# A REVIEW ON EFFECTS OF SOME HEAVY METALS ON PLANTS AND HUMAN HEALTH

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***Abstract—Wastes are the major source of soil pollution, originating from mining, chemical, metal processing industries and other allied industries. These wastes include many chemicals like heavy metals, phenolic, organic, non-metals etc. Heavy metals are the intrinsic components of the environment, with essential and non-essential both types. Heavy metal accumulation in soil is major concern in agricultural production due to its adverse effect on food safety, marketability and crop growth and also due to phyto-toxic effects and environment health of soil organism .The toxic effect of heavy metals, even though they do not have any biological role, remain present in some or the other form harmful for human body and its person functioning . Metal toxicity depends upon the absorbed dose, the route of exposure and duration of exposure, acute or chronic .This can lead to various disorder and can also result in excessive damage due to oxidative stress induced by free radical formation. This review paper details about some heavy metals and their toxicity mechanism along with their health effect. Heavy metals exhibit toxic effects towards soil by affecting key microbial process and decrease the number and activity of soil micro-organism. Even low concentration of heavy metal in plants and subsequent accumulation along the food chain is potential threat to human health***

***Index Terms—Heavy metals, Effects on Human health, Toxicity, Effects on plants***

## I. INTRODUCTION

Metallic elements are intrinsic components of the environments. Heavy metals or toxic metals when present in excess of required concentration or is unwanted which were found naturally on the earth , and become concentrated as a result of human caused activities , enter in plants , animal and human tissues via inhalation, diet and manual handling can bind to, and interfere with the functioning of vital cellular components1. Heavy metals are significant environment pollutants and their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reason .They are group of metals and metalloids with atomic density greater than 4g\cm$^3$ or those which are 5 times or more, greater than water, including copper, manganese, lead, cadmium, nickel, cobalt, iron, zinc, chromium, silver. Uptake of heavy metals by plants and subsequent accumulation along the food chain is a potential threat to human health. Adverse health effects of heavy metals have been known for a long time. Exposure to heavy metals continues and is even increasing in some areas. For example mercury is still used in gold mining in many part of Latin America. Arsenic is still common in wood preservatives, and tetraethyl lead remain a common additive to petrol, although this use has decreased dramatically in the developed countries. This paper briefly describes the nature and properties of heavy metal and its effect on the plants and human health.

## II. SOURCE AND EMISSION

Toxic metals, to a large extent, are dispersed in the environment through industrial effluents, organic wastes, refuse burning and transport and power generation. They can be carried to places many miles away from the sources by wind, depending upon weather. They are found in gaseous form or as particulates.

**Table 1 List of Metals**

| ***Metals*** | ***Manufacturing Industry*** |
|---|---|
| Arsenic | Paints and Textile |
| cadmium- | Electronics and pigments |
| chromium | Metal plating |
| copper | Plating |
| lead | Plating |
| zinc | Galvanizing, plating iron |

## III. EFFECTS ON PLANTS

The heavy metals available for plant uptake are those present as soluble components in the soil solution or those soluble by root exudates 8. Plants require certain heavy metals for their growth and upkeep, but excessive amounts of these metals can become toxic to plants. The ability of plants to accumulate essential metals equally enables them to acquire other non-essential metals 9. They adversely affect the plant both directly and indirectly. Some of the direct toxic effects caused by high metal concentration include inhibition of cytoplasmic enzymes and damage to cell structure due to oxidative stress10. Indirect toxic effect includes replacement of essential nutrients at cation exchange sites of plants11. The negative influence of heavy metals on the growth and activities of soil microorganisms also indirectly affect the growth of plants. Reduction in the number of beneficial soil microorganisms due to high metal concentration may lead to decrease in organic matter

decomposition, leading to a less fertile soil. Enzyme activities are very much useful for plant metabolism, hampered due to heavy metal interference with activities of soil microorganisms12. These toxic effects(both direct and indirect) lead to a decrease in plant growth which finally results in the death of plant 13.Heavy metal accumulation in plants depends upon plant species and the efficiency of different plants for absorbing metals is evaluated by either plant uptake or soil to plant transfer factors of the metals 14. Elevated lead in soils may decrease soil productivity, and a very low lead concentration may inhibit some vital plant processes, such as photosynthesis, mitosis and water absorption with toxic symptoms of dark green leaves, wilting of older leaves, stunted foliage and brown short.

