Metals/Metalloids

Title	**Understanding Heavy Metal Stress in a Rice Crop: Toxicity, Tolerance Mechanisms, and Amelioration Strategies**
Author Name	Namira Arif , Nilesh C. Sharma , Vaishali Yadav , Naleeni Ramawat , Nawal Kishore Dubey , Durgesh Kumar Tripathi , Devendra Kumar Chauhan & Shivendra Sahi
Journal Name	Journal of Plant Biology
Year	2019
Volume and Issue	Volume 62
Pages	Pages 239-253
Abstracts	Heavy metal (HMs) pollution is regarded as one of the major concerns for soil and water, causing varieties of toxic and stress effects on plants and ecosystems. It has become one of the important limiting factors to crop productivity and quality. Due to an ever-increasing population growth and food demands, this situation has further worsened. Rice, a leading staple food crop that feeds more than 50% populations of the world, is constantly affected by abiotic stressors including HMs. In most of the countries, a major source of HM intake by humans is the rice grain produced through the paddy soils contaminated with HMs such as As, Al, Cu, Cr, Cd, Pb, Hg, Mn, Se, and Zn. Thus, gradual agglomeration of HMs in rice grains and their subsequent transfer to the food chain is a major menace to agriculture and human health. In recent years, several studies examined the impact of HMs toxicity on rice at multiple levels: molecular, biochemical, physiological, cellular and tissue, and demonstrated a correlation between HMs toxicity and the decreasing trend in rice productivity. Therefore, it is necessary to understand the interaction of HMs with rice crop spanning from the cell to whole plant level and devise appropriate effective means to alleviate these stress responses. This review focuses on tracing the pathways involved in stress responses and stress tolerance mechanisms displayed by different varieties of rice. However, it is essential to uncover the mechanisms related to stress responses in rice for designing improved investigations to develop novel varieties with high attributes. Therefore, this communication summarizes various defense strategies induced against HM stress and includes the function of metabolites (metabolomics), trace elements (ionomics), transcription factors (transcriptomics), and various stress-inducible proteins (proteomics) including the role of plant hormones.
Keywords	Heavy metals; Ionomics; Metabolomics; metallophytes; Proteomics; Rice; Transcriptomics

Title	**Nanomaterials and plants: Positive effects, toxicity and the remediation of metal and metalloid pollution in soil**
Author Name	Yi Zhu, Fang Xu, Qin Liu , Ming Chen, Xianli Liu, Yanyan Wang, Yan Sun & Lili Zhang
Journal Name	Science of the Total Environment
Year	2019
Volume and Issue	Volume 662
Pages	Pages 414-421
Abstracts	Currently, the pollution of metals and metalloids in the soil has attracted considerable attention. Phytoremediation is considered an environmentally friendly means of remediating pollution, but often takes a long time to perform. Therefore, the combination of plants and nanomaterials in environmental management has attracted the attention of many researchers because some nanomaterials can promote the germination of plant seeds and the growth of whole plants. However, when the concentration of nanomaterials is not controlled properly, certain toxicity will be produced. This paper reviews research on the combination of plant and nanomaterials for the remediation of contaminated environments, as well as on the effects of nanomaterials on plants.
Keywords	Nanoparticle; Nanomaterial; Heavy metal; PlantsToxicity

