AGRIALLIS
Science for Agriculture and Allied Sector: A Monthly Magazine
Volume 6, Issue 11
www.agriallis.com

Article Id
AL04401

RECLAMATION OF HEAVYMETAL CONTAMINATION IN SOIL: DIFFERENT APPROACHES

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There are currently many sites that contain soils contaminated with heavy metals and low levels of radionuclides. Soil contamination with toxic metals is a widespread environmental issue resulting from global industrialization within the past few years. Therefore, decontamination of heavy metal contaminated soils is very important to reduce the associated risks and for maintenance of environmental health and ecological restoration. Heavy metal-contaminated soil is one of the most common problems constraining cleanup at hazardous waste sites across the country. Heavy metals are natural components of soil, but human activities have increased their concentration. Sources of heavy metals in soil include excessive application of agrochemicals, sewage sludge, industrial wastewater, bio solids and manure. Consequently, heavy metal accumulation in soil causes severe health problems for plants, animals and humans. To overcome this, proper management or remediation is needed for future soil security and sustainability. This article briefs on various reclamation approaches involved in heavy metal contaminated soils.

Soil Remediation Technologies

Remediation is a concept of overcoming the issue or constrains at right present. Here when the soils are polluted with heavy metal contamination, it may increase the toxicity levels in the soil, thereby it directly affect the soil ecosystem. Like the living drivers of soil system are microorganisms, when it gets contaminated with heavymetals, all the enzymatic

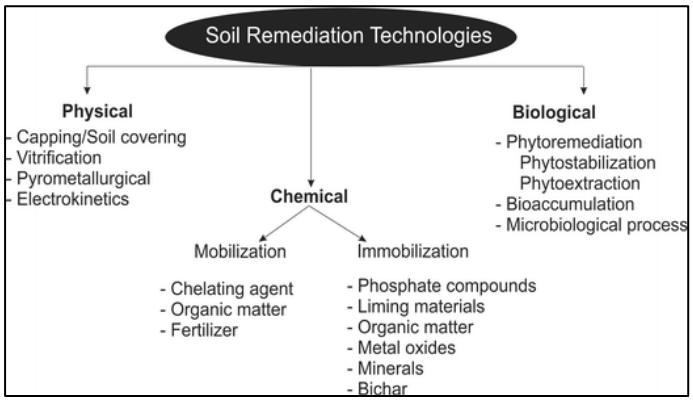

Fig. 1: Soil Remediation technologies

process from microorganisms are getting disturbed. To overcome this, there are remediation techniques are there. They are inclusion of Soil physical, chemical and biological approaches. The detailed techniques were illustrated in Fig. 1.