***Effects of copper on plants***

Copper is an essential metal for normal plant growth and development, although it is also potentially toxic. In M.P, it was found that copper dust had adverse effect on various photosynthesis pigmentation secretions in many trees species leaves16. Copper is also an essential component of various proteins like plastocyanin of photosynthetic system and cytochrome oxidase of respiratory electron transport chain 17. Mining activities generate a large amount of waste rocks and tailings, which get deposited at the surface. Excess of Copper in soil plays a cytotoxic role, induces stress and causes injury to plants. This leads to plant growth retardation and leafchlorosis18.

***Effect of zinc on plants***

Zinc (Zn) is an essential micronutrient that affects several metabolic processes of plants19 and has a long biological half-life. The phytotoxicity of Zn and Cd is indicated by decrease in growth and development, metabolism and an induction of oxidative damage in various plant species such as Phaseolus vulgaris20. Excess Zn can also give rise to manganese (Mn) and copper (Cu) deficiencies in plant shoots. Such deficiencies have been ascribed to a hindered transfer of these micronutrients from root to shoot. This hindrance is based on the fact that the Fe and Mn concentrations in plants grown in Zn rich media are greater in the root than in the shoot. Another typical effect of Zn toxicity is the appearance of a purplish red color in leaves, which is ascribed to phosphorus (P) deficiency21. Zinc in excess reduces the germination, chlorophyll, carotenoid, sugar, amino acid and growth of cluster beans (Cyamopsis tetragonoloba 22 whereas, in pea (Pisum sativum) reduces chlorophyll, photosynthesis and plant growth23. In rye grass (Lolium perenne) it reduces the growth, nutrient content and photosynthetic energy conversion24.

***Effects of cadmium on plants***

The permissible limit of cadmium (Cd) in agricultural soil is 100 mg/kg soil25. Plants grown in soil containing high levels of Cd show visible symptoms of injury reflected in terms of chlorosis, growth inhibition, browning of root tips and finally death. Metal toxicity can affect the plasma membrane permeability, causing a reduction in water content; in particular, Cd has been reported to interact with the water balance27. Cadmium treatments have been shown to reduce ATPase activity of the plasma membrane fraction of wheat and sunflower roots28. Cadmium produces alterations in the functionality of membranes by inducing lipid per-oxidation 29 and disturbances in chloroplast metabolism by inhibiting chlorophyll biosynthesis and reducing the activity of enzymes involved in CO2 fixation30. In wheat (Triticum sp.) excessive of cadmium reduces the seed germination; decrease in plant nutrient content; reduced shoot and root length 31. Whereas in garlic (Allium sativum) Cd accumulation reduced shoot growth 32Lastlyin Maize (Zea mays) it reduces shoot growth and inhibition of root growth 34

***Effects of nickel on plants***

Nickel (Ni) is an essential nutrient for plants. However, the amount of Ni required for normal growth of plants is very low. Hence, with the level of Ni pollution in the environment increasing, it is essential to understand the functional roles and toxic effects of Ni in plants. Ni+2 concentration in polluted soil may range from 20 to 30 fold (200–26,000 mg/kg) higher than the overall range (10–1,000 mg/kg) found in natural soil34. However, Ni+2 concentration is increasing in certain areas by human activities such as mining works, emission of smelters, burning of coal and oil, sewage, phosphate fertilizers and pesticides 35Plants grown in high Ni+2 containing soil showed impairment of nutrient balance and resulted in disorder of cell membrane functions. Finally, in Rice (Oryza sativa) Inhibition of root growth36.

