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A Review on Green Technology, Heavy Metal Phytoremediation

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ABSTRACT: ***Organic or inorganic contaminants have polluted the environment. Organic pollutants are mostly manmade and enter the environment in a variety of ways. As a consequence of global industrialization, soil pollution with hazardous metals including such Cd, Zn, Pb, Cr, Ni, or Cu has risen significantly in recent years. There are several traditional remediation methods that may be used to remediate polluted regions, particularly metal-contaminated soils. Despite their efficiency, these techniques are costly, time-consuming, and harmful to the environment. Scientists and engineers have recently created phytoremediation as a cost-effective and ecologically friendly technique in which biomass/microorganisms or live plants are utilized to repair contaminated regions. Phyto filtration, Phyto stabilization, phytoextraction, as well as phytodegradation are only a few of the uses available. To demonstrate the broad application of this green technique, a short overview of phytoremediation of heavy metal-contaminated soils has been compiled.***

KEYWORDS: ***Green Technology, Phytoremediation, Heavy Metals, Soil Pollution, Toxicity.***

1. INTRODUCTION

Heavy metal pollution of the biosphere has grown dramatically since the beginning of the industrial revolution, and it has become a major environmental issue. Heavy metal contamination may be regarded as one of the most serious dangers to soil and water resources, as well as human health. The yearly broad discharge of heavy metals has been a tradition for decades. Anthropogenic and geological processes are both sources of metal pollution. Metal pollution is caused by human activities such as industrial emissions, smelting, mining, military operations, fuel generation, and agricultural chemicals. The use of phosphate fertilizers in agricultural soil has resulted in a rise in Cd, Cu, Zn, and other metals. As a result of the growing need for agricultural goods, agricultural areas have been extensively cultivated. To preserve the quality and quantity of these goods, fertilizers, insecticides, and herbicides must be used. Excessive use of these agrochemicals, on the other hand, causes environmental issues such as chemical buildup in the soil and plant absorption. Pollution in the Environment and Contamination Sources[1].

The presence of dangerous amounts of chemicals in land, water, and air is referred to as environmental pollution. Pollution is defined as the unintentional or intentional pollution of the environment by waste produced by human activity. Because pollutants are discharged into the environment in a variety of ways, our environment has been polluted by organic and inorganic contaminants. As a consequence of industrial operations and the uncontrolled development of big cities, soil, water, and air have been polluted. Metals including Cd, Cu, Cr, Ni, Zn, and Pb are recognized to be harmful to the environment.

Heavy metal pollution of the soil Heavy metals introduced into the environment in two ways: naturally and via human causes. The weathering of mines, which are themselves anthropogenically produced, is a common natural source of heavy metal pollution. Any element having metallic properties, such as density, conductivity, cation stability, and an atomic number higher than 20, is classified as heavy metal. Heavy metal contamination is a major environmental issue that affects people all over the globe. It may be found in the soil, water, live creatures, and sediments at the bottom. In the late 19th and early 20th centuries, environmental pollution by heavy metals as a consequence of industrial and mining operations became prevalent. Heavy metals, such as Cd, Cu, Cr, Zn, Ni, and Pb, which are classified as critical pollutants, have a negative impact on the environment, particularly at high concentrations in regions where human activities are prevalent. Heavy metals' biological equivalency and geochemical cycles have altered significantly as a result of human activity, despite the fact that they are natural components of the earth's crust. Because of their incapacity to decay naturally, these metals are just being converted from one form to another Cu, Heavy metal pollution of the biosphere has grown dramatically since the beginning of the industrial revolution, and it has become a major environmental issue. Heavy metal contamination may be regarded as one of the most serious dangers to soil and water resources, as well as human health[2].

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1.1. Pollution in the Environment and Contamination Sources:

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Soil contamination is a critical issue that has received a great deal of public attention in recent decades. Because of widespread pollution, a significant part of the land has become toxic and uninhabitable for people and animals. Heavy metals are rarely absent from soils, and their levels rise as a result of human or natural processes that damage biological systems. In contrast to heavy metals, which are non-degradable and exist naturally in the environment, organic contaminants are manmade and decay in the soil. Industrial processes, volcanic eruptions, and parent material may all produce heavy metals. Metal concentrations in the soil may vary from traces to as high as 100000 mg kg-1, depending on the kind of element and its location. Heavy metal toxicity in plants Heavy metals may harm macro- and microorganisms by interfering with biochemical and physiological processes, decreasing growth, degrading cell organelles, and inhibiting photosynthesis. Because of certain obstacles that hinder metals from moving from the roots to the aerial parts of the plants, some metals (particularly Pb) tend to concentrate in the roots more than in the aerial parts. Other metals, such as Cd, move more freely in plants. For growth and development, all plants are able to collect important elements such as Cu, Fe, Zn, Ca, K, Mg, and Na from soil solutions. Plants, on the other hand, accumulate non-essential elements including Cd, As, Cr, Al, and Pb, which have no biological function[4].

