters are significantly different at $P < 0.05$ (TukeyHSD test).

Table 6: α-diversity of rhizosphere soils.

Sites	***n***	**Observed OTUs**	**Chao1**	**Shannon**
Site 01	3	853 [711–935] d	930 [772–1014] c	8.25 [8.05–8.41] ab
Site 02	6	1574 [1330–1702] abc	1709 [1546–1807] a	8.82 [7.11–9.35] a
Site 03	5	1682 [1501–1824] ab	1806 [1630–1935] a	9.34 [8.91–9.66] a
Site 04	3	1433 [1139–1661] abcd	1555 [1231–1824] ab	9.05 [8.57–9.34] ab
Site 05	4	1398 [1138–1639] abcd	1562 [1320–1792] ab	8.77 [7.74–9.39] ab
Site 06	8	1748 [1488–1861] a	1867 [1635–1992] a	9.40 [8.96–9.71] a
Site 07	4	1233 [1038–1602] bcd	1427 [1211–1816] abc	7.48 [6.39–8.57] b
Site 08	6	1538 [1320–1723] abc	1693 [1545–1808] a	8.65 [6.79–9.51] ab
Site 09	5	1140 [604–1663] cd	1222 [643–1774] bc	8.44 [7.78–9.31] ab
Site 10	8	1524 [984–1684] abc	1637 [1042–1853] ab	9.00 [8.47–9.38] a

Mean and range are provided, n is the number of samples. Data followed by different letters are significantly different at $P < 0.05$ (TukeyHSD test).

Source: https://sfamjournals.onlinelibrary.wiley.com/doi/full/10.1111/1462-2920.14970

Nickel tolerance, translocation and accumulation in a Cd/Zn co-hyperaccumulator plant Sedum alfredii (2020)

Table 1: Ni concentrations in roots, stems, and leaves of HE and NHE S. alfredii treated with different Ni levels in solution for one to four weeks

Treatments	**Roots (mg kg^{-1} DW)**			**Stems (mg kg^{-1} DW)**		**Leaves (mg kg^{-1} DW)**	
Time	Ni (μM)	HE	NHE	HE	NHE	HE	NHE
	0	12±8	4±1	1±0	2±1	2±1	2±0
	10	652±26**	403±17	33±2	39±8	21±1	28±4
	25	1715±25**	806±28	90±4	107±12	58±7	47±5
	50	1889±34**	1273±29	131±6	124±7	67±8	56±4
	100	2004±58	1997±39	206±24	217±6	134±3**	83±2
	200	2287±90	2846±118**	283±6	300±14	162±13**	97±4
	0	14±1	10±1	4±1	4±2	2±0	3±2
	10	1057±74	1050±23	49±3	56±13	21±1	25±1
	25	2054±155**	1157±70	150±5	159±22	44±3	45±1
	50	2072±66**	1606±28	203±5	229±21	48±1	48±4
	100	2869±222**	2086±82	294±6*	259±3	145±3**	108±7
	200	3457±178	3960±77*	495±12**	410±8	194±4**	136±2
	0	9±0	5±0	2±1	1±0	1±0	1±0
	10	1231±84*	975±85	64±11	87±13	37±0	51±2*
	25	2867±81**	1540±48	142±12	156±17	94±5	134±8*
	50	3551±91**	2397±38	275±22	285±14	150±5	160±2
	100	2291±49	3045±108*	410±27**	315±1	201±6	198±12
	200	3125±109	--	753±44**	--	216±21**	--

"*" and "**" indicated significance under $P < 0.05$ and $P < 0.01$ level, respectively. "-" indicated data unavailable due to NHE cannot survive under 200 μM Ni stress for 28 days.

Source: https://www.sciencedirect.com/science/article/abs/pii/S0304389420310633

Table 1: The LOD and LOQ values of Ni calculated for different food samples.

Food sample	LOD µg kg^{-1}	LOQ µg kg^{-1}
Coffee and chocolate	2.0	6.7
Canned fruits, eggs and mayonnaises	4.8	16.1
Rest of solid foods	12.0	40.1
Beer	0.04	0.13
Rest of liquid foods	0.36	1.2

Table 2: Average recovery of Ni spiked to the products prior to the microwave digestion.

