

## Speciation and Distribution of Heavy Metals in Plants

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### Abstract

Heavy metal not only contaminating our natural ecosystem but also enters in food chain. Heavy metal contamination occurs because of unmanaged exploitation of natural resources. Disposal of industrial effluent and municipal sewage emerges as core issue for environmental safety. Plant needs specific metals for their physiological and metabolic requirement. But their excess in soil can cause toxicity. Besides these, some heavy metal in high concentration are accumulated in plants tissues. These heavy metals compete with essential nutrients in rhizosphere. They interfere in plant metabolism and cell functioning and ultimately affect plant growth. Recently phytoremediation emerges as tools for the removal of toxic metals from soils and waters. Phytoremediation is a cost effective and eco-friendly technology. In this review we have discussed the toxic effect of essential and nonessential heavy metals on plant growth and detoxification mechanism that enable them to survive in excess metal concentration.

*keywords: Phytoremediation; Heavy meta; Contaminati; Pollutant*

### Introduction

Galloping demands of foods and shelter ultimately enforce humans to ignore environmental laws. Our resources are mostly non-renewable and limited. Excessive and unlawful exploitation of valuable resources is making our environment inhabitable. Some of the primary resources like soil and plant are now facing severe threat because of industrialization and urbanization. Urbanization speedily grasping agricultural and forest land. Plant is one of the prime victims of this event.

Naturally plant requires a group of essential nutrients for proper growth and development. Mengel and Kirkby discussed the essentiality of nutrients based on their requirement and physiological role. Essential metal include nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, copper, zinc, boron, molybdenum. Usually these nutrients play a vital role in plant metabolism. But in excess concentration they cause severe toxicity and retard plant growth [1].

Some non-essential metals like chromium, cadmium, lead and mercury also ceases plant metabolism [2-6]. These toxic metals in excess concentration interfere biosynthetic pathways and ion-uptake phenomenon. Generally toxicity in crop field arise because of anthropogenic activities or rock weathering [7-11]. High tissue concentration of heavy metals in edible part

of crop plant was reported by several authors [12-17]. In humans, heavy metal causes neurological disorders, indigestion, vomiting, headache, and long term exposure may carcinogenic [18-21].

### **Tolerance to Heavy metal**

Fortunately some plant can accumulate heavy metals in excess and now emerges as tools in remediation process. We are using phytoremediation techniques in removal of excess metal from contaminated site [22-29]. Continuous cropping of these hyper-accumulating species, in contaminated site for several years giving promising results [30-33]. Tolerance of high metal concentration in soil brought by two methods:

1. Inhibiting metal absorption by root and their further transport through xylem vessel
2. Chelating and sequestering of heavy metals to avoid cell damage

Heavy metal toxicity in plants and their effect varies from plant to plant. Some soil factors also affect the bioavailability of heavy metals like pH, organic matter, and cation exchange capacity of the soil [34-37]. Heavy metal toxicity not only retard the growth of underground plant parts i.e. root but also the above ground part like leaf and stem [38,39]. In leaves, photosynthetic apparatus is highly sensitive to heavy metals because these metals hinder the chlorophyll synthetic pathway. They replace key elements Mg which ultimately cause senescence. Besides this heavy metals incorporated in enzyme as cofactor and disrupt various metabolic pathways [40-43]. To mitigate such situation plants applied specific mechanism to tolerate heavy metal toxicity.

### **Phytoremediation**

They cause change in behaviour and composition of natural communities and finally loss of biodiversity. In such conditions different approaches are being accepted to reclaim contaminated site. Among various techniques phytoremediation has potential to remove excess metal concentration from polluted site [44-47]. In this technique we use natural hyper-accumulator plant species that can easily survive in high soil metal concentration. Heavy metal accumulated in tolerant plant species and removed from polluted site after harvesting. So phytoremediation is an eco-friendly approach for detoxification of contaminated site [48-53]. Phytoremediation would be more effective approach if we will able to discover the biochemical, physiological and genetics of tolerant plant species. New tolerant plant species can be developed by genetic engineering. On the basis of plant soil interaction these can be divided in three categories: a) accumulator species b) indicator species and c) excluder species.

