Title	**Iron-modified biochar and water management regime-induced changes in plant growth, enzyme activities, and phytoavailability of arsenic, cadmium and lead in a paddy soil**
Author Name	Ergang Wen, Xing Yang, Hanbo Chen, Sabry M. Shaheen, Binoy Sarkar, Song Xu, Hocheol Song, Yong Liang, Jorg Rinklebe, Deyi Hou, Yong Li, Fengchang Wu, Michael Poho, Jonathan W.C. Wong, Hailong Wang
Journal Name	Journal of Hazardous Materials
Year	2021
Volume and Issue	407:124344
Pages	0304-3894
Abstracts	The aim of this study was to evaluate the effect of raw (RawBC) and iron (Fe)-modified biochar (FeBC) derived from Platanus orientalis Linn branches on the plant growth, enzyme activity, and bioavailability and uptake of As, Cd, and Pb by rice in a paddy soil with continuously flooded (CF) or alternately wet and dry (AWD) irrigation in a pot experiment. Application of RawBC (3%, w/w) significantly increased soil pH, while FeBC decreased it. The FeBC was more effective in reducing As and Pb bioavailability, particularly under the AWD water regime, while RawBC was more conducive in reducing Cd bioavailability under the CF water regime. The FeBC decreased As concentration, but increased concentrations of Cd and Pb in the straw and brown rice, as compared to the un treated soil. Soil catalase and urease activities were enhanced by RawBC, but decreased by FeBC treatment. The FeBC increased the grain yield by 60% and 32% in CF and AWD treatments, respectively. The FeBC can be recommended for immobilization of As in paddy soils, but a potential human health risk from Cd and Pb in FeBC treated soils should be considered due to increased uptake and translocation of the metals to brown rice.
Keywords	Heavy metal; Bioavailability; Soil enzyme; Engineered Biochar; Irrigation

Title	**Lead Toxicity in Cereals: Mechanistic Insight Into Toxicity, Mode of Action, and Management**
Author Name	Muhammad Aslam, Ayesha Aslam, Muhammad Sheraz, Basharat Ali, Zaid Ulhassan, Ullah Najeeb, Weijun Zhou, Rafaqat Ali Gill
Journal Name	Frontiers in Plant Science
Year	2021
Volume and Issue	11:587785
Pages	-
Abstracts	Cereals are the major contributors to global food supply, accounting for more than half of the total human calorie requirements. Sustainable availability of quality cereal grains is an important step to address the high-priority issue of food security. High concentrations of heavy metals specifically lead (Pb) in the soil negatively affect biochemical and physiological processes regulating grain quality in cereals. The dietary intake of Pb more than desirable quantity via food chain is a major concern for humans, as it can predispose individuals to chronic health issues. In plant systems, high Pb concentrations can disrupt several key metabolic processes such as electron transport chain, cellular organelles integrity, membrane stability index, PSII connectivity, mineral metabolism, oxygen-evolving complex, and enzymatic activity. Plant growth-promoting rhizobacteria (PGPR) has been recommended as an inexpensive strategy for remediating Pb-contaminated soils. A diverse group of Ascomycetes fungi, i.e., dark septate endophytes is successfully used for this purpose. A symbiotic relationship between endophytes and host cereal induces Pb tolerance by immobilizing Pb ions. Molecular and cellular modifications in plants under Pb-stressed environments are explained by transcription factor families such as bZIP, ERF, and GARP as a regulator. The role of metal tolerance protein (MTP), natural resistance-associated macrophage protein (NRAMP), and heavy metal ATPase in decreasing Pb toxicity is well known. In the present review, we provided the contemporary synthesis of existing data regarding the effects of Pb toxicity on morpho-physiological and biochemical responses of major cereal crops. We also highlighted the mechanism/s of Pb uptake and translocation in plants, critically discussed the possible management strategies and way forward to overcome the menace of Pb toxicity in cereals.
Keywords	bioremediation; cereals; lead toxicity; mechanism; management; plant growth and development