Product category	Ni concentration of spike (µg kg^{-1})	N	Recovery (%)±SD
Chocolate	5	3	98 ± 2
	10	3	95 ± 6
	20	3	95 ± 5
Coffee	0.8	4	83 ± 29
	4	4	93 ± 9
	8	4	102 ± 3

Table 3: Recovery of Ni spiked to different food products after microwave digestion.

Food type	Sample	Ni concentration of spike (µg L^{-1})	Recovery (%)±SD
Legumes	Lentil	10, 50	104 ± 1
Soy products	Soy dessert	10, 50, 100, 200	109 ± 1
	Soy drink	10, 50, 100, 200	98 ± 5
Solid tea ingredients	Black tea	10, 50	107 ± 3
	Green tea	10, 50	103 ± 3
Gelatine		5, 10, 50	99 ± 1
Tomato passata		10, 50, 100, 200	106 ± 2
Dried fruits	Banana	1, 5, 10, 50	109 ± 1
	Walnut	10, 50	106 ± 2
	Hazelnut	10, 50	94 ± 10
Choco-hazelnut paste		10, 50	107 ± 1
Vegetables	Carrot	1, 5, 10, 50	107 ± 4
	Potato	1, 5, 10, 50	108 ± 4
Plain yoghurt		1, 5, 10, 50	107 ± 2
Fish		1, 5, 10, 50	105 ± 5
Minced meat		1, 5, 10, 50	97 ± 7
Salami		1, 5, 10, 50	103 ± 6

Table 4: Average recovery of Ni obtained for certified reference materials (CRMs). Analysis of the CRMs conducted in duplicate.

Reference material	CODE	Certified Ni concentration (mg kg^{-1})	Average Recovery (%)
Lobster Hepatopancreas	TORT2	2.50 ± 0.19	98
Rye grass	ERM CD 281	15.2 ± 0.6	104
White cabbage	BCR-679	27.0 ± 0.8	107
Spinach leaves	1570a	2.14 ± 0.06	99

Table 5: Summary statistics for the Ni content (μg kg^{-1}) in different plant-based food products purchased from the Belgian market (N = 406).

Category	Product	N	Ni content (μg kg^{-1}) FW					
			Mean		Minimum	P_{50}	Maximum	Weight basis[a]
Legumes[b]	Beans[c]	33		2892	867	2170	10050	DW
	Lentils	14		1883	734	2099	3694	
	Peas	16		1413	552	1135	4162	
	Legumes with pods	8		2169	695	2067	4673	
	Peanut	3		1356	594	1631	1841	
Soy products	Drinks	15		227	110	170	482	FW
	Desserts & Creams	12		170	94	155	406	
	Tofu	7		425	89	425	942	
Chocolate	Sugar-based	24		4140	2204	3955	8457	FW
	Polyol-based	20		2620	883	3161	4912	
Coffee (beans and ground coffee)	Coffee beans	20		723	394	548	1507	DW
	Ground coffee	20		992	312	581	4268	
Tea (loose tea and tea bags)	Black tea	11		6271	3518	5723	9758	DW
	Green tea	11		6194	3704	6643	8504	
Tomato sauces	Passata	20		124	36	106	281	FW
Dried fruits	Fig	8		1566	861	1249	3683	DW
	Raisin	12		125	72	92	253	
Nuts	Almond	7		869	577	896	1092	DW
	Hazelnut	6		2383	1196	2280	3846	
	Pistachio	4		950	406	827	1740	
	Walnut[f]	6		2411	720	2253	4623	
Chocolate spreads (hazelnut)		11		1226	661	1280	1502	FW
Peanut butter		10		1348	227	1401	3106	FW
Vegetables (fresh and frozen)	Carrot	21	LB[d]	21	0.0	0.0	96	FW
			UB[e]	42	12	40	96	
	Spinach	21	LB	109	0.0	154	267	
			UB	123	12	154	267	
	Tomato	20		241	110	221	438	
	Potato	20	LB	199	0.0	233	370	
			UB	204	12	233	370	
Breakfast cereals (Not containing nuts, raisins)		20		908	166	814	2262	DW
Canned fruits		6	LB	42	0.0	0.0	163	FW
			UB	48	5.0	16	163	

[a]In this column, DW and FW refer to the dry weight base and fresh weight base respectively.

