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Study of Effect of Heavy Metal on Physiology of Plants

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ABSTRACT:

The main aim of this present work is to study the toxic effect of heavy metals (Cd, Pb, Hg,Cr) on plant growth and physiological activity of plants and the tolerance mechanism of heavy metal toxicity.

Keyword: Heavy metal,

Introduction:

"Toxicity" that means the quality being very harmful or poisonous or unwanted or excessive amount of any element. Heavy metal such as Hg, Cd, and Pb causes a toxic effect on plants. Industrial wastes are major source of these heavy metals. Which greatly influence the quality of soil and the bio biological, chemical and physical property of soil. This industrial water uses in agriculture land and as a result these heavy metals transferred and finally concentrated into plant cells and causes toxicity in plant cell**[1].** These have hazardous damaging effects on plant growth and development. These metals have atomic weight greater than 4g / cm3 than water. The toxicity of heavy metal elements varies with species to species, specific metal concentration, chemical form, Ph etc. These are required in a minimum or less quantity**[1-2].**In this review paper we will explore the heavy meatltoxity effects on plant growth and physiology and the mechanism of tolerance of plants.

Source of Heavy metals:

A large amount of heavy metals are injected into the environment by industrial, agricultural and other sources. It is reported that Japan, Indonesia and China are contaminated by heavy metals like Cd, Cu and Zn by mining, smelting and agricultural operations**[5].**

A. Natural source of heavy metals

Almost of heavy metals are also present in Earth's crust but there occurrence in soil will depends upon the weathering process**[5].** Soil formation will takes place from sedimentary rocks which contain the small amount of heavy metals. But by volcanoes will emit high level of toxic gases to the soil**[6].** While marine aerosols and forest fires will also inject the toxic heavy metals to the soil**[7].**

B. Agricultural sources

For the sake of high yield production and some other reasons farmers are using the fertilizers, pesticides and fungicides in the maximum ratio which cause the deposition of heavy metals in the soil**[4].** The organic and inorganic fertilizers specifically fungicides and phosphate fertilizers contain high level of Cd, Cr, Ni, Pb and Zn which cause increase in heavy metal in plant more than they need causing the high metal toxicity**[2-3].**

C. Industrial sources

The wastes released from industrial activities also contain the heavy metals. The improper disposal of industrial waste is the major source for heavy metal toxicity in aquatic as well as terrestrial ecosystems**[8].** Activities like mining, smelting and casting will also emits the heavy metals. For example, Colamines, are source of As, Cd, Fe. And Hg used in gold mining is the source of this pollution**[9].**

Effect of heavy metal on plants:

Heavy toxic elements such as Pb, Hg, Cd, Cr, etc. Usually present in soluble form in soil solution. Plant require several types of heavy metals for their growth and development but these are require in a definite amount**[5]**. Excessive amount become toxic to plants and reduce the ability to uptake other elements which requires in more amount and they causes hazardous effect on plant metabolism directly as well as indirectly due to heavy metal stresses. It reduces the microorganisms to plant interactions**[17].** In plant metabolism enzyme play a vital role in metabolism but due to excess amount of heavy metal the activity of enzyme reduces**[10].** It also reduces soil fertility due to loss of soil microorganisms. Hg, Cd,As, Pb these are toxic to plant metabolism**[21].** The heavy metals also affect the crop yield and productivity. The concentration of heavy metal in soil is high than more toxic effects on plant growth**[15].** The phytotoxic effect of heavy metals in following order: Cd > Cu> Ni>Pb> Cr.

Fe(II) deficiency induced in root due to inhibition of Fe(III)Reductase by Cd. Increaingcolonisation had contribution in increasing concentration of heavy metal. Cr is less toxic yet it cause reduction in germination, fresh and dry weight, chlorophyll content, plant height **[20].** Seed germination and early growth of wheat and barley altered due to excess in Cu and Mg. Early Symptoms of Zn toxicity are curling and rolling of young leaves & stunning of shoot **[21].** Phytotoxicity of Hg induce physiological disorder , visible injuries, closing of stomata & physical obstruction of water flow in plant by binding to water aquaporins. As and Al decrease activity of nitrite and nitrate reductase and glutamine synthetase **[8].**Heavy metal cause Secretion of phytosiderophores in rhizospres of plant cause acidification and exudation of carboxylates are potential means to enhancing metal accumulation **[9].** Most obvious common effect of all HMs are Chlorosis, necrosis, decreased water potential effect of cation, alternation in membrane function **[7].**