Title	**Transport and detoxification of metalloids in plants in relation to plant-metalloid tolerance**
Author Name	Akhilesh Kumar Pandey, Arti Gautam & Rama Shanker Dubey
Journal Name	Plant Gene
Year	2019
Volume and Issue	Volume 17
Pages	----
Abstracts	Metalloids are key environmental contaminants and when present in high concentrations in soil, adversely affect crop productivity. Plants possess several transporters that maintain required level of essential metal ions inside the cells so as to perform different metabolic activities. Transporters are responsible for the entry and distribution of different elements inside various cells and organs of the plant. Many toxic metalloid ions share the transport network of essential ions due to their similar structural properties like phosphate transporters, aquaglyceroporins, hexose transporters, sulphate transporters, etc. Presence of excess amounts of toxic metalloid ions inside the plant tissues causes severe damages to cell biomolecules, affects key metabolic processes, inhibits growth of plants ultimately leading to decreased crop yield. Therefore detoxification strategies of metalloids at the tissue level are essential in order to minimize their toxic effects. Employing mutants, attempts have been made by various groups of workers to restrict the uptake of many pollutant metalloids by plants by reducing the activities of transporters and to overexpress metalloid binding peptides and proteins such as phytochelatins, metallothioneins for sequestration of metalloids in the tissues. Reduced transport of metalloids in the tissues coupled with their increased sequestration inside the cells would lead to generation of metalloid-tolerant crop plants. The present review summarizes our current status of knowledge in this direction related to transport mechanisms and detoxification strategies of metalloids in crop plants in relation to Plant-Metalloid tolerance.
Keywords	Metalloids; Transporters; Aquaglyceroporins; Metallothioneins; Phytochelatins

Title	Environmental Chemistry and Ecotoxicology of Hazardous Heavy Metals: Environmental Persistence, Toxicity, and Bioaccumulation
Author Name	Hazrat Ali, Ezzat Khan & Ikram Ilahi
Journal Name	Journal of Chemistry
Year	2019
Volume and Issue	Volume 2019
Pages	14
Abstracts	Heavy metals are well-known environmental pollutants due to their toxicity, persistence in the environment, and bioaccumulative nature. Their natural sources include weathering of metal-bearing rocks and volcanic eruptions, while anthropogenic sources include mining and various industrial and agricultural activities. Mining and industrial processing for extraction of mineral resources and their subsequent applications for industrial, agricultural, and economic development has led to an increase in the mobilization of these elements in the environment and disturbance of their biogeochemical cycles. Contamination of aquatic and terrestrial ecosystems with toxic heavy metals is an environmental problem of public health concern. Being persistent pollutants, heavy metals accumulate in the environment and consequently contaminate the food chains. Accumulation of potentially toxic heavy metals in biota causes a potential health threat to their consumers including humans. This article comprehensively reviews the different aspects of heavy metals as hazardous materials with special focus on their environmental persistence, toxicity for living organisms, and bioaccumulative potential. The bioaccumulation of these elements and its implications for human health are discussed with a special coverage on fish, rice, and tobacco. The article will serve as a valuable educational resource for both undergraduate and graduate students and for researchers in environmental sciences. Environmentally relevant most hazardous heavy metals and metalloids include Cr, Ni, Cu, Zn, Cd, Pb, Hg, and As. The trophic transfer of these elements in aquatic and terrestrial food chains/webs has important implications for wildlife and human health. It is very important to assess and monitor the concentrations of potentially toxic heavy metals and metalloids in different environmental segments and in the resident biota. A comprehensive study of the environmental chemistry and ecotoxicology of hazardous heavy metals and metalloids shows that steps should be taken to minimize the impact of these elements on human health and the environment.
Keywords	Bioaccumulative; anthropogenic sources; heavy metals; metalloids; ecotoxicology

Title	Engineering plants for heavy metal stress tolerance
Author Name	Wasia Wani, Khalid Z. Masoodi, Abbu Zaid, Shabir H. Wani, Farheena Shah, Vijay Singh Meena, Shafiq A. Wani, Kareem A. Mosa
Journal Name	Rendiconti Lincei. Scienze Fisiche e Naturali
Year	2018
Volume and Issue	Volume 29,3
Pages	Pages 709-723
Abstracts	We here assess the biodiversity of the *rhizosphere* microbial communities of metal-tolerant plant species *Arabidopsis arenosa*, *Arabidopsis halleri*, *Deschampsia caespitosa*, and *Silene vulgaris* when growing on various heavy metal polluted sites. Our broad-spectrum analyses included counts for total and metal-tolerant culturable bacteria, assessments of microbial community structure by phospholipid fatty acid (PLFA) profiling and community-level analysis based on BIOLOG-CLPP to indicate functional diversity. The genetic-biochemical diversity was also measured by denaturing gradient gel electrophoresis (PCR-DGGE) and *metabolomic* analysis (HPLC-MS). Different *rhizospheres* showed distinctive profiles of microbial traits, which also differed significantly from bulk soil, indicating an influence from sampling site as well as plant species. However, total bacterial counts and PCR-DGGE profiles were most affected by the plants, whereas sampling site-connected variability was predominant for the PLFA profiles and an interaction of both factors for BIOLOG-CLPP. Correlations were also observed between pH, total and *bioavailable* Cd or Zn and measured microbial traits. Thus, both plant species and heavy-metals were shown to be major determinants of microbial community structure and function.
Keywords	Heavy metal stress tolerance; Metabolic engineering; Physiological and cellular changes ; Transgenics; Crop improvement

