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RESEARCH ARTICLE

Harmful Effects of Different Classes of Heavy Metals in Our Beautiful Environment

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ABSTRACT:

Today we all take care very much about environment because it degrades day by day for several reasons; one of them is the accumulation of heavy metals which are one of the intrinsic components of this environment. The excessive accumulation of heavy metals affects all sides viz. air, soil, water of our beautiful environment through their adverse impacts. There are too many sources open till now for helping them to enter into the environment. This paper shows how they enter together and affects food chain, plant growth, seed germination, photosynthesis and so many. Excess accumulation of both types of heavy metals viz. essential (Zn, Cu, Fe etc) and non-essential (Pb, Hg, As etc) are responsible for disturbance of both aquatic as well as non-aquatic environment parallelly. Human beings also face slow but steady affect either direct or indirect way. So, we try to reflect how toxic level of heavy metals contamination poses a serious threat to our living environment.

KEYWORDS: Environment, heavy metals, toxicity, remedies.

1. INTRODUCTION:

There are several classes and types of metals are found in our earth crust. Among them those having relatively high density (5 times grater than water) ¹ as well as high specific gravity (5 or more times greater than water) ² are considered as Heavy Metals. Basically, they are positioned at the bottom of the periodic table and non-biodegradable in nature. Some common heavy metals are copper, Iron, Manganese etc. Heavy metals are not always harmful to us but side by side it is also true that there are few ones (lead, silver, cadmium, mercury etc) having no beneficial role for both plant and animals. But it should be mind that when both essential and non-essential heavy metals are accumulated in large quantity in anywhere say in soil, air or in animal body, they must become harmful and show several toxic effects on the place of accumulation. Though there are several sources are responsible for their high pile up, industrial areas are the largest one among all.

All types of environmental cycle are greatly influenced for this large aggregation of heavy metals. Consequently, all sectors related to environment are also affected greatly by the heavy metals and by non-metals like chloride for a long time in an indirect and direct way ^{3,4}. So, it's time to take needful remedies for saving our beautiful environment.

2. Classification:

They are classified into two different basic categories as follow.

- a) Based on their biological importance.
- b) Based on their toxicity level.

All heavy metals may or may not have biological role though they present in earth crust in larger amount (Table 1). Zr, Si, Al, Tc are fall under thus category. Beside this both V and W are not found in large quantity like Cu, Zn but they have important role in animal body. Thus, category A is further subdivided into two classes viz i) Essential and ii) non-essential.

On the other hand, some elements having low environmental abundance such as As, Pb, Hg etc are extremely toxic. Tin (Sn) is a beneficial metal is less toxic than mentioned before. So, this category also

further classified into two sub categories i.e., i) Less toxic and ii) Highly toxic. A detail flow chart is shown below.

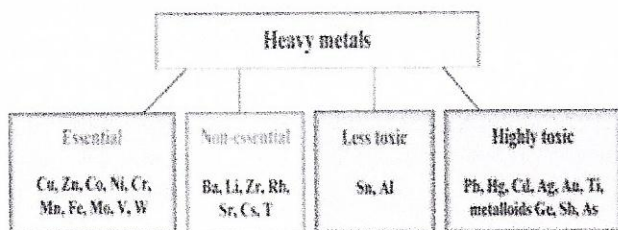


Table 1: Range of heavy metal present in plant

Symbol of heavy metal	Amount range($\mu\text{g/gm}$)
As	0.02-7
Cd	0.1-2.4
Hg	0.005-.02
Pb	1-13
Sb	0.02-0.06
Co	0.05-0.5
Cr	0.2-1
Cu	4.15
Fe	140
Mn	15-100
Mo	1-10
Ni	1
Sr	0.30
Zn	8-100

3. Major Sources:

Heavy metals produce bad impact on our beautiful environment through direct or indirect way. But the important question is what the source is? How they mix to the environments? Now the answer is there are so many till now including natural as well as artificial. Some sources are listed below.

Major Sources of Heavy Metal Release



Some Sources are discussed in a detail below.