1.2. Heavy Metal Remediation :

Ex situ excavation, landfill of the top contaminated soils detoxification, and physico-chemical remediation are currently used to remediate heavy metal contaminated soil and water. These methods are costly, time consuming, labor intensive, and increase the mobilization of contaminants while also destroying the biotic and structural integrity of the soil. As a result, these remediation methods are not appropriate for large polluted regions, either technically or financially. Bioremediation is a technique that uses microorganisms to reduce contaminants to a low harmful level. However, for significant metal and organic contaminants, the application of this technique to repair polluted regions by adding live organisms proved less effective. Plants can metabolize chemicals found in natural environments. Phytoremediation is a method of cleaning up polluted regions by using plants.

1.3. Affinition and Phytoremediation Types in General:

Phytoremediation, or the use of plants to clean up polluted regions, is a promising new technique. Immobilizing/stabilizing, degrading, transferring, eliminating, or detoxifying pollutants, such as metals, pesticides, hydrocarbons, and chlorinated solvents, is a low-cost, long-term, ecologically and aesthetically acceptable technique. It has become a widely recognized method of detoxifying

polluted water and soil during the last two decades. Phytoremediation has long been thought to be a natural process, having been discovered and proven more than 300 years ago. This technique's particular plant and wild species are efficient in accumulating increasing quantities of harmful heavy metals. Accumulators are the name for these plants. Phyto filtration or rhizofiltration are two different types of filtration[5].

The removal of contaminants from waste water, surface water, or extracted ground water by plant roots is known as phyto filtration or rhizofiltration. In a hydroponic experiment, the potential of Limnocharis flava (L.) Buchenau for phytofiltration of Cd in polluted water with low Cd concentrations was investigated. The roots had the greatest concentration of Cd, followed by the leaves and peduncle. This indicated that L. flava would be a good candidate for phyto filtration of low-level Cd in water.

Phyto stabilization By utilizing plants to stabilize and decrease the bioavailability of pollutants, phyto stabilization is a simple, cost-effective, and less environmentally intrusive method. Plant roots, in fact, are used in this method to limit the mobility and bioavailability of pollutants in the soil. Plants may minimize the negative impacts of pollutants in the environment in the future by preventing them from entering ground water or spreading via the air. When there is no immediate action to detoxify contaminated areas (for example, if a responsible company only exists for a short time or if an area is not a high priority on a remediation agenda), this method is used to change the chemical and biological characteristics of polluted soils by increasing organic matter content, cation exchange capacity (CEC), nutrient level, and other factors.

1.4. Phytovolatilization is a term used to describe the process of plants becoming more volatile.

Green plants are used to collect volatile pollutants such as Hg and Se from contaminated soils and ascend them into the air via their leaves. It was shown that certain plants could convert Se into dimethyl selenide and dimethyl diselenide in high-selenium conditions.

1.5. Phytodegradation is a term that refers to the process of plants degrading.

The employment of plants and microorganisms to absorb, metabolize, and breakdown the organic pollutant is known as phytodegradation. Plant roots are utilized in conjunction with microorganisms to detoxify soil polluted with organic chemicals in this method. Phyto transformation is another name for it. By generating enzymes, certain plants may cleanse soil, sludge, sediment, and ground and surface water. Herbicides, insecticides, chlorinated solvents, and inorganic pollutants are among the organic chemicals used in this method. Fe, Zn, Mo, and Mn are heavy metals that are considered micronutrients and are necessary for biological systems to function. These metals, however, become extremely hazardous at greater quantities, endangering the health of animals and people through affecting the quality of crops, water, and the environment. Heavy metals such as Cd, Cu, Ni, and Hg are more harmful to plants than Zn and Pb.

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1.6. Heavy Metal Remediation :

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1.7. Phytoextraction

Phytoextraction Phytoextration is a phytoremediation method in which plants are used to extract heavy metals like Cd from water, soil, and sediments. It's an excellent way to remove contaminants from soil without compromising the soil's characteristics. Furthermore, metals collected in harvestable portions of the plant may be easily replenished using the ash generated after drying, ashing, and composting these harvestable parts using this method. Phytoextraction, often known as phytomining or biomining, is a method of extracting plants. This is a more sophisticated type of phytoremediation in which heavy metals are bioharvested and recovered using high-biomass crops cultivated in polluted soil. Cropping may be used in the mining sector to economically produce metals[8].

1.8. Plant hyper-accumulators are chosen based on the following criteria:

Successful phytoremediation requires the identification of appropriate plant species capable of accumulating hazardous amounts of metals while also producing a large amount of biomass. Phytoextraction plants should, in general, have a high ability to collect hazardous amounts of

metals in their aerial portions (shoots), high growth rates, and resistance to high salinity and high pH. Furthermore, these plants must generate high dry biomass, be easy to grow and harvest, and effectively absorb and translocate metals to aerial portions. Overall, using native plant species that grow naturally around the location is advised. Under local circumstances, these species are less competitive and will decrease the metal concentration to a tolerable level for normal plant development.

1.9. Phytoremediation has the following benefits:

Phytoremediation is a low-cost and efficient method for cleaning up polluted soils that does not need high-cost equipment or specialized human resources (Environmental Protection Agency, 2007). It is suitable for many types of organic and inorganic pollutants as a green technology, and it offers aesthetic advantages to the environment by utilizing trees and generating green spaces, which is socially and psychologically good for everyone. This green technology can be used in vast regions when other methods would be too costly and ineffectual. Furthermore, wastes may be reused with little environmental impact as a practical method to decontaminating land and water. Furthermore, by limiting leaching and soil erosion caused by wind and water activities, the spread of pollutants to air and water is minimized[9].

1.10. Capacity for tolerance:

Tolerance capacity refers to a plant's ability to thrive in heavy metal-contaminated environments while maintaining a high level of tolerance to heavy metals without experiencing negative consequences such as chlorosis, necrosis, yellowish brown hue, or a decrease in above-ground biomass (or at least not a significant reduction)

1.11. Efficacy of removal:

The total metal concentrations or dry biomass of plant to the total loaded metals in the growth medium is the removal efficiency based on plant biomass[10].

1.12. Phytoremediation's disadvantages

The most significant constraint of phytoremediation is time, since this method may take many years to complete. Furthermore, carefully maintaining the vegetation in It's difficult to clean up polluted regions and Entering the ocean may potentially endanger human health. contaminant into the food chain through animals that eat it plants that have been polluted. This technology is revolutionary. When just a tiny portion of the pollutant is bio-available to plants in the soil, it's not remarkable. Aside from that, it's only available in low or moderate doses. plant root district enclosing polluted regions

2. DISCUSSION

Since the start of the industrial age, heavy metal contamination of the biosphere has increased significantly, and it has become a serious environmental problem. Heavy metal pollution poses one of the greatest threats to soil or water resources, but also human health. The environment has been contaminated by organic and inorganic pollutants. Organic pollutants are mainly created by humans and may enter the environment in a number of ways. Soil contamination with dangerous metals such as Cd, Zn, Ni, Pb, Cr, or Cu has increased substantially in recent years as a result of

global industrialization. Traditional remediation techniques, especially for metal-contaminated soils, may be utilized to clean up polluted areas. This environmentally friendly method may be used to clean up polluted soils without creating any structural harm. Herbs and woody plants, for example, have been found to absorb toxic metals in considerable amounts. These plants are referred to as hyperaccumulators. Researchers are looking for new plant species that may be used to detoxify heavy metals from contaminated soils.

3. CONCLUSION

Heavy metals are a major danger to soil or water resources, or also human health. Mining, smelting of metals and minerals, industrial emissions, or the use of pesticides, herbicides, or fertilizers all release metals into the ecosystem. Metallic pollutants include metals such as Cd, Cu, Pb, and Zn, as well as metalloids. Traditional repair methods are costly, time-consuming, and harmful to the environment. As a result, using a low-cost, environmentally acceptable method to remediate heavy metal-polluted soils is unavoidable, especially in poor nations. The most efficient plant-based technique for removing contaminants from polluted regions is phytoremediation of metals. This green technique may be used to clean up contaminated soils without causing any structural damage to the soil. Herbs and woody plants, for example, have been shown to have a significant capacity to absorb harmful metals. Hyperaccumulators are the name given to these plants. Researchers are on the lookout for novel plant species that may be utilized to remove heavy metals from polluted soils.

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