

Nickel

Title	Soil amendments affecting nickel uptake and growth performance of tropical ‘metal crops’ used for agromining
Author Name	Philip Nti Nkrumah, Guillaume Echevarria, Peter D. Erskine, Rufus L. Chaney, Sukaibin Sumail & Antony van der Ent
Journal Name	Journal of Geochemical Exploration
Year	2019
Volume and Issue	203
Pages	78-86
Abstracts	<p>Ultramafic soils are usually marginal in macronutrients (nitrogen (N), phosphorus (P), potassium (K) and calcium (Ca)) for growth of crop plants. Commercial nickel (Ni) <i>agromining</i> is dependent on attaining high yield and high Ni concentration in harvestable biomass of Ni <i>hyperaccumulator</i> species. We previously reported on the biomass responses of two promising tropical ‘metal crops’ (<i>Phyllanthus rufuschaneyi</i> and <i>Rinorea cf. bengalensis</i>) to rates of N, P, and K fertilisers. Calcium, sulphur (S) and organic matter amendments have varied effects on the biomass production and Ni uptake in temperate Ni <i>hyperaccumulator</i> species used in <i>agromining</i>, but the trends in tropical ‘metal crops’ are not reported to-date. We investigated the effects of these amendments on the growth performance and the Ni (and other elements) uptake in <i>P. rufuschaneyi</i> and <i>R. cf. bengalensis</i>. The experiments consisted of a large 12-month randomised growth trial in large pots in Sabah (Malaysia) using ultramafic soils under different treatment levels of soluble Ca and S, and organic matter amendments. We found that Ca and S additions had no significant effects on the growth of <i>P. rufuschaneyi</i> and <i>R. cf. bengalensis</i>. Organic matter amendments had strong positive effect on the growth of <i>R. cf. bengalensis</i> ($p < 0.05$), but we recorded significant negative growth response in <i>P. rufuschaneyi</i>. Whereas Ca and S additions improved the Ni uptake in these species, organic matter amendments significantly reduced the shoot Ni concentrations in both species. Our findings indicate that Ca and S additions are important in the agronomy of tropical ‘metal crops’ to be used in economic Ni <i>agromining</i>, but organic matter amendments may not be useful.</p>
Keywords	Biomass production; Hyperaccumulator plants; Metal crops; Nickel tolerance; Nickel yield; Organic matter amendments

Title	Nickel and ozone stresses induce differential growth, antioxidant activity and mRNA transcription in <i>Oryza sativa</i> cultivars
Author Name	Herman Eijsackers, Adriaan Reinecke, Sophie Reinecke & Mark Maboeta
Journal Name	Journal of Plant Interactions
Year	2019
Volume and Issue	14, 1
Pages	87-101
Abstracts	<p>This study evaluates the influences of nickel and ozone exposure individually and/ or in combination on growth performance, antioxidant activity and genes up regulation of two rice cultivars Sakha 101 and Giza 178. Ni treatment at high doses (100 μM Ni) and 75 ppb O₃ alone reduced the fresh weight, mineral content, membrane integrity and Rubisco content. There was an increase in SOD and APX activity in the shoots of rice cultivars, whereas, there was a decrease in GR and GST in the roots and shoots. In contrast combined stresses appeared to be stimulatory for growth and mineral contents, Rubisco content and antioxidant enzymes. Nonspecific lipid transfer protein and transmembrane protein genes were up regulation in rice cultivars in response to Ni stress. Carotenoid cleavage dioxygenase is upregulated in response to ozone stress; RNA pseudouridine synthase, heat shock proteins and cytochrome P450-like were upregulated in response to combined stresses. The results revealed that the interactive effects of both stresses were antagonistic on growth parameters and antioxidant activities to overcome the adverse effects of both pollutants.</p>
Keywords	Antioxidant enzymes, gene expression, nickel, ozone, <i>Oryza sativa</i>