A) Volcanic eruption:

It basically affects aquatic environment through change the temperature, pH of the sea water where they mix up. H_2SO_4 , HCl , and HF are 3 major components of surface coat of fresh volcanic ash and thus it is highly acidic in nature and as a result it has capability of lowering the pH of aquatic environment⁵. Even minor amount of ash can produce bad impact on the water system⁶. A list of metals present in volcanic ash is given below in Table 2.

Table 2: List of metals present in volcanic ash.

Metal symbol	Amount in volcanic ash(mg/kg)	Amount in volcanic ash and water mixture(mg/kg)
As	8.95	8.302
Cd	1.30	0.839
Cr	3.88	2.262
Cu	7.40	2.492
Mn	1.31	0.796
Mo	1.43	1.436
Ni	2.76	1.623
Pb	10.14	11.70
Zn	160.6	72.34

B) Industrial waste:

Most of the industries throw their waste into water^{7, 8}. Minamata disease is one of the examples of it. Smoke generated from some industrial manufacturing, directly mix with fresh water and some other industries like cement, fertilizer etc discharge waste to land. So, every component must be directly affected by the industrial waste. Consequently, it becomes the largest source of heavy metal. Among all industries Chemical reagent manufacturing industries become the most responsible factor for pollution. These also enhance the cost of purification⁹. Table 3 represents the manufacturing industries of metals.

Table 3: Source of metals in different industries.

Metal	Manufacturing industries
As	Phosphate and fertilizer, metal hardening, paints and textile.
Cd	Phosphate fertilizer, electronics, pigments and paints
Cr	Metal plating, tanning, rubber and photography
Cu	Plating, rayon and electrical
Pb	Paints and battery
Zn	Galvanizing, plating iron, and steel
Hg	Alkali, scientific instrument, chemicals.

C) E-waste:

We all the part of modern technical generation where most of the work become instrumental rather than manual as before. Consequently, the amount of e-waste also rises up day by day. The heavy metals including E-waste are Pd, Cd, Hg, Ni etc¹⁰. Some chemicals also treated as e-waste like polychlorinated biphenyls (PCBs), Nonylphenol (NP) and triphenyl phosphate (TPPs)¹¹. As E-waste is not properly recycled, they become major threat towards environmental health.

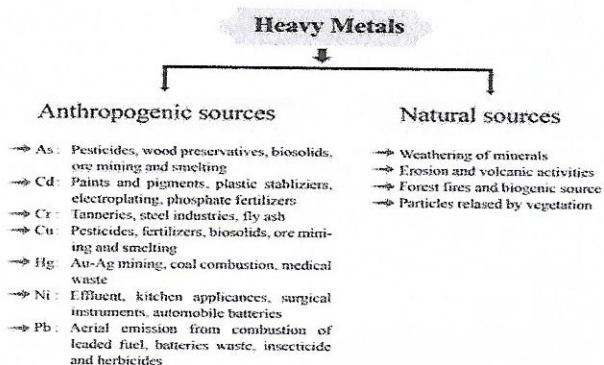
D) Agricultural sector:

Necessity of food is increasing day by day with enhancement of population. Consequently, there must be need to grow up more and more food¹² and this leads to increase the use of both natural and artificial fertilizer. It increases pollution basically to both soil and water. Agrochemicals are thus become one of the major sources. Long term use of phosphate-based fertilizers, dust from smelters, sewage sludge application, industrial waste and bad watering practices in agricultural lands contaminate agricultural soil. Phosphatic fertilizers are

made from rocks containing phosphates, it is found as sedimentary, igneous and metamorphic rock in the earth's crust.

3.1 Specific Sources:

Not only are the mentioned areas responsible for the generation of heavy metals but also, we human being are also responsible for the production of heavy metals. So, a list is given below which show anthropogenic sources of heavy metals.



4. Soil pollution:

Soil is the main land of some microbes. They enhance fertility of soil. But accumulation of heavy metal like Cu, Ni, Cd, Zr, Cr, and Pb¹³ change biological as well as chemical properties and therefore, both pH and fertility changes.

