Title	**Phytoremediation of Arsenic-Contaminated Soils Amended with Red Mud Combined with Phosphogypsum**
Author Name	Enio Tarso de Souza Costa, Guilherme Lopes, Geila Santos Carvalho, Henrique Gualberto Vilela Penha, Nilton Curi & Luiz Roberto Guimarães Guilherme
Journal Name	Water, Air, & Soil Pollution
Year	2021
Volume and Issue	232(417)
Pages	1-21
Abstracts	Several industrial by-products may be used as amendments to reduce arsenic availability in contaminated areas, hence contributing to phytoremediation processes. This study was conducted aiming to evaluate red mud (RM) and a mixture containing 75% of RM + 25% of phosphogypsum (PG) (hereafter, RMPG) as amendments in arsenic-contaminated soils presenting distinct properties, like clay and organic matter content and chemical composition. Two contrasting soils were artificially contaminated with 150 mg dm3 of arsenic and after that cultivated with *Urochloa brizantha*. The experiment was carried out using a Typic Dystrudox (LV, 750 g kg^{-1} clay) and a Typic Quartzipsamment (RQ, 70 g kg^{-1} clay), with the following RM and RMPG rates: 0, 0.5, 1.0, and 2.0% (w/v). Also, limestone was tested as an additional amendment for comparison. Hydrogen potential (pH), electrical conductivity (EC), sodium, and arsenic concentrations were analyzed on leachates, and the dry matter production of *Urochloa brizantha* and *arsenic concentration* in plant root and shoot dry matter were also recorded. The amendments increased pH, EC, and sodium concentration and the addition of RMPG decreased the arsenic concentration on leachates. RMPG increased plant dry matter production and decreased arsenic concentration in the plant's shoot. The plant resistance to arsenic contamination was influenced by soil properties, with arsenic toxicity being more evident in the sandy soil (RQ) compared with the clayey soil (LV). The mixture (RMPG) has shown to be an advantageous amendment since, besides decreasing arsenic availability, it also furnishes the nutrients calcium and sulfur from the PG.
Keywords	Trace element; Remediation; By-product; Reuse; Amendment

Title	**Arsenic Phytoremediation in Contaminated and Flooded Soil: Accumulation and Translocation in Two Macrophytes**
Author Name	Amanda Duim Ferreira, Douglas Gomes Viana, Fábio Ribeiro Pires, Fernando Barboza Egreja Filho, Matheus Bortolanza Soares, Cássio Francisco Moreira de Carvalho, Robson Bonomo, Leila Beatriz Silva Cruz & Mauro César Pinto Nascimento
Journal Name	Water, Air, & Soil Pollution
Year	2021
Volume and Issue	232(299)
Pages	1-13
Abstracts	Few aquatic plants can accumulate As from flooded soils. Given the high toxicity and bioavailability of As in these environments, a study was carried out in Brazil to test the As phytoextraction potential of *Typha domingensis* and *Eleocharis acutangula*, comprising three cutting/regrowth cycles of 120 days each. The species were grown in uncontaminated (control), moderately contaminated (75 mg kg^{-1} As), and highly contaminated (250 mg kg^{-1} As) soil. The amount of As extracted was influenced by the level of As contamination and the plant species. *E. acutangula* was the most suitable species for removing As from moderately contaminated soil (up to 75 mg kg^{-1}), while *T. domingensis* could remove As from soil with As levels up to 250 mg kg^{-1}. This small-scale study provides a theoretical basis for the selection of macrophytes with potential for As extraction from soils, and these species should be tested in the future under field conditions.
Keywords	Phytoextraction; Soil pollution; *Typha domingensis*; *Eleocharis acutangula*

Title	**Comparative study of three *Pteris vittata*-crop intercropping modes in arsenic accumulation and phytoremediation efficiency**
Author Name	Tianying Wan,Xiangwei Dong, Lihua Yu, Hengliang Huang, Dandan Li, Haozhan Han, Yumin Jia, Yihui Zhang, Zhiyang Liu, Qingya Zhang, Shuxin Tu
Journal Name	Environmental Technology & Innovation
Year	2021
Volume and Issue	24
Pages	101923
Abstracts	Arsenic (As) can be transferred from soil and accumulated in food plants. So far, we have a knowledge gap about transference of As from agricultural soils to wheat plant in the natural polluted environment. The aim of present study was to investigate As transfer from soil to different tissues of wheat at a highly As polluted area. In this regard, the mobility indices were used to explain As transfer and accumulation from soil to wheat plant. Moreover, the relationships between soil properties including soil As content, pH, cation-exchange capacity (CEC), electrical conductivity (EC), organic matter (OM), Fe, and Al percentage with As concentrations in wheat root, straw, and grain were investigated. Finally, the potential health risks of As exposure to humans through consumption of the local wheat crops were assessed. According to the results, harmful degree of As was accumulated in different parts of wheat plant. The impact of different soil properties on As accumulation in wheat was found to be as follows: soil As content > Al% > Fe% > OM > pH > CEC > EC. High carcinogenic and noncarcinogenic risks in all age groups of consumers were found. The minimum and maximum values for target hazard quotient and excess lifetime cancer risk were found to be 1.22, 102.97 and 0.000061, 0.33, respectively. These findings strongly support the notion that As can be entered to food chain through agricultural products cultivated in polluted soils.
Keywords	Intercropping; Pteris vittata; Phytoremediation; Arsenic; Bioavailability

