Mercury

Title	**Mangifera indica as Bioindicator of Mercury Atmospheric Contamination in an ASGM Area in North Gorontalo Regency, Indonesia**
Author Name	Hendra Prasetia, Masayuki Sakakibara, Koji Omori, Jamie S. Laird, Koichiro Sera and Idham A. Kurniawan
Journal Name	Geosciences
Year	2018
Volume and Issue	Volume 8, Issue 1
Abstracts	We report the atmospheric Hg contamination in an artisanal and small-scale gold mining (ASGM) area in North Gorontalo, Indonesia. It is well known that atmospheric Hg contaminates the air, water, soil, and living organisms, including trees. In this study, we calculated total weight of heavy metals, especially Hg, and quantitatively measure the concentrations of heavy metals, especially Hg, in tree bark from an ASGM area. Tree bark can be used for the environmental assessment of atmospheric contamination because it attaches and absorbs heavy metals. Atmospheric Hg and other heavy metals, including Fe and Mn, and As were detected on the tree bark samples. The total weight of Hg, As, Fe, and Mn in the tree bark samples ranged from undetectable (ND) to 9.77,NDto 81.3, 124–4028, 37.0–1376 _g dry weight (DW), respectively per weight of sample. Based on quantitatively analysis micro-PIXE, the highest concentrations of all these metals were detected in the outer part of the bark. We conclude that tree bark can absorb atmospheric contamination, which is then absorbed into the inner tissues.
Keywords	atmospheric; mercury; ASGM; environmental; tree bark; heavy metals

Title	Evaluation of leafy vegetables as bioindicators of gaseous mercury pollution in sewage-irrigated areas
Author Name	Shun-an Zheng, Zeying Wu, Chun Chen, Junfeng Liang, Hongkun Huang, Xiangqun Zheng
Journal Name	Environmental Science and Pollution Research
Year	2018
Volume and Issue	Volume 25, Issue 1,
Page	From 413 to 421
Abstracts	Mercury (Hg) can evaporate and enter the plants through the stomata of plant leaves, which will cause a serious threat to local food safety and human health. For the risk assessment, this study aimed to investigate the concentration and accumulation of total gaseous mercury (TGM) in five typical leafy vegetables (Chinese chives (*Allium tuberosum* Rottler), amaranth (*Amaranthus mangostanus* L.), rape (*Brassica campestris* L.), lettuce (*Lactuca sativa* L.), and spinach (*Spinacia oleracea* L.)) grown on sewage-irrigated areas in Tianjin, China. The following three sites were chosen to biomonitor Hg pollution: a paddy field receiving sewage irrigation (industrial and urban sewage effluents) for the last 30 years, a vegetable field receiving sewage irrigation for 15 years, and a grass field which did not receive sewage irrigation in history. Results showed that the total Hg levels in the paddy (0.65 mg kg^{-1}) and vegetation fields (0.42 mg kg^{-1}) were significantly higher than the local background level (0.073 mg kg^{-1}) and the China national soil environment quality standard for Hg in grade I (0.30 mg kg^{-1}). The TGM levels in ambient air were significantly higher in the paddy (71.3 ng m^{-3}) and vegetable fields (39.2 ng m^{-3}) relative to the control (9.4 ng m^{-3}) and previously reported levels (1.45 ng m^{-3}), indicating severe Hg pollution in the atmospheric environment of the sewage-irrigated areas. Furthermore, gaseous mercury was the dominant form of Hg uptake in the leaves or irreversibly bound to leaves. The comparison of Hg uptake levels among the five vegetables showed that the gradient of Hg accumulation followed the order spinach > red amaranth > Chinese chives > rape > lettuce. These results suggest that gaseous Hg exposure in the sewage-irrigated areas is a dominant Hg uptake route in leafy vegetables and may pose a potential threat to agricultural food safety and human health.
Keywords	Gaseous mercury, Mercury, Sewage-irrigated area, Leafy vegetable, Soil, Biological indicators