[b]The Ni content of fresh/frozen, canned and in glass legumes were originally obtained on FW. Recalculation was done to make them available on DW.

[c]These bean samples were collected from different types bean including white bean (N = 11), kidney bean (N = 10), broad bean without pod (N = 3), black bean (N = 3), green bean without pod (N = 2), black eyed bean (N = 1), mung bean (N = 1) and calypso bean (N = 1).

[d]LB = Lower bound scenario at which results below LOD/LOQ were substituted with zero.

[e]UB = Upper bound scenario at which results below LOD were replaced with reported value as the LOD and those lower than LOQ were substituted with the LOQ.

[f]Samples were collected from different trees located in different areas of Flemish region.ay

Table 6: Summary statistics for the Ni content (μg kg^{-1}) in different animal-based food products purchased from the Belgian market (N = 113). Results are based on the fresh weight of the edible portion (FW).

Category	Product	N	Ni content (μg kg^{-1}) FW				
			Mean		Minimum	P50	Maximum
Gelatines	Pure gelatines	6	0.0[a]		NA[d]	NA	NA
	Gelatine products[c]	14	0.0[a]		NA	NA	NA
Emulsified sauces	Mayonnaise	20	0.0[a]		NA	NA	NA
Eggs	Fresh eggs	15	LB	0.0[a]	0.0	0.0	26
			UB	15.5[b]	4.8	16.1	26
Dairy	Milk	13	LB	0.9	0.0	0.0	3.4
			UB	1.9	0.36	1.2	3.4
	Yoghurt	11	LB	3.8	0.0	3	10
			UB	3.9	0.3	3	10
	Milk – direct steam injection	2	0.0[a]		NA	NA	NA
Fish and Seafood	Fatty fish	5	0.0[a]		NA	NA	NA
	Lean fish	6	0.0[a]		NA	NA	NA
	Mussels	7	LB	68	0.0	57	227
			UB	71	12	57	227
	Shrimps	8	LB	0.0[a]	0.0	0.0	61.5
			UB	38.9[b]	12	40	61.5

[a]Ni was below the level of reliable detection or it was not detected (ND).

[b]Ni was present at trace level that was below the limit of reliable quantification (TR).

[c]Gelatine containing candies (N = 14).

[d]Abbreviation of not applicable.

Table 7: Summary statistics for the Ni content (μg kg^{-1}) in different drinks purchased/prepared in the current study (N = 189).

Category	Product	N	Ni content (μg kg^{-1})			
			Mean	Minimum	P50	Maximum
Beer	Pilsener	46	4.5	1.5	4.4	8.1
	Top-fermented beer	67	7.7	2.0	6.7	21.4
	Sour beer	35	12.9	2.0	10.5	33.8
Coffee beverages[a] (prepared with ultrapure water through domestic protocol)	Ground	5	16.8	6.0	8.1	36
	Unground	5	7.0	3.0	5.4	13
Coffee beverages[b] (prepared with ultrapure water through Golden coffee protocol)	Ground	5	12	2.0	7.8	26
Commercial coffee drinks[c]		3	17	4.0	9.0	38
Tea beverages[d] (prepared with ultrapure water through domestic protocol)	Black tea	4	85	72	73	121
	Green tea	4	194	112	207	252
Tea beverages[e] (prepared with ultrapure water through ISO 3130 protocol)	Black tea	2	56	28	56	84
	Green tea	2	85	66	85	105
Ice tea	Without flavour	6	34	13	32	58
	Lemon	5	26	14	28	34

[a]Refers to the coffee beverages made through non-standard (domestic) practices.

[b]Refers to the coffee beverages made through standard (std) protocols.

[c]Espresso macchiato.

[d]Refers to the tea beverages made through non-standard (domestic) practices.

[e]Refers to the tea made through standard protocols.