Title	**Evaluation of Phytoremediation Potential of *Pteris vittata L.* on Arsenic Contaminated Soil Using *Allium cepa* Bioassay**
Author Name	Kiran Gupta, Sudhakar Srivastava, Gauri Saxena & Amit Kumar
Journal Name	Bulletin of Environmental Contamination and Toxicology
Year	2021
Volume and Issue	155
Pages	1-7
Abstracts	The present study assessed the utility of *Allium cepa* based cyto-genotoxicity bioassays in evaluating the arsenic toxicity and remediation potential of *Pteris vittata* on contaminated soil of Lakhimpur-Kheri district. Untreated and *P. vittata* treated soil extracts were used for cyto-genotoxicity tests in *A. cepa*. Results showed that *P. vittata* extracted high concentration of arsenic, which ranged from 220 to 1420 $mgkg^{-1}$ in different soils. Cyto-genotoxic assessment of *A. cepa* showed that extract of *P. vittata* treated soil had lower cyto-genotoxic effects as compared to untreated soil. A higher mitotic index (10%) while lower mitotic depression (29%), relative abnormality rate (10%), chromosomal aberrations (1%) and micronuclei (2%) were detected in root meristematic cells of *A. cepa* exposed to remediated soil extract in comparison to untreated soil. The studies provide a simple, rapid and economic cyto-genotoxicity bioassay tool for evaluating toxicity of contaminated soils of contaminated soils as well as revealed the phytoremdiation property of *P. vittata* against arsenic toxicity.
Keywords	Arsenic toxicity; *Allium cepa*; Chromosomal aberrations; Mitotic depression; Mitotic index; *Pteris vittata*

Title	***Cannabis sativa L.* and *Brassica juncea L.* grown on arsenic-contaminated industrial soil: potentiality and limitation for phytoremediation**
Author Name	Carolina Picchi, Lucia Giorgetti, Elisabetta Morelli, Marco Landi, Irene Rosellini, Martina Grifoni, Elisabetta Franchi, Gianniantonio Petruzzelli & Meri Barbafieri
Journal Name	Environmental Science and Pollution Research
Year	2021
Volume and Issue	177
Pages	1-15
Abstracts	Phytoremediation represents a natural method to remove contaminants from soil. The goal of this study was to investigate the potential of phosphate-assisted phytoremediation by two energy crops, *Cannabis sativa L.* and *Brassica juncea L.*, for the sustainable remediation of heavily arsenic-contaminated industrial soil. The two species were investigated for uptake, translocation, and physiological effects of arsenic and phosphate in a microcosm test. Although *C. sativa* and *B. juncea* were symptomless when grown in arsenic-contaminated soil, an important reduction of biomass (50 and 25%, respectively) was observed as a stress marker. Phytotoxicity and cytotoxicity effects promoted by contaminated soils were investigated in both the species and a model plant for ecotoxicity studies, *Vicia faba L.*, which is the most developed model to test genotoxicity effects in terms of chromosomal aberration and micronuclei presence. The higher amount of arsenic was found in *C. sativa* and *B. juncea* roots (on average 1473 and 778 mg kg^{-1}, respectively), but both species were able to uptake and translocate arsenic in leaves and stems, up to 47.0 and 189 mg kg^{-1}, respectively. Phosphate treatment had no effect on arsenic uptake in none of the crop, but significantly improved the plant performance. Biomass production resulted similar to that of *B. juncea* control plants. Antioxidant enzymatic activities and photosynthetic performance responded differently in the two crops. The present investigation provides new insight for a proficient selection of the most suitable crop species for sustainable phytomanagement of a highly polluted As-contaminated site by coupled phytoremediation-bioenergy approach.
Keywords	Soil remediation; Stress responses; Antioxidant enzymes; Phytotoxicity; Genotoxicity; Phosphate

Title	**Evaluation of cadmium and arsenic effects on wild and cultivated cardoon genotypes selected for metal phytoremediation and bioenergy purposes**
Author Name	Chiara Leonardi, Valeria Toscano, Claudia Genovese, Julian Frederick Willem Mosselmans, Bryne Tendelo Ngwenya, Salvatore Antonino Raccuia
Journal Name	Environmental Science and Pollution Research
Year	2021
Volume and Issue	28
Pages	55102–55115
Abstracts	*Cynara cardunculus L.* is a multipurpose crop, characterized by high production of biomass suitable for energy purposes and green chemistry. Taking advantage of its already demonstrated ability to grow in polluted environments that characterize many world marginal lands, the aim of this work was to investigate the response of different cardoon genotypes to exposure to cadmium (Cd) and arsenic (As) pollution, in order to use this crop for rehabilitation of contaminated sites and its biomass for energy production. In this study, seeds of two wild cardoon accessions harvested in rural and industrial Sicilian areas and of a selected line of domestic cardoon were used, and the grown plants were spiked with As and Cd, alone or in combination, at two different concentrations (500 and 2000 μM) and monitored for 45 days. The growth parameters showed that all the plants survived until the end of experiment, with growth stimulation in the presence of low concentrations of As and Cd, relative to metal-free controls. Biomass production was mostly allocated in the roots in As treatment and in the shoots in Cd treatment. Cd EXAFS analysis showed that tolerance to high concentrations of both metals was likely linked to complexation of Cd with oxygen-containing ligands, possibly organic acids, in both root and leaf biomass with differences in behaviour among genotypes. Under As+Cd contamination, the ability of the plants to translocate As to aboveground system increased also showing that, for both metal (loid)s, there were significant differences between genotypes studied. Moreover, the results showed that *Cynara cardunculus* var. sylvestris collected in an industrial area is the genotype that, among those studied, had the best phytoextraction capability for each metal(loid)
Keywords	Heavy metal(loid)s; C. cardunculus var. altilis; C. cardunculus var. sylvestris; Detoxification mechanisms; Speciation distribution