Title	**Phytoremediation of Nickel and Lead Contaminated Soils by Hedera colchica**
Author Name	Mahsa Sadat Mirhosseini, Keivan Saeb, Aptin Rahnavard & Masoud Kiadaliri
Journal Name	Soil And Sediment Contamination: an International Journal
Year	2021
Volume and Issue	30:1
Pages	122–133
Abstracts	Phytoremediation is an effective and affordable technological solution to extract or remove metal pollutants from contaminated soil. In this study, the ability of *Hedera colchica* plant for the removal of Pb and Ni metals with different concentrations from soil and also metal efficacy on morphological parameters of the plant were investigated. The morphological results showed that as the concentration of heavy metals increases in soil up to 600 $mg.kg^{-1}$ soil, the dry weights of shoot and root reduce about 46 and 60% with Pb and 18 and 51% with Ni, and also total length up to 31% with Pb and 3% with Ni, respectively. The maximum concentration of Pb and Ni in shoots (92.2 and 77.2 $mg.kg^{-1}$ Dwt, respectively) and roots (252 and 218 $mg.kg^{-1}$, respectively) were recorded in the cultivated plant in soil amended with metal high concentrations. The highest bio-concentration (BCF) and translocation factor (TF) were recorded for Pb in the roots. In addition, this study showed that *H. colchica* plant was more favorable for Pb uptake compared to Ni, but we do not suggest using it for the remediation of the contaminated soils with Pb and Ni metals.
Keywords	Heavy metal; contaminated soil; *Hedera colchica*; plant biomass; phytoremediation

Title	**Role of plant growth promoting rhizobacteria in the alleviation of lead toxicity to *Pisum sativum L.***
Author Name	Muhammad Shabaan, Hafiz Naeem Asghar, Muhammad Javed Akhtar, Qasim Ali & Mukkaram Ejaz
Journal Name	International Journal of Phytoremediation
Year	2021
Volume and Issue	23:8
Pages	837–845
Abstracts	Plant-microbe interaction is a significant tool to tackle heavy metals problem in the soil. A pot trial was conducted to evaluate the efficiency of lead tolerant rhizobacteria in improving pea growth under Pb stress. Lead sulfate ($PbSO_4$) was used for spiking (250, 500, and 750 mg kg^{-1}). Results indicated that inoculation with Pb-tolerant PGPR strain not only alleviated the harmful impacts of Pb on plant growth but also immobilized it in the soil. PGPR in the presence of Pb at concentra tions of 0, 250, 500 and 750 mg kg^{-1}, increased shoot and root lengths by 21, 15, 18% and 72, 80,84%, respectively, than uninoculated control. Moreover, fresh biomass of shoots and roots were also increased by 51, 45, 35% and 57, 101, 139% respectively, at Pb concentrations of 250, 500 and 750 mg kg^{-1}. In addition, PGPR inoculation also reduced Pb concentration in the roots and shoots by 57, 55, 49% and 70, 56 and 58% respectively, than uninoculated control. So, PGPR proved to be an efficient option for reducing Pb mobility and can be effectively used for its phytostabilization. **Novelty statement** Lead (Pb) is highly noxious and second most toxic element in the nature having high persistence. It ranks 1st in the priority list of hazardous substances and causes adverse effects after its entry into the living system. So, its remediation is inevitable. Plant growth promoting rhizobacteria (PGPR) possess the potential to not only survive under stressed environments, but also promote plant growth on account of their different plant growth promoting mechanisms. Most researchers have worked on its bioaccumulation in plant body. This study however, used pea as a test crop and caused Pb phytostabilization and thereby, suppressed its entry in the above-ground plant parts.
Keywords	Plant growth promoting rhizobacteria (PGPR); Bioaugmentation; Lead (Pb); *Pisum sativum L.*; heavy metal