Title	Effects of different concentrations of mercury on accumulation of mercury by five plant species
Author Name	Zhongchuang Liu, Li-ao Wang, Jianhua Xu, Shimin Ding, Xianghua Feng, Hongyan Xiao
Journal Name	Ecological Engineering
Year	2017
Volume and Issue	Volume 106, Part A
Pages	Pages 273-278
Abstracts	The paper studied the absorption of Hg by five common herb species selected, *Opuntia stricta*, *Aloe vera*, *Setcreasea* purpurea, *Chlorophytum comosum* and *Oxalis corniculata*, in solution with different levels of mercury. We compared the accumulation of roots and shoots of the plants selected in medium containing different concentrations of mercury. The study was to explore what extent of mercury the five plant species were suitable for absorbing and transferring. The mercury amount uptake by five herb species was tested by CVAAS. The results demonstrated that the effect of different concentrations of mercury on the accumulation condition of roots was greater than that of shoots. There was an ideal Hg concentration for transfer by each plant species. *Oxalis corniculata* was the most suitable for transferring Hg and was more suitable for repairing soils with Hg at concentrations of less than 500 μg/L.
Keywords	Phytoremediation, Mercury-contaminated soils, Accumulation

Title	Mercury accumulation plant *Cyrtomium macrophyllum* and its potential for phytoremediation of mercury polluted sites
Author Name	Yu Xun, Liu Feng, Youdan Li, Haochen Dong
Journal Name	Chemosphere
Year	2017
Volume and Issue	Volume 189
Pages	161 to 170
Abstracts	*Cyrtomium macrophyllum* naturally grown in 225.73 mg kg^{-1} of soil mercury in mining area was found to be a potential mercury accumulator plant with the translocation factor of 2.62 and the high mercury concentration of 36.44 mg kg^{-1} accumulated in its aerial parts. Pot experiments indicated that *Cyrtomium macrophyllum* could even grow in 500 mg kg^{-1} of soil mercury with observed inhibition on growth but no obvious toxic effects, and showed excellent mercury accumulation and translocation abilities with both translocation and bio concentration factors greater than 1 when exposed to 200 mg kg^{-1} and lower soil mercury, indicating that it could be considered as a great mercury accumulating species. Furthermore, the leaf tissue of *Cyrtomium macrophyllum* showed high resistance to mercury stress because of both the increased superoxide dismutase activity and the accumulation of glutathione and proline induced by mercury stress, which favorited mercury translocation from the roots to the aerial parts, revealing the possible reason for *Cyrtomium macrophyllum* to tolerate high concentration of soil mercury. In sum, due to its excellent mercury accumulation and translocation abilities as well as its high resistance to mercury stress, the use of *Cyrtomium macrophyllum* should be a promising approach to remediating mercury polluted soils.
Keywords	Soil, Cyrtomium macrophyllum, Mercury, Phytoremediation

Title	The Ability of Water Plants to Reduce the Level of Mercury Pollution in Water Quality in Irrigation
Author Name	Rusnam and Efrizal
Journal Name	International Journal of Waste Resources
Year	2016
Volume and Issue	Volume-6, Issue-2
Abstracts	This research was conducted on July–October 2013 about a mercury analysis which has been performed in Environmental Engineering Laboratory of Engineering Faculty, Andalas University. The level of mercury that is permitted by Government Regulation Republic Indonesia No. 82 of 2001 at the fourth grade for water are at 0.005 mg/l. In that analysis, mercury contents with 0.020169 mg/l at irrigated areas in Batang Hari River. This research aims to find out the ability of water lilies (Salvinia molesta), wood lettuce (Pistia stratiotes), and water hyacinth (Eichhornia crassipes) to decrease the content of water level. This research used experimental methods and the initial content of heavy metals mercury (Hg) by using 0.02 mg/L, 0.06 mg/L, and 0.1 mg/L. The results at decreasing concentrations of heavy metals mercury will be compared with the quality standard of heavy metal mercury at the fourth grade of water. The result showed that water lilies (Salvinia molesta), wood lettuce (Pistia stratiotes), and water hyacinth (Eichhornia crassipes) were able to fix the water quality for irrigation which contaminated heavy metal (Hg). Then, mercury concentration reached a quality standard for irrigation at early concentration 0.02 mg/L during the 15 days and at early concentration 0.1 mg/L during 35 days. From the analysis, it was found that Water hyacinth (Eichhornia crassipes) is the best plant to decrease the concentration of heavy metals mercury.
Keywords	Water lilies (*Salvinia molesta*); Wood lettuce (*Pistia stratiotes*); Water hyacinth (*Eichhornia crassipes*); Mercury (Hg); Water quality; Phytoremediation