Title	**The mobility of arsenic from highly polluted farmlands to wheat: Soil–Plant transfer model and health risk assessment**
Author Name	Kamaladdin Karimyan, Mahmood Alimohammadi, Afshin Maleki, Masud Yunesian, Ramin Nabizadeh Nodehi, Abbas Rahimi Foroushani
Journal Name	Land Degradation and Development
Year	2020
Volume and Issue	31(12)
Pages	1560-1572
Abstracts	Arsenic (As) can be transferred from soil and accumulated in food plants. So far, we have a knowledge gap about transference of As from agricultural soils to wheat plant in the natural polluted environment. The aim of present study was to investigate As transfer from soil to different tissues of wheat at a highly As polluted area. In this regard, the mobility indices were used to explain As transfer and accumulation from soil to wheat plant. Moreover, the relationships between soil properties including soil As content, pH, cation-exchange capacity (CEC), electrical conductivity (EC), organic matter (OM), Fe, and Al percentage with As concentrations in wheat root, straw, and grain were investigated. Finally, the potential health risks of As exposure to humans through consumption of the local wheat crops were assessed. According to the results, harmful degree of As was accumulated in different parts of wheat plant. The impact of different soil properties on As accumulation in wheat was found to be as follows: soil As content > Al% > Fe% > OM > pH > CEC > EC. High carcinogenic and noncarcinogenic risks in all age groups of consumers were found. The minimum and maximum values for target hazard quotient and excess lifetime cancer risk were found to be 1.22, 102.97 and 0.000061, 0.33, respectively. These findings strongly support the notion that As can be entered to food chain through agricultural products cultivated in polluted soils.
Keywords	Bioconcentration Factor (BCF); Biotranslocation Factor (BTF); Arsenic; Farmland; Wheat Plant

Title	**Use of plants in the remediation of arsenic contaminated waters**
Author Name	Elisa C. Berg, Alisson C. Borges
Journal Name	Water Environment Federation
Year	2020
Volume and Issue	92
Pages	1669–1676
Abstracts	Arsenic-contaminated waters represent environmental and public health problems. The use of plants has emerged as a viable, cost-effective, and low environmental impact alternative to treat these polluted waters. This review presents studies published in the year 2019 on phytoremediation covering the effects observed on plants, trends in plant species selection and treatment of arsenic-rich biomass. Studies on application of this technology are exposed through constructed (treatment) wetlands, and a brief contex-tualization on the impacts of arsenic contamination was also performed. **Practitioner points** • Arsenic is a toxic element that can be found in aquatic environments, and phy-toremediation is a promising technology for treating waters contaminated by this pollutant. • Constructed wetlands are a form of wastewater treatment that uses phytoremedia-tion and other processes to remove arsenic from waters. • Trends in future studies involve understanding the plants physiological anti-stress responses, treatment of contaminated biomass and application of constructed wet-lands on a full scale.
Keywords	Arsenic; Constructed Wetlands; Contaminated Water; Phytoremediation

Title	**Effects of arbuscular mycorrhizal fungi, biochar, selenium, silica gel, and sulfur on arsenic uptake and biomass growth in *Pisum sativum L***
Author Name	Mohammad ZahangeerAlam, Md. AnamulHoque, Golam JalalAhammed, LynneCarpenter-Boggs
Journal Name	Emerging Contaminants
Year	2020
Volume and Issue	6
Pages	312-322
Abstracts	Arsenic (As) is carcinogenic and highly toxic to plants. Crops accumulate As when grown in field soils irrigated with As-contaminated groundwater. The accumulation of As in roots, shoots, and grains of pea varieties can negatively affect human health via the food chain. This research is focused on the biomass growth and alleviation of As accumulation in roots, shoots, and grains of pea varieties in high As soil amended with arbuscular mycorrhizal fungi (AMF), biochar (BC), selenium (Se), silica gel (Si-gel), and sulfur (S). Root, shoot, and grain masses were found higher in pea grown in As soil amended with AMF, Se, Si-gel, and S. Amendments with rice husk and sawdust BC was found less effective to increase growth parameters in Bangladesh Agricultural Research Institute (BARI) Motor 2. Arsenic in grains was reduced by 77%, 71%, and 69% by AMF, Se, and Si-gel, respectively. It is recommended that soil amendments with AMF, S, and Se have great potential for improving biomass production of pea grown in As-contaminated soil, as well as reducing As transfer to humans through the food chains.
Keywords	Arsenic; Pea; Food chain; AMF; Food safety; Metal