Title	**Bioaccumulation of lead in different varieties of wheat plant irrigated with wastewater in remote agricultural regions**
Author Name	Wuyi Liu, Asma Zafar, Zafar Iqbal Khan, Muhammad Nadeem, Kafeel Ahmad, Kinza Wajid, Humayun Bashir, Mudasra Munir, Ifra Saleem Malik & Asma Ashfaq
Journal Name	Environmental Science and Pollution Research
Year	2020
Volume and Issue	27
Pages	27937–27951
Abstracts	The accumulation of heavy metals by crops irrigated with wastewater has been considered as a serious environmental problem in many developing countries, where the wastewater irrigation has emerged as a common practice. In this research, we were concerned with the highly toxic metal lead (Pb) in water, agricultural soils, and wheat crops, and the possible risk on human health in the peripheral agricultural regions of Punjab, Pakistan. Various types of irrigated water (ground, sewage, industrial), soil, and wheat plant (root, shoot, grain) samples of five different varieties (Seher-2006, Punjab-2011, Faislabad-2008, Watan, and Galaxy-2013) were collected from seven different districts and then pooled up to make one composite sample and analyzed for Cd concentration. The various pollution and mobility indices (pollution load index, enrichment factor, daily intake of metal, health risk index, translocation factor, bioaccumulation factor, and bio-concentration factor) were also calculated. The descending order for Pb concentration was as follows: water>soil>wheat plant. The range of concentration of Pb in all types of water, soil, and wheat plant (root, shoot, grains) samples was (7.05–7.83 mg/l), (6.32–7.74 mg/kg), (3.23–4.82, 1.14–2.75, 0.09–0.51 mg/kg), respectively. The concentration of Pb in all types of water samples exceeded the maximum permissible limit. There were values found to be < 1.00 in all the pollution and mobility indices for all types of samples. These results reveal that high levels of Pb in irrigated water may pollute the soil and wheat plants of these regions in the near future, if various control measures have not been taken. It may pose a great health risk to the local human and animal populations. Preventive measures should be taken to reduce heavy metal pollution of irrigation water and soils to protect both human and animal health in various regions of Punjab, Pakistan.
Keywords	Lead; Mobility indices; Bio-concentration factor; Pollution load index

Title	**In vitro lead tolerance and accumulation in three Chrysanthemum cultivars for phytoremediation purposes with ornamental plants**
Author Name	Agripina Ramírez, Gregorio García , Olaf Werner & Rosa M. Ros
Journal Name	International Journal of Phytoremediation
Year	2020
Volume and Issue	22 (11)
Pages	1110-1121
Abstracts	The use of ornamental plants for the phytoremediation of potentially toxic elements in polluted soils is an interesting task. It makes possible to combine environmental restoration, re-use of land, and the production of goods and services of economic interest. In this work, in vitro experiments using three cultivars of *Chrysanthemum (Asteraceae)* were carried out with 0, 300, 600, 900, and 1500 mg/kg of lead concentrations for a period of 12 weeks. The objective was to obtain data about their lead tolerance and bioaccumulation capacity in order to know their potential as phytoremediators in a densely populated Caribbean area of the Dominican Republic with a high concentration of lead in soils. The variations in biomass, root growth as well as accumulation of this element in the plants were measured. The results suggest that the three cultivars have a good potential for phytoextraction at moderate pollution levels, as they showed a good bioaccumulation of lead, which had mild effects on their biomass production and root elongation. Additional studies should be carried out to assess their effectiveness as phytoextractors under field conditions, as well as other alternative uses that could generate esthetic, environmental, and/or economic benefits for tropical areas contaminated by Pb.
Keywords	Asteraceae; Caribbean; floriculture; heavy metals; phytoextractors; tropical areas

