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Enhancing the Phytoextraction Capacity of Ornamental Plants by Organic Fertilizer: Review

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Abstract **Review Article**

Highly polluting the environment with heavy metals is a severe problem in almost every country on earth. These activities are including mining, ore processing, industrial effluents deposition, and agricultural pesticides application, etc. The importance of organic amendments in the rehabilitation of metal-contaminated soils may be seen in the improvement of soil physico-chemical properties as well as the increase in plant development. In previous studies, a variety of techniques, including as chelators, agronomic practices, genetic manipulation, and so on, were employed to improve phytoextraction. However, phytoextraction of heavy metals by means of organic fertilizer has been identified as one of the most promising strategies. As a result, it is critical to seek out creative, sustainable green solutions that may help crops perform better and are relatively straightforward to adopt.

Keywords: organic amendments, physico-chemical properties, agronomic practices, Organic Fertilizer.

INTRODUCTION

Phytoremediation

The use of phytoremediation strategies proven to be a suitable long-term option to less eco-friendly conventional methods of soil purification (Antoniadis *et al.*, 2017). Environmental phytoremediation is the use of plants and the microbes that live on them to remove toxic substances from their surrounding environment and to degrade or isolate them from the rest of the eco system. It entails the use of plants as a cleaning agent in situ to remediate soil systems. A variety of mechanisms may be employed in the purification process (Grzegórska *et al.*, 2020) such as phytoextraction, phytovolatilization, phytostabilization, phytodegradation, rhizodegradation, and rhizofiltration.

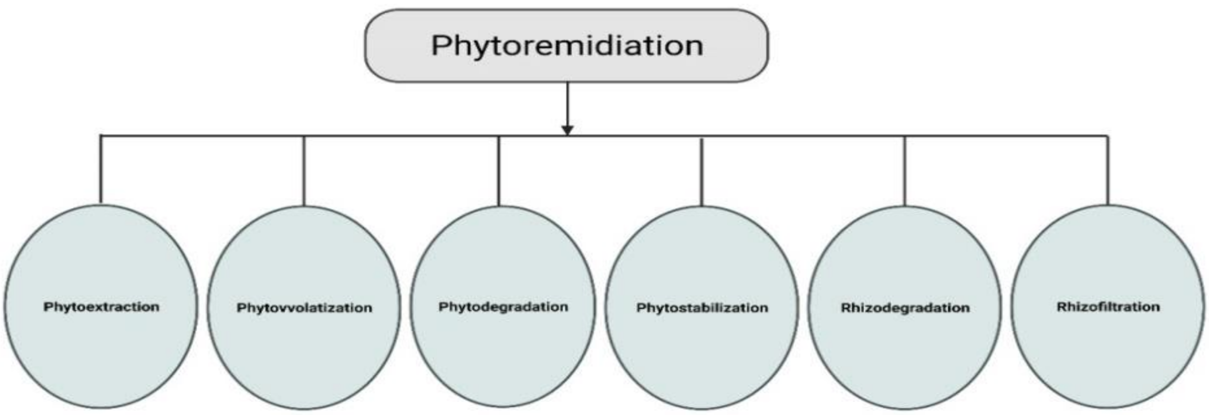

Figure 1: Mechanisms of phytoremediation with examples of removed pollutants

Phytoextraction

Phytoextraction, also known as phytoaccumulation, is a method used to remove toxins from the ecosystem. It is most commonly used to remove heavy metals and radionuclides from the environment, although it can be used to remove other contaminants as well. Beginning with the uptake of pollutants from soil or water and progressing via transport from roots to above-ground plant tissues and ultimately accumulation in these tissues, the mechanism of phytoextraction can be broken down into many steps.