Title	Heavy metals and metalloids: Sources, risks and strategies to reduce their accumulation in horticultural crops
Author Name	Menahem Edelstein & Meni Ben-Hur
Journal Name	Scientia Horticulturae
Year	2018
Volume and Issue	234
Page	431-444
Abstracts	Food production in areas contaminated with heavy metals is associated with health risks because of their adverse effects on food safety and marketability, and on crop growth and yield quality. The present review focuses on sources and risks of heavy metals, mainly in cultivated fields in various regions, and strategies to reduce their accumulation in horticultural crops. The following heavy metals are discussed: arsenic (As), boron (B), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), mercury (Hg), molybdenum (Mo), nickel (Ni), strontium (Sr), tin (Sn), titanium (Ti), vanadium (V) and zinc (Zn). Heavy metal sources in the environment can originate from natural and anthropogenic activities. Their main natural enrichment in soils stems from parent-material weathering. However, in coastal areas, precipitation of sea spray may enrich soil with B. In contrast, the main anthropogenic sources of heavy metals in cultivated areas are irrigation with treated sewage water, application of residual *biosolids*, and atmospheric pollution. Plants absorb heavy metals predominantly through roots and, to a lesser extent, through leaves. Leaf uptake can occur through the *stomata, cuticular cracks, ectodesmata,* and *aqueous pores*. Heavy metal uptake may lead to their accumulation in vegetables and fruit trees, and their consequent introduction into the food chain, which is recognized as one of the major pathways for human exposure to them. This exposure can result in retardation, several types of cancer, kidney damage, endocrine disruption, and immunological and neurological effects. High concentrations of heavy metals can also affect the growth and yield of many crops: Zn and Cd decrease plant metabolic activity and induce oxidative damage; Cu generates oxidative stress and reactive oxygen species; Hg can induce visible injury and physiological disorders; Cr affects photosynthesis in terms of CO2 fixation, electron transport, *photophosphorylation* and enzyme activities; Pb induces plant abnormal morphology; Ni spoils the nutrient balance, resulting in disorders of cell membrane functions; Fe causes free radical production that irreversibly impairs cell structure and damages membranes, DNA and proteins; As causes leaf necrosis and wilting, followed by root discoloration and retardation of shoot growth. Therefore, international organizations, such as the US EPA and EU bodies, are working on regulating the maximum allowable levels of food pollutants. A number of direct (*mycorrhiza*, transgenic plants and grafting) approaches can be deployed to overcome problems of heavy metal contamination in horticulture.
Keywords	Contamination; Fruits; Health risks; Heavy metals; Pollution; Vegetables; Wastewater

Title	Toxicity and detoxification of heavy metals during plant growth and metabolism
Author Name	Sonali Dubey, Manju Shri, Anubhuti Gupta, Vibha Rani & Debasis Chakrabarty
Journal Name	Environmental Chemistry Letters
Year	2018
Pages	Pages 01-24
Abstracts	Pollution of plants by heavy metals is a critical health issue because metals can be transmitted to animals and humans. Heavy metal exposure induces an oxidative stress in plant, resulting in cellular damage and altered cellular ionic homeostasis. As a consequence, plants start detoxification mechanisms. Here, we review heavy metal toxicity and impact. We discuss *metabolism* and *detoxification* strategies of heavy metals and metalloid, with emphasis on the use of *transcriptomics, metabolomics*, and proteomics. A section highlights *microRNA (miRNA)* as critical regulators of heavy metal stress in plants. We also present bioremediation and *phytoremediation* methods to remove metals.
Keywords	Heavy metal; Toxicity; Plants; Oxidative stress; Tolerance; Detoxification; Defense mechanism; microRNAs; Phytoremediation