***Effects of iron on plant***

Iron is mainly involved in the process of plant photosynthesis. The micronutrient's availability to plant roots depends on the pH level of the soil with iron more readily available in soil with a low pH. Iron is a major constituent of the cell redox systems such as heme proteins including cytochromes, catalase, peroxidase and leghemoglobin and iron sulfur proteins including ferredoxin, acontiase and superoxide disumutase (SOD) [38]. Iron as an essential element for all plants and has many important biological roles in the processes as diverse as photosynthesis, chloroplast development and chlorophyll biosynthesis. Iron toxicity in tobacco, canola, soybean and Hydrilla verticillata are accompanied with reduction of plant photosynthesis and yield and the increase in oxidative stress and ascorbate peroxidise activity39

***Effects of manganese on plants***

Manganese (Mn) is an essential plant mineral nutrient, playing a key role in several physiological processes, particularly photosynthesis. Manganese deficiency is a widespread problem, most often occurring in sandy soils, organic soils with a pH above 6 and heavily weathered, tropical soils40. Necrotic brown spotting on leaves, petioles and stems is a common symptom of Mn toxicity 41. This spotting starts on the lower leaves and progresses with time toward the upper leaves. Mn in pea (Pisumsativum) reduces chlorophylls a and b content; reduction in relative growth rate; reduced photosynthetic O2 evolution activity and photo system II activity. However, in tomato (Lycopersicon esculentum) Mn slower plant growth; decrease in chlorophyll concentration42.

***Effects of arsenic on plants***

In tomato (Lycopersicon esculentum) arsenic reduces fruit yield, decreases the leaf fresh weight [50]. Whereas, in canola (Brassica napus) arsenic causes stunted growth, chlorosis and wilting43. Further, arsenic in rice (Oryzasativa) reduces seed germination, decrease in seedling height, and reduces leaf area and dry matter production 44.

## IV. Effects on Human Health

Utilization of food crops contaminated with heavy metals is a major food chain route for human exposure. Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues44. Chronic level ingestion of toxic metals has undesirable impacts on humans and the associated harmful impacts become perceptible only after several years of exposure45.

***Cadmium (Cd)***

Cadmiums a heavy metal toxicant with a specific gravity 8.65 times greater than water. The target organs for Cd toxicity have been identified as liver, placenta, kidneys, lungs, brain and bones Depending on the severity of exposure, the symptoms of effects include nausea, vomiting, abdominal cramps, dyspnea and muscular weakness. Severe exposure may result in pulmonary odema and death. Pulmonary effects (emphysema, bronchiolitis and alveolitis) and renal effects may occur following subchronic inhalation exposure to cadmium and its compounds . The Itai-itai disease in Japan brought the dangers of environmental Cd to world attention.47.

***Zinc***

The clinical signs of zinc toxicosis have been reported as vomiting, diarrhea, bloody urine, icterus (yellow mucus membrane), liver failure, kidney failure and anemia .

***Copper (Cu)***

Copper can result in a number of adverse health effects. Excessive human intake of Cu may leads to severe mucosal irritation and corrosion, widespread capillary damage, hepatic and renal damage and central nervous system irritation followed by depression. Severe gastrointestinal irritation and possible necrotic changes in the liver and kidney can also occur48.

***Nickel***

The effects of Ni exposure vary from skin irritation to damage to the lungs, nervous system, and mucous membranes 49.

***Lead (Pb)***

Lead poisoning also causes inhibition of the synthesis of haemoglobin; cardiovascular system and acute and chronic damage to the central nervous system (CNS) and peripheral nervous system (PNS). Other chronic effects include anemia, fatigue, gastrointestinal problems and anoxia. Lead can causes difficulties in pregnancy, high blood pressure, muscle and joint pain50. Other effects include damage to the gastrointestinal tract (GIT) and urinary tract resulting in bloody urine, neurological disorder and can cause severe and permanent brain damage. Lead affects children; particularly in the 2-3 years old range by leading to the poor development of the grey matter of the brain, thereby resulting in poor intelligence quotient (IQ).

***Chromium***

Chromium (Cr)-Cr (VI) is toxic to plants and animals, being a strong oxidizing agent, corrosive, soluble in alkaline and mildly acidic water, toxic and potential carcinogens The toxicity of Cr (VI) derives from its ability to diffuse through cell membranes and oxidize biological molecules56

***Mercury***

Mercury cause spontaneous abortion, congenital malformation and gastrointestinal disorders (like corrosive esophagitis and hematochezia). Poisoning by its organic forms, which include monomethyl and dimenthylmecury presents with erethism (an abnormal irritation or sensitivity of an organ or body part to stimulation), acrodynia (Pink disease, which is characterized by rash and desquamation of the hands and feet), gingivitis, stomatitis, neurological disorders, total damage to the brain57.