Heavy metal pilling also influences on enzymatic activities of microbial community¹⁴. The toxicity level of metal basically depends on mobility through the soil pore. Chen et. al.,¹⁵ concluded that heavy metal aggregation lowers the level of bacterial communities. Kasaca et.al.,¹⁶ reported that heavy metal influence also enzymatic activities of bacteria present in the soil. Some effects of metals are listed below. We summarize all effects as follow.

- Change the size, composition and activity of microbial community.
- Effect on biological and biochemical properties.
- Organic composition of soil and pH is greatly influenced.
- Cause a deuteriation of bacterial species and relative increase in soil actinomycetes⁷.
- Have an effect on biomass and diversity in bacterial community.
- Microbial population, their respiration rate, enzymatic activity also influenced.
- Fertility of soil become low

The table 4 shows the affected enzymes by the metals.

Table 4: List of affected enzymes by the metals.

Metal	Enzyme affected
Cu	Beta glucosidase
Pb	Urease, catalase, invertase and acid phosphate

Cd	Protease, urcase, alkaline phosphatase and arylsulphatase
As	Phosphatase and sulphatase.
Zn, Cr	Cell metabolism of microbes.

Thus, day by day lands are not available for germination of seeds growing of plants, fertilizing crops and at last for living human beings.

5. Aquaculture:

The worst affected component of environment is water. Every aquatic part present in the world viz. sea, river, pond and ground level water are affected very much. Due to contamination, the physical and chemical properties of water must change which in turn directly affect the ecosystem of every aquatic life because of change of all kind of biological chain. Growth, development and life span of fishes decreases due to heavy metal pollution¹⁷. From contaminated water heavy metal directly enters into the fish body and when we human are being taken those affected fishes, heavy metals also enter into our body also. Flora and fauna are also affected¹⁸. In present the rate of such diseases causing due to heavy metal accumulation grows up and spread out through both rural and urban areas. Hg, Pb, Cu etc directly influence reproductive system of fish and affect fertility, embryonic maturation^{19-24, 25, 26}. Side by side pH, salinity and temp of water also changes when amount of metal crosses their toxic level. A summary of adverse influence on aquaculture is given below.

1. Decrease growth rate and development of fish.
2. Problems occur in reproductive system of fish.
3. Gills and respiratory system are greatly affected.
4. Neurotoxic effect.
5. Genotoxic effect.
6. Blood and circulatory system are greatly influenced.
7. Physiological damage occurs.
8. Normal lifespan becomes short

Bio-amplification and Biomagnifications both affect fish. Some heavy metals are responsible for malformations in fishes. Cd inhibit oxidative metabolism and Pb degrade growth rate of fishes. A detail chart of several toxic effects on fishes is shown below in Table 5.

Table 5: A detail chart of several toxic effects on fishes.

Affected areas	Responsible metals
1. Growth rate and development	Pb, As, Cd, Cr.
2. Reproductive System	Zn, Pb, Cu, Hg, Cd.
3. Gills and respiratory damage	Zn, Cr
4. Neurotoxic effect	Hg
5. Blood and Circulatory System	Cd, Ni
6. Genotoxic effect	As, Cd, Ni, Cr.
7. Physiological Damage	Cd, Ni, Hg, Cr, Pb, Ar, Zn.

6. Effect on plant:

Some heavy metal must need for plant growth but only when the amount is not too high. When their amount exceeds over certain level then they start to show their adverse effect in both direct and indirect way. Every

corner of growth and development inhibit due to excess accumulation. A chart is shown below Table 6.

Table 6: Toxic influences of metals

Metal Symbol	Toxic Influences
Cu	1. Plant growth inhibition and chlorosis. 2. Enhancing generation rate of ROS. 3. Disturbance metabolic action. 4. Reduce root growth.
Zn	1. Reduce germination. 2. Alternate catalytic action. 3. purplish red colour in leaves. 4. Limit the growth of both root and shoot.
Cd	1. Browning of root tips 2. Decrease plant nutrient content 3. Reduce ATPase activity. 4. Inhibit both root and shoot length.
Hg	1. Decrease plant height 2. Reduction in flowering 3. Reduce germination percentage. 4. Bioaccumulation.
Cr	1. Damage cell membrane. 2. Disturbance of Ultra structure of chloroplast. 3. Metabolic alternation and modification.
Pb	1. Induce oxidative stress 2. Reduce number of leaves 3. decrease leaf area. 4. Decrease enzyme activity affecting CO ₂ fixation.
As	1. Lowering fruit yield 2. Decrease leaf weight. 3. Reduce germination and growth.

