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Toxicity Effect by Heavy Metals as Pollutants on Fertile Soil

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Abstract: ***There are rising geologic and anthropogenic processes and as a result, now a days soils polluted by heavy metals have become more common and it is a problem across the globe. Soil polluted due to heavy metal can be freed from pollutants effectively by use of bioremediation process. It's a very well-known process and is used in situ, making it ideal to make soil free from pollutants as a part of crop establishment as well as restoration of soil which are being treated. Microorganisms as well as plants uses a variety of processes/methods to bioremediate the pollutants present in the different types of soils.***
Keywords: Heavy metal contamination, Remediation process, Soil pollutants, bioremediation process, soil pollutants

I. INTRODUCTION

In the atmosphere/environment around us, pollutants such as heavy metals can be found. In comparison and apart from the natural activities happening, as a consequence of almost every activity performed by human has the possibility of potential to generate heavy metals. The spread of heavy metals containing sewage sludge and the migration of these pollutants/contaminants into non-contaminated soil carried as dust and leachates, are two examples of existence that leads to contribute to ecosystem damage and contamination as overall. Plants that grow in these polluted soils are having less yield compared to non-polluted soil. Soils damaged due to heavy metals can be freed from pollutants more efficiently using mixing of microbes and plants, by the use of bioremediation technique. As a part to treat soil by the use of microbes and plants to remove pollutants/contaminants present in the soil by the process of bioremediation and to remove heavy metals from polluted soil is being adopted and now a days becoming more common.
The pollution of soil caused due to heavy metals is very critical and having a global environmental issue. The experts in this area have estimation of about more than 20 million hectares of farmland in the asian country, China, has been polluted/contaminated, almost accounting to about 20% of the total land [1]. Cadmium (Cd) metal is being considered as one of the most phytotoxic in the metal pollutant because of its high mobility, especially in the soil which have low cation exchange capacity (CEC) and as well acidic pH, along with bioaccumulation in the lower organisms as it is easily being moved to higher trophic levels in the food chain [2]. The toxicity effect due to cadmium (Cd) metal as pollutant and its presence can have influence on plant survival, success of reproduction and migration [3].
As plants are considered to be sedentary in nature i.e., inactive because of lack of their ability to move actively to avoid pollutants/contaminants present in the environment, hence the chances of plants for their survival in the unfavorable surroundings is the mobilization of their defense mechanisms, and to evolution of them as tolerate genotype [4]
Soil microorganisms in the rhizosphere of plants growing on metal-contaminated soils, both free-living and symbiotic soil microbes, can boost plant biomass production while also aiding the phytoremediation process. On the other hand, heavy metals have an effect on the growth, metabolism and morphology of soil microorganisms by functional disruption, the destruction of cell membrane integrity and protein denaturation. Traditionally, heavy-metal contaminated soils have been remedied by onsite management of excavation and with disposal to a landfill. The activity through disposal only relocates the problem caused due to contamination, as well as the risks are associated with carrying contaminated soil and as it migrates from the landfill into the surrounding ecosystem. There is an alternative as soil washing in comparison to excavation and landfill discarding as a part to clearing of polluted soil. As this process is quite expensive and produces a heavy metal-rich residue which will require further processes to treat the residue. The techniques used in the remediation of soil considering physico-chemical characteristics for the use of land, are tools for the growth of plants as all biological activities are being removed [5].
Many plant species have been successful in absorbing pollutants from soils, such as arsenic, chromium, cadmium, lead as well as different radionuclides i.e., radioactive nuclide/isotope. Phytoextraction, one of the categories considered for phytoremediation, can be used to eliminate heavy metals from the soil by utilization of the ability to ingest ions that are required for essential growth of plants such as copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni) and zinc (Zn). The capacity of these metals to have uncertain biological activities (e.g., silver (Ag), cadmium (Cd), cobalt (Co), chromium (Cr), mercury (Hg), lead (Pb) and selenium (Se) may also have the possibility to accumulate. Heavy metals are originated from many sources [6]. The views as well as opinion expressed in this article are based on the literature/documents available to explain in simple ways however guidelines or documents from respective government agencies should be refereed for actual numerical data.

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II. VARIOUS SOURCES FOR CONTAMINATION OF SOILBY HEAVYMETALS

As heavy metals are present in the soil and their excess amount originated from many other sources such as mining activities, sewage, irrigation, atmospheric deposition, improper stacking of the industrial solid waste, and excessive use of the pesticides and fertilizers due to different types of processes/industry are tabulated in below table 1.

