A Review on Effects of Heavy Metals on Plants, Soil and Human Health

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Abstract: Several heavy metals are found naturally in the earth crust and are exploited for various industrial and economic purposes. Among these heavy metals a few have direct or indirect impact on human health, Plants and Soil. These are all naturally occurring substances which are often present in the environment at low levels. In larger amounts, they can be dangerous. Some common heavy metals are arsenic, barium, cadmium, chromium, lead, mercury, selenium, Copper, Cobalt, Iron and Nickel. Heavy metals exhibit toxic effects towards soil biota by affecting key microbial processes and decrease the number and activity of soil microorganisms. Even low concentration of heavy metals may inhibit the physiological metabolism of plant. These metals are released into the environment by both natural and anthropogenic means, especially mining and industrial activities. They leach into the underground waters, moving along water pathways and eventually depositing in the aquifer, or are washed away by run-off into surface waters thereby resulting in water and subsequently soil pollution. Heavy metals are also impact on human health. Generally, humans are exposed to these metals by drinking or respiration. Working in or living near an industrial site which utilizes these metals and their compounds increases ones risk of exposure, as does living near a site where these metals have been improperly disposed. Therefore this paper reviews certain heavy metals and their virulent effect on Plants, Soil and Human Health.

Keywords: Heavy metals, Effects on Human health, exhalation, virulent effect etc.

I. INTRODUCTION

Metals are substances with high electrical conductivity, malleability, and luster, which voluntarily lose their electrons to form cat ions. Metals are found naturally in the earth's crust and their presence is considered unique in the sense that it is difficult to remove them completely from the environment once they enter in it. Few metals, such as aluminum, can be removed through elimination activities, while some metals get accumulated in the body and food chain, exhibiting a chronic nature. Various public health measures have been undertaken to control, prevent and treat metal toxicity occurring at various levels, such as occupational exposure, accidents and environmental factors. Metal toxicity depends upon the absorbed dose, the route of exposure and duration of exposure. Heavy metals have largest availability in soil and ecosystems and to a relatively smaller proportion in atmosphere as particulate or vapors. 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 components. Heavy metals are significant environment pollutants and their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reason. With the increasing use of a wide verity of metals in industry and in our daily life, problems arising from toxic metal pollution of the environment have assumed serious dimensions. This paper briefly describes the nature and properties of heavy metal and its virulent effect on Plants, Soil and Human health.

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II. SOURCES AND EXHALATION

Heavy metals are naturally occurring elements their multiple industrial, domestic, agricultural, medical and technological applications have led to their wide distribution in the environment raising concerns over their potential effects on human health and the environment. Their toxicity depends on several factors including the dose, route of exposure, and chemical species, as well as the age, gender, genetics, and nutritional status of exposed individuals**.** They can be carried to places many miles away from the sources by wind, depending upon whether they are in gaseous form or as particulates. Metallic pollutants are ultimately washed out of the air into land or the surface of water ways. Thus air is also a route for the pollution of environment. Some common toxic metals are shown in table-1

Table 1 - List of Metal

Metals	Primary Sources
Arsenic	Phosphate and Fertilizer, Metal Hardening , Paints And Textile smelters, electronics waste
cadmium	Electronics, Pigments, Paints, Galvanized pipe corrosion and batteries
chromium	Mining, Metal Plating , Tanning, Rubber
copper	Plating, Rayon and Electrical
Lead	Paints, Battery
Nickel	Electroplating , Iron
Zinc	Galvanizing, Plating and Steel
Mercury	Scientific Instruments , Chemicals

III. EFFECTS ON PLANTS

Some of these heavy metals i.e. Cd, As, Pb, Se, Hg are not important for the growth of plants, since they do not perform any organic function in plants. But the essential elements required for normal growth and metabolism of plants are Mn, Co, Mo, Cu, Fe, Zn and Ni, but these elements can easily lead to poisoning when their concentration greater than normal values. Heavy metal accumulation in plants depends upon plant species and the efficiency of different plants in absorbing metals is evaluated by either plant uptake or soil to plant transfer factors of the metals. Elevated Pb in soils may decrease soil productivity, and a very low Pb 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 roots The use of compost to improve agricultural yield without caring with possible negative effects might be a problem since the waste composts are most applied to improve soils used to grow vegetables. Considering the edible part of the plant in most vegetable species, the risk of transference of heavy metals from soil to humans should be a matter of concern. Uptake of heavy metals by plants and subsequent accumulation along the food chain is a potential threat to animal and human health. The absorption by plant roots is one of the main routes of entrance of heavy metals in the food chain. Absorption and accumulation of heavy metals in plant tissue depend upon many factors which include temperature, moisture, organic matter, pH and nutrient availability. The uptake and accumulation of Cd, Zn, Cr and Mn were higher during the summer season, whereas Cu, Ni, and Pb accumulated more during the winter season. It may be expected that during the summer season the relatively high decomposition rate of organic matter is likely to release heavy metals in soil solution for possible uptake by plants. The higher uptake of heavy metals i.e. Cd, Zn, Cr and Mn during the summer season may be due to high transpiration rates as compared to the winter season due to high ambient temperature and low humidity.

Heavy metals are potentially toxic for plants resulting in chlorosis, weak plant growth, yield depression, and may even be accompanied by reduced nutrient uptake, disorders in plant metabolism and reduced ability to fixate molecular nitrogen in leguminous plants. Seed germination was gradually delayed in the presence of increasing concentration of lead (Pb), it may be due to prolong incubation of the seeds that must have resulted in the neutralization of the toxic effects of lead by some mechanisms e. g. leaching, metal binding and accumulation by microorganisms.