Source: https://www.tandfonline.com/doi/full/10.1080/19440049.2020.1714751

Table 1: The effects of different doses of Ni on the chlorophyll content, dry weight, GSH and Ni concentrations of *Xanthium strumarium L.* (n = 3)

	Ni (mg kg^{-1})	**Chlorophyll (SPAD Unit)**		**Dry weight (g plant^{-1})**	**GSH (µg mL^{-1})**	**Ni concentration (mg kg^{-1})**
		Old leaf	**Young leaf**			
***Xanthium strumarium* L.**	0	30.7 a	32.5 a	6.61 a	266 b	**5.03 e**
	50	28.6 b	31.6 ab	6.50 a	281 ab	**10.7 d**
	100	28.5 b	30.3 b	5.88 b	269 b	**21.7 c**
	200	28.4 b	31.4 ab	5.61 bc	336 a	**49.5 b**
	400	22.4 c	32.4 a	5.25 c	225 b	**101 a**
Dose	**F**	**53.2****	**5.92****	**21.0****	**4.82***	**3411****

**p ≤ 0.01 statistically significant within error bounds
*p ≤ 0.05 statistically significant within error bounds
SPAD: Soil-Plant Analyses Development
GSH: Glutathione
The Ni applications cause a reduction in dry weights of *Xanthium strumarium L.* plant and likewise, chlorophyll contents were also decreased with those applications ($p \leq 0.01$). The increased application doses of Ni on the plant resulted with the lowest GSH concentration in the control group as 266 µg mL^{-1} and the highest as 336 µg mL^{-1} at 200 mg Ni kg^{-1} dose in the plant. The GSH concentrations were decreased with Ni applications. The Ni concentration of the *Xanthium strumarium L.* plant increased (5.03-101 mg kg^{-1}) with increasing Ni doses.

Table 2: The effect of different doses of Ni on N, P, K, Ca and Mg concentration of *Xanthium strumarium L.* (n = 3)

	Ni	**N**	**P**	**K**	**Ca**	**Mg**
	(mg kg^{-1})	**(g kg^{-1})**				
***Xantium strumarium* L.**	0	32.2 a	10.3 a	57.5 a	33.9 a	**1.26 a**
	50	28.7 b	10.2 ab	48.4 b	30.7 b	**1.22 b**
	100	28.2 b	9.74 bc	48.3 b	29.5 b	**1.20 bc**
	200	27.6 bc	9.62 c	47.8 b	28.7 b	**1.19 c**
	400	26.2 c	9.55 c	46.6 b	28.7 b	**1.19 c**
Dose	**F**	**22.5 ****	**4.9 1***	**55.7 ****	**11.9 ****	**12.1****

**p ≤ 0.01 statistically significant within error bounds
*p ≤ 0.05 statistically significant within error bounds
The effects of increasing doses of Ni on N, K, Ca and Mg concentrations of the plant were found statistically significant ($p \leq 0.01$). Compared to the control application the macro (N, P, K, Ca and Mg) element concentrations of plants were reduced with Ni applications.

Table 3: The effect of different doses of Ni on Fe, Zn, Cu, and Mn concentrations in *Xanthium strumarium L.* (n = 3)

	Ni	Fe	Zn	Cu	Mn
	(mg kg^{-1})	(mg kg^{-1})			
***Xantium strumarium* L.**	0	49.0 a	15.7 a	43.0 c	**116 a**
	50	48.3 a	15.3 ab	45.3 c	**111 ab**
	100	45.7 a	13.7 bc	45.7 c	**107 b**
	200	45.0 a	12.9 c	54.3 b	**107 b**
	400	35.0 b	10.9 d	63.3 a	**106 b**
Dose	**F**	**11.1****	**13.06****	**15.7****	**5.58****

**$p \leq 0.01$ statistically significant within error bounds

It was observed that the effects of Ni applications on microelement concentrations of *Xanthium strumarium L*. plant were statistically significant ($p \leq 0.01$). When the rise in Ni doses was compared with the control group on the microelements (Fe, Zn, and Mn) of the plants, it was found that the concentration of these elements was decreased, while the Cu element concentration was increased.

Source:https://www.researchgate.net/publication/331553049_The_effects_of_nickel_applications_on_the_growth_of_cocklebur_Xanthium_Strumarium_L_Plant

Nickel toxicity in plants: reasons, toxic effects, tolerance mechanisms, and remediation possibilities - a review (2019)