Title	**Lead-induced oxidative stress and role of antioxidant defense in wheat *(Triticum aestivum L.)***
Author Name	Saeid Navabpour, Ahad Yamchi, Saeed Bagherikia & Haniyeh Kafi
Journal Name	Physiology and Molecular Biology of Plants
Year	2020
Volume and Issue	26
Pages	793–802
Abstracts	The aim of this study was to investigate soil lead pollution on biochemical properties and gene expression pattern of antioxidant enzymes in three wheat cultivars (*Morvarid*, *Gonbad* and *Tirgan*) at flag leaf sheath swollen stage. Lead ($Pb(NO_3)_2$) was used at four different concentrations (0, 15, 30 and 45 mg/kg of soil). The leaf and roots samples were taken at late-booting stage (Zadoks code, GS: 45). The results showed that lead heavy metal toxicity increased the expression of some genes and the activity of key enzymes of the antioxidant defense system in wheat. Moreover, the cell oxidation levels (MDA, LOX) enhanced under lead stress conditions. The relative gene expression and activity of antioxidant enzymes (CAT, SOD, GPX and APX) increased significantly in the both leaves and root tissues under lead stress conditions. The level of gene expression and enzymatic activity were higher in the root than the leaf tissue. There was no significant difference among cultivars in each of lead concentrations but *Morvarid* and *Tirgan* cultivars had more tolerance to toxic concentrations of lead when compared to Gonbad cultivar.
Keywords	*Triticum aestivum L.*; Lead; Gene expression; Antioxidant enzymes

Title	Antioxidant responses of barley (*Hordeum vulgare L.*) genotypes to lead toxicity
Author Name	Ali Doğru
Journal Name	Biologia
Year	2020
Volume and Issue	75
Pages	1265-1272
Abstracts	The effects of lead toxicity were studied in the leaves of two barley cultivars. Plants were grown for 32 days in perlite and then exposed to 10- and 15-mM $Pb(NO_3)_2$ for additional 6 days. Lead toxicity decreased the photosynthetic pigment contents in the leaves of Tokak 157/37. The phenolic content of the leaves was reduced in Tarm-92 and increased in Tokak 157/37. The malondialdehyde content in leaves showed that lipid peroxidation in Tokak 157/37 was lower than in Tarm-92. H_2O_2 accumulation was more remarkable in the leaves of Tokak 157/37 exposed to 15 mM lead. Significantly higher superoxide dismutase activity observed in our study indicates a likely higher rate of superoxide radical dismutation. Lower ascorbate peroxidase activities were observed at 10 mM lead in Tarm-92 and at 15 mM lead in Tokak 157/37. The glutathione reductase activity in Tarm-92 was lower whereas it was induced by 10 mM lead treatment in Tokak 157/37. Lead toxicity resulted in increased level of the guaiacol peroxidase activity in both cultivars. Our results suggest that lead toxicity induced membrane damage in barley leaves, led to photosynthetic pigment loss and that guaiacol peroxidase activity may be critical for lead tolerance at early stage of seedling oxidative stress development.
Keywords	Ascorbate peroxidase; Glutathione reductase; Guaiacol peroxidase Lead toxicity; Superoxide dismutase

Title	**Probing the effects of different lead compounds on the bioavailability of lead to plants**
Author Name	Shamali De Silva, Chloe Bernett, Jean Meaklim, Erandika Abeywardane & Suzie M.Reichman
Journal Name	Chemosphere
Year	2019
Volume and Issue	--
Pages	24-28
Abstracts	Lead (Pb) is an important pollutant and is released into the environment in many forms. Different lead compounds have a variety of solubilities and so may impact on lead bioavailability and toxicity when added to soil. In this experimental study, we investigated the bioavailability of Pb in soil spiked with 300, 900 and 1500 mg/kg of Pb-acetate, $PbCl_2$ and PbO using lettuce and wallaby grass. The concentration of Pb in the shoots of both species from control soils (2–3 mg/kg) was similar to previously reported concentrations in plants grown on uncontaminated soils. The Pb concentrations in the plant shoots increased with Pb concentrations in soil for lettuce ($R2 = 0.526$, $P < 0.001$) and wallaby grass ($R2 = 0.776$, $P < 0.001$). This study demonstrated that Pb bioavailability in soil was not affected by the type of Pb compound added to the soil for both plant species up to 1500 mg/kg Pb concentrations. Instead, the Pb concentration in the plant was best predicted by the total concentration of lead in the soil, irrespective of the original lead compound added to the soil. This research suggests that the original Pb compounds that contaminated the soil are unlikely to be an important factor in assessing Pb bioavailability, and hence risk, in soils.
Keywords	Lead acetate; Lead chloride; Lead oxide; Plant uptake; Risk assessment; Soil