7. Other Indirect Effects:

Not only the all three environmental components but also all we, human and animals live on this earth are victims for this pollution very badly. Heavy metals enter into our body mainly from contaminated fishes. As we all walk on the soil and live on the soil so it is also become a vital source of heavy metal accumulation in human body. A list is given below showing other influences.

1. Air becomes polluted in large extent due to decrease in production of oxygen.
2. Food chains is greatly affected.
3. Human beings are mostly affected. They have faced a large number of problems mainly several diseases like Minamata, Itai-itai etc.
4. Agriculture economy is influenced due to lower production of crops.

8. Remediations:

There are basically 3 major classes of remediations viz. physical, chemical and biological. The main target is to minimize the contaminated metal amount which leads to good for both human and environmental health. The choice of process basically depends on several factors like

- a) Nature of heavy metal.
- b) Amount of heavy metal.
- c) Nature of environmental component
- d) Ecosystem of component

e) Physiological characteristics of the contaminated area.

8.1. Physical Methods:

The most famous method is dig and haul ²⁷ method which basically employed for soil pollution. But it is limited to small area as well as expensive one. It is not the solution because it's only based on the transferring concept i.e., from high contaminated areas to lower one. Another physical method for removal of heavy metals from soil is washing ²⁸. But it is best for sandy and granular type soil. Several chemicals like surface active agents, chelating agents, organic acid/base, co-solvents are used for washing purpose. The choice of washing chemicals basically depends on physiochemical properties of the area. For example, EDTA is basically employed for Pb, Ni, Zn, Cu, Cd etc.

Vitrification ²⁹ is one of the best methods for detoxification for toxified soil. This goes through several stages like pre-treatment, recycle etc. Mind I, it's mainly applicable for the removal of Hg and can be applied through both ex and insitu manner.

8.2. Chemical Remedies:

Immobilization and extraction are two chemical ways to detoxify soil. 1st one decreases the metal mobility through the soil. Some agents help in this work like organic compost, cement, minerals, oil, clay etc ^{30, 31}. Immobilization based on some common principle like precipitation, sorption and complexation ^{32, 33}. But it is not limitation free i.e., some organic materials make this one imperfect due to formation of organic vapour. On the other hand, for extraction process several chemical reagents are used. A list of reagents is given below (Table 7). Basically, these are suitable for the removal of as and Pb.

Table 7: Some Chelating agents

Chelating agent code	Chelating agent name
EDTA	Ethylenediamine tetra acetate
DTPA	Diethylenetriaminepentaacetic acid
HEDTA	N-2-hydroxyethyl-ethylene-diamminetriacetic acid
NTA	Nitrilotriacetate
EDDS	Ethylenediamine-N,N'-Di succinic acid

8.3. Biological Remediation:

This involves mainly removal of heavy metal from plants since sometimes plants accumulate heavy metals ³⁴. One emerging process is Phytoremediation. Plant microbes play a crucial role in this methodology. Several heavy metals like Cu, Cd, As, Au, Pb, Zn etc can be removed with the help of this one.

8.4. Other Remedies:

1. WHO should pay their attention more strictly to various industries so that they follow all norms

effectively as well as rigorously?

2. Government must take necessary steps for setting up greater no of water treatment plants.

3. Awareness programmes are one of the best tools for making this environment beautiful.

9. CONCLUSION:

We all must agree to the fact that Human beings are mainly responsible for all types of harmful effects directly or indirect way. Thus, today we as well as our beautiful environment is in danger. So, all must take at least little bid of responsibility to make toxic free environment. We cannot remove them totally but we must reduce it and give long life span to future generation.

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11. CONFLICT OF INTEREST:

We have no any conflict of interest.

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