Title	Phosphate microbial mineralization removes nickel ions from electroplating wastewater
Author Name	Xiaoniu Yu & Jianguo Jiang
Journal Name	Journal of Environmental Management
Year	2019
Volume and Issue	Volume 245
Pages	447-453
Abstracts	Nickel ions in electroplating wastewater can be removed by the bio-mineralization method. <i>Bacillus subtilis</i> can produce alkaline phosphatase, which hydrolyzes organophosphate monoesters and produces phosphate ions. Fourier-transform infrared spectroscopy (FTIR) showed that the precipitated material contains phosphate ions. X-ray diffraction (XRD) showed that nickel ions in electroplating wastewater react with <i>Bacillus subtilis</i> and organophosphate monoesters to obtain nickel phosphate octahydrate ($\text{Ni}_3(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}$). The removal efficiency of nickel ions could reach 76.41% with the optimum content of the organophosphate monoester (0.02 mol), <i>Bacillus subtilis</i> powder (2 g), pH (6), standing time (36 h), and reaction temperature (25 °C) in the medium solution (100 mL). The average particle size of $\text{Ni}_3(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}$ was 80.51 nm, which was calculated by the Scherrer formula. The Lorentz–Transmission Electron Microscope (L-TEM) further showed that $\text{Ni}_3(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}$ was composed of clusters of irregular nanoparticles, and the individual particle size was in the range of 40–90 nm. The TGA curve shows that the mass loss of crystal water was 25.45%, which was close to the theoretical total mass loss of 28.24% in bio- $\text{Ni}_3(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}$.
Keywords	Nickel ions, Electroplating wastewater, <i>Bacillus subtilis</i> , Phosphate ions, Nickel phosphate octahydrate

Title	Rare-earth element yttrium enhances the tolerance of curly-leaf pondweed (<i>Potamogeton crispus</i>) to acute nickel toxicity
Author Name	Kai Lyu, Xuan Wang, Lei Wang & Guoxiang Wang
Journal Name	Environmental Pollution
Year	2019
Volume and Issue	248
Pages	114-120
Abstracts	Nickel is a ubiquitous heavy-metal pollutant in lakes and severely affects aquatic organisms. Aquatic plants are often initially linked to having heavy metal contents and further are proposed as <i>phytoremediation</i> agent to remove heavy metal from water. Although the toxic effects of nickel on aquatic plants are thoroughly explored, the effective investigation to increase Ni tolerance is still in its infancy. The role of rare-earth elements (REEs) in plant resisting heavy-metal pollution has recently received considerable interest. To explore the physiological effects of REEs on <i>Potamogeton crispus</i> under Ni stress, we explored whether or not the additive exposure to low-dose yttrium (Y; 2.5 μ M) promotes the polyamine metabolism, antioxidation, and photosynthesis performance of <i>P. crispus</i> under Ni stress values of 0, 50, 100, 150, and 200 μ M. Results showed that Y exposure did not influence Ni bioaccumulation in <i>P. crispus</i> . Furthermore, Y exposure alleviated the adverse effects of Ni stress to convergent degrees because Y positively converts putrescine into spermidine and spermine, inhibits oxidative stress, increases the total chlorophyll content, and maximum/potential quantum efficiency of photosystem II. We concluded that low-dose Y can positively regulate polyamine transformation, inhibit oxidative stress, stimulate photosynthesis, and finally promote the resist ability of <i>P. crispus</i> to nickel stress. Thus, REEs have potential to be applied in regulating submerged plant tolerance to aquatic heavy-metal pollution.
Keywords	Heavy metal; REEs; Macrophytes; Polyamine metabolism; Antioxidation

Title	Nitric oxide induces rice tolerance to excessive nickel by regulating nickel uptake, reactive oxygen species detoxification and defence-related gene expression
Author Name	Muhammad Rizwan, Mohammad Golam Mostofa , Muhammad Zulfiqar Ahmad, Muhammad Imtiaz, Sajid Mehmood, Muhammad Adeel, Zhihua Dai, Zheyong Li, Omar Aziz, Yihui Zhang, Shuxin Tu
Journal Name	Chemosphere
Year	2018
Volume and Issue	Volume 191, January 2018
Pages	23-35
Abstracts	<p>Soil contamination with nickel (Ni) is a persistent threat to crop production worldwide. The present study examined the putative roles of nitric oxide (NO) in improving Ni-tolerance in rice. Our findings showed that application of exogenous sodium nitroprusside (SNP), a NO donor, significantly improved the growth performance of rice seedlings when grown under excessive Ni. The enhanced Ni-tolerance of rice prompted by SNP could be ascribed to its ability to regulate Ni uptake, decrease Ni-induced oxidative stress as evidenced by reduced levels of hydrogen peroxide, malondialdehyde, and electrolyte leakage in Ni-stressed plants. The positive roles of NO against Ni-toxicity also reflected through its protective effects on photosynthetic pigments, soluble proteins and proline. SNP also boosted antioxidant capacity in Ni-stressed plants by maintaining increased levels of ascorbate, enhanced activities of ROS-detoxifying enzymes, particularly peroxidase (POD) and catalase (CAT) in both roots and shoots compared with Ni-stressed alone plants. Moreover, SNP treatment also upregulated the transcript levels of CAT, POD, ascorbate peroxidase, glutathione reductase and superoxide dismutase genes in shoots under Ni-stress. Using different sulfide compounds and NO scavenger cPTIO, we also provided evidence that NO, rather than other byproducts of SNP, contributed to the improved performance of rice seedlings under Ni-stress. Collectively, our results conclude that exogenous SNP-mediated modulation of endogenous NO enhanced rice tolerance to Ni-stress by restricting Ni accumulation, maintaining photosynthetic performance and reducing oxidative damage through improved antioxidant system, thereby suggesting NO as an effective stress regulator in mitigating Ni-toxicity in economically important rice, and perhaps in other crop plants.</p>
Keywords	Antioxidant system, Gene expression, Nickel stress, Nitric oxide Oxidative stress, Rice