Title	**Sulphur and calcium attenuate arsenic toxicity in Brassica by adjusting ascorbate–glutathione cycle and sulphur metabolism**
Author Name	Rachana Singh , Parul Parihar & Sheo Mohan Prasad
Journal Name	Plant Growth Regulation
Year	2020
Volume and Issue	91
Pages	221–235
Abstracts	Present study was performed in order to explicate whether added sulphur (S; 60 mg S kg^{-1} sand) and calcium (Ca; 250 mg Ca kg^{-1} sand) alone and in combination could modulate arsenic-induced (As_1; 15 mg As kg^{-1} sand and As_2; 30 mg As kg^{-1} sand) toxicity in *Brassica juncea L.* seedlings. To study this, growth and growth regulating processes i.e. status of oxidative stress biomarkers (H_2O_2 generation and lipid peroxidation), enzymes and metabolites of AsA-GSH cycle and S-metabolism were examined. Both the doses of As significantly reduced the growth as evident from diminishing dry weight and increased lipid peroxidation as a consequence of excess H_2O_2 accumulation. Arsenic also altered the redox status of the cell thereby depleting the AsA and GSH pool that consequently decreased AsA/DHA, AsA/H_2O_2 and GSH/GSSG ratios. Neverthless, APX, DHAR and GR activities were enhanced under similar conditions. Contrary to this, additional S and/ or Ca maintained the redox status of the cell that improved AsA/DHA and GSH/GSSG ratios, and further enhanced the enzymatic activities in both root and leaves of the test seedlings. Upon As exposure, test seedlings exhibited an increase in S assimilation as a result of increased enzyme activities of ATPS, OASTL and γ-ECS, which were further enhanced upon S and/ or Ca addition to stressed seedlings. Due to increment in S assimilation, PCs synthesis was also increased that restricted As translocation from root to shoot. Collectively, our result provides an insight for protective role of S and Ca alone and more efficiently in combination (S+Ca) to As-stressed Brassica seedlings suggesting that S and Ca together could be a promising candidates in managing As toxicity in crops.
Keywords	Arsenic stress; Ascorbate–glutathione (AsA-GSH) cycle; Brassica; Calcium; Native-PAGE; Sulphur assimilation

Title	**Silicon-mediated genotoxic alterations in *Brassica Juncea* under arsenic stress: A comparative study of biochemical and molecular markers**
Author Name	Afsana Praveen, Chandana Pandey , Ehasanullah Khan, Medha Panthri, Meetu Gupta
Journal Name	Pedosphere
Year	2020
Volume and Issue	30(4)
Pages	517-527
Abstracts	Arsenic (As), one of the most harmful toxicant at the global level, severely affects plant metabolism when taken up. Interestingly, the presence of silicon (Si) as a fertilizer in As-contaminated soil is an effective strategy to decrease As accumulation in plants. *Brassica Juncea* (var. Varuna) were grown hydroponically to investigate the role of Si at biochemical and molecular levels under arsenite (As^{3+}) stress. Seedlings of *B. Juncea* were exposed to As^{3+}, Si, and a combination of both elements. Our data demonstrated that seedlings exposed to As^{3+} showed an inhibition in shoot length, chlorophyll, carotenoid, and protein, while co-application of Si improved these growth parameters. Silicon supplementation reduced As accumulation in shoot. Increase/decrease was observed in stress-related parameters (cysteine and proline), antioxidant enzymes (superoxide dismutase, ascorbate peroxidase, and catalase), and oxidative stress markers (malondialdehyde and H_2O_2), which were improved upon co-application of Si as compared to As^{3+} alone treatment. Random amplified polymorphic DNA (RAPD) is a suitable biomarker assay for plants for assessing the genotoxicity. Seven RAPD primers produced a total of 39 and 48 bands in the leaves of the untreated and treated seedlings, respectively. The RAPD band-profiles and genomic template stability were consistent with other growth and physiological parameters. In conclusion, the genotoxic alterations along with the biochemical parameters indicate that the exposure to Si mitigates As^{3+}-induced oxidative stress by improving the stress-related parameters and antioxidant system in *B. Juncea*.
Keywords	antioxidant enzyme; genomic template stability; genotoxicity; polymorphism; RAPD

Title	**Geographical variations in arsenic contents in rice plants from Latin America and the Iberian Peninsula in relation to soil conditions**
Author Name	X. L. Otero O. Atiaga, R. Estrella, W. Tierra, J. Ruales, L. Zayas, V. Souza Jr., T. O. Ferreira, G. N. Nóbrega, D. P. Oliveira, H. M. Queiroz & L. M. Nunes
Journal Name	Environmental Geochemistry and Health
Year	2020
Volume and Issue	42
Pages	3351–3372
Abstracts	Arsenic is a ubiquitous, toxic element that is efficiently accumulated by rice plants. This study assessed the spatial variability in the total As (tAs) contents and organic and inorganic forms in different types of rice, plant parts (husk, stem, leaves and phytoliths) and residues. Samples were collected in different countries in Latin America (Ecuador, Brazil and Peru) and the Iberian Peninsula (Spain and Portugal). The tAs content in commercial polished rice from the Latin American countries was similar (0.130–0.166 mg kg^{-1}) and significantly lower than in the rice from the Iberian countries (0.191 ± 0.066 mg kg^{-1}), and together, the tAs concentration in brown rice (236 ± 0.093 mg kg^{-1}) was significantly higher than in polished and parboiled rice. The inorganic As (iAs) content in rice was similar in both geographical regions, and the aforementioned difference was attributed to dimethylarsinic acid (DMA). The relative abundance of organic species increased as the tAs content in rice grain increased. A meta-analysis of our and previously reported data confirmed the negative correlation between iAs/tAs and tAs. At low tAs concentrations, inorganic forms are dominant, while at higher values ($tAs > 0.300$ mg kg^{-1}) the concentration of organic As increases substantially and DMA becomes the dominant form in rice grain. On the contrary, inorganic arsenic was always the dominant form, mainly as arsenate [As(V)], in leaves and stems. The presence in soils of high concentrations of amorphous Fe and Al oxides and hydroxides, which are capable of strongly adsorbing oxyanions (i.e. arsenate), was associated with low concentrations of As in rice plants. In addition, the presence of high concentrations of As(V) in stems and leaves, low concentration of As in phytoliths, and the As associated with organic matter in stems and husk, together suggest that rice plants take up more As(V) than As(III).
Keywords	Source Soil properties; Arsenic speciation; Phytoliths; Local and intercontinental variability