Title	**Potential health risk assessment of potato (Solanum tuberosum L.) grown on metal contaminated soils in the central zone of Punjab, Pakistan**
Author Name	Yishu Peng, Ruidong Yang, Tao Jin, Jun Chen & Jian Zhang
Journal Name	Food and Chemical Toxicology
Year	2017
Volume and Issue	120
Pages	328-339
Abstracts	We investigated potentially toxic metal *(loid*)s (arsenic, As; cadmium, Cd; chromium, Cr; copper, Cu; mercury, Hg; lead, Pb; selenium, Se; and zinc, Zn) in agricultural samples (i.e., *Solanum tuberosum* L. tubers (potatoes) and their planting media) in the indigenous zinc smelting area of *northwestern Guizhou* Province, China. Based on the pollution index values for As, Cd, Pb and Zn, the order of the samples was as follow: slag > planting soil with slag > planting soil without slag, and the order of the samples in terms of the *bioconcentration* factor was the opposite. Cr, Cu and Hg were present in the planting soil with and without slag at slight pollution levels, and the other potentially toxic metal (*loid*)s had different degrees of contamination. Additionally, the potentially toxic metal (*loid*) contents in potato were under their limit values except for Cd (all samples) and Pb and Se (some samples). All *bioconcentration* factors for potatoes were below 0.5, and no health risk index value for potatoes was higher than 0.1. Therefore, although no significant health risk associated with potentially toxic metal (*loid*)s via consuming potato exists for either adult men or women in the research area, the Cd concentration in this crop should be monitored.
Keywords	Potentially toxic metal(loid); sIndigenous zinc smelting; Solanum tuberosum L.; Enrichment factor; Bioconcentration factor; Health risk index

Title	Field accumulation risks of heavy metals in soil and vegetable crop irrigated with sewage water in western region of Saudi Arabia
Author Name	Khaled S.Balkhair, Muhammad Aqeel Ashrafc
Journal Name	Saudi Journal of Biological Sciences
Year	2016
Volume and Issue	23,1
Pages	S32-S44
Abstracts	Wastewater irrigated fields can cause potential contamination with heavy metals to soil and groundwater, thus pose a threat to human beings . The current study was designed to investigate the potential human health risks associated with the consumption of okra vegetable crop contaminated with toxic heavy metals. The crop was grown on a soil irrigated with treated wastewater in the western region of Saudi Arabia during 2010 and 2011. The monitored heavy metals included Cd, Cr, Cu, Pb and Zn for their bioaccumulation factors to provide baseline data regarding environmental safety and the suitability of sewage irrigation in the future. The pollution load index (PLI), enrichment factor (EF) and contamination factor (CF) of these metals were calculated. The pollution load index of the studied soils indicated their level of metal contamination. The concentrations of Ni, Pb, Cd and Cr in the edible portions were above the safe limit in 90%, 28%, 83% and 63% of the samples, respectively. The heavy metals in the edible portions were as follows: Cr > Zn > Ni > Cd > Mn > Pb > Cu > Fe. The Health Risk Index (HRI) was >1 indicating a potential health risk. The EF values designated an enhanced bio-contamination compared to other reports from Saudi Arabia and other countries around the world. The results indicated a potential pathway of human exposure to slow poisoning by heavy metals due to the indirect utilization of vegetables grown on heavy metal-contaminated soil that was irrigated by contaminated water sources. The okra tested was not safe for human use, especially for direct consumption by human beings. The irrigation source was identified as the source of the soil pollution in this study.
Keywords	Health risk; Heavy metals; Sewage water; Metal transfer index; Soil