***Arsenic***

It is possibly carcinogenic in com-pounds of all its oxidation states and high-level exposure can cause death. Arsenic toxicity also presents a disorder, which is similar to, and often confused with Guillain-Barre syndr-ome, an anti-immune disorder that occurs when the body's immune system mistakenly attacks part of the PNS, resulting in nerve inflammation that causes muscle weakness58.

## V. Conclusion

In this review we reviewed the effects of some heavy metals, i.e. arsenic, lead, mercury, cadmium, on the environment and living organisms, mainly human beings. Effective legislation, guidelines and detection of the areas where there are higher levels of heavy metals are necessary. Failure to control the exposure will result in severe complications in the future because of the adverse effects imposed by heavy metals. Occupational exposure to heavy metals can be decreased by engineering solutions. Monitoring the exposure and probable intervention for reducing additional exposure to heavy metals in the environment and in humans can become a momentous step towards prevention. National as well as international co-operation is vital for framing appropriate tactics to prevent heavy metal toxicity .Plants grow on heavy metal polluted soils resultant in reduction in growth due to changes in their physiological and biochemical activities especially true when the heavy metal involved does not play any beneficial role towards the growth and development of plants. Thus, it is evident from the several research findings that judicious use and presence of heavy metals having toxic effects on plants, animals and many living organisms after certain limits. There are two aspects on the interaction of plants and heavy metals, one hand, heavy metals show negative effects on plants and other hand, plants have their own resistance mechanisms against toxic effects and for detoxifying heavy metal pollution. Our review showed that both growth and photosynthetic pigments are affected by the presence of heavy metals. Plants employ different mechanisms in there mediation of heavy metal polluted soils and phyto extraction is the most common method of phyto remediation used for treatment of heavy metal polluted soils which ensures the complete removal of the pollutant.

## References

**[1]** Iwasaki Y., Kagaya T., Miyamoto K. and Matsuda H., Environmental Effects of Heavy Metals on Riverine Benthic Macroinvertebrate Assemblages With Reference to Potential Food Availability for Drift-Feeding Fishes. Toxicology and Chemistry 28 (2) 354–363 (2002).

**[2]** Sobha K., Poornima A., Harini P., and Veeraiah K., A study on biochemical changes in the fresh water fish, catla catla (hamilton) exposed to the heavy metal toxicant cadmium chloride. Kathmandu).

**[3]** Lalor G.C., Review of cadmium transfers from soil to humans and its health effects in the Jamaican environment. Science of the Total Environment, 400, 162 – 172 (2008).

**[4]** Stern B.R., Solioz M., Krewski D., Aggett P., Aw T. C., Baker S., Crump K., Dourson M., Haber L., Hertzberg R., Keen C., Meek B., Rudenko L., Schoeny R., Slob, W. and Starr T., Copper and human health: biochemistry, genetics, and strategies for modeling doseresponse relationships. Journal of Toxicology and Environmental Health,).

**[5]** Argun M.E., Dursun S., Ozdemir C., Karatas M., Heavy metal adsorption by modified oak sawdust: Thermodynamics and kinetics. Journal of Hazardous Materials, 141, 77–85 (2007).

**[6]** Odum H.T., 2000, Back Ground of Published Studies on Lead and Wetland. In: Howard T. Odum (Ed), Heavy Metals in the Environment Using Wetlands for Their Removal, Lewis Publishers, New York USA, pp. 32 (2000). Singh et al. Int. J. Res. Chem. Environ. Vol. 1 Issue 2 Oct. 2011(15-21) 21

**[7]** Kazemipour M., Ansari M., Tajrobehkar S., Majdzadeh M., and Kermani H.R., Removal of lead, cadmium, zinc, and copper from industrial wastewater by carbon developed from walnut, hazelnut, almond, pistachio shell, and apricot stone. Journal of Hazardous Materials, 150, 322–327 (2008).

**[8]** Shaffer R.E., Cross J.O., Pehrsson S. L. R., and Elam W.T., Speciation of chromium in simulated soil samples using X-ray absorption spectroscopy and multivariate calibration. Analytica Chimica Acta, 442, 295–304 (2001).