Title	**Lead toxicity induced phytotoxic effects on mung bean can be relegated by lead tolerant Bacillus subtilis ($PbRB_3$)**
Author Name	Muhammad Saleem Arif, Tahira Yasmeen Sher, Muhammad Shahzad, Muhammad Riaz, Muhammad Rizwan, ShahidIqbal, Muntaha Asif, Mona H.Soliman & Shafaqat Ali
Journal Name	Chemosphere
Year	2019
Volume and Issue	Volume 234
Pages	70-80
Abstracts	Being a primary toxic heavy metal, lead (Pb) contamination presents an imposing environmental and public health concern worldwide. A Bacillus subtilis $PbRB_3$, displaying higher Pb tolerance, was isolated from the textile effluent. The bacterial culture was able to remove >80% of Pb from culture solution. Upon screening in the presence of Pb, $PbRB_3$ strain exhibited significant plant growth promoting potential. A 3 weeks long pot experiment was established to examine the capability of $PbRB_3$ strain for physiological and biochemical traits, and Pb accumulation tendency of mung bean at 250 and 500 $mg\,kg^{-1}$ of Pb toxicity, respectively. With respect to control treatments, photosynthetic pigments, protein synthesis, net assimilation rate, transpiration rate and stomatal conductance were significantly constrained by Pb toxicity levels. Intrinsic and instantaneous water use efficiencies were considerably improved in inoculated plants under Pb toxicity. Compared to inoculated control, significantly higher superoxide dismutase activity in both Pb toxicity treatments, while higher malondialdehyde contents only at Pb500 treatment was recorded with $PbRB_3$ inoculation. Catalase activity between Pb250 and Pb500 treatments was comparable at both inoculation level. Moreover, $PbRB_3$ inoculation led to significantly higher peroxidase activity under Pb toxicity treatments compared to inoculated control. The PbRB3 inoculation led to comparable differences in root Pb content between Pb250 and Pb500 treatments. These results suggest that inoculation of Pb tolerant, Bacillus subtilis $PbRB_3$, could be employed to improve mung bean growth potential and adaptation against Pb toxicity, and thereby accelerated Pb rhizoaccumulation from metal contaminated environment.
Keywords	Metal contamination; Legume; Oxidative stress; Biosorption; Microbial inoculants

Title	**Lead accumulation, growth responses and biochemical changes of three plant species exposed to soil amended with different concentrations of lead nitrate**
Author Name	Chandana Chandrasekhar & Joseph George Ray
Journal Name	Ecotoxicology and Environmental Safety
Year	2019
Volume and Issue	171
Pages	26-36
Abstracts	Lead (Pb) contamination of soil is a serious environmental problem, adversely affecting ecosystems, globally. Phytoremediation is an alternative to conventional methods of soil remediation. The success of *phytoremediation* depends on the identification of suitable native plant species with high biomass to deal with metal contamination. In the present experiment, response of *Eclipta prostrata (L.) L*., *Scoparia dulcis L*. and *Phyllanthus niruri L*. to increase in concentrations of $PbNO_3$•$5H_2O$ in the soil for a period of 30 days was tested to assess their suitability in phytoremediation. Pb accumulation in all the three plants was in a concentration-dependent manner. Although *S. dulcis* survived the soil metal concentrations, it exhibited a stunted growth; *P. niruri* was found susceptible to Pb toxicity; *E. prostrata* recorded a maximum uptake of 12484 μg/g dry weight in its root and 7229 μg/g dry weight in its shoot, without any adverse impact on growth traits. Bioconcentration factor and translocation factor of the three plants were also calculated, which revealed that *E. prostrata* has Pb accumulation potential. Therefore, enzymatic antioxidant activities and transmission electron microscopic analysis were carried out to determine the physiological adaptation and tolerance of E. prostrata to Pb stress. Overall, *E. prostrata* is identified as a tolerant plant showing Pb hyperaccumulation tendencies with essential features for *phytoextraction*.
Keywords	Soil pollution; lead; accumulation; phytoextraction; phytostablization