Sr.No.	Name of Metal	Type of process/Industry
1	Chromium (Cr)	a. Leather tanning b. Mining c. Industrial coolants d. Chromium salts production
2	Lead (Pb)	a. Paints, b. E-waste c. Smelting operations d. Coal-based thermal power plants e. Ceramics f. Bangle industry
3	Mercury (Hg)	a. Hospital waste (e.g., damaged thermometers, barometers, sphygmomanometers) b. Electrical appliances c. Thermal power plants d. Fluorescent lamps
4	Arsenic (As)	a. Smelting operations b. Thermal power plants
5	Copper (Cu)	a. Sulphuric acid plant b. Mining c. Electroplating d. Smelting processes
6	Nickel (Ni)	a. Smelting operations b. Thermal power plants c. Battery manufacturers
7	Cadmium (Cd)	a. Zinc smelting b. Waste batteries c. E-waste d. Paint sludge e. Incinerations f. Fuel combustion
8	Zinc (Zn)	a. Smelting, b. Electroplating

Table 1: Sources for the hazardous metals from different type of processes/industries

Sewage water and industrial wastewater generated in the cities and towns are dumped in surface water bodies (mainly untreated), causing river water quality to deteriorate near numerous cities. From the studies observed, the usage of waste water and water from contaminated surfaces for the purpose of irrigation has increased the heavy metal content in agricultural fields in various cities/villages in India [7]. Different materials are discharged into sewage as a result of increased industrialization in residential areas, resulting in environmental contamination. A mixture of waste water created by home, municipal, and industrial activity is carried by a large number of open and covered channels.

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III. EFFECTS ON PLANTS

Some heavy metals, such as arsenic (As), cadmium (Cd), mercury (Hg), lead (Pb), or selenium (Se), are not essential for the growth of plants as they have no established physiological role to function in plants. Other metals, such as cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), and zinc (Zn), are required considering its necessity as essential elements for the growth of metabolism of plants, but as their concentrations gets increased beyond the acceptable range can quickly lead to poisoning. The use of waste composts are most commonly used to improve the quality of soil used for production of crops, fruits, vegetables by the use of compost to boost agricultural productivity without regard for possible negative impacts may be an issue however the most vegetable species have edible parts, as concern for transfer of heavy metals from soil to human being.

Many plant species have been successful in absorbing pollutants from soils, such as lead, cadmium, chromium, arsenic, and different radionuclides i.e., radioactive nuclide/isotope. Phytoextraction, one of the phytoremediation categories, can be used to remove heavy metals from soil by utilizing its ability to ingest ions that are required for plant growth such as Iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), magnesium (Mg), molybdenum (Mo), and nickel (Ni). Some metals with unknown biological function such as cadmium (Cd), chromium (Cr), lead (Pb), cobalt (Co), silver (Ag), selenium (Se), mercury (Hg) can also be accumulated.

Soil can be polluted with lead from a variety of sources, including industrial sites, fuel wit lead content, ancient lead plumbing pipes, and even old orchard sites where lead arsenate is used in manufacture. Lead is very immobile and collects in the top layer of soil. Contamination lasts a long time. Lead content in high levels in soil will never return to normal without remediation.

IV. VARIOUS EFFECTS ON AQUATIC ENVIRONMENT

Heavy metals have a long half-life and are hazardous in small concentrations as well, causing severe oxidative stress in aquatic organisms. As a result, these pollutants are extremely important in terms of ecotoxicology. Furthermore, metals are not degraded by microbes and hence persist in the marine environment indefinitely. Contamination/pollution of a river water with heavy metals can have disastrous consequences for the aquatic environment's biological balance, as the diversity of aquatic creatures decreases as contamination increases. Heavy metals are frequently associated to particulate matter in aquatic systems, which settles down and gets incorporated into sediments over time. As a result, surface sediment is the most important reservoir or sink of metals and other pollutants in aquatic environments. Sediment containing pollutants have the possibility to be absorbed by rooted aquatic macrophytes as well as with other aquatic organisms.

V. VARIOUS EFFECTS ON PROCESS OF COMPOSTING

The consequences of pollutants due to heavy metals are major to soil, plants, and human health and have an impact on the composting process by altering microbial diversity. Microorganisms aid in the decomposition of organic matter, the detoxification of some organic and inorganic contaminants, and the modification of heavy metal mobility and bioavailability in plants, because heavy metals can impair microbial reproduction and cause morphological and physiological abnormalities, they should be avoided. As a result, hazardous heavy metals in the environment may influence biodegradation processes. Heavy metals have the capacity to impede both enzymatic reactions and complex metabolic processes, which could impair microbial enzymes. During the composting process, heavy metals reduce phosphatase synthesis. Microorganisms must deal with hazardous lead (Pb) during their growth in lead (Pb)-contaminated substrates, as microbial growth and activity are always inhibited when they are exposed to metals.