Title	Nickel biopathways in tropical nickel hyperaccumulating trees from Sabah
Author Name	Antony Van Der Ent, Damien L.Callahan, Barry N. Noller, Jolanta Mesjasz-Przybylowicz, Wojciech J. Przybylowicz, Alban Barnabas & Hugh H. Harris
Journal Name	Scientific Reports
Year	2017
Volume and Issue	7:41861
Pages	1-21
Abstracts	<p>The extraordinary level of accumulation of nickel (Ni) in hyperaccumulator plants is a consequence of specific metal sequestering and transport mechanisms, and knowledge of these processes is critical for advancing an understanding of transition element metabolic regulation in these plants. The Ni biopathways were elucidated in three plant species, <i>Phyllanthus balgooyi</i>, <i>Phyllanthus securinegioides</i> (Phyllanthaceae) and <i>Rinorea bengalensis</i> (Violaceae), that occur in Sabah (Malaysia) on the Island of Borneo. This study showed that Ni is mainly concentrated in the phloem in roots and stems (up to 16.9% Ni in phloem sap in <i>Phyllanthus balgooyi</i>) in all three species. However, the species differ in their leaves – in <i>P. balgooyi</i> the highest Ni concentration is in the phloem, but in <i>P. securinegioides</i> and <i>R. bengalensis</i> in the epidermis and in the spongy mesophyll (<i>R. bengalensis</i>). The chemical speciation of Ni²⁺ does not substantially differ between the species or between the plant tissues and transport fluids, and is unambiguously associated with citrate. This study combines ion microbeam (PIXE and RBS) and metabolomics techniques (GC-MS, LC-MS) with synchrotron methods (XAS) to overcome the drawbacks of the individual techniques to quantitatively determine Ni distribution and Ni²⁺ chemical speciation in hyperaccumulator plants.</p>
Keywords	Hyperaccumulator , Biopathways, metabolomics techniques

Title	Nickel bioaccumulation by the chosen plant species
Author Name	Jacek Antonkiewicz, Czesława Jasiewicz, Małgorzata Koncewicz-Baran & Renata Sendor
Journal Name	Acta Physiol Plant
Year	2016
Volume and Issue	
Pages	38:40
Abstracts	<p>Concentrations of ground-level ozone ([O₃]) over much of the Earth's The investigations aimed at the evaluation of nickel bioaccumulation ability of plants from various families (Poaceae—maize, Fabaceae—field bean and Asteraceae—lettuce). The research was conducted under hydroponic conditions. The experimental design comprised ten objects differing with nickel concentrations in the solution (ranging from 0.0 to 10.0 mg Ni dm⁻³ of the nutrient solution). The parameters, assumed as the basis on which nickel bioretention by selected plant species was determined were: the yield, nickel content in various plant parts, uptake and utilization of this element by the plant, tolerance index (TI) and translocation factor (TF), the metal concentrations in the aboveground parts index (CI) and bioacummulation factor (BAF). On the basis of the obtained results it was found that, due to low tolerance of nickel, maize could be used as the indicator plant for the environment quality assessment.</p>
Keywords	Bioaccumulation, Hydroponic, Heavy metals