Title	**Accumulation and distribution of lead (Pb) in plant tissues of guar (*Cyamopsis tetragonoloba L.*) and sesame (*Sesamum indicum L.*): profitable phytoremediation with biofuel crops**
Author Name	Hira Amin, Basir Ahmed Arain, Taj Muhammad Jahangir, Muhammad Sadiq Abbasi & Farah Amin
Journal Name	Geology, Ecology, and Landscapes
Year	2018
Volume and Issue	Volume 02, January 2018
Pages	51–60
Abstracts	Contamination of lead indicates one of the major threats to soil system. *Phytoremediation* technique utilized plants which are able to tolerate and accumulate metals within in their tissues. It has recently been suggested that biofuel plants are more suitable for both utilization and remediation of metal contaminated soil. This study reported Pb phytoremediation potential of *Cyamopsis tetragonoloba L.* in comparison with *Sesamum indicum L.* in the framework of a pot-experiment. Plants were subjected to seven Pb concentrations (0, 100, 200, 400, 600, 800 and 1000 mg kg^{-1} soil) for 12 weeks. Our results demonstrated that both *C. tetragonoloba* and *S. indicum* were able to tolerate Pb concentrations up to 1000 mg kg^{-1} which confirms the plant ability to grow well in higher Pb levels. Significant metal accumulation was observed in root along with reduced biomass for both plants species. Furthermore, both plant species could possibly be used for *phytostabilization*, with success in marginally polluted soils where their growth would not be impaired and decontamination of Pb could be maintained at satisfying levels. However, bioconcentration factor (BCF), bioaccumulation coefficient (BAC) and translocation factor (TF) values proposed that *C. tetragonoloba* was more efficient for *phytoremediation* than *S. indicum* at higher Pb levels.
Keywords	Soil pollution; lead; accumulation; phytoextraction; phytostablization

Title	**Lead (Pb) Toxicity; Physio-Biochemical Mechanisms, Grain Yield, Quality, and Pb Distribution Proportions in Scented Rice**
Author Name	Umair Ashraf, Adam S. Kanu, Quanquan Deng, Zhaowen Mo, Shenggang Pan, Hua Tian and Xiangru Tang
Journal Name	Frontiers in Plant Science
Year	2017
Volume and Issue	Volume 08, February 2017
Pages	01-17
Abstracts	Lead (Pb) caused interruptions with normal plant metabolism, crop yield losses and quality issues are of great concern. This study assessed the physio-biochemical responses, yield and grain quality traits and Pb distribution proportions in three different fragrant rice cultivars i.e., *Meixiangzhan-2*, *Xinagyaxiangzhan* and *Basmati-385*. Plants were exposed to 400, 800, and 1,200 ppm of Pb while pots without Pb were taken as control (0 ppm). Our results showed that Pb toxicity significantly ($P < 0.05$) reduced photosynthetic pigments (chlorophyll contents and carotenoids) and inducted oxidative stress with increased production of hydrogen peroxide (H_2O_2), malanodialdehyde (MDA) and leaves leachates; while such effects were more apparent in *Xinagyaxiangzhan* than other two rice cultivars. Pb stress differentially affected the production protein, proline and soluble sugars; however the production rates were higher at heading stage (HS) than maturity stage (MS). Furthermore, Pb stress altered superoxide dismutase (SOD), peroxidases (POD), catalases (CAT) and ascorbate peroxidases (APX) activities and glutathione (GSH) and oxidized glutathione (GSSG) production in all rice cultivars at both HS and MS. All Pb levels reduced the yield and yield components of all rice cultivars; nonetheless such reductions were observed highest in *Xinagyaxiangzhan* (69.12%) than *Meixiangzhan-2* (58.05%) and *Basmati-385* (46.27%) and resulted in grain quality deterioration. Significant and positive correlations among rice yields with productive tillers/pot and grains per panicle while negative with sterility percentage were also observed. In addition, all rice cultivars readily taken up the Pb contents from soil to roots and transported upward in different proportions with maximum in roots followed by stemss, leaves, ears and grains. Higher proportions of Pb contents in above ground plant parts in *Xinagyaxiangzhan* possibly lead to maximum losses in this cultivar than other two cultivars; while less damage in *Basmati-385* might be related to strong anti-oxidative defense system and lower proportions of Pb contents in its aerial parts.
Keywords	antioxidant defense; grain yield; lead; oxidative stress; scented rice; quality characters