**[9]** Malley C., Nair J. and Ho G., Impact of heavy metals on enzymatic activity of substrate and on composting worms Eisenia fetida. Bioresource Technology, 97, 1498–1502 (2006)

**[10]** Chen G.Q., Chen Y., Zeng G.M., Zhang J.C., Chen Y.N., Wang L. and Zhang W. J., Speciation of Cadmium and Changes in Bacterial Communities in Red Soil Following Application of Cadmium-Polluted Compost. Environmental Engineering Science, 27 (12), 1019- 1026 (2010).

**[11]** Bhattacharyya P., Chakrabarti K., Chakraborty A., Tripathy S. and Powell M.A., Fractionation and bioavailability of Pb in municipal solid waste compost and Pb uptake by rice straw and grain under submerged condition in amended soil. Geosciences Journal, 12, (1), 41 –45 (2008).

**[12]** Jordao C.P., Nascentes C.C., Cecon P.R., Fontes R.L.F. and Pereira J.L., Heavy metal availability in soil amended with composted urban solid wastes. Environmental Monitoring and Assessment, 112, 309–326 (2006).

**[13]** Khan S., Cao, Q., Zheng Y.M., Huang Y.Z. and Zhu Y.G., Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. Environmental Pollution, 152, 686-692 (2008).

**[14]** Hinojosa M.B., Carreira J.A., Ruiz R.G., and Dick R.P., Soil moisture pre-treatment effects on enzyme activities as indicators of heavy metalcontaminated and reclaimed soils. Soil Biology & Biochemistry, 36, 1559–1568 (2004).

**[15]** Yao H., Xu J. and Huang C., Substrate utilization pattern, biomass and activity of microbial communities in a sequence of heavy metalpolluted paddy soils. Geoderma, 115, 139– 148 (2003)

**[16]** Speira T.W., Kettlesb H.A., Percivalc H.J. and Parshotam A., Is soil acidification the cause of biochemical responses when soils are amended with heavy metal salts? Soil Biology and Biochemistry, 31, 1953-1961 (1999).

**[17]** Shun-hong H., Bing P., Zhi-hui Y. Li-yuan C., and Li-cheng Z., Chromium accumulation, Singh et al. Int. J. Res. Chem. Environ. Vol. 1 Issue 2 Oct. 2011(15-21) 20 microorganism population and enzyme activities in soils around chromium-containing slag heap of steel alloy factory. Transactions of Nonferrous Metals Society of China, 19, 241-248 (2009).

**[18]** R. Moral, J. Navarro Pedreno, I. Gomez, and J. Mataix (1995) "Effects of chromium on the nutrient element content and morphology of tomato," Journal of Plant Nutrition, vol. 18, no. 4, pp. 815–822.

**[19]** Cakmak I, Marshner H (1993) Effect of zinc nutritional status on superoxide radical and hydrogen peroxide scavenging enzymes in bean leaves. In: Barrow NJ (ed) Plant nutrition from genetic engineering field practice. Kluwer, The Netherlanads, pp 133–137.

**[20]** Fernandes JC, Henriques FS (1991) Biochemical, physiological and structural effects of excess copper in plants.Bot Rev 57:247–273. [62] Prasad KVSK, Pardha saradhi P, Sharmila P (1999) Concerted action of antioxidant enzyme and curtailed growth under zinc toxicity in Brassica juncea. Environ Exp Bot 42:1–10.

**[21]** Lee CW, Choi JM, Pak CH (1996) Micronutrient toxicity in seed geranium (Pelargonium 9 hortorum Baley). J Am Soc Horti Sci 121:77–82. [70]Salt DE, Blaylock M, Kumar NPBA, Dushenkov V, Ensley D, Chet I, Raskin I (1995) Phytoremediation: a novel strategy for the removal of toxic metals from the environment using plants. Biotechn 13:468–474.

**[22]** Sanita di Toppi L, Gabbrielli R (1999) Response to cadmium in higher plants. Environ Exp Bot 41:105–130. 22Mohanpuria P, Rana NK, Yadav SK (2007) Cadmium induced oxidative stress influence on glutathione metabolic genes of Camella sinensis (L.). O Kuntze. Environ Toxicol 22:368–374.

