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# Microbial Remediation for Contaminated Soil Restoration

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Soil heavy metal pollution generally refers to the deposition of heavy metals, such as nickel, chromium, mercury, lead, cadmium, and other toxic heavy elements in the soil due to outcome of man-made activities. These heavy metals are not easily biodegradable, and through biological intensification, their concentrations can be augmented thousands of times, with major effects on human health. In recent years, discharges of large volumes of heavy metals from industrial and mining activities, leads to their deposition in the soil. Widespread use of pesticides and fertilizers in agricultural operations may also have led to an increase in heavy metal concentrations in the soil.

Heavy metal contamination in soil can be managed through two methods: (1) Traditional chemical, chemical restoration methods which involve curing and leaching and (2) ecological restoration methods involve adsorption and transfer. Traditional chemical methods usually engage direct reactions between chemical reagents and heavy metal ions, without any other promotion method, such as chelation and redox, while chemical restoration methods are often promoted by other methods, such as electrochemical repair. Nevertheless, traditional methods are often expensive, complicated, and may cause secondary pollution, and considerably alter the soil structure. Traditional ecological restoration generally includes the process called as phyto-remediation, i.e., the use of hyperaccumulators to absorb heavy metals from contaminated soils. The ecological restoration has become more widely used because of its lower cost and measurable ecological, social, and economic benefits.

**Bio-sorption**

Heavy metals can be accumulated by microbes either through adsorption or absorption, which are two main ways to increase metal ions in soil. The process of adsorption differs from absorption, in



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that a fluid (the absorbate) is dissolved by or permeates a liquid or solid (the absorbent). Thus, adsorption is a surface phenomenon, while absorption involves the entire volume of material.

**Bio-leaching**

Bio-mining is a common term that covers both bio-leaching and bio-oxidation. Bio-leaching involves the mobilization of positive heavy metal ions from insoluble ores often by biological dissolution or complexation processes. Microbial metabolism can produce secretions, such as low molecular weight organic acids, that can dissolve heavy metals and soil particles containing heavy metal minerals.

**Microbes assisted phyto-remediation**

Remediation of contaminated soils using plants is termed as phyto-remediation. Micro-organisms are used to enhance the process of phyto-remediation. Many microorganisms, *viz.*, bacteria, fungi, including mycorrhizal fungi and other organisms in the rhizosphere, can enhance the ability of plants to absorb or adsorb heavy metals (Dixit et al., 2015). Microbial remediation used for mitigating the heavy metal pollution of the soil has specific advantages including low cost and maintenance of the soil health and quality. Enormous microbial species, including bacteria (*Bacillus*, *Pseudomonas*) and fungi (*Aspergillus Rhizopus* and *Penicillium*) have significant removal ability (Table 1). *Synechococcus* sp. (cynobacterial strains) has been found to be good for metal ion removal (Huckle et al., 1993). Genetically modified *Ralstonia eutropha* has been found to reduce the toxic effect of the Cd (II) in the contaminated sites (Valls et al., 2000).

**Table 1. Heavy metals removal by Microorganisms**

| S.No | Microbes used | Heavy Metal removed |
|---|---|---|
| 1 | *Rhizopus arrhizus* | Cd, Zn, Cu, |
| 2 | *Saccharomyces cerevisiae* | Ag, Cu, Cd, |
| 3 | *Aspergillus niger* | Mn, Ni, Zn, Cu, Cr, Pb |
| 4 | *cherichia coli* K-12 | Cd, Pb, Cu, Ni, Zn |
| 5 | *Thiobacillus thiooxidans* | Cu, Pb, Zn, Cd |

**Factors determining microbial remediation**

| | |
|---|---|
| pH | It plays a major role in microbial remediation process. Optimum pH is required for microbial remediation with the range of 5.5–6.5, unsuitable pH leads to adverse effects on the microorganisms. |
| Temperature | Based on the microorganism used for remediation process, temperature varies. The most suitable temperatures generally range from 25 to 35 ˚C (i.e., the range is not significant |



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| | |
|---|---|
| Substrate Concentration | The concentration of heavy metal ions also affects the adsorption rate of microorganisms. Generally, a proper evaluation should be used to establish the quantification of the accumulative features of a bio-sorbent |

## Conclusions

Contaminated soils can easily be restored using microorganisms using various techniques like bio-sorption, bio-leaching and bioremediation. Microbes assisted remediation process in the contaminated soil could be achieved effectively only based on certain factors like microbes used for remediation process, pH, temperature and heavy metal concentration.

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