Title	**Efficiency of green waste compost and biochar soil amendments for reducing lead and copper mobility and uptake to ryegrass**
Author Name	Nadia Karami, Rafael Clemente, Eduardo Moreno-Jiménez, Nicholas W. Lepp, Luke Beesley
Journal Name	Journal of Hazardous material
Year	2011
Volume and Issue	191, 1-3
Pages	41-48
Abstracts	Green waste compost and biochar amendments were assessed for their assistance in regulating the mobility of copper (Cu) and lead (Pb) and the resultant uptake of these metals into vegetation. The amendments were mixed with a heavily Cu and Pb contaminated soil (600 and 21,000 mg kg^{-1}, respectively) from a former copper mine in Cheshire (UK), on a volume basis both singly and in combination in greenhouse pot trials. Ryegrass (*Lolium perenne L. var. Cadix*) was grown for the following 4 months during which biomass, metals in soil pore water and plant uptake were measured in three consecutive harvests. Very high Pb concentrations in pore water from untreated soil (>80 mgl^{-1}) were reduced furthest by compost amendment (<5 mgl^{-1}) whereas biochar was the more effective treatment at reducing pore water Cu concentrations. Duly, ryegrass shoot Cu levels were reduced and large, significant reductions in shoot Pb levels were observed after biochar and compost amendments, respectively during successive harvests. However, because green waste compost singly and in combination with biochar vividly enhanced biomass yields, harvestable amounts of Pb were only significantly reduced by the compost amendment which had reduced shoot Pb levels furthest. The low biomass of ryegrass with biochar amendment meant that this was the only amendment which did not significantly increase harvestable amounts of Cu. Therefore the two amendments have opposing metal specific suitability for treating this contaminated soil regarding whether it is a maximum reduction in plant tissue metal concentration or a maximum reduction in harvestable amount of metal that is required.
Keywords	Heavy metals; Compost; Biochar; Ryegrass; Pore water; Remediation

Title	**Isolation of phosphate solubilizing bacteria and their potential for lead immobilization in soil**
Author Name	Jin Hee Park, Nanthi Bolan, Mallavarapu Megharaj, Ravi Naidu
Journal Name	Journal of Hazardous material
Year	2011
Volume and Issue	185, 2-3
Pages	829-836
Abstracts	Lead (Pb), a highly toxic heavy metal forms stable compounds with phosphate (P). The potential of phosphate solubilizing bacteria (PSB) to immobilize Pb by enhancing solubilization of insoluble P compounds was tested in this research. Eighteen different PSB strains isolated from P amended and Pb contaminated soils were screened for their efficiency in P solubilization. The PSB isolated from P amended soils solubilized 217–479 mg/L of P while the PSB from Pb contaminated soil solubilized 31–293 mg/L of P. Stepwise multiple regression analysis and P solubility kinetics indicated that the major mechanism of P solubilization by PSB is the pH reduction through the release of organic acids. From the isolated bacteria, two PSB were chosen for Pb immobilization and these bacteria were identified as Pantoea sp. and Enterobacter sp., respectively. The PSB significantly increased P solubilization by 25.0% and 49.9% in the case of Pantoea sp., and 63.3% and 88.6% in the case of Enterobacter sp. for 200 and 800 mg/kg of rock phosphate (RP) addition, respectively, thereby enhancing the immobilization of Pb by 8.25–13.7% in the case of Pantoea sp. and 14.7–26.4% in the case of Enterobacter sp. The ability of PSB to solubilize P, promote plant growth, and immobilize Pb can be used for phytostabilization of Pb contaminated soils.
Keywords	Pb contamination; Pb immobilization; Phosphate solubilizing bacteria (PSB); Rock phosphate; P solubilization