Title	**Titanium nanoparticles attenuates arsenic toxicity by up-regulating expressions of defensive genes in *Vigna radiata L***
Author Name	PriyaKatiyar, BhumikaYadu, JyotiKorram, ManmohanL.Satnami, MeetulKumar, S.Keshavkant
Journal Name	Journal of Environmental Sciences
Year	2020
Volume and Issue	92
Pages	18-27
Abstracts	Arsenic (As)-toxicity is recognized as one of the major environmental problems, affecting productivity of crops worldwide, thereby threatening sustainable agriculture and food security. Progression in nanotechnology and its impacts have brought up concerns about the application of engineered nanoparticles (NPs) in various sectors of the economy, including the field of agronomy. Among various NPs, there has been a rising amount of interest regarding the effects of titanium NPs (TiNPs) on plants growth and development, and their fate of abiotic stress tolerance. Hence, the present study was aimed to assess the ameliorative potentialities of chemically and biologically/green synthesized TiNPs to alleviate As-induced toxic responses in *Vigna radiata L*. The results revealed that exposure to As hindered the growth indices (radicle length and biomass) and membrane integrity, while were improved with the application of chemical and green synthesized TiNPs. In addition, treatment of As provoked the accretion of reactive oxygen species (superoxide and hydrogen peroxide) and malondialdehyde (a lipid peroxidized product), but were diminished by the supplementation of chemical and green manufactured TiNPs. The experimental data also signified that exogenous application of chemical and green synthesized TiNPs conferred tolerance to As-induced oxidative injuries via perking-up the expressions of antioxidant genes and enzyme systems viz; superoxide dismutase and catalase. Therefore, the present study inferred that chemically and green synthesized TiNPs, particularly green manufactured, effectively mitigated the adverse impacts of As by augmenting antioxidant machinery, thereby proving its potentiality in the alleviation of As-toxicity, at least in *Vignaradiata L.*
Keywords	Antioxidants; Arsenic; Gene expression; Titanium nanoparticles (TiNPs); Reactive oxygen species (ROS); *Vigna radiata L*

Title	**Temporal dynamics of arsenic uptake and distribution: food and water risks in the Bengal basin**
Author Name	Sarath Pullyottum Kavil, Devanita Ghosh, Indira Pasic, & Joyanto Routh
Journal Name	Toxicological & Environmental Chemistry
Year	2020
Volume and Issue	102(1-4)
Pages	62-77
Abstracts	Contaminated food chain is a serious contender for arsenic (As) uptake around the globe. In Nadia, West Bengal, we trace possible means of transfer of As from multiple sources reaching different trophic levels, and associated seasonal variability leading to chronic As uptake. This work considers possible sources-pathways of As transfer through food chain in rural community. Arsenic concentration in groundwater, soil, rice, and vegetable-samples collected detected in different harvest seasons of 2014 and 2016. Arsenic level in shallow groundwater samples ranged from 0.1 to 354 µg/L, with 75% of the sites above the prescribed limit by WHO (10 µg/L) during the boro harvest season. High soil As content (~20.6 mg/kg), resulted in accumulation of As in food crops. A positive correlation in As conc. with increase over period in all sites indicating gradual As accumulation in topsoil. Unpolished rice samples showed high As content (~1.75 mg/kg), polishing reduced 80% of As. Among vegetables, the plant family Poaceae with high irrigation requirements and Solanaceae retaining high moisture, have the highest levels of As. Contaminated animal fodder (Poaceae) and turf water for cattle are shown to contaminate milk (0.06 to 0.24 µg/L) and behoves strategies, practices to minimize As exposure.
Keywords	Arsenic; vegetables; paddy; food intoxication; health risk

Title	**Recent advances in arsenic metabolism in plants: current status, challenges and highlighted biotechnological intervention to reduce grain arsenic in rice**
Author Name	Manju Shri, Pradyumna Kumar Singh, Maria Kidwai, Neelam Gautam, Sonali Dubey, Giti Verma and Debasis Chakrabarty
Journal Name	Metallomics
Year	2019
Volume and Issue	3
Pages	1 - 33
Abstracts	Arsenic (As), classified as a "Metalloid" element, is well known for its carcinogenicity and other toxic effects to human. Arsenic exposure in plants results in alteration of physiochemical and biological properties, consequently loss of crop yield. Being a staple food for half of the world's population, subsequent consumption of As-contaminated rice grain by the human may pose serious health issues and risk for food security. Our study describes the principal understanding of the molecular basis of arsenic toxicity and accumulation in plant parts. We describe the measures to decrease As accumulation in rice and to understand the mechanism and transport of As uptake, its transport from root to shoot to rice grain, its metabolism, detoxification as well as the mechanisms lying behind its accumulation in rice grain. There are various checkpoints which can be targeted to reduce As accumulation in rice grain such as tuning of As V/Pi specific Pi transporters, arsenate reductase, transporters which are involved in efflux of As to either vacuole or outside the cell, xylem loading, loading and unloading to phloem and finally transporters involved in the loading of As to grain are also good choice to reduce As accumulation. Genes/protein involved in As detoxification particularly glutathione (GSH) biosynthesis pathway, phytochelatin (PC) synthesis, and arsenic methyltransferase also provide a great pool of pathways that can also be castellated for the low As in rice grains. Paddy rice is also used as fodder for the animal, enhancing vacuolar sequestration and using constitutive promoter may be a concern for the animal health. Therefore, using root-specific promoter and/or converting inorganic arsenic to volatile organic arsenic might be a better strategy for low As in grain. Furthermore, in this review, the other specific approach such as bio-remediation, bioaugmentation practices, and molecular breeding which have great potential to reduce As uptake from soil to finally rice grain has also been highlighted.
Keywords	Arsenic; Rice; Food chain contamination; Transgenic; Bioremediation; Molecular breeding