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IV. EFFECTS ON SOIL

Soils may become contaminated by the accumulation of heavy metals and metalloids through emissions from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition. Heavy metals constitute an ill-defined group of inorganic chemical hazards, and those most commonly found at contaminated sites are lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), and nickel (Ni). Soils are the major sink for heavy metals released into the environment by aforementioned anthropogenic activities and unlike organic contaminants which are oxidized to carbon dioxide by microbial action, most metals do not undergo microbial or chemical degradation and their total concentration in soils persists for a long time after their introduction. Changes in their chemical forms (speciation) and bioavailability are, however, possible. The presence of toxic metals in soil can severely inhibit the biodegradation of organic contaminants.

Heavy metal contamination of soil may pose risks and hazards to humans and the ecosystem through: direct ingestion or contact with contaminated soil, the food chain (soil-plant-human or soil-plant-animal-human), drinking of contaminated ground water, reduction in food quality via phytotoxicity, reduction in land usability for agricultural production causing food insecurity, and land tenure problems. Heavy metal pollution not only result in adverse effects on various parameters relating to plant quality and

yield but also cause changes in the size, composition and activity of the microbial community .Therefore, heavy metals are considered as one of the major sources of soil pollution. Heavy metal pollution of the soil is caused by various metals especially Cu, Ni, Cd, Zn, Cr, and Pb. The soil properties i.e. organic matter, clay contents and pH have major influences on the extent of the effects of metals on biological and biochemical properties. Heavy metals exhibit toxic effects towards soil biota by affecting key microbial processes and decrease the number and activity of soil microorganisms. Conversely, long-term heavy metal effects can increase bacterial community tolerance as well as the tolerance of fungi such as arbuscular mycorrhizal fungi, which can play an important role in the restoration of contaminated ecosystems. Pb decreases the activities of urease, catalase, invtase and acid phosphates significantly. Cd is the more toxic to enzymes than Pb because of its greater mobility and lower affinity for soil colloids. Cu inhibits b-glucosidase activity more than cellulose activity. Phosphates and sulfates are inhibits but that urease was unaffected. Each soil enzyme exhibits a different sensitivity to heavy metals. The order of inhibition of urease activity generally decreased according to the sequence Cr > Cd > Zn > Mn > Pb.

The heavy metals exert toxic effects on soil microorganism hence results in the change of the diversity, population size and overall activity of the soil microbial communities and observed that the heavy metal Cd, Zn and Cr pollution influenced the metabolism of soil microbes in all cases.

Diversity and activity of soil microbes play significant roles in recycling of plant nutrients, maintenance of soil structure, detoxification of noxious chemicals and the control of plant pests and plant growth communities are important indices of soil quality. It is important to investigate the functioning of soil microorganisms in ecosystems exposed to long-term contamination by heavy metals. In general, an increase of metal concentration adversely affects soil microbial properties e.g. respiration rate, enzyme activity, which appears to be very useful indicators of soil pollutions.

V. EFFECT ON HUMAN HEALTH

Humans may directly get in contact with heavy metals by consuming contaminated food stuffs, sea animals, and drinking of water, through inhalation of polluted air as dust fumes, or through occupational exposure at workplace. The contamination chain of heavy metals almost usually follows this cyclic order from industry, to the atmosphere, soil, water and foods then human. These heavy metals can be taken up through several routes. Some heavy metals such as lead, cadmium, manganese, arsenic can enter the body through the gastrointestinal route that is through the mouth when eating food, fruits, vegetables or drinking water or other beverages. Others can enter the body by inhalation while others such as lead can be absorbed through the skin.

The plant uptake of heavy metals from soils at high concentrations may result in a great health risk taking into consideration food-chain implications. Utilization of food crops contaminated with heavy metals is a major food chain route for human exposure. The food plants whose examination system is based on exhaustive and continuous cultivation have great capacity of extracting elements from soils. The cultivation of such plants in contaminated soil represents a potential risk since the vegetal tissues can accumulate heavy metals. Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues. Chronic level ingestion of toxic metals has undesirable impacts on humans and the associated harmful impacts become perceptible only after several years of exposure.

Arsenic toxicity also presents a disorder, which is similar to, and often confused with Guillain-Barre syndrome, 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 weakness. It is possibly carcinogenic in com-pounds of all its oxidation states and high-level exposure can cause death.

Cadmium is 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.

Zinc is considered to be relatively non-toxic, especially if taken orally. However, excess amount can cause system dysfunctions that result in impairment of growth and reproduction. 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 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 occur.

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

Lead poisoning also causes inhibition of the synthesis of hemoglobin, 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 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 derives from its ability to diffuse through cell membranes and oxidize biological molecules.

Mercury is toxic and has no known function in human biochemistry and physiology. Inorganic forms of mercury cause spontaneous abortion, congenital malformation and gastrointestinal disorders (like corrosive esophagi is 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 brain and CNS and are also associated with congenital malformation.

VI. CONCLUSION

In this paper I reviewed the effects of some heavy metals, i.e. arsenic, barium, cadmium, chromium, lead, mercury, selenium, Copper, Cobalt, Iron and Nickel on plants, soil and mainly on human health. The exposure of heavy metals to humans involve various diverse forms through food and water consumption, inhalation of polluted air, skin contact and most important by occupational exposure at workplace. These metals uptake by plants from the soil, it reduces the crop productivity by inhibiting physiological metabolism. Heavy metals uptake by plants and successive accumulation in human tissues and biomagnifications through the food chain causes both human health and environment concerns. 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 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.

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