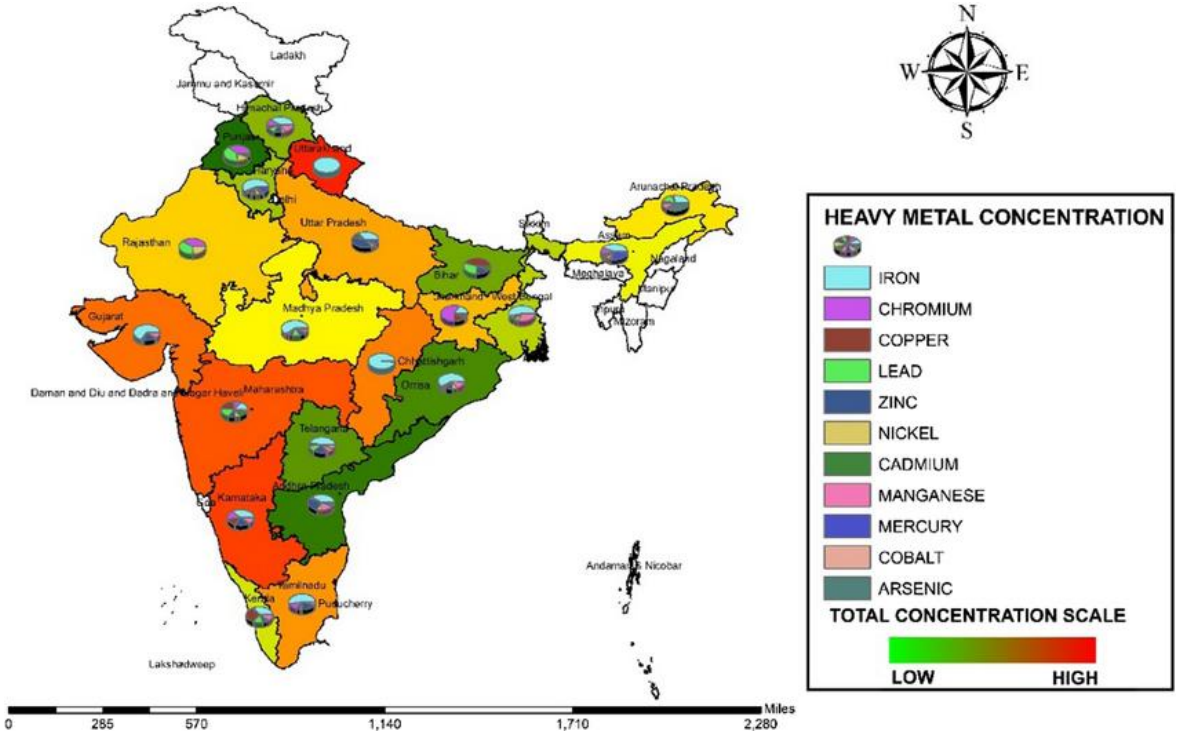

Fig. 2. Choropleth map showing state-wise distribution of heavy metals and total heavy metal concentration as on 2022 status.

Physical Remediation

Capping / Soil covering

It is the process by which the ground surface were isolated from the contaminated soil. It can be done using sand cap system both conventionally and technologically

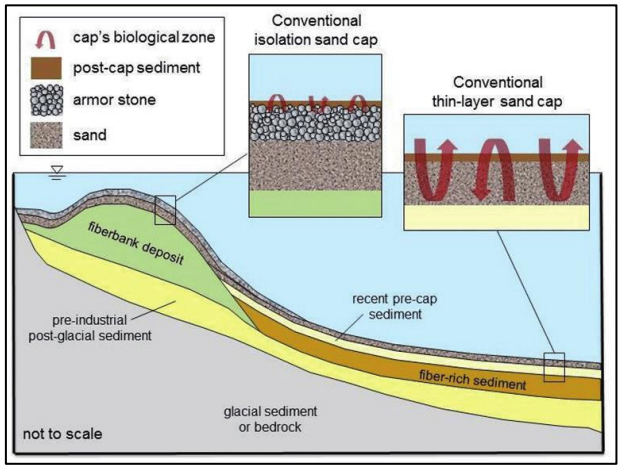

Fig. 3: Capping technology to overcome heavy metal pollutant in soil

Vitrification

Vitrification is a thermal treatment process that can be used to remediate heavy metal contamination in soil. Here, they use electricity to heat contaminated soil or sludge to high temperatures (1,600–2,000 °C) to create an inert glass product.

Pyrometallurgical process

It is the process of Pyrometallurgy emerges as a very promising, easy to adapt, and efficient route for recovery of the metallic fractions from WEEE. It includes the main pyrometallurgical methods like smelting, incineration, combustion, pyrolysis, molten salt, and pyrochemical processes. It is the most difficult and expensive one among other physical approaches.