Title	**Arsenic accumulation in lentil (*Lens culinaris*) genotypes and risk associated with the consumption of grains**
Author Name	Mohammad Zahangeer Alam, Md. Anamul Hoque, Golam Jalal Ahammed, Rebecca McGee, & Lynne Carpenter-Boggs
Journal Name	Scientific Reports
Year	2019
Volume and Issue	9:9431
Pages	1 - 9
Abstracts	Arsenic (As) is a toxic metalloid. As phyto-toxicity is manifested by its accumulation in different tissue types and subsequent growth inhibition in plants. Despite the vital role of leguminous crops in providing proteins to human diets, a little is known about the As accumulation in lentil. In this study, the rate of As uptake and transport from soil to root, shoot and grain of lentil as well as associated risks with the consumption of As contaminated food were examined. Biomass accumulation of lentil genotypes pardina, red chief and precoz drastically decreased when treated with As at 6mgkg^{-1} concentration in comparison to 0 and 3mgkg^{-1} As. Quantifcation of As concentrations following different treatment periods showed that As accumulation in roots and shoots of 0, 3 and 6mgkg^{-1} As-treated lentil genotypes was statistically different. Arsenic content in grains of red chief genotype was found significantly lower than pardina and precoz. Moreover, As transport signifcantly increased in roots and shoots compared to the grains. Due to the high concentrations of As in biomass of lentil genotypes, animal as well as human health risk might be associated with the consumption of the As contaminated legume crops.
Keywords	Metalloid; leguminous; accumulation; genotypes; biomas; health risk

Title	**An overview of plant-based interventions to ameliorate arsenic toxicity**
Author Name	Ann Susan, Kayalvizhi Rajendran, Kaviarasi Sathyasivam, Uma Maheswari, Krishnan
Journal Name	Biomedicine & Pharmacotherapy
Year	2019
Volume and Issue	109
Pages	838-852
Abstracts	The industrial and technological advancements in the world have also contributed to the rapid deterioration in the environment quality through introduction of obnoxious pollutants that threaten to destroy the subtle balance in the ecosystem. The environment contaminants cause severe adverse effects to humans, flora and fauna that are mostly irreversible. Chief among these toxicants is arsenic, a metalloid, which is considered among the most dangerous environmental toxinsthat leads to various diseases which affect the quality of life even when present in small quantities. Treatment of arsenic-mediated disorders still remains a challenge due to lack of effective options. Chelation therapy has been the most widely used method to detoxify arsenic. But this method is associated with deleterious effects leading various toxicities such as hepatotoxicity, neurotoxicity and other adverse effects. It has been discovered that indigenous drugs of plant origin display effective and progressive relief from arsenic-mediated toxicity without any side-effects. Further, these phytochemicals have also been found to aid the elimination of arsenic from the biological system and therefore can be more effective than conventional therapeutic agents in ameliorating arsenic-mediated toxicity. This review presents an overview of the toxic effects of arsenic and the therapeutic strategies that are available to mitigate the toxic effects with emphasis on chelation as well as protective and detoxifying activities of different phytochemicals and herbal drugs against arsenic. This information may serve as a primer in identifying novel prophylactic as well as therapeutic formulations against arsenic-induced toxicity.
Keywords	Arsenic; Toxicity; Phytochemicals; Plant extracts; Chelation

Title	**Arsenic-phosphorus interactions in the soil-plant-microbe system: Dynamics of uptake, suppression and toxicity to plants**
Author Name	Hossain M. Anawara, Zed Rengela, Paul Damona, Mark Tibbettb
Journal Name	Environmental Pollution
Year	2018
Volume and Issue	Volume 233
Pages	Pages 1003-1012
Abstracts	High arsenic (As) concentrations in the soil, water and plant systems can pose a direct health risk to humans and ecosystems. Phosphate (Pi) ions strongly influence As availability in soil, its uptake and toxicity to plants. Better understanding of As(V)-Pi interactions in soils and plants will facilitate a potential remediation strategy for As contaminated soils, reducing As uptake by crop plants and toxicity to human populations via manipulation of soil Pi content. However, the As(V)-Pi interactions in soil-plant systems are complex, leading to contradictory findings among different studies. Therefore, this review investigates the role of soil type, soil properties, minerals, Pi levels in soil and plant, Pi transporters, mycorrhizal association and microbial activities on As-Pi interactions in soils and hydroponics, and uptake by plants, elucidate the key mechanisms, identify key knowledge gaps and recommend new research directions. Although Pi suppresses As uptake by plants in hydroponic systems, in soils it could either increase or decrease As availability and toxicity to plants depending on the soil types, properties and charge characteristics. In soil, As(V) availability is typically increased by the addition of Pi. At the root surface, the Pi transport system has high affinity for Pi over As(V). However, Pi concentration in plant influences the As transport from roots to shoots. Mycorrhizal association may reduce As uptake via a physiological shift to the mycorrhizal uptake pathway, which has a greater affinity for Pi over As(V) than the root epidermal uptake pathway.
Keywords	Arsenic toxicity; As-Pi interactions; As-Pi uptake by plants; Mycorrhizalassociation; Soil mineralogy; Soil types

