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Heavy Metal Pollution in Plants

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Introduction

The outbreak of population and rapid industrialization in recent years has resulted in pollution of the earth with toxic metals. The advancement of industries and hastyurbanization, has increased the accumulation of heavy metals in the environment during the past decades, which raised notable concerns throughout the world (Suman *et al.*, 2018 and Ashraf *et al.*, 2019).Some specific features of plants enable them to absorb these metals from soil and water. Such heavy metals which are essential for their growth and development includes iron (Fe), manganese (Mn), copper (Cu), Molybdenum (Mo) and nickel (Ni). Plants also absorb toxic metals, which may not have any biological function, these include: silver (Ag), cadmium (Cd), chromium (Cr), cobalt (Co), mercury (Hg), lead (Pb), and selenium (Se) etc. Metal concentration in soil range less than 1 mg/kg (ppm) to high as 100,000 mg/kg, whether due to the geological origin of the soil or as a result of human activity. Excess concentration of some heavy metal in soil (Cd, Cr, Ni, Zn) have caused disruption of natural aquatic and terrestrial ecosystem. Currently cleanup process of heavy metal pollution is expensive and environmentally destructive. Recently scientists and engineers have started to generate cost effective technologies that includes the use microorganisms, biomass and live plants in the cleaning processes of polluted areas. Some heavy metal at low doses is essential micronutrient of the plant species, but in higher doses they may cause disorder and growth inhibition for most of the plants. Researchers reported some plant species endemic to metalliferous soils and can tolerate greater than usual amount of heavy metal and other toxic compounds. Several studies have been conducted in order to evaluate the effects of different heavy metal concentrations on live plants. However, excessive accumulation of these metals could be harmful to most plants. The use of terrestrial plants for environmental remediation through metal accumulation is gaining popularity in recent years and the accumulation of Ni, Co, Cu, Mn, Pb, Zn, Se and Hg in high concentration is extensively reported.

Heavy Metal contamination

Any metal (or metalloid) species may be considered a ‘‘contaminant’’ if it occurs where it is unwanted, or in a form or concentration that causes a detrimental effect to environmental. Elevated concentration of both essential and nonessential heavy metal in the soil can lead to toxicity symptoms and the inhibition of growth by altering the major plant physiological and metabolic processes of most plants. Transfer to the human food chain leads to the mutagenic ability cause DNA damage and carcinogenic effects in the bodies of animals or human (Knasmuller *et al.*, 1998).

Sources of heavy metal pollution

Heavy metals are natural constituents of soils and occur naturally in the environment but nowadays, contamination of soils by toxic metals and metalloids is of major concern all over the world. The problem of heavy metal pollution is aggravating due to series of human activities like overuse of fertilizers, emissions from municipal waste, car exhaust, residues from metalliferous mines and use of pesticides. The contamination of heavy metal increases many folds due to their persistent nature and bio-magnification potential. Due to such reasons, intensification of research is going on dealing with the phytotoxicity of these contaminants and with the mechanisms used for remediation of heavy metal.

Remediation of heavy metal contamination

There are three popular methods for heavy metal remediation. They are as follows:

1. **Conventional remediation method**: Methods such as chemical precipitation of heavy metal by coagulation and flocculation are not used widely as it is not cost effective.
2. **The technique using hyper accumulator plants in phytoremediation**: It is a cost-effective and new technology, to remediate the contaminated soil. The advantage of the technique lie in making the living plants act as a solar-driven pump, which can extract and concentrate certain heavy metals from the environment (Raskin *et al.*, 1997). There have been many transgenic plants generated for phytoremediation.
3. **Bioremediation employing engineered microbes:** Some microbes have genes that encode heavy metal detoxification enzymes that can bio transform toxic form of heavy metal into nontoxic form. *Pseudomonas putida* is a Gram-negative bacterium

found in water and soil, particularly in the rhizosphere has been studied extensively as a model for biodegradation of aromatic compounds such as naphthalene and styrene.

Results of heavy metal toxicity in plants

Heavy metals can be highly reactive resulting in toxicity of plant cells in many ways depending on their oxidation state. At the cellular and molecular level, heavy metal toxicity results in modification of different plant physiological processes which includes inactivation and denaturation of enzymes, proteins, blocking of functional groups of metabolically important molecules, displacement/substitution of essential metal ions from bio molecules and functional cellular units, conformational modifications and disruption of membrane integrity which is finally credited to affected plant metabolism, inhibition of photosynthesis, respiration, and alerted activities of several key enzymes.

Plant response to heavy metal stress

Plant synthesizes stress-related amino acids, protein, genes, and signaling molecules as a consequence of molecular response to heavy metals. Several studies showed that heavy metals increase the synthesis of heat shock proteins (HSPs).Phytosiderophores, nicotianamine, and organic acids are a few examples of chelating compounds that are released by roots and might interfere in heavy metal uptake. Different kinetics of mitogen-activated protein kinase (MAPK) cascades in response to heavy metal stress has also been reported.

Plant response to heavy metal toxicity

The exposure of plants to high levels of heavy metals activates wide range of physiological and metabolic alterations. Some visible evidence of heavy metal toxicity includes reduction in plant growth including leaf chlorosis, necrosis, turgor loss, a decrease in the rate of seed germination, and a crippled photosynthetic apparatus, often correlated with progressing senescence processes or with plant death.

Conclusion

Pollution due to heavy metals is the major abiotic issue which is related to the crop productivity. Presence of high quantities of heavy metals in plants leads to reduction in growth and yield by interfering with biochemical and physiological activities. Although, plant has own line of defence mechanisms against these heavy metals such as physical barriers or biochemical substances emphasis should be given to combat heavy metal stress and increase crop productivity.

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