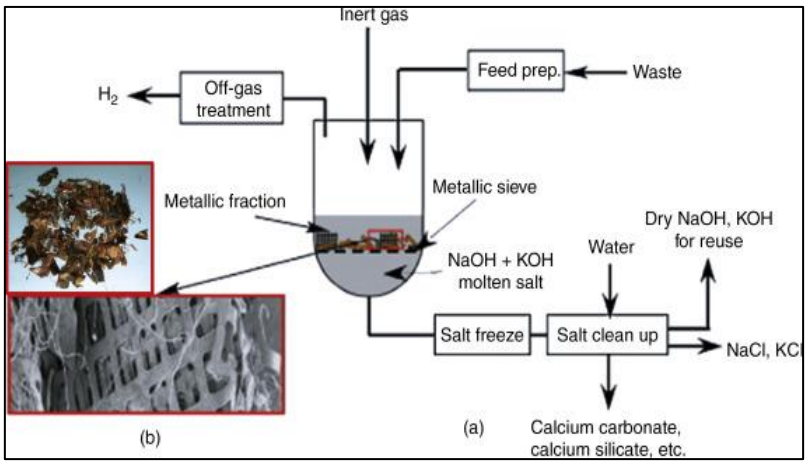

Fig. 4: Pyrometallurgical process to overcome heavy metal pollutant in soil

Electrokinetics

The electrokinetic remediation technology can separate the contaminated from the soil by electromigration, electropercolation and electrophoresis in the low density DC electric field.

Chemical approaches

By mobilisation behaviour, Chelating agents increase the solubility of heavy metals, promoting their uptake by plants to remediate heavy metal-contaminated soil. Although EDTA is one of the most widely used chelating agents and is very effective in promoting phytoremediation of Cd, Pb, and other heavy metal-contaminated soils by enhancing the mobility of heavy metals in soil, it has been suggested that EDTA is a potential risk to groundwater and drinking water due to its remobilization of metals from sediments and soil.

In Immobilisation process, application of liming material, phosphate compound, organic matter imposition and application of bio char can enhance remediation from polluted soil environment.

Organic matter chelated with heavy metals: The usefulness of organic matter contained for example in brown coal, brown coal-derived preparations and farmyard manure was used as a factor which decrease the uptake of heavy metals by plants and/or their migration within groundwater by immobilizing them in soil.

Bio char: Bio char amendment immobilizes heavy metals and POPs in contaminated soils and reduces their bioavailability primarily through precipitation, electrostatic interaction, surface adsorption, structural sequestration, and facilitated decomposition

Fig. 5. Bio char as an amendment to overcome heavy metal pollutant in soil

Biological approaches

Phytoremediation: Ryegrass, a genus of the Poaceae, is a heavy metal-enriched plant and a common cool-season turfgrass for lawn establishment in northern China owing to its rapid growth, well-developed root system, large biomass, and strong adaptability. It has good potential for certain heavy metals and is suitable for repairing heavy metals in soil. Ryegrass also shows good potential in phytoextraction for single metal Cd pollution and combined Cd and Zn pollution

Microbial process

Microorganisms can reclaim heavy metals in soil through a process called bioremediation, which uses microorganisms to clean up contaminated land and water. Microbes can absorb

heavy metals and convert them into less toxic forms. They can also precipitate, oxidize, and sequester heavy metals. Bioremediation is an efficient and cost-effective way to treat heavy metals. However, to make the process effective, optimal environmental conditions must be controlled to promote microbial growth and accelerate degradation

Bioaccumulation

Bioaccumulation is a process that can help reclaim heavy metals from soil through the use of plants or microorganisms.

Phytoaccumulation

Plants can absorb and accumulate heavy metals from the soil, and then translocate them to their aboveground biomass. This process is called phytoremediation, and it's considered an effective, economical, and environmentally friendly way to detoxify heavy metals. Some plants, called hyper accumulators, can accumulate higher concentrations of heavy metals in their tissues. For example, the plant *Thlaspi caerulescens* can accumulate high levels of cadmium and zinc.

Microbial bioaccumulation

Microorganisms like bacteria, algae, fungi, and yeasts can be used to bioaccumulate heavy metals from polluted environments. Bioremediation using microorganisms is an alternative to conventional techniques for waste management.

Conclusion

The heavy metals are amongst the most critical threats to the soil and human health. These metals are released into the environment through different sources. Conventional remediation techniques are costly and environmentally devastating. Therefore, it is unavoidable to implement low cost and eco-friendly technologies to remediate heavy metal polluted soils. Hence integrating bioremediation will be the most suitable and eco-friendly and budget one. Hence it is our responsibility to handle soil with care.

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