After that, plants that have been exposed to pollutants are gathered. Plants with TF and BCF greater than 1 have the ability to be employed as extractives in the phytoextraction process. A number of recent researches have looked into the effects of phytoremediation on soil that has been polluted only once. Yang and Shen (2020) studied the possibility of *Typha latifolia* for cadmium cleanup in wetland soils and discovered that it has a high potential. The researchers discovered that the plant has good tolerance to pollutants; nevertheless, the higher concentration of metal in the roots compared to the shoots shows that the plant has a limited ability to transfer accumulated cadmium in the soil. *Sinapis alba* was used in a hydroponic or semi-hydroponic study by Holubk *et al*., (2020) to explore the elimination of thallium by the plant. The maximum metal content was found in the shoots in this case, indicating that the application of *S. alba* in phytoremediation is adequate for harvesting above-ground biomass in this situation. Using the plant *Linum usitatissimum*, Hamzah *et al*., (2020) conducted research on the phytoremediation of copper-contaminated soil. Copper concentrations in soils greater than 400 mg/kg were found to impede plant growth and biomass deposition. The copper was mostly absorbed by shoots 140 days after planting, with 39–43% of the initial Cu concentration being taken from the soil. Zhang and Liu (2019) evaluated the potential of *Gypsophila paniculata* to accumulate cesium and use it as a phytoremediation agent. This plant demonstrated excellent tolerance to the level of metals in the soil. Leaf and shoot accumulation were found to be highest in plants with a translocation factor greater than one. After 75 days, the amount of cesium extracted from the soil was approximately 10–12%. Many research publications have been reported about the effects of phytoremediation on soils that have been polluted by multiple contaminants. Marathe and Ravichandran (2019) researched into the ability of *Helianthus annuus* to remove heavy metals from soil that had been contaminated by landfill leachate. There were no indicators of injury to the crops, and the removal efficiency for lead was approximately 68 %, as was the removal efficiency for arsenic and mercury, which was 100 percent. Marchiol *et al*., (2004) investigated the potential of *Brassica napus* and *Raphanus sativus* to phytoextract heavy metals such as Cd, Cr, Cu, Ni, Pb, and Zn from polluted soils by growing them in a greenhouse. *B. napus* exhibited higher metal accumulation in shoots, but Raphanus sativus displayed greater metal accumulation in shoots. Both of these plants, on the other hand, had a low phytoremediation impact. *Chenopodium album* was found to have the ability to absorb metals from soil that has been modified with tannery sludge (Gupta and Sintha, 2007). The following elements accumulated in the plants: Fe > Mn > Zn > Cr > Cu > Pb > Ni > Cd. The largest concentrations of Cr, Pb, Fe, and Cd were found in the leaves, while the greatest concentration of Mn and Zn were found in the roots. Keeling *et al*., (2003) investigated the phytoextraction effectiveness of *Berkheya coddii* in soils that were single-contaminated with Ni or Co, as well as soils that were both single-contaminated with Ni and Co. According to the bioconcentration factor, plant absorption of both metals from a single-contaminated soil increases as overall metal concentrations grow. Plants quickly collected cobalt, regardless of whether or not nickel was present in the environment. The presence of an equal mass concentration of cobalt in the same solution, on the other hand, hindered the elimination of nickel. Heavy metals can accumulate in large proportions in these types of plants. The name hypperacumulator was initially used to describe a species that could accumulate more than 1000 mg/kg Ni in its aerial portions (Brooks and Wither, 1977), which was the first time the word was used. *Alyssum pintodasilvae* (Goncalaves *et al*., 2007) and *Alyssum murale* (Broadhurst *et al*., 2004) for nickel, *Pteris vittata* (Tongbin *et al*., 2000) for arsenic, *Solanum nigrum* (Sun *et al*., 2007) for cadmium, and *Arabidopsis helleri* (Zhao *et al*., 2000) for zinc are only a few examples of the plants that can be used to extract these metals. *Thlaspi caerulescens*, on the other hand, is a plant that demonstrates hyperaccumulation for both metals—zinc and cadmium—in its leaves (Vázquez *et al*., 1992).

Factors affecting the phytoextraction processes

Heavy metals bioavailability:

The solubility of the metals in the soil solution is the most important condition for metal accumulation by the plants. If a metal is not at least partly soluble in water, a plant will not be able to extract it from soil. In order for plants to benefit from it, the solubility fraction needs to be in a form that they can absorb. Metal fractions can be classified into three categories based on the accessibility of metal for plant uptake: available fractions, unavailable fractions, and exchangeable fractions. Free metal ions and soluble metal complexes can be found in soil solution as well as adsorbed to inorganic soil minerals at ions exchangeable sites, which is where the bioavailability of metals can be determined.

Unavailable metals are found in a variety of fractions, including those that are chemically bonded to organic matter, those that have precipitated as oxides, hydroxides, and carbonates, and those that are integrated in the structure of silicate minerals, and are therefore extremely difficult for plants to absorb and utilize.

Between available and unavailable are the exchangeable fractions, which include fractions bonded to organic matter, carbonates, and iron-magnesium oxides, which are not partially removed by plants and are therefore available for exchange (Li *et al*., 2014). In soils, the available and unavailable portions of heavy metals are frequently in equilibrium with one another. Once the available heavy metal fractions are depleted as a result of plant absorption, the remaining heavy metal fractions would be sourced from the unavailable fractions.

Approaches for enhancing phytoextraction
Organic fertilizer/amendments:

It has been shown that organic matter content is among the most essential soil components. Organic matter content has the capacity to keep heavy metals in soil as a result of metal-organic matter interactions, and as a consequence, it restricts metal phytoavailability. It has been demonstrated that increasing the amount of organic matter in the soil can help lower the amount of metal ions (Lu *et al*., 2005). Having the lowest organic matter content in polluted soils can cause plant growth to be hampered. Organic amendments can include things like chicken, cow and horse compost, sludge, biochar, and humic acids, among other things. According to Pillai *et al*., (2013), the effect of organic manure addition (1g powdered cow dung/kg soil) on the phytoremediation potential of *Vetiveria zizanioides*, which was grown on soil contaminated with chromium, was thoroughly investigated. In soils containing organic manure, a high level of biomass production was observed. Furthermore, the adding of cow dung precludes chromium toxicity, which was manifested as a yellowing of the plant leaves when the plants were grown in soil that did not contain organic amendments. With the addition of cow manure, the uptake of chromium by *V.zizanioides* was increased. Wai Mun *et al*., (2008) imposed chicken manure to enhance cleanup of sand tailings contaminated with lead by Hibiscus cannabinus, which was found to be a source of Pb contamination. Organic fertilizer application was found to increase biomass production while also increasing the accumulation capacity of lead in plant tissues.

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