High metal concentration is reported in roots followed by stems, leaves and fruits. Most of the tolerant plant belongs to excluder group and accumulates heavy metals in underground parts especially in rhizodermis and cortex [54,55]. Plant applied specific mechanism for internal sequestration. Some amino acids and organic acids ligands plays an important role in transportation and homeostasis of heavy metals. For example, phytochelatin (PCs) binds heavy metals inside the cell which help in sequestration and detoxification process [56-59]. Similarly metallothioneins (MTs) are also involving in detoxification of metals ions [60,61]. Genes for tolerance are now identified, isolated and manipulated to produce novel transgenic crop plants with superior resistance to stress condition.

### **Heavy Metal Speciation**

Exposure to elevated concentration, sensitive plants develop visible phenotypic toxicity symptoms such as wilting, chlorosis and necrosis in leaf, senescence and premature death [62-66]. Extensive research has done by researchers on visible

symptoms and diagnosis [67-74]. However, we are lacking significant information on biochemical basis of heavy metal toxicity. It is well known that metals are integral part of many enzymes and essential for proper folding of protein [75-79]. Some nonessential heavy metals displace essential metals from these biomolecules and disrupt many enzymes based synthetic pathways [80-87]. Furthermore, heavy metals enhance the production of free radicle (FR) and reactive oxygen species (ROS). Free radicle and reactive oxygen species are generated either by direct electron transfer to metal cations, or as a result of metal-mediated inhibition of metabolic reactions. Presence of FR and ROS induces antioxidative machinery that produces antioxidant for their detoxification [88-93]. But in metal stress condition cell cannot balance the rate of FR and ROS formation and antioxidant production. Therefore, FR and ROS oxidised the cellular biomolecules and damage the cell metabolism [94-98].

A comparison was done between metal sensitive and tolerant plant species. Metal tolerant species are easily survived in high metal concentration because of their sequestration ability [99-102].

### **Global Meetings**

Among all environmental contaminants heavy metals are most important. Plant physiologists all over the world are working together to find out the way to overcome this problem. Conference Series LLC will organize several conferences worldwide to provide a platform to scientific community to combat this problem. 17th International Conference on Food & Nutrition is one of them where Scientist, Academics, Dieticians & Nutritionists will meet to discuss advance technologies and recent scientific explorations for Food safety. Eminent speakers from all around the world are meeting to introduce the recent advancement in researches and technologies in Food & Nutrition and other related fields. 3rd Global Summit on Plant Science will be organized around the theme of "Explore Plant Science Research". For sustainable growth it's essential for us to include developing countries in global effort. So they are organizing one such conference meeting in Thailand i.e. 2nd International Conference on Plant Science & Physiology. Some others related conferences are 7th European Food Safety & Standards Conference, 7th International Conference on Global Food Safety; 6th International Conference on Food Safety & Regulatory Measures.

Some prominent societies are working on this to finds suitable solution, like Nepal Herbs and Herbal Products Association (NEHHPA) is an association of herbal producers. Another one European Biotechnology Thematic Network Association (EBTNA), which is an association of biotechnology professionals. Open access journal also play a major role in dissemination of latest research in scientific community. Journal of Plant Physiology & Pathology, VEGETOS: An International Journal of Plant Research is publishing quality research article in field of plant physiology.

### **Conclusion**

The problem of soil contamination and remediation is significantly more intense in recent few years because of its potential impact on agriculture and human being. Among different toxins man made organic and inorganic chemicals are posing a serious threat to our biosphere. Absorption of heavy metals by plants above critical level causes toxic effects on cell metabolism like protein folding, enzyme activity, photosynthetic pigments, osmotic potential and generation of reactive oxygen species. Some plants adapted to high metal concentration in soil solution, are now extensively used for phytoremediation. High tolerance to heavy metal concentration is approached either by reduced uptake or cellular sequestration. Through coordination in various biological pathways, tolerant plants are able to survive in metal contaminated site. Many transgenic plant species are now developed with the help of genetic engineering for the purpose of bioremediation

process. This article reviews advantages, disadvantages, possible mechanisms, current status and future directions of phytoremediation for heavy metal contaminated soils and environments.

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