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Role of medicinal plants in environmental pollution

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ABSTRACT

Soil pollution refers to the contamination of soil with anomalous concentrations of toxic substances. Heavy metals such as zinc (Zn), copper (Cu) and lead (Pb) are wall to wall in the environment due to natural and anthropogenic activities. Phytoremediation is the process which use plants as hyper accumulator to remove heavy metal from contaminated soil, is considered to be one of the most promising remediation methods. This study focused on the effects of medicinal plant extracts and plantation of medicinal plant to accumulate Cd, Pb, Zn, Cu from soil. These medicinal plants were common and relatively cheap. Among 10% aqueous extracts of plant, treatment with fruit of Phyllanthus emblica L. (FPE) resulted in the significant increase ($p < 0.05$) of Cd and Pb concentration in shoots and roots of S. nigrum. In the study of C.asiatica and O. stamineus, copper was highly accumulated in C. asiatica roots while the leaves were more concentrated with zinc and lead. Conversely, all three tested metals (Cu, Zn, Pb) were highly detected in the roots of O. stamineus, although the root elongation was not adversely affected. Low amount of metals in the stems of both species permits longer stem length. Based on the bioaccumulation, translocation and enrichment factor, study showed that C. asiatica was tolerant towards zinc, copper and lead; hence suitable for phytoextraction. By contrast, O. stamineus acted as a moderate accumulator of the tested metal elements. Snapdragon is another medicinal plant with low energy consumption, which has low requirements on environmental factors and strong resistance. This studies provided valuable information on improving the phytoremediation potential of hyper accumulator.

KEYWORDS:- Pollution, Phytoremediation, Hyperaccumulator, Phytoextraction

INTRODUCTION

Pollution is defined as an addition or excessive addition of certain materials to the physical environment (water, air, land), making it less fit or unfit for life. pollutants are the materials or factors, which cause adverse effect on the natural quality of any component of the environment. Soil pollution refers to the contamination of soil with anomalous concentrations of toxic substances. Heavy metals such as zinc (Zn), copper (Cu) and lead (Pb) are wall to wall in the environment due to natural and anthropogenic activities. Enormous development in industrial sectors has led to the productions of heavy metals that contaminate the surroundings and significantly accumulated in certain organisms.[1] However, current conventional techniques, such as the dig-and-dump approach, are expensive and may further contaminate more sites.[2]

The remediation of heavy metals such as cadmium (Cd) and lead (Pb) contaminated soil, is one of the world's biggest problems. Phytoremediation is the process which use plants as hyperaccumulator to remove heavy metal from contaminated soil, is considered to be one of the most promising remediation methods.[3] In phytoremediation, plants may adopt strategies such as phytostabilisation, phytoextraction, phytovolatilisation phytofiltration, phytodegradation, rhizodegradation and/ or phytodesalination.[4] The main functions of plants as accumulators, excluders or indicators have been suggested based on their potential to grow on metal contaminated soils.[5] The Accumulators take up heavy metals and translocate them into above ground tissues, while excluders avoid excessive transport of metal ions from root to shoot.[6] Generally, hyper accumulator refers to the plant with four basic characteristics of heavy metal accumulation including the accumulation content (for Cd hyper accumulator, Cd concentration in stem or leaf is greater than 100 mg/kg; for lead, it is greater than 1000 mg/kg); the translocation factor (TF > 1, i.e. the concentration of heavy metal in the shoot is greater than that in the root); the enrichment factor (EF > 1, the concentration of heavy metal accumulated in a plant is higher than that of in soil); and the tolerance capacity (no significant decrease in biomass)[7].

ROLE OF MEDICINAL PLANTS IN ENVIRONMENTAL POLLUTION ACCORDING TO DIFFERENT REPORTED STUDIES

STUDY 1. For amplifying the heavy metal concentration in hyperaccumulator, the effective method is to improve the bioavailabilities of heavy metals concentration in the polluted soil. The main methods in this regard are constructed electric field, or applying organic acids or chelators.[8] EDTA act as a chemical chelating agent and has an advantage in improving the bioavailabilities of heavy metals in polluted soil, but it also has the disadvantage of inhibiting plant growth.[9] Few studies have been conducted on the effects of remediation of heavy metals through plant etract from contaminated soil. Ning et al. (2019) found that the activation agent derived from lemon residue combined with N, N-bis (carboxymethyl) glutamic acid (GLDA) and tea saponin enhanced *S. alfredii* potential to accumulate Pb in soil without biomass reduction.[9]

The effects of aqueous extracts of the eight common and relatively cheap medicinal plants on *S. nigrum* accumulating Cd and Pb were compared. CK Control without any addition, EDTA 3 mM Ethylene diamine tetra acetic acid, 10% water extract from peel of *Citrus reticulata* Blanco, FPE 10% water extract from fruit of *Phyllanthus emblica* L, RPL 10% water extract from root of *Pueraria Lobata* (Willd.) Ohwi, RPS 10% water extract from rhizome of *Polygonatum sibiricum* Red, 10% water extract from root of *Astragalus propinquus* Schischkin, BHC 10% water extract from bud of *Hemerocallis citrina* Baroni, SNN 10% water extract from seed of *Nelumbo nucifera* Gaertn, FPM 10% water extract from fruit of *Prunus mume* (Sieb.) Sieb.etZuce.

The remediation capacity of hyper accumulator for the heavy metal contaminated soil is mainly reflected by the product of plant biomass with heavy metal concentration. Though EDTA treatment amplified the *S. nigrum* Cd and Pb concentration in its shoots and roots, the biomass was significantly decreased compared to CK, and thus the Cd and Pb loads. The addition of FPE treatment did not affect the biomass of *S. nigrum,* but significantly increased its Cd and Pb concentration. In general, the lower the soil pH is, the higher concentration of Cd and Pb is accumulated in plants.[10] Low pH improves the effects of organic acids on hyperaccumulators potential to remove heavy metal from the soil and accumulate them in their tissues.[11](Simek et al., 2018). Though the pH of EDTA was higher than the CK and FPE's pH was lower than CK. The results showed that among all exposures, the treatment with FPE resulted in the significant increase ($p < 0.05$) of Cd and Pb concentration in shoots and roots of *S. nigrum* The biomasses of *S. nigrum* in all plant extract treatments were not significantly changed ($p < 0.05$) compared to the control (CK). The Cd and Pb extraction rates of *S. nigrum* in FPE treatment were increased respectively by 60.5% and 40.5% compared to CK. Though the treatment with EDTA significantly improved ($p < 0.05$) the concentration of Cd and Pb of *S. nigrum*, the Cd and Pb masses (ug plant□ 1) of *S. nigrum* did not show any significant difference compared to the CK due to the significant decrease in the shoot (20.4%) and root (22.0%) biomasses. The chelative role of FPE might be relation with its higher polyphenolic compounds. However, not sure if the contents of polyphenolic compounds was the only differences between FPE and other additives.[12]

STUDY 2. Previous studies have shown that C. asiatica and O.stamineus have the ability to chelate or take up metals.[13]. *C. asiatica* grown in contaminated soil had significantly reduced root elongation compared with control plants. Since roots are in direct contact with soil, retardation of root growth is one of the implications of metal stress.[14] In *C. asiatica*, the highest amount of Zn and Pb were detected in the leaves, followed by the roots and stems. For *O. stamineus*, all metals were detected at the highest concentrations in plant roots, followed by the leaves and at the lowest amount in stems.

C. asiatica and *O. stamineus* accreted significant amounts of Zn, Cu and Pb in their tissues. In *C. asiatica*, the highest amount of Zn and Pb were detected in the leaves, followed by the roots and stems. [15] . High Pb content in the leaves suggests active translocations of Pb from roots to leaves. In contrast to Zn and Pb, Cu accumulation was higher in *C. asiatica* root system compared to leaves and stems. This indicates that Cu was not preferably or was only slowly translocated to the aboveground tissues in *C. asiatica*.

Correlation study showed that the accumulation of zinc, copper and lead in plant tissues varies depending on plant species and the type of metals. Based on the bioaccumulation, translocation and enrichment factor, our study showed that C. asiatica was tolerant towards zinc, copper and lead; hence suitable for phytoextraction. By contrast, O. stamineus acted as a moderate accumulator of the tested metal elements.[16]

STUDY 3. Another study of snapdragon in a pot-culture experiment under two concentrations of Cd (1.0 and 2.5 mg/kg) was evaluated. Snapdragon is a medicinal plant with low energy consumption, which has low requirements on environmental factors and strong resistance. The results showed that both Cd concentrations interfere with the uptake of B, P, Cu, Mn, Mo, and Zn by the soil. The results also showed that plant type and Cd stress can significantly change the concentrations and species of root exudates. The metabolic changes of root exudates revealed the active defense mechanism of plants to Cd stress: up-regulating of amino acids to sequester/exclude Cd, regulation of citric acid on chelation/complexation, and precipitation of cadmium ions. The application of snapdragon can effectively reduce energy consumption and gradually improve the utilization rate of vegetation, which promotes the degradation of cadmium pollutants in soil.[17]

CONCLUSIONS

These studies showed that applying some medicinal plant extracts and plantation of medicinal plants can facilitate phytoremediation. Among the eight aqueous extracts used in first study, only FPE significantly increased the *S. nigrum*'s potential in removing Cd and Pb from the soil without a significant effect on plant growth and some main soil environmental index. This study provided significant information to improve heavy metal phytoremediation approaches using green organic materials like medicinal plant extracts.. In second study, *C. asiatica* and *O. stamineus* had different strategies of removing heavy metals from soil. The roots of *O. stamineus* accumulated high concentrations of Zn, Cu and Pb, while the leaves of *C. asiatica* were more concentrated with Zn and Pb. The root of *O. stamineus* was more adaptive in contaminated soil as the elongation was not affected with high metal concentrations. The BCF, TF and EF values indicated the capacity of *C. asiatica* to extract metals and *O. stamineus* as a moderate accumulator of Zn, Cu and Pb. The application of snapdragon in third study reported effectively reduce energy consumption and gradually improve the utilization rate of vegetation, which reflects the concept of energy saving and environmental protection to a certain extent and meets the actual needs of low-carbon life. However, further investigation is required to better understand the improving mechanism of such organic material as phytoremediation agent.

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