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PHYTOREMEDIATION OF LEAD CONTAMINATED SOILS BY *RUELLIA TUBEROSA*, L.

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ABSTRACT

Human activities such as mining, transport, agriculture, waste disposal and military actions frequently release these inorganic pollutants in high and toxic concentrations. Heavy metal pollution causes potential ecological risk. Metals like Cadmium (Cd), Lead (Pb), Zinc (Zn) and Chromium (Cr) when present in high concentrations in soil exert potential toxic effects on overall growth and metabolism of plants and bioaccumulation of such toxic metals in the plant poses a risk to human and animal health. Phytoremediation is an Environmentally Sound Technology for Pollution Prevention, Control and Remediation. Phytoremediation consists of mitigating pollutant concentrations in contaminated soils, water, air or other sediments with plants able to contain, degrade, or eliminate metals, pesticides, solvents, explosives, crude oil and various other contaminants from the media that contain them. In the present study experiments were conducted using *Ruellia tuberosa*. . The species belongs to Acanthaceae family. *Ruellia* is commonly known as ruellias or wild petunias. Ruellias are popular ornamental plants. Some are used as medicinal plants. *Ruellia tuberosa*, also known as Minnie Root, Snap dragon Root and Sheep Potato, is a species of flowering plant in the Acanthaceae family. It is a small biennial plant with thickfusi form tuberous roots and striking funnel-shaped violet coloured flowers. Bioconcentration factor of lead was 10.19 and Translocation factor was 2.71. The plant species *Ruellia tuberosa* exhibited both BCF and TF values >1. *Ruellia tuberosa* was good accumulator of lead. The species can be recommended for the phytoextraction of lead contaminated soils.

Introduction:

Heavy metals (HMs) in soils primarily result from the weathering of parent materials and from human activities, which including mining, smelting, application of sludges, and discharge of wastewaters, etc. (Kabata-Pendias & Pendias, 2001). Soil contaminated with HMs has become a worldwide problem and pose a serious threat to the environment (Anwar et al., 2009), leading to losses in agricultural yield and hazardous health effects as they enter the food chain (Salt et al., 1995).

Human activities such as mining, transport, agriculture, waste disposal and military actions frequently release these inorganic pollutants in high and toxic concentrations. Heavy metal pollution causes potential ecological risk. Metals like Cadmium (Cd), Lead (Pb), Zinc (Zn) and Chromium (Cr) when present in high concentrations in soil exert potential toxic effects on overall growth and metabolism of plants (Agrawal and Sharma, 2006) and bioaccumulation of such toxic metals in the plant poses a risk to human and animal health.

Phytoremediation, the use of plants for environmental restoration, is an emerging cleanup technology. To exploit plant potential to remediate soil and water contaminated with a variety of compounds, several technological subsets have been proposed. Phytoextraction is the use of higher plants to remove inorganic contaminants, primarily metals, from polluted soil. In this approach, plants capable of accumulating high levels of metals are grown in contaminated soil. At maturity, metal-enriched aboveground biomass is harvested and a fraction of soil metal contamination removed.

There were many techniques been used to treat the HMs-contaminated soils which including isolation, mechanical separation, chemical treatment, electrokinetics, soil washing, and phytoremediation (Mulligan et al., 2001). The contamination of the environment with toxic metals has become a worldwide problem, affecting crop yields, soil biomass and fertility, contributing to the bioaccumulation and biomagnifications in the food chain *(Table 1)*. In the last few decades, research groups have recognized that certain chemical pollutants such as toxic metals may remain in the environment for a long period and can eventually accumulate to levels that could harm humans. Biological and engineering strategies designