International Journal of New Media Studies (IJNMS), ISSN: 2394-4331
Volume 10 Issue 1, January-June, 2023, Impact Factor: 7.786

Phytoremediation Technology: Heavy Metals Uptake by Plants

Deepika Sharma[1], Shobha Gupta[2], Rashmi Singh[3]

[1]APS University, Rewa
[2]Govt.Girls PG College, Satna, M.P.
[3]Govt. P.G. College, Satna, M.P.

Abstract

Heavy metal contamination is one of the biggest environmental issues of our time as a result of the industrialization of many nations. Heavy metals, which also contribute to a number of severe diseases, have toxic effects on human health. Diverse methods have been employed to remove heavy metal contamination from the environment, however these processes have limitations such high cost, protracted process periods, logistical problems, and mechanical complexity.

Phytoremediation, a technology that uses plants that accumulate metals, has the potential to replace the heavy metal remediation process due to its advantages. Environmentally advantageous, cost-effective and safe. According to past studies, the heavy metal phytore mediation technique can utilize a variety of plants with a high potential for bio accumulating heavy metals.

Introduction

Contamination with heavy metals is one of the major environmental problems. Heavy metal exposure continues, and in certain places, even rises1, despite the fact that its negative effects on health have long been acknowledged. Heavy metal poisoning may result in mortality due to its negative effects on human health2. It has been established that industrial regions have significant concentrations of some of these metals. As a result of the growth of industry, the environment has become more heavily polluted with heavy metals.

Pollutants can be Removed from Contaminated Settings Using a Variety of Techniques

A number of methods can be used to clean up heavy metal-contaminated soils, including acid leaching, soil washing, physical or mechanical separation of the contamination, electro-chemical treatment, electro kinetic treatment, chemical treatment, thermal or pyrometallurgical separation, and biochemical procedures 3-5.

Chemical, biological, biochemical, and absorptive treatment methods, as well as air stripping, activated carbon adsorption, and the use of microbes, can all be used to remove and repair heavy metals from contaminated ground water. 6 These corrective measures include several that are expensive, time-consuming, logistically challenging, and technically challenging. 7-10.

Phytoremediation

Additional methods are required to increase soil fertility. Phytoremediation is economically feasible by using an autotrophic system that is powered by solar energy. As a result, management is simple and installation and maintenance are affordable.

The benefits include the following:

- It is simple to remove and can be used on expansive fields.
- It can lessen the amount of pollutants exposed to the ecosystem and the environment.
- It may be eco- and environmentally beneficial.
- By releasing various organic components into the soil, it can raise soil fertility.
- By stabilizing heavy metals, it can (v) prevent erosion and metal leaching; (iv) it can stop the spread of pollutants.

Over the past few decades, substantial research has been done on the molecular mechanisms underlying heavy metal tolerance, and techniques to improve phytoremediation effectiveness have also been created.

The current study examines the mechanisms of heavy metal uptake and translocation in plants in addition to the detoxifying strategies (avoidance and tolerance) employed by plants to deal with heavy metals. Phytoremediation is a type of bioremediation that can be used in place of conventional heavy metal cleanup techniques. Using plants that accumulate metals, a procedure known as phytoremediation of metals uses radionuclides and organic contaminants to remove them from contaminated soils and water. It is an affordable, effective, environmentally conscious, and "green" method. 11-12.

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This review's objective is to provide readers with a fundamental grasp of phytoremediation the practice of using plants to remove heavy metals from the environment. The amount of heavy metals in the environment has sharply increased since the 1980s as industry and urbanization have expanded, posing severe implications around the world.

Common heavy metals/metalloids include chromium (Cr), cadmium (Cd), mercury (Hg), lead (Pb), arsenic (As), zinc (Zn), copper (Cu), nickel (Ni), and nickel-chromium (Ni) (Cr). In agriculture, phosphate fertiliser is used.

Based on their roles in biological systems, heavy metals are classified as either essential or non-essential. Heavy metals including Cu, Fe, Mn, Ni, and Zn are needed by plants at all phases of their life cycles for physiologic and metabolic processes (Cempel and Nikel, 2006). These metals could be dangerous, though, if there is an overabundance of them.

Hazardous heavy non-essential metals including Pb, Cd, As, and Hg are exceedingly toxic and have no known function in plants. Additionally, they might harm crop plants' ability to thrive, interfere with a number of physiological and biochemical processes, and pollute the environment. In order to lessen the amount of polluted land and prevent heavy metals from entering terrestrial, aerated, and aquatic environments, remediation techniques must be put into place 13.

Currently, heavy metal-contaminated soil can be repaired using a variety of remediation methods. The majority of these processes, such as soil burning, excavation and land filling, soil washing, solidification, and electric field application, use mechanical or physio-chemical techniques. 14-15.

The stability and reclamation of contaminated soil is made possible by plants. The main objective is to give a summary of recent advancements in phytoremediation techniques, including measures to improve the bioavailability, tolerance, and accumulation of heavy metals.

This work also emphasises the use of genetic engineering to improve plant performance during phytoremediation.

Sources of environmental heavy metals

The term "heavy metal" is frequently used to refer to elements with an atomic number > 20 and metallic properties16. By their very nature, metals are an essential component of soil. However, excessive amounts of metals can be poisonous to animals, plants, and microbes 17.

The possibility for heavy metal bioaccumulation in plants due to soil and water contamination has been highlighted in earlier studies. Studies show that phytoremediation, a method that uses plants to clean up places where heavy metal contamination has happened, can aid in ecosystem restoration. There have been several documented heavy metal removal facilities. Each plant responds differently to different heavy metal exposures. While some plants can tolerate heavy metals rather well, others are particularly susceptible to them. Some plants can accumulate heavy metals from the soil as a result of the interaction between plants and metals, which also inhibits growth and development. While some plants can still grow and develop normally in their heavy metal-free environments, other plants have a higher tolerance for exposure.

The majority of crops are chosen to limit the establishment of weedy plants, even though some may be highly attractive and imperil grazing animals. Deep-rooted plants should be used for more severe pollution, whilst shallow-rooted species should be used for contamination that just affects the soil's surface. Using living plants to remove toxins from the environment is known as phytoremediation. Phytoremediation is a green solution for heavy metal-contaminated environments. 19-20.

The production of safe food is now seriously threatened by heavy metal contamination, which has become a major global environmental problem. As tannery sludge application concentration increased, the amount of heavy metals increased. Phytoremediation is relatively simple to implement because it doesn't call for any expensive machinery or highly skilled employees. It can permanently treat a variety of pollutants in a variety of situations. Consequently, phytoremediation of contaminated environments offers an economical, efficient, and carbon-neutral method for the removal of hazardous contaminants from the environment. For environmental restoration, it is crucial to use plants that can hyperaccumulate, accumulate, exclude, and signal heavy metals. The majority of phytoremediation research use various methods referred to as phytoextraction (the use of metal collecting plants) to target inorganic contaminants.

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