Table : Effect of Ni toxicity on plant physiological processes

Toxicity level	Crop/plant	Effects	References
200 mg/L	Sunflower	Reduction in carotenoids and protein content and increase in the sugar accumulation	Hassanpour and Rezayatmand (2015)
50 mM	*Catharanthus roseus*	The activity of the catalase enzyme and proline accumulation increased, while the amount of protein and pigments, and the efficiency of photosystem II were decreased	Arefifars et al. (2014)
100 µM	Wheat	The decrease in chlorophyll content and the rate of photosynthesis	Yusuf et al. (2010)
100 µM	*Brassica juncea*	The decrease in chlorophyll content and rate of photosynthesis	Alam et al. (2007)
40 mg L^{-1}	Mungbean	Reduction in chlorophyll content and chlorophyll a and b ratio	Ahmad et al. (2007)
500 mM	Barley	Reduction in chlorophyll contents	Shalygo et al. (1999)

Source: https://link.springer.com/article/10.1007/s11356-019-04892-x

Table 1: Bacterial inoculation improves *R. sativus* biomass in Ni contaminated soil.

Nickel concentration	Bacterial inoculation	Shoot length	Root length	Shoot dry biomass	Root dry biomass	Root girth
mg kg^{-1} soil		**cm**		**g plant^{-1}**		**cm plant^{-1}**
Ni-0	Control	‡14.9 ± 0.08^{f}	19.9 ± 0.13^{f}	3.1 ± 0.08^{e}	6.9 ± 0.13^{e}	6.8 ± 0.28^{e}
	CIK-516	18.9 ± 0.13^{a}	25.1 ± 0.25^{a}	4.7 ± 0.07^{a}	9.1 ± 0.13^{a}	10.1 ± 0.22^{a}
	CIK-517Y	17.2 ± 0.22^{c}	23.2 ± 0.22^{c}	3.4 ± 0.05^{d}	7.2 ± 0.17^{cd}	8.9 ± 0.17^{b}
Ni-50	Control	14.1 ± 0.17^{g}	19.0 ± 0.17^{g}	2.9 ± 0.06^{f}	5.9 ± 0.17^{g}	6.1 ± 0.09^{f}
	CIK-516	18.2 ± 0.17^{b}	23.8 ± 0.54^{b}	4.4 ± 0.05^{b}	8.3 ± 0.22^{b}	8.9 ± 0.17^{b}
	CIK-517Y	16.6 ± 0.78^{d}	21.9 ± 0.13^{d}	3.1 ± 0.08^{e}	6.9 ± 0.21^{e}	8.2 ± 0.13^{c}
Ni-100	Control	13.0 ± 0.41^{h}	18.5 ± 0.89^{h}	2.5 ± 0.09^{h}	5.3 ± 0.21^{h}	5.2 ± 0.24^{g}
	CIK-516	17.4 ± 0.30^{c}	22.8 ± 0.24^{c}	3.9 ± 0.13^{c}	7.3 ± 0.13^{c}	8.2 ± 0.13c
	CIK-517Y	16.0 ± 0.15^{e}	20.5 ± 0.82^{e}	2.9 ± 0.06^{f}	6.5 ± 0.13^{f}	7.3 ± 0.25^{d}
Ni-150	Control	12.3 ± 0.21^{i}	16.9 ± 0.11^{i}	2.2 ± 0.13^{i}	4.2 ± 0.13^{i}	5.0 ± 0.05^{g}
	CIK-516	16.1 ± 0.18^{de}	21.6 ± 0.47^{c}	3.4 ± 0.08^{d}	7.0 ± 0.08^{de}	7.3 ± 0.25^{d}
	CIK-517Y	15.1 ± 0.45^{f}	19.5 ± 0.13^{g}	2.6 ± 0.06^{g}	6.2 ± 0.13^{g}	6.9 ± 0.15^{e}

‡Values are presented as means of four replicates ± SD, means sharing similar superscript letters within column are statistically non-significant according to HSD Tukey test at $p < 0.05$.

Nickel contamination caused significant reduction in shoot/root length and dry biomass. Increasing the concentration of Ni resulted into a significant decrease in radish growth. However, the maximum reduction in growth was observed at 150 mg Ni kg^{-1} soil. Root girth of radish also decreased in response to application of Ni with the maximum reduction at the highest Ni contamination. It is noteworthy that the negative impact of Ni was mitigated in the plants inoculated with bacteria (Table). Inoculation with both bacterial strains (CIK-516 and CIK-517Y) improved radish dry biomass and root/shoot growth significantly in normal as well as in Ni contaminated soils as compared to their respective un-inoculated controls. However, the strain CIK-516 performed better than CIK-517Y and resulted into 31, 28, 54, 68 and 44% increase in shoot length, root length, shoot dry biomass, root dry biomass and root girth, respectively, as compared to un-inoculated plants grown at 150 mg Ni kg^{-1} soil.

