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Methods for Remediation of Heavy Metals from Soil, a Review

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Abstract
A number of studies reveal the contamination of soil by heavy metals through various sources such as industrialization, urbanisation and many more. Another important source of heavy metals is wastewater irrigation, practised across the nations struggling with shortage of water. Though wastewater is a source of nutrients for soil still it may pose the soil to the risk of heavy metal contamination such as Pb, Cd, Hg, As, Cr, Ni etc. With the passage of time concentration of heavy metals may get increased in soil. Many studies indicate that heavy metals have been translocated into the plants and may become part of the food chain causing human health risk. Therefore there is a need toremove these. The review illustrates the methods such as phytoremediation, phytoextraction, phytostabilization and biochar application. A number of plants have been used as hypo accumulators for phytoremediation. Considerable research is still required to arrive at a certain conclusion.

Key words: Phytoremediation, phytoextraction, phytostabilization, biochar application

Introduction

A number of countries experience long droughts because of low production of food, due to shortage of water around the world. Therefore it may lead to global food shortage. Some of the countries have decided to practisethe wastewater irrigation so as toescalate food production[1].There may be accumulation of toxic heavy metals such as lead (Pb), cadmium (Cd), nickel (Ni) and chromium (Cr) in the soils due to irrigation with wastewatereffluent[2].It has been observed thatit is easier for theHeavy metals to accumulate in edible parts of leafy vegetables as compared to the fruits or the grains.Thismaylead to complicationsin thehealth of animals and human beings [3]**.**A number of Studies have revealed the increase of heavy metals in the plant tissues irrigated with wastewater.A study described higher concentrations of heavy metals in vegetables irrigated with wastewater than with fresh water [3].

Accumulation of Heavy metals in soil disturbs the normal functioning of soil ecosystem and growth of plant [4], [5]. Plants absorb various kinds of heavy metals when available in the soil or irrigation water [6].A research investigated the accumulation of some heavy metals in the different parts of spinach irrigated with secondary wastewater effluent treated through a pilot filtration system. Various heavy metals got accumulated differently in the roots, stem and leafy parts of the vegetable. Heavy metals such as copper, iron and zinc revealed high translocation factors in the stems than leaves, whereas arsenic, chromium, nickel, manganese

and lead had high translocation factors in the leaves than stems [7]. Another investigation revealedheavy matal accumulation in the vegetable spinach being grown in wastewater irrigated soils. Zn, Mn, Fe, Cu, Cr and Cd metals were found to have more concentration in roots and leaves of spinach irrigated with integrated industrial wastewater (IIW) than that irrigated with borewell water (BWW) [8]. Thus it becomes essential to remove heavy metals from contaminated soil.

Remediation

The circulation and processing of heavy metals by extraction from their ores for various applications resulted in the release of these elements into the environment. Being non-biodegradable, these get accumulated in the environment and consequently affect the food chain. This results into ecological and human health risk. Some of the heavy metals are carcinogenic, mutagenic, teratogenic and endocrine disruptors while others cause changes in nervous system and behaviour especially in children. Thereforedue attention should be paid to the remediation methods of heavy metal contamination. We can't think about physical and chemical methods as these suffer from serious limitations, such as high cost, toughlabour, modificationsin theproperties of soil and disturbance of soil native microflora. Contrary to this, phytoremediation is a healthierway out. Phytoremediation is the usage of plants and associated soil microbes to lessen the concentrations of contaminants in the environment[9].

Phytoremediation is an eco-friendly and cost-effective green technology taking advantage of the plants having capabilities of natural uptake through organization of roots, as well as translocation, bioaggregation or detoxifying abilities to purify the soil and water from toxic pollutants [10].

Phytoremediation is the method to detoxify the polluted environment i.e. water, soil and air with the help of plants. It is an eco-friendly and economic method to decrease the concentration of hazardous metals [11].Phytoextraction andPhytostabilization and are the sub processes involved in Phytoremediation of heavy metal-contaminated soils [12].

Phytoextraction involves the absorption of the contaminants like heavy metals by the plants through their roots and store in the tissue that can be harvested. Induced phytoextraction technique involves the conversion of heavy metals into water soluble compounds i.e. complexes by adding chelating agents in the soil. Roots of Plants can efficiently absorb the water soluble chelates. Few plants such as *Thalaspi*and *Arabidopsis* have hundred times more capability to take up non-essential elements or toxic elements because of their large biomass. There are more than 400-500 plant species of this kind and are known as Hyper accumulators [13].

Most of the plants can hyper accumulate one particular metal only. The declinein the mobility of heavy metals in soil is known asPhytostabilization.Contaminants are retained in the soil in Phytostabilization and further dispersal is prevented. Contaminants can be stabilized in the roots or within the zone of soil that immediately surrounds the root of plant i.e. rhizosphere [14].

In a study, soils were mixed with different concentrations of lead using lead salt. A plant *N. reynaudiana* was planted in the soils and variation in the concentration of lead in the soil, roots and shoots was found during stages of growth. It was concluded thatthe roots could absorb Pb and transfer maximum up to 79.45% to the shoots.Accumulation ability of the plant gradually was found to be increased with its growth but decreased above certain concentration of lead in the soil [15]. In a study in Indonesia, *Eleusineindica L.* was found to be the most tolerant plant out of *Eleusineindica L.*, *Ageratum conyzoides L* and *Euphorbia hirta L.*against Cd contamination, and also proven to be the suitable plant in reducing soil available Cd [16].

Chemical, physical and microbiological methods that are Conventional methods used for reclamation of contaminated soils are costly enough to set up and run.*Vetiveriazizanioides,* a

vetiver grass**,** can accumulate heavy metals, chiefly lead (shoot 0.4% and root 1%) and zinc (shoot and root 1%) [17].Phytoremediation is one of the cheap and alternative method as well as environmentally suitable approach to overcome contamination by toxic metalsand to clean up the heavy metals-contaminated sites [18].Low efficiency of remediation and disposal of biomass are the factors responsible for limited phytoremediation [19].

In a study it has been found that an activated P-loaded rice husk-derived biochar produced at 500 °C used for soil Pb remediation considerably reduced the bioavailability of lead and increased the bioavailability of Phosphorous in the soil [20]. Another study indicates that applying biochar could decrease the mobility and bioavailability of heavy metals in the soils and their accumulation in plants. Although biochar applications is advantageous for decreasing heavy metals in soil but could cause ecological and health risks, as biochar dust can be inhaled and secondly can release toxic substances into the soils [21].

Biochar acts as a great absorbent for heavy metals remediation from soils. Many factors affect the adsorption capability of biochar, such as the species and properties of raw materials, the methods of preparation [22].Biochar is a type of solid biofuel with high concentration of carbon and hydrogen and has a large specific surface area. Pyrolysis of Biomass such as plants, industrial and agricultural wastes, sludge and livestock manure, etc. is done in anaerobic environment at a temperature not higher than 1000 °C [23], [24]. A study examined the effectiveness of biochar made from different sources such as wood, and agricultural residues like sunflower and rice husks in remediation of soil. The maximum adsorption capacity for HM is found to be possessed by wood biochar because of its higher Brunauer-Emmett-Teller (BET) Specific Surface Areas and more aromatic functional groups [25].

Biochar is advantageous as it increases pH value and organic carbon content of soil, improves water-holding capacity of soil, reduces the available fraction of heavy metals, increases crop yield and obstructs the uptake and accumulation of heavy metals. The mechanismof interaction between biochar and heavy metals primarily includes complexation, reduction, cation exchange, electrostatic attraction and precipitation. These are affected by the pH value, dissolved organic carbon and ash content of biochar [26]. Another study describes that pH, cation exchange capacity, functional groups, porosity, and surface area are the key factors affecting the performance of biochar as heavy metal adsorbent.Physicochemical properties of biochar are upgraded by the process of activation consequentlyimproving its use as adsorbent [27].

Conclusion

Phytoremediation has been discussed a method to remediate soil contaminated with heavy metals in a number of studies. But review shows that low efficiency of remediation and disposal of biomass are the factors responsible for limited phytoremediation. Biochar made from different sources has been found to be another method for removing heavy metals from soil. But it may also pose ecological risk and health risk through release of toxic materials into soil or through inhaling dust of biochar. Plenty of research is still required to arrive at a certain conclusion.

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