Title	Mercury toxicity, molecular response and tolerance in higher plants
Author Name	Jian Chen , Zhi Min Yang
Journal Name	Springer Science+Business Media
Year	2012
Volume and Issue	25
Pages	847–857
Abstracts	Mercury (Hg) contamination in soils has become a great concern as a result of its natural release and anthropogenic activities. This review presents broad aspects of our recent understanding of mercury contamination and toxicology in plants including source of Hg contamination, toxicology, tolerant regulation in plants, and minimization strategy. We first introduced the sources of mercury contamination in soils. Mercury exists in different forms, but ionic mercury (Hg^{2+}) is the predominant form in soils and readily absorbed by plants. The second issue to be discussed is the uptake, transport, and localization of Hg^{2+} in plants. Mercury accumulated in plants evokes severe phytotoxicity and impairs numerous metabolic processes including nutrient uptake, water status, and photosynthesis. The mechanisms of mercury-induced toxicology, molecular response and gene networks for regulating plant tolerance will be reviewed. In the case of Hg recent much progress has been made in profiling of transcriptome and more importantly, uncovering a group of small RNAs that potentially mediates plant tolerance to Hg. Several newly discovered signaling molecules such as nitric oxide and carbon monoxide have now been described as regulators of plant tolerance to Hg. A recently emerged strategy, namely selection and breeding of plant cultivars to minimize Hg (or other metals) accumulation will be discussed in the last part of the review.
Keywords	Mercury Plants, Toxicology, Tolerance, Small RNA, Gene expression, Molecular response

Title	Expression of a Brassica napus heme oxygenase confers plant tolerance to mercury toxicity
Author Name	QI Shen, Ming Jiang, Hua li, Li ling Che and Zhi Min Yang
Journal Name	Plant, Cell and Environment
Year	2011
Volume and Issue	Volume 34, Issue 5
Pages	752 – 763
Abstracts	Plant heme oxygenases (HOs) regulate biosynthesis of phytochrome which accounts for photo-acceptance and -morphogenesis. Recent studies have demonstrated that plant HOs also regulate many other physiological processes including response to environmental stimuli. To elucidate the mechanism by which HOs regulate plant adaptation to heavy metal exposure, three novel HOs genes were isolated from rapeseed (Brassica napus) and their expression patterns were analysed. Alignment of deduced protein sequences revealed that the three BnHOs share high identity with their corresponding orthologos (AtHO1-3) from Arabidopsis. To investigate whether the BnHO regulates plant tolerance to Hg toxicity, we constructed B. napus transgenic plants overexpressing BnHO-1. Under Hg stress, the transgenic plants had 1.41–1.59 folds higher biomass than the untransformants. However, overexpression of BnHO-1 resulted in less accumulation of Hg in some lines of transformants than in untransformants. The transgenic plants show lower abundance of reactive oxygen species and attenuated oxidative injury compared with the untransgenic plants. We cloned the promoter sequences of BnHO-1 from B. napus. Analysis revealed that the 1119 bp fragment contains a conserved Cd responsive element (CdRE) and others responding to multiple environmental stimuli. Transient expression in tobacco leaves showed differential responses to heavy metals (Zn, Cu, Pb, Hg and Cd).
Keywords	Heavy Metals; oxidative stress; promoter; rapeseed

Title	Metallothionein expression in chloroplasts enhances mercury accumulation and phytoremediation capability
Author Name	Oscar N. Ruiz, Derry Alvarez, Cesar Torres, Laura Roman and Henry
Journal Name	Daniell Plant Biotechnology journal
Year	2011
Volume and Issue	Volume-9, Issue-5
Pages	609–617
Abstracts	Genetic engineering to enhance mercury phytoremediation has been accomplished by expression of the merAB genes that protects the cell by converting Hg[II] into Hg[0] which volatilizes from the cell. A drawback of this approach is that toxic Hg is released back into the environment. A better phytoremediation strategy would be to accumulate mercury inside plants for subsequent retrieval. We report here the development of a transplastomic approach to express the mouse metallothionein gene (mt1) and accumulate mercury in high concentrations within plant cells. Real-time PCR analysis showed that up to 1284 copies of the mt1 gene were found per cell when compared with 1326 copies of the 16S rrn gene, thereby attaining homoplasmy. Past studies in chloroplast transformation used qualitative Southern blots to evaluate indirectly transgene copy number, whereas we used real-time PCR for the first time to establish homoplasmy and estimate transgene copy number and transcript levels. The mt1 transcript levels were very high with 183 000 copies per ng of RNA or 41% the abundance of the 16S rrn transcripts. The transplastomic lines were resistant up to 20 µm mercury and maintained high chlorophyll content and biomass. Although the transgenic plants accumulated high concentrations of mercury in all tissues, leaves accumulated up to 106 ng, indicating active phytoremediation and translocation of mercury. Such accumulation of mercury in plant tissues facilitates proper disposal or recycling. This study reports, for the first time, the use of metallothioniens in plants for mercury phytoremediation. Chloroplast genetic engineering approach is useful to express metal-scavenging proteins for phytoremediation.
Keywords	plastid genome; real-time PCR; bioremediation; genetic engineering; chelator; environmental biotechnology