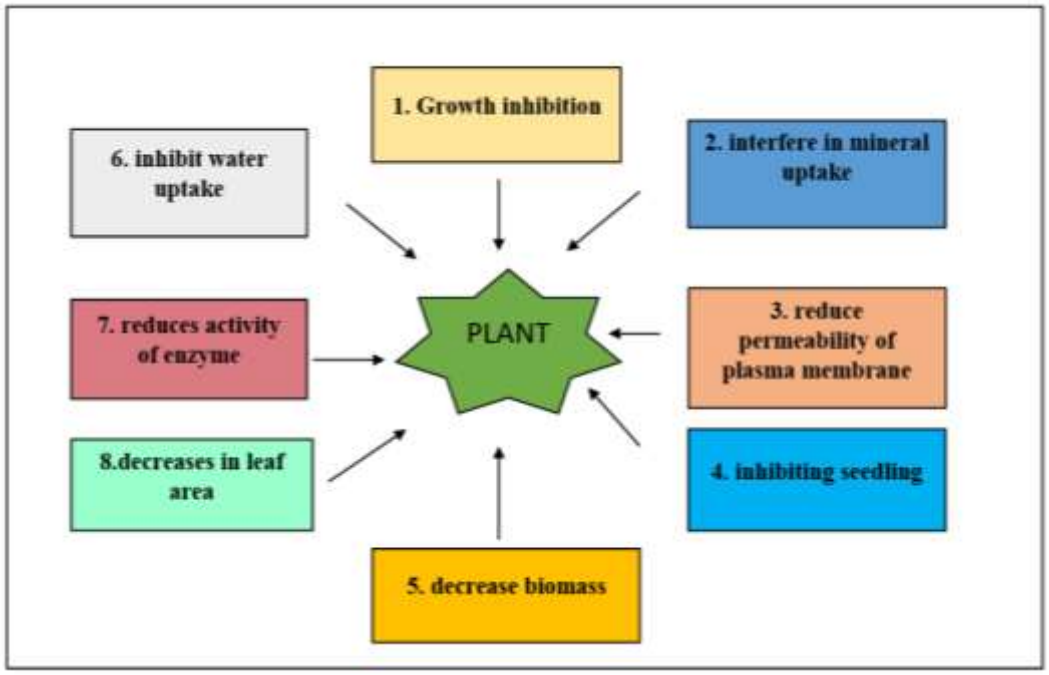

Figure:1. Effect of heavy metal on plant. (*source:* Ambika Asati*et al.,* 2016).

i. Effect on the plant growth:

Some elements are non-essential for plant growth or require in less amount. Due to accumulation of heavy metal in excess amount will affects the plant metabolism, their metabolic rate and reproduction**[15].** Due to pollution of cd the growth of barley reduced. The excess amount of Cd affects mostly growth of root. Seedlings of *Brassica chinensis L*. and *Braseniaschreberi L*. easily reduce due to heavy metal pollution. The major effects on plants is to prevent water absorption. Major effect on root because it directly contact with soil which polluted by heavy metal toxicity**[11].** Due to heavy metal toxicity root elongation inhabited. The precipitation of Cr^{+3} inhibit translocation. The length of root decreases with increase in concentration of As^{5+}**[7].**Cr directly affect the metabolism of shoot and as result height if shoot decreases**[10].**As a result of adverse effect of heavy metal toxicity leaf growth also inhibited and shows chlorosis and necrosis in leaves. Heavy metal contamination recognized as a potential threat to plants growth. Interrelated network of molecular and physiological mechanisms determine the sensitivity of plant to heavy metal. Complexation of heavy metal ion by various substances inside the cell like phytochelatins and metallothioneins**[5].** The growth pattern undergoes some sensitive and rapid change when plant part have direct contact with contaminated soil with heavy metal. Main threat for plant growth are Pb, Cd, Hg mainly accumulate through plant root. Interference of lead with important enzyme inhibit seed germination of *Pinus helipensis***[3].**

ii. Effect on physiology and metabolism:

Heavy metals (HMs) not only affect the growth of plant but also affect the physiology and metabolism of the plants such as translocation of nutrient, photosynthesis, respiration, activity of enzymes. Etc. it also inhibit CO_2 fixation and activity of chloroplasts organization etc.heavy metal toxicity influence

the light reaction and dark reaction. (NADP reduction, chlorophyll degradation, photophosphorylation). In the excess amound of Cd reduction of chlorophyll in peas seedlings and in the high concentration of Cu the rate of CO2 consuption by leaf are become decreased (SabrineHattab et al., 2009). Ribulose 1,5-bisphosphate carboxylase (RuBisCO) and phosphophenol pyruvate carboxylase (PEPC) main two influenced by Pb. High level Pb soil cause irregularities in cortical parenchyma and cell wall of endodermis. **[15].** Cd disturb aminolevuline acid dehydratase and protochlorophyllide reductase. Reactive oxygen species and free radicals produced by heavy metal pose constant oxidative damage. Because of an irreversible inhibition exerted by Cd on proton pump responsible for reduction of growth **[6].** 100mg/Kg soil is the permissible limit of Cd in agriculture soil. It interfere with the uptake, transport and use of several element (Ca, Mg, P & K) and affect photosynthesis **[25].** Zn and Pb also decline Photosynthesis rate by affecting the function of PSI and PSII. In the leaves of *Helianthus annus* Pb, Cd and Ni influence the srtomatl opening. Photosynthesis also imfluemce by reduction in pigment due to heavy metal treatment*(I. V. Seregin and A. D. Kozhevnikova, 2005).*In the presence of heavy metals (Zn, Cd, Ni) in excessive amount photosynthetic pigments become reduced while in some cases, the photosynthetic pihments increases. Eg. In *Chlorella pyrenoidosa* increase in chl-*a* in the presence of Ni (0.1-1.0 mgl^{-1}) *(Wong PK and Chang L. ,1991).*The protochlorophyllide reductase enzyme inhibited by heavy meatsl which has main function of reduction of protochlorophyll to chlorophyll.

Table:1. Effect of different types of heavy metals:

Sr. no.	Heavy metal name	Effect on plant	References
1.	Cadmium (Cd)	It shows symptoms of chlorosis and growth inhibition. Interfere in the uptake of mineral nutrition. It reduces the permeability of plasma membrane. It reduces shoot growth. It causes delay in seed germinate] on.	**[1]**
2.	Arsenic (As)	It reduces fruit yield and also decreases the leaf fresh weight. It causes stunted growth, chlorosis, and wilting. It decreases in leaf area and dry matter productivity.	**[1]**
3.	Lead (Pb)	It id most abundant toxic element in the soil. It affects morphology, growth and photosynthesis, process of plants. It also inhibits seedlings. High concentration of lead produce ROS as result induces oxidative stress. It decreases biomass production.	**[1]**
4.	Nickel (Ni)	It retarded growth of many crops. Reduces activity of enzymes. Such as protease, amylase. Affect photosynthetic pigment and chlorophyll content. It also decreases membrane stability.	**[12]**
5.	Zinc (Zn)	Alteration in catalytic efficiency of enzymes. Decrease in biomass, Leaf chlorosis.	**[12]**
6.	Copper (Cu)	Decrease in antioxidant activities. Impairment of photosynthetic parameters. Decrease in chlorophyll content. Reduced leangth and weights of embryonic axis of germinating seeds	**[12]**
7.	Mercury (Hg)	Decrease in elongation of primary roots in Zea mays	**[12]**

Source: (Ambika Asati et al. 2016, Sunil Kumar Sethy and Shyamasree Ghosh, 2013).

Conclusion:

HMs Contamination result leading us to unsecure sustainable environment, biodiversity loss, soil infertility & loss in farming yield. HMs certainly involved in the metabolism through displacement of essential elements from functional site & Compete for uptake. Through ROS and free radicals they reduce Carbon dioxide fixation and cause disorganization of chloroplast. In addition heavy metal stress changes stomatal size and higher degree of root suberization. Plant employ different mechanisms in remediation of phytotoxicity. Plant use complex process such as perception ,transmission of stress stimuli and enzymatic mechanism such as POD, CAT, APX that activate cell to adapt their metabolism to metal stress. The toxicity removed by using hyperaccumulator plant through Bioremediation process. It is evident that presence of heavy metal having toxic effect on plants. Therefore indeed to intensify the research of heavy metal toxicity on plant for better understanding & ecological harmony of our planet.

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Authors contribution:

Yashwant Sompuraand TansukhBarupal provided the general concept and drafted part of the manuscript. Yashwant Sompura, TansukhBarupal, H Chaya devi, Anita and Suhani Bhardwajwrote the manuscript. TansukhBarupal supervised the study. All authors read and approved it for publication.

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