Arsenic

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
Page	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.

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 As^{III} and As^{V}. Methylated As and arsenite (as As^{III}) move through the noduline 26-like intrinsic protein (NIP) aquaporin channels while arsenate (as As^{V}) 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
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