Title	**Heavy metals toxicity in plants: An overview on the role of glutathione and phytochelatins in heavy metal stress tolerance of plants**
Author Name	S.K. Yadav
Journal Name	South African Journal of Botany
Year	2010
Volume and Issue	Volume-76, Issue-2
Pages	167–179
Abstracts	Plants experience oxidative stress upon exposure to heavy metals that leads to cellular damage. In addition, plants accumulate metal ions that disturb cellular ionic homeostasis. To minimize the detrimental effects of heavy metal exposure and their accumulation, plants have evolved detoxification mechanisms. Such mechanisms are mainly based on chelation and subcellular compartmentalization. Chelation of heavy metals is a ubiquitous detoxification strategy described in wide variety of plants. A principal class of heavy metal chelator known in plants is phytochelatins (PCs), a family of Cys-rich peptides. PCs are synthesized non-translationally from reduced glutathione (GSH) in a transpeptidation reaction catalyzed by the enzyme phytochelatin synthase (PCS). Therefore, availability of glutathione is very essential for PCs synthesis in plants at least during their exposure to heavy metals. Here, I reviewed on effect of heavy metals exposure to plants and role of GSH and PCs in heavy metal stress tolerance. Further, genetic manipulations of GSH and PCs levels that help plants to ameliorate toxic effects of heavy metals have been presented.
Keywords	Glutathione; Heavy metal stress; Phytochelatins; Plants; Tolerance mechanism

Title	Growth and antioxidant responses in Jatropha curcas seedling exposed to mercury toxicity
Author Name	Shun Gao, Chao Ou-yang, Lin Tang, Jin-qiu Zhu, Ying Xu, Sheng-hua Wang, Fang Chen
Journal Name	Journal of Hazardous Materials
Year	2010
Volume and Issue	Volume-182, Issue-1-3
Pages	591–597
Abstracts	Jatropha curcas seedlings were exposed to varying concentrations of mercury in order to investigate mercury accumulation, and the changes in growth and antioxidant enzyme activities using in vitro embryo germination and culture. Our results showed that mercury is readily accumulated by germinating embryos and growing seedlings, and its content was greater in the radicles than those of in the cotyledons and hypocotyls. This accumulation was directly correlated with an increase in tested mercury concentrations in the medium. Biomass in the cotyledons, hypocotyls and radicles increased gradually with increasing mercury concentrations, peaking in seedlings exposed to mercury concentration of 50 μM, and then decreased. Superoxide dismutase activities in the cotyledons, hypocotyls and radicles showed largest increment at mercury concentration of 100 μM. Peroxidase activities in the cotyledons and hypocotyls reached peaks at mercury concentration of 200 μM, and the highest activity in the radicles was observed at 100 μM. Catalase activities in the cotyledons and hypocotyls were significantly induced, and the highest activity in the radicles was observed at mercury concentration of 200 μM. Phenylalanine ammonia-lyase activities in the hypocotyls had a positive correlation to mercury concentrations, and the highest activities in the cotyledons and radicles were found at mercury concentrations of 200 and 100 μM, respectively. Analysis of superoxide dismutase, peroxidase and catalase isoenzymes suggested that different patterns depend on mercury concentrations and tissue types, and the staining intensities of these isoenzymes are consistent with the changes of these enzyme activities assayed in solutions.
Keywords	In vitro embryo culture; Mercury toxicity; ROS-scavenging enzymes; Defensive mechanism of plant