VI. CONCLUSION

Heavy metal contamination is rapidly increasing as a result of industrialization and modern lifestyles. It travels from plant to person or animal through the soil, interfering with biological processes in the human body. The majority of remediation strategies lowered crop absorption by converting the toxic form of heavy metal to a nontoxic form; or by converting the available form of heavy metal to an unavailable form in soil. Segregation and safe disposal of heavy metal-containing waste should be the primary strategy. Heavy metal contaminated crops such as flowers, caster, and jatropha are used for non-edible food crops. Where contaminated water is used for agricultural production operations, regular monitoring of effluent, soil, and crop produce is required. The contaminated water discharge units, as well as their consumers, should be subjected to a strict policy. A large-scale public awareness campaign about heavy metal toxicity and its consequences, aided by government agencies or non-governmental organizations (NGOs) is required.

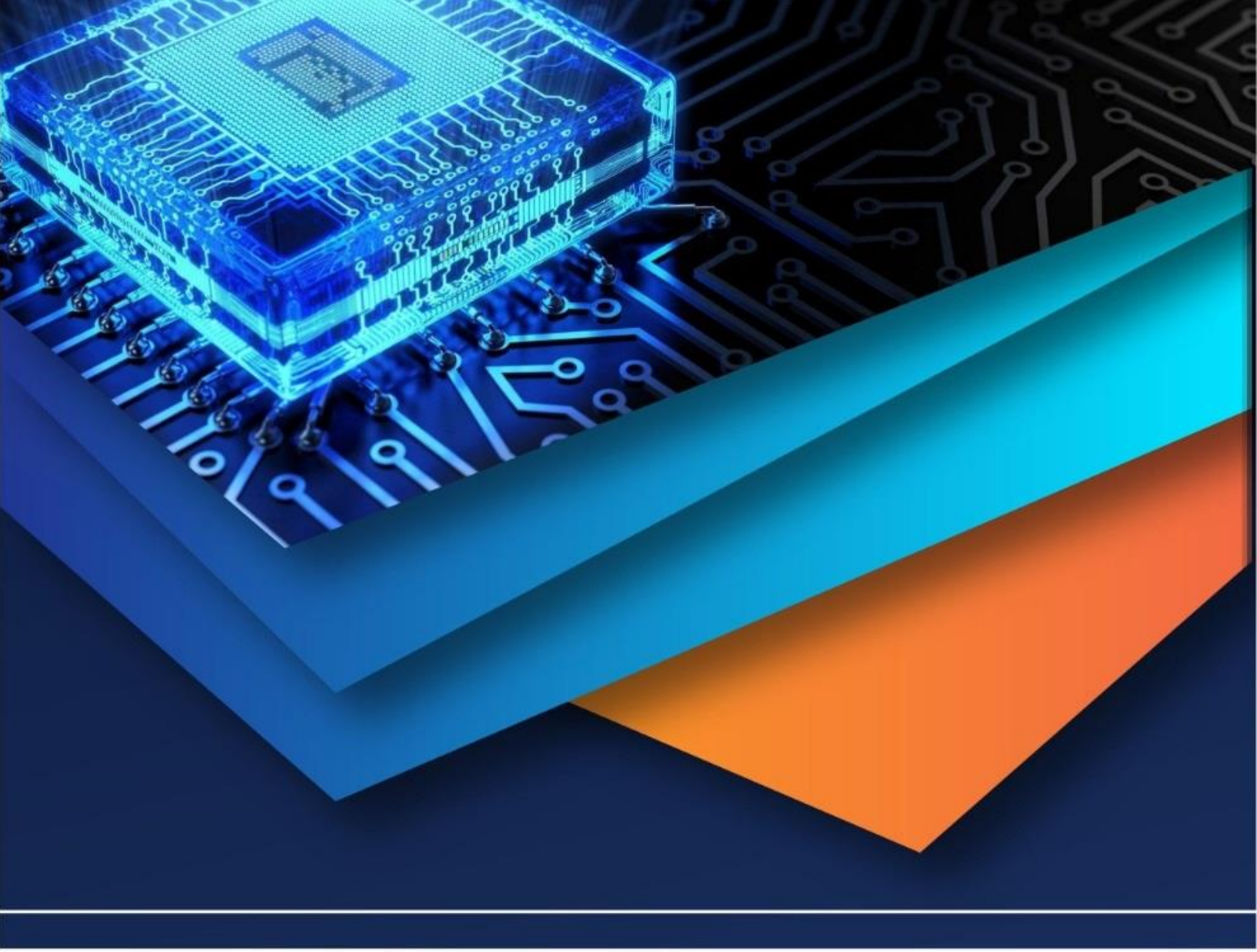
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