Title	Arsenic Pollution: An Environmental Problem
Author Name	Arvind Kumar Singh And Shraddha Rai
Journal Name	Indian J. Sci. Res.
Year	2017
Volume and Issue	Volume 15, Issue 1
Pages	51-53
Abstracts	Arsenic, a toxic metalloid occurs naturally, being the 20th most abundant element in the earth's crust. Arsenic and its component are mobile in the environment. Arsenic enters into the environment mainly from industrial processes, phosphate fertilizer and atmospheric deposition. It is highly toxic to the crop plants as well as human beings. Arsenic contamination in the soil may cause a variety of problems such as loss of vegetation, ground water contamination etc. Groundwater contamination by arsenic is a serious threat to mankind and plants all over the world. Two forms of arsenic are present in the environment viz., inorganic and organic. Inorganic arsenic is more toxic than organic arsenic. Arsenic toxicity severely affects the growth and development of plants resulting in perturbation in various physiological and chemical processes which ultimately poses a threat to the environment. In this way arsenic pollution is becoming a serious environmental problem in the world which needs more research towards its detoxification.
Keywords	Arsenic, Environment, Pollution, Phytotoxicity, Crop plants.

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Title	**Arsenic toxicity in plants: Cellular and molecular mechanisms of its transport and metabolism**
Author Name	Muhammad A.Farooqa, Faisal Islam, Basharat Ali, Ullah Najeeb, Bizeng Mao, Rafaqat A.Gill, Guijun Yane, Kadambot H.M.Siddique, Weijun Zhou
Journal Name	Environmental and Experimental Botany
Year	2016
Volume and Issue	Volume 132
Pages	Pages 42-52
Abstracts	Arsenic (As), a naturally-occurring metalloid, is not essential for plant growth, but it can accumulate in plants to toxic levels. As a result, it can enter the food chain and pose health risk to humans. Multiple mechanisms are involved in the uptake and metabolism of As in plants. The most toxic forms of this element are AsIII and AsV. Methylated As and arsenite (as AsIII) move through the noduline 26-like intrinsic protein (NIP) aquaporin channels while arsenate (as AsV) is taken up through the phosphate transporters. In the Pteridaceae family, some fern species show hyper-accumulating behavior towards As in aboveground tissues. However, generally in plants, the chelation phenomenon detoxifies arsenite through complexation with the thiol-rich peptide. This comprehensive review encompasses the mechanisms of transport, metabolism, and tolerance that plants show in response to As. Some recent advancement in plant breeding, genetic modifications and remediation approaches to overcome soil and food contamination problems are also summarized. We will also evaluate the implications of these new findings and assess how this may help in developing the crops that can be grown in high As regions and ultimately will be safe for consumers.
Keywords	Arsenic;Bioavailability;Speciation;Transport;Metabolism;Toxicity; Mitigation

Title	**Potential Risk of Arsenic and Antimony Accumulation by Medicinal Plants Naturally Growing on Old Mining Sites**
Author Name	Marek Vaculík & Ľubomír Jurkovič, Peter Matejkovič, Marianna Molnárová, Alexander Lux
Journal Name	Water Air Soil Pollution
Year	2013
Volume and Issue	--
Pages	224:1546
Abstracts	Abstract It was found that some of the medicinal plants accumulate increased amounts of toxic elements like Cd or Pb. Less is known about the accumulation of other hazardous elements like arsenic (As) and antimony (Sb) in these species. The present paper investigated selected medicinal plants naturally growing on old mining sites in Slovakia, Central Europe, contaminated by As and Sb. Both these elements are nonessential for plants and, in higher level, might be phytotoxic. The soil concentration of As and Sb at three different localities extensively used for mining of Sb ores in former times highly exceed values characteristic for non contaminated substrates and ranged between 146 and 540 mg kg^{-1} for As and 525 and 4,463 mg kg^{-1} for Sb. Extraction experiments of soils show differences between As and Sb leaching, as the highest amount of mobile As was released in acetic acid while Sb was predominantly released in distilled water. In total, seven different plant species were investigated (Fragaria vesca, Taraxacum officinale, Tussilago farfara, Plantago major, Veronica officinalis, Plantago media, and Primula elatior), and the concentration of investigated elements in shoot ranged between 1 and 519 mg kg^{-1} for As and 10 and 920 mg kg^{-1} for Sb. Differences in the bioaccumulation of As and Sb as well as in the translocation of these elements from root to shoot within the same species growing on different localities have been found. This indicate that efficiency of As and Sb uptake might vary between individual plants of the same species on different sites. Increased bioaccumulation of As and Sb in biomass of investigated plants might be dangerous for human when used for traditional medicinal purposes.
Keywords	Arsenic, Selenium, Antagonism, Antioxidants, Detoxification

Title	**Occurrence of arsenic species in algae and freshwater plants of an extreme arid region in northern Chile, the Loa River Basin**
Author Name	Albert Pell, Anna Márquez, José Fermín López-Sánchez, Roser Rubio, Mercedes Barbero, Susana Stegen, Fabrizio Queirolo, Paula Díaz-Palma
Journal Name	Chemosphere
Year	2013
Volume and Issue	556-564
Pages	---
Abstracts	This study reports data on arsenic speciation in two green algae species (*Cladophora sp.* and *Chara sp.*) and in five aquatic plants (Azolla sp., Myriophyllum aquaticum, Phylloscirpus cf. desserticola, Potamogeton pectinatus, Ruppia filifolia and Zannichellia palustris) from the Loa River Basin in the Atacama Desert (northern Chile). Arsenic content was measured by Mass spectrometry coupled with Inductively Coupled Plasma (ICP–MS), after acidic digestion. Liquid chromatography coupled to ICP–MS was used for arsenic speciation, using both anionic and cationic chromatographic exchange systems. Inorganic arsenic compounds were the main arsenic species measured in all samples. The main arsenic species in the extracts of freshwater algae and plants were arsenite and arsenate, whereas glycerol-arsenosugar (gly-sug), dimethylarsinic acid (DMA) and methylarsonic acid (MA) were present only as minor constituents. Of the samples studied, algae species accumulated more arsenic than aquatic plants. Total arsenic content ranged from 182 to 11 100 and from 20 to 248 mg As kg^{-1} (d.w.) in algae and freshwater plants, respectively. In comparison with As concentration in water samples, there was hyper-accumulation (>0.1% d.w.) in Cladophora sp.
Keywords	Arsenic speciation, LC–ICP–MS; Algae, Aquatic plants, Loa River

Title	**Biochar addition to an arsenic contaminated soil increases arsenic concentrations in the pore water but reduces uptake to tomato plants (*Solanum lycopersicum L.*)**
Author Name	Luke Beesley, Marta Marmiroli, Luca Pagano, Veronica Pigoni, Guido Fellet, Teresa Fresno, Teofilo Vamerali, Marianna Bandiera, Nelson Marmiroli
Journal Name	Science of The Total Environment
Year	2013
Volume and Issue	Volume 454 - 455, Issue 1
Pages	598-603
Abstracts	Arsenic (As) concentrations in soil, soil pore water and plant tissues were evaluated in a pot experiment following the transplantation of tomato (*Solanum lycopersicum L.*) plantlets to a heavily As contaminated mine soil (~ 6000 mg kg^{-1} pseudo-total As) receiving an orchard prune residue biochar amendment, with and without NPK fertiliser. An in-vitro test was also performed to establish if tomato seeds were able to germinate in various proportions of biochar added to nutrient solution (MS). Biochar significantly increased arsenic concentrations in pore water (500 μg L^{-1}–2000 μg L^{-1}) whilst root and shoot concentrations were significantly reduced compared to the control without biochar. Fruit As concentrations were very low (< 3 μg kg^{-1}), indicating minimal toxicity and transfer risk. Fertilisation was required to significantly increase plant biomass above the control after biochar addition whilst plants transplanted to biochar only were heavily stunted and chlorotic. Given that increasing the amount of biochar added to nutrient solution in-vitro reduced seed germination by up to 40%, a lack of balanced nutrient provision from biochar could be concluded. In summary, solubility and mobility of As were increased by biochar addition to this soil, but uptake to plant was reduced, and toxicity-transfer risk was negligible. Therefore leaching rather than food chain transfer appears the most probable immediate consequence of biochar addition to As contaminated soils.
Keywords	Toxicity; Bioavailable; Transfer; Soluble arsenic; Biochar; Mine soil

Title	**Metabolites of arsenic and increased DNA damage of p53 gene in arsenic plant workers**
Author Name	Weihua Wen, Jinghua Wen, Lin Lu, Hua Liu, Jun Yang, Huirong Cheng, Wangjun Che, Liang Li, Guanbei Zhang
Journal Name	Toxicology and Applied Pharmacology
Year	2011
Volume and Issue	Volume 254, Issue 1
Pages	41-4
Abstracts	Recent studies have shown that monomethylarsonous acid is more cytotoxic and genotoxic than arsenate and arsenite, which may attribute to the increased levels of reactive oxygen species. In this study, we used hydride generation-atomic absorption spectrometry to determine three arsenic species in urine of workers who had been working in arsenic plants,and calculated primary and secondary methylation indexes. The damages of exon 5, 6, 8 of p53 gene were determined by the method developed by Sikorsky, et al. Results show that the concentrations of each urinary arsenic species,and damage indexes of exon 5 and 8 of p53 gene in the exposed population were significantly higher, but SMI was significantly lower than in the control group. The closely positive correlation between the damage index of exon 5 and PMI,MMA, DMA were found, but there was closely negative correlation between the damage index of exon 5 and SMI. Those findings suggested that DNA damage of exon 5 and 8 of p53 gene existed in the population occupationally exposed to arsenic. For exon 5, the important factors may include the model of arsenic metabolic transformation, the concentrations of MMA and DMA, and the MMA may be of great importance.
Keywords	Arsenic, Monomethylarsonic acid, Dimethylarsinic acid, Oxidative DNA damage, P53 gene, ROS

Title	**Long-distance transport, vacuolar sequestration, tolerance, and transcriptional responses induced by cadmium and arsenic**
Author Name	David G Mendoza-Cózatl, Timothy O Jobe, Felix Hauser, Julian I
Journal Name	Schroeder Current Opinion in Plant Biology
Year	2011
Volume and Issue	Volume 14, Issue 5
Pages	554-562
Abstracts	Iron, zinc, copper and manganese are essential metals for cellular enzyme functions while cadmium, mercury and the metalloid arsenic lack any biological function. Both, essential metals, at high concentrations, and non-essential metals and metalloids are extremely reactive and toxic. Therefore, plants have acquired specialized mechanisms to sense, transport and maintain essential metals within physiological concentrations and to detoxify non-essential metals and metalloids. This review focuses on the recent identification of transporters that sequester cadmium and arsenic in vacuoles and the mechanisms mediating the partitioning of these metal (loid)s between roots and shoots. We further discuss recent models of phloem-mediated long-distance transport, seed accumulation of Cd and As and recent data demonstrating that plants posses a defined transcriptional response that allow plants to preserve metal homeostasis. This research is instrumental for future engineering of reduced toxic metal (loid) accumulation in edible crop tissues as well as for improved phytoremediation technologies.
Keywords	Arsenic; cadmium; homeostasis; accumulation; phytoremediation technologies