Table 2: Bacterial inoculation improves chlorophyll contents of *R. sativus* in Ni contaminated soil.

Nickel concentration	**Bacterial inoculation**	**Chlorophyll *a***	**Chlorophyll *b***	**Carotenoids**	**Total chlorophyll**
mg kg^{-1} soil		**mg g^{-1} fresh biomass**			
Ni-0	Control	$^{‡}5.10 \pm 0.22^{bc}$	1.83 ± 0.12^{ef}	0.63 ± 0.06^{cde}	7.56 ± 0.31^{cd}
	CIK-516	6.60 ± 0.26^{a}	2.86 ± 0.07^{a}	0.95 ± 0.05^{a}	10.41 ± 0.16^{a}
	CIK-517Y	5.43 ± 0.14^{b}	2.22 ± 0.09^{c}	0.87 ± 0.07^{ab}	8.52 ± 0.06^{b}
Ni-50	Control	3.80 ± 0.14^{de}	1.70 ± 0.18^{fg}	0.60 ± 0.06^{de}	6.10 ± 0.13^{g}
	CIK-516	5.20 ± 0.22^{bc}	2.50 ± 0.10^{b}	0.85 ± 0.05^{ab}	8.55 ± 0.25^{b}
	CIK-517Y	4.11 ± 0.10^{d}	2.16 ± 0.07^{cd}	0.78 ± 0.03^{bc}	7.05 ± 0.08^{de}
Ni-100	Control	3.30 ± 0.18^{f}	1.55 ± 0.11^{g}	0.52 ± 0.06^{de}	5.37 ± 0.28^{h}
	CIK-516	4.90 ± 0.18^{c}	2.20 ± 0.11^{c}	0.78 ± 0.08^{bc}	7.88 ± 0.19^{c}
	CIK-517Y	3.70 ± 0.14^{def}	1.99 ± 0.08^{cde}	0.60 ± 0.08^{de}	6.29 ± 0.24^{fg}
Ni-150	Control	2.50 ± 0.12^{g}	1.20 ± 0.11^{h}	0.49 ± 0.06^{e}	4.19 ± 0.08^{i}
	CIK-516	4.13 ± 0.23^{d}	1.90 ± 0.08^{def}	0.65 ± 0.03^{cd}	6.68 ± 0.31^{ef}
	CIK-517Y	3.40 ± 0.18^{ef}	1.85 ± 0.12^{ef}	0.52 ± 0.05^{de}	5.77 ± 0.24^{gh}

‡ Values are presented as means of four replicates ± SD, means sharing similar superscript letters within column are statistically non-significant according to HSD Tukey test at $p < 0.05$.

The nickel stress negatively affected the chlorophyll contents and nitrogen contents of radish. The negative impacts of Ni were intensified with increasing levels of Ni in the soil. Interestingly, the negative effects of Ni stress were diluted in response to bacterial inoculation. Bacterial inoculation significantly improved chlorophyll contents of radish at all levels of Ni-contamination. However, the most prominent results were observed by the inoculation of bacterial strain CIK-516, which enhanced chlorophyll a, b, carotenoids, and total chlorophyll contents by 29, 56, 51, and 38%, respectively, as compared to un-inoculated control in the normal soil and 65, 58, 33, and 59%, respectively, in the soil containing 150 mg Ni kg^{-1} soil. Similarly, shoot and root N contents of radish were also significantly improved upon bacterial inoculation both in normal and Ni contaminated soils. In contrast to chlorophyll contents, N contents were significantly improved up to 50 mg Ni kg^{-1} soil, however, further addition of Ni (100 and 150 mg Ni kg^{-1} soil) caused significant reduction in N contents, as compared to their respective controls. The maximum N contents (32 in shoot and 37 mg g^{-1} dry weight in root) were observed upon inoculation of bacterial strain CIK-516 in soil containing 50 mg Ni kg^{-1} of soil.