**[23]** Guo J, Dai X, Xu W, Ma M (2008) Over expressing GSHI and AsPCSI simultaneously increases the tolerance and accumulation of cadmium and arsenic in Arabidopsis thaliana. Chemo-sphere 72:1020–1026.

**[24]** Das P, Samantaray S, Rout GR (1997) Studies on cadmium toxicity in plants: a review. Environ Pollut 98:29–36. 25Hernandez LE, Carpena-Ruiz R, Garate A (1996) Alterations in the mineral nutrition of pea seedlings exposed to cadmium. J Plant Nutr 19:1581–1598.

**[25]** Mathys W (1975) Enzymes of heavy metal-resistant and non-resistant populations of Silene cucubalus and their interactions with some heavy metals in vitro and in vivo. Physiol Plant 33:161–165.

**[26]** Balestrasse KB, Benavides MP, Gallego SM, Tomaro ML (2003) Effect on cadmium stress on nitrogen metabolism in nodules and roots of soybean plants. Func Plant Biol 30:57–64.

**[27]** Costa G, Morel JL (1994) Water relations, gas exchange and amino acid content in Cd-treated lettuce. Plant Physiol Biochem 32:561–570.

**[28]** Fodor A, Szabo-Nagy A, Erdei L (1995) The effects of cadmium on the fluidity and H+-ATPase activity of plasma membrane from sunflower and wheat roots. J Plant Physiol 14:787–792.

**[29]** De Filippis LF, Ziegler H (1993) Effect of sublethal concentrations of zinc, cadmium and mercury on the photosynthetic carbon reduction cycle of Euglena. J Plant Physiol 142:167–172. [81]Han FX, Su Y, Monts DL, Waggoner AC, Plodinec JM (2006) Binding distribution, and plant uptake of mercury in a soil from Oak Ridge, Tennesse, USA. Sci Total Env 368:753–768.

**[30]** Kamal M, Ghalya AE, Mahmouda N, Cote R (2004) Phytoaccumu-lation of heavy metals by aquatic plants. Environ Intern

29:1029–1039. [83]Israr M, Sahi S, Datta R, Sarkar D (2006) Bioaccumulation and physiological

**[31]** Shanker AK, Djanaguiraman M, Pathmanabhan G, Sudhagar R, Avudainayagam S (2003b) Uptake and phytoaccumulation of chromium by selected tree species. In: Proceedings of the international conference on water and environment held in Bhopal, India.

**[32]** Schmfger MEV (2001) Phytochelatins: complexation of metals and metalloids, studies on the phytochelatin synthase. PhD Thesis, Munich University of Technology (TUM), Munich.

**[33]** Shanker AK, Sudhagar R, Pathmanabhan G (2003a) Growth Phytochelatin SH and antioxidative response of Sunflower as affected by chromium speciation. In: 2nd international congress of plant physiology on sustainable plant productivity under changing environment, New Delhi.

**[34]** Morzck E Jr, Funicclli NA (1982) Effect of lead and on germination of Spartina alterniflora Losiel seeds at various salinities. Environ Exp Bot 22:23–32. [104] Mukherji S, Maitra P (1976) Toxic effects of lead growth and metabolism of germinating rice (Oryza sativa L.) seeds mitosis of onion (Allium cepa) root tip cells. Ind J Exp Biol 14:519–521.

**[35]** Huang CV, Bazzaz FA, Venderhoef LN (1974) The inhibition of soya bean metabolism by cadmium and lead. Plant Physiol 34:122–124. [106] Miller JE, Hassete JJ, Koppe DE (1975) Interaction of lead and cadmium of electron energy transfer reaction in corn mitochondria. Physiol Plant 28:166–171.

**[36]** Sudhakar C, Symalabai L, Veeranjaveyuler K (1992) Lead tolerance of certain legume species grown on lead or tailing. Agri Eco Environ 41:253–261.

**[37]** Juwarkar AS, Shende GB (1986) Interaction of Cd-Pb effect on growth yield and content of Cd, Pb in barley. Ind J Environ Heal 28:235–243. [109] Goldbold DJ, Hutterman A (1986) The uptake and toxicity of mercury and lead to spruce (Picea abies) seedlings. Wat air Soil Pollu 31:509–515. [110] Kumar G, Singh RP, Sushila (1992) Nitrate assimilation and biomass production in Seasamum indicum (L.) seedlings in lead enriched environment. Wat Soil Pollu 215:124–215.