Title	Evaluation of nickel tolerance in <i>Amaranthus paniculatus</i> L. plants by measuring photosynthesis, oxidative status, antioxidative response and metal - binding molecule content
Author Name	Fabrizio Pietrini, Valentina Iori, Alexandra Cheremisina, Nina I. Shevyakova, Nataliya Radyukina, Vladimir V. Kuznetsov, Massimo Zacchini
Journal Name	Environmental Science and Pollution Research
Year	2015
Volume and Issue	22, Issue 1
Pages	482-494
Abstracts	<p>Among metals, Ni has been indicated as one of the most dangerous for the environment, and plants exposed to this metal are frequently reported to undergo a severe stress condition. In this work, the tolerance responses to different Ni concentrations at physiological and biochemical levels were evaluated in <i>Amaranthus paniculatus</i> L., a plant species previously characterised for their ability to phytoremove Ni from metal-spiked water. Results indicated a good metal tolerance of this plant species at environmentally relevant Ni concentrations, while clear symptoms of oxidative damages were detected at higher Ni concentrations, both in roots and leaves, by measuring lipid peroxide content. At the photosynthetic level, pigment content determination, chlorophyll fluorescence image analysis and gas-exchange parameter measurements revealed a progressive impairment of the photosynthetic machinery at increasing Ni concentrations in the solution. Regarding biochemical mechanisms involved in antioxidative defence and metal binding, antioxidative enzyme (ascorbate peroxidase, APX; catalase, CAT; guaiacol peroxidase, GPX; superoxide dismutase, SOD) activity, polyamine (PA) content, polyamine oxidase (PAO) activity and organic acid (OA) content were differently affected by Ni concentration in the growth solution. A role for GPX, SOD, PAs, and oxalic and citric acid in Ni detoxification is suggested. These results can contribute to elucidate the tolerance mechanisms carried out by plants when facing environmentally relevant Ni concentrations and to identify some traits characterising the physiological and biochemical responses of <i>Amaranthus</i> plants to the presence and bioaccumulation of Ni.</p>
Keywords	Photosynthetic, <i>Amaranthus</i> , bioaccumulation , chlorophyll fluorescence

Title	Photosynthetic response and proline bioaccumulation in black gram induced by Nickel stress
Author Name	Das S, Samantaray S, Mohanty RC, Mohanty M, Pradhan C
Journal Name	The International Daily journal
Year	2015
Volume and Issue	27 : 97
Pages	36-42
Abstracts	<p>The present study assesses the impact of varying treatment concentrations of nickel (Ni) on photosynthetic responses and stress induced proline accumulation in a leguminous plant i.e. black gram [<i>Vigna mungo</i> (L.) Hepper] cultivars (PU31C and Shekhar1C). After exposure to different concentrations of toxic Ni²⁺, the two cultivars of <i>V. mungo</i> i.e. PU31C and Shekhar1C showed significant changes in their photosynthetic response. Sekhar1C variety showed high chlorophyll content in seedlings treated with toxic Ni (200µM) when compared to Control and other variety. PU31C variety showed four times more Chlorophyll content than seedlings of control treatment. The present hydroponic study exhibited stimulatory effects of nickel on total chlorophyll content, carotenoid and increased proline level after two weeks exposure period. Present preliminary study indicates the tolerance nature of two green gram cultivars to toxic doses of Ni²⁺.</p>
Keywords	Nickel, Chlorophyll, Proline, Hydroponics

Title	Estimation of plant growth promoting potential of a nickel accumulating isolate obtained from Dhapa industrial wasteland (Kolkata, India) soil on Indian yellow mustard (<i>Brassica hirta</i>)
Author Name	Santanu Maitra and Pranab Kumar Banerjee
Journal Name	Int.J.Curr.Microbiol.App.Sci
Year	2015
Volume and Issue	4 : 1
Pages	765-772
Abstracts	Plant growth promoting bacteria (PGPB) are known to influence plant growth by various direct or indirect mechanisms. Present study was conducted with an aim to estimate the PGP potential of one nickel tolerant bacterial isolate from Dhapa industrial wasteland, Kolkata, India. Isolate I (Gram negative <i>coccobacilli</i>) was observed to tolerate and accumulate significant amounts of nickel and also have multiple Plant Growth Promoting (PGP) activities like IAA production and phosphate solubilization. Present study also shows that seeds of yellow mustard (<i>Brassica hirta</i>) inoculated with the test isolate individually, significantly enhanced root and shoot growth and also protected the plant from the various phytotoxic effects of nickel.
Keywords	Nickel, Accumulation, IAA Production, Phosphate Solubilization, Brassica hirta Bioremediation