Source: https://www.sciencedirect.com/science/article/pii/S0045653517315102#tbl2

The accumulating ability and nickel tolerance of *Brassicaceae* species of the North Caucasus in connection with the problem of phytoremediation (2017)

Table 1: Content of nickel in shoots and roots (mg kg $^{-1}$ dry weight) of some plants species of fam. *Brassicaceae* exposed to 0 (control), 1 mM or 2 mM Ni for 11 days. Values are mean ± standard deviation (n = 4).

Species		**Treatment**		
		Control	Ni 1 mM	Ni 2 mM
Alyssum alyssoides	Shoots	2.54 ± 0.20	189 ± 12.3a	163 ± 6.45
	Roots	13.5 ± 1.09	132 ± 2.57b	197 ± 23.5
Alyssum campestre	Shoots	1.59 ± 0.01	250 ± 8.54	735 ± 13.5
	Roots	3.21 ± 0.03	75.2 ± 0.71	123 ± 6.11
Alyssum murale	Shoots	11.3 ± 0.65	1413 ± 22.8	1736 ± 5.44
	Roots	128 ± 10.6	816 ± 26.6	1014 ± 36.6
Erysimum ibericum	Shoots	2.29 ± 0.20	260 ± 8.50a	379 ± 5.36
	Roots	7.15 ± 0.07	146 ± 11.8b	386 ± 22.8

Different letters indicate not significant differences of shoots and roots of species at $p < 0.05$.

Table 2: Effect of nickel on content of macronutrients in shoots and roots of some species plants fam. *Brassicaceae*. Values are mean ± standard deviation (n = 4).

Species		**Treatment**	**P (%)**	**Ca(%)**	**K(%)**	**Mg(%)**
Alyssum alyssoides	Shoots	Control	1.20 ± 0.02	7.35 ± 0.14	3.27 ± 0.14	1.23 ± 0.05
		Ni 1 mM	1.36 ± 0.06*	7.86 ± 0.67	2.40 ± 0.09*	1.23 ± 0.10
		Ni 2 mM	1.30 ± 0.04*	7.53 ± 0.62	2.49 ± 0.01*	1.29 ± 0.11
	Roots	Control	0.68 ± 0.01	2.50 ± 0.12	1.32 ± 0.01	0.39 ± 0.05
		Ni 1 mM	0.39 ± 0.02*	1.79 ± 0.11	0.80 ± 0.05*	0.46 ± 0.01
		Ni 2 mM	0.27 ± 0.02*	2.29 ± 0.12	0.55 ± 0.02*	0.62 ± 0.05*
Alyssum campestre	Shoots	Control	1.61 ± 0.02	8.29 ± 0.04	3.42 ± 0.01	0.87 ± 0.01
		Ni 1 mM	1.61 ± 0.04	8.08 ± 0.12	2.80 ± 0.14*	0.95 ± 0.07
		Ni 2 mM	1.68 ± 0.03	8.49 ± 0.06*	2.61 ± 0.06*	0.99 ± 0.04
	Roots	Control	0.36 ± 0.01	1.94 ± 0.05	0.56 ± 0.01	0.51 ± 0.02
		Ni 1 mM	0.22 ± 0.01*	1.54 ± 0.02*	0.44 ± 0.01*	0.43 ± 0.04
		Ni 2 mM	0.16 ± 0.02*	1.75 ± 0.17	0.46 ± 0.02*	0.46 ± 0.01
Alyssum murale	Shoots	Control	0.50 ± 0.01	6.86 ± 0.07	2.48 ± 0.02	0.57 ± 0.01
		Ni 1 mM	0.47 ± 0.01	6.53 ± 0.13	1.88 ± 0.01*	0.58 ± 0.02
		Ni 2 mM	0.50 ± 0.02	6.81 ± 0.19	2.36 ± 0.04*	0.61 ± 0.01*
	Roots	Control	0.51 ± 0.04	1.60 ± 0.01	1.98 ± 0.06	0.34 ± 0.01
		Ni 1 mM	0.64 ± 0.03	1.98 ± 0.48	2.34 ± 0.23	0.14 ± 0.02*
		Ni 2 mM	0.59 ± 0.01	1.60 ± 0.10	2.17 ± 0.11	0.16 ± 0.01*
Erysimum ibericum	Shoots	Control	0.76 ± 0.01	5.69 ± 0.03	2.50 ± 0.02	0.98 ± 0.01
		Ni 1 mM	0.61 ± 0.02*	5.51 ± 0.01*	2.23 ± 0.03*	1.02 ± 0.01
		Ni 2 mM	0.54 ± 0.01*	5.07 ± 0.18*	1.77 ± 0.01*	0.88 ± 0.02*
	Roots	Control	0.62 ± 0.10	1.75 ± 0.29	1.49 ± 0.06	0.47 ± 0.02
		Ni 1 mM	0.37 ± 0.02*	1.46 ± 0.03	1.04 ± 0.02*	0.17 ± 0.01*
		Ni 2 mM	0.42 ± 0.01*	1.54 ± 0.10	1.11 ± 0.04*	0.12 ± 0.02*