Title	**Utilization of laser-assisted analytical methods for monitoring of lead and nutrition elements distribution in fresh and dried *Capsicum annuum l.* leaves**
Author Name	Nadia Karami, Rafael Clemente, Eduardo Moreno-Jiménez, Nicholas W. Lepp, Luke Beesley
Journal Name	Journal of Hazardous material
Year	2011
Volume and Issue	191, 1-3
Pages	41-48
Abstracts	Green waste compost and biochar amendments were assessed for their assistance in regulating the mobility of copper (Cu) and lead (Pb) and the resultant uptake of these metals into vegetation. The amendments were mixed with a heavily Cu and Pb contaminated soil (600 and 21,000 mg kg^{-1}, respectively) from a former copper mine in Cheshire (UK), on a volume basis both singly and in combination in greenhouse pot trials. Ryegrass (*Lolium perenne L. var. Cadix*) was grown for the following 4 months during which biomass, metals in soil pore water and plant uptake were measured in three consecutive harvests. Very high Pb concentrations in pore water from untreated soil (>80 mgl^{-1}) were reduced furthest by compost amendment (<5 mgl^{-1}) whereas biochar was the more effective treatment at reducing pore water Cu concentrations. Duly, ryegrass shoot Cu levels were reduced and large, significant reductions in shoot Pb levels were observed after biochar and compost amendments, respectively during successive harvests. However, because green waste compost singly and in combination with biochar vividly enhanced biomass yields, harvestable amounts of Pb were only significantly reduced by the compost amendment which had reduced shoot Pb levels furthest. The low biomass of ryegrass with biochar amendment meant that this was the only amendment which did not significantly increase harvestable amounts of Cu. Therefore the two amendments have opposing metal specific suitability for treating this contaminated soil regarding whether it is a maximum reduction in plant tissue metal concentration or a maximum reduction in harvestable amount of metal that is required.
Keywords	Heavy metals; Compost; Biochar; Ryegrass; Pore water; Remediation

Title	**The detoxification of lead in Sedum alfredii H. is not related to phytochelatins but the glutathione**
Author Name	D.K. Gupta , H.G. Huang, X.E. Yang, B.H.N. Razafindrabe, M. Inouhe
Journal Name	Journal of Hazardous material
Year	2010
Volume and Issue	177, 1-3
Pages	437–444
Abstracts	Two ecotypes of *S. alfredii* [Pb accumulating (AE) and Pb non-accumulating (NAE)] differing in their ability in accumulating Pb were exposed to different Pb levels to evaluate the effects on plant length, photosynthetic pigments, antioxidant enzymes (SOD and APX), cysteine, non-protein thiols (NP-SH), phytochelatins (PCs) and glutathione (GSH) vis-à-vis Pb accumulation. Both ecotypes showed significant Pb accumulation in roots, however only the AE showed significant Pb accumulation in shoots. We found that both AE and NAE of S. alfredii-induced biosynthesis of GSH rather than phytochelatins in their tissue upon addition of even high Pb levels (200 μM). Root and shoot length were mostly affected in both ecotypes after addition of higher Pb concentrations and on longer durations, however photosynthetic pigments did not alter upon addition of any Pb treatment. Both superoxide dismutase (SOD) and ascorbate peroxidase (APX) activities of AE were higher than NAE. The levels of cysteine and NP-SH were also higher in AE than in NAE. Hence, the characteristic Pb accumulation of ecotypes differed presumably in relation to their capacity for detoxification of Pb. These results suggest that enzymatic and non-enzymatic antioxidants play a key role in the detoxification of Pb-induced toxic effects in Sedum alfredii. This plant can be used as an indicator species for Pb contamination.
Keywords	Ascorbate peroxidase; Glutathione; Lead; Phytochelatins; Superoxide dismutase; Sedum alfredii