**[38]** Paivoke H (1983) The short term effect of zinc on growth anatomy and acid phosphate activity of pea seedlings. Ann Bot 20:307–309.

**[39]** Kaji T, Suzuki M, Yamamoto C, Mishima A, Sakamoto M, Kozuka H (1995) Severe damage of cultured vascular endothelial cell monolayer after simultaneous exposure to cadmium and lead. Arch Environ Contam Toxicol 28:168–172

**[40]** Hewilt EJ (1953) Metal inter-relationships in plant nutrition. J Exp Bot 4:59–64.

**[41]** Reddy AM, Kumar SG, Jyotsnakumari G, Thimmanayak S, Sudhakar C (2005) Lead induced changes in antioxidant metabolism of horsegram (Macrotyloma uniflorum (Lam.) Verdc.) and bengal-gram (Cicer arietinum L.). Chemosphe 60:97–104.

**[42]** Kukier U, Peters CA, Chaney RL, Angle JS, Roseberg RJ (2004) The effect of pH on metal accumulation in two Alyssum species. J Environ Qual 33:2090–2102.

**[43]** Bakkaus E, Gouget B, Gallien JP, Khodja H, Carrot H, Morel JL, Collins R (2005) Concentration and distribution of cobalt in higher plants: the use of micro-PIXE spectroscopy. Nucl Instr Meth B 231:350–356.

**[44]** Li HF, Gray C, Mico C, Zhao FJ, McGrath SP (2009) Phytotoxicity and bioavailability of cobalt to plants in a range of soils. Chemosphere 75:979–986.

**[45]** Izosimova A (2005) Modelling the interaction between calcium and nickel in the soil-plant system. FAL Agric Res Special issue 288:99.

**[46]** Gimeno-Garcia E, Andreu V, Boluda R (1996) Heavy metals incidence in the application of inorganic fertilizers and pesticides to rice farming soils. Environ Pollu 92:19–25.

**[47]** Zornoza P, Robles S, Martin N (1999) Alleviation of nickel toxicity by ammonium supply to sunflower plants. Plant Soil 208: 221–226.

**[48]** Rahman H, Sabreen S, Alam S, Kawai S (2005) Effects of nickel on growth and composition of metal micronutrients in barley plants grown in nutrient solution. J Plant Nutri 28:393–404.

**[49]** Das P, Samantaray S, Rout GR (1997) Studies on cadmium toxicity in plants: a review. Environ Pollut 98:29– International Journal of Application or Innovation in Engineering & Management (IJAIEM) Web Site: www.ijaiem.org Email: editor@ijaiem.org Volume 5, Issue 3, March 2016 ISSN 2319 - 4847 Volume 5, Issue 3, March 2016 Page 66 36.

**[50]** Ros R, Cook DavidT, Picazo CarmenMartinez-CortinaIsabel (1992) Nickel and cadmium related changes in growth, plasma membrane lipid composition, ATPase hydrolytic activity and proton pumping of rice (Oryza sativa L. cv. Bahia) Shoots. J Exp Bot 43:1475–1481.

**[51]** Pandey N, Sharma CP (2002) Effect of heavy metals Co+2, Ni+2, and Cd+2 on growth and metabolism of cabbage. Plant Sci 163: 753–758.

**[52]** Gajewska E, Sklodowska M, Slaba M, Mazur J (2006) Effect of nickel on antioxidative enzymes activities, proline and chlorophyll contents in wheat shoots. Biol Planta 50:653–659.

**[53]** Marschner H (1995) Mineral nutrition of higher plants, 2nd edn. Academic Press, Toronto.

**[54]** Becker M, Asch F (2005) Iron toxicity in rice conditions and management concepts. J Plant Nutr Soil Sci 168:558–573. [128] Sinha S, Guptha M, Chandra P (1997) Oxidative Stress induced by iron in Hydrilla verticillata (i.f) Royle: response of antioxidants. Ecotoxicol Environ Safe 38:286–291.

**[55]** Arora A, Sairam RK, Srivastava GC (2002) Oxidative stress and antioxidative system in plants. Cur Sci 82:1227–1338.