Source: https://www.sciencedirect.com/science/article/abs/pii/S0375674217301668

Nickel bioaccumulation by the chosen plant species (2016)

Table: Yield of maize, field bean and lettuce (g growing container-1)

Ni dose (mg Ni dm^{-3})	Maize *Zea mays L.*					Field bean *Vicia faba* L. *(partim)*					Lettuce *Lactuca sativa* L. var. *capitata*		
	Leaves	**Stems**	**Above ground parts**	**Roots**	**Total**	**Leaves**	**Stems**	**Above ground parts**	**Roots**	**Total**	**Above ground parts**	**Roots**	**Total**
0	81.1^{h*}	72.8^{e}	153.9^{g}	35.5^{e}	189.4^{g}	24.9^{f}	16.2^{e}	41.1^{e}	20.3^{e}	61.4^{d}	7.4^{b}	2.4^{ab}	9.8^{b}
0.5	60.5^{g}	51.4^{d}	111.9^{f}	24.9^{d}	136.8^{f}	21.9^{e}	15.3^{e}	37.2^{d}	19.3^{e}	56.5^{c}	7.4^{b}	3.0^{bcd}	10.4^{b}
2.5	40.9^{f}	27.4^{c}	68.3^{e}	15.0^{c}	83.3^{e}	13.3^{d}	11.7^{d}	25.0^{c}	9.1^{d}	34.1^{b}	10.6^{d}	3.1^{cd}	13.7^{d}
5.0	35.2^{e}	25.3^{c}	60.5^{d}	13.5^{bc}	74.0^{d}	12.0^{cd}	10.2^{cd}	22.2^{b}	7.4^{abc}	29.6^{ab}	10.9^{d}	3.4^{d}	14.3^{d}
7.5	28.8^{d}	13.5^{ab}	42.3^{c}	12.6^{b}	54.9^{c}	10.6^{bc}	10.0^{bc}	20.6^{b}	8.1^{cd}	28.7^{ab}	10.4^{d}	2.8^{bcd}	13.2^{d}
8.0	24.2^{c}	14.4^{b}	38.6^{bc}	11.9^{b}	51.5^{c}	10.9^{bc}	10.8^{cd}	21.7^{b}	8.2^{cd}	29.9^{ab}	10.2^{d}	3.1^{cd}	13.3^{d}
8.5	23.8^{bc}	12.0^{a}	35.8^{bc}	10.3^{a}	46.1^{b}	9.6^{ab}	8.3^{ab}	17.9^{a}	6.8^{ab}	24.7^{a}	8.9^{c}	2.9^{bcd}	11.8^{c}
9.0	23.0^{bc}	12.1^{a}	35.1^{b}	9.7^{a}	44.8^{b}	8.9^{a}	8.3^{ab}	17.2^{a}	6.4^{a}	23.6^{a}	7.8^{b}	2.8^{bcd}	10.6^{bc}
9.5	21.3^{b}	11.6^{a}	32.9^{ab}	8.7^{a}	41.6^{ab}	8.9^{a}	8.5^{ab}	17.4^{a}	6.4^{a}	23.8^{a}	6.0^{a}	2.1^{a}	8.1^{a}
10.0	18.8^{a}	11.3^{a}	30.1^{a}	9.0^{a}	39.1^{a}	8.3^{a}	8.1^{a}	16.4^{a}	6.5^{a}	22.9^{a}	5.7^{a}	2.0^{a}	7.7^{a}

* Means followed by the same letters in columns did not differ significantly at $p < 0.05$ according to the Duncan test

Source: https://link.springer.com/article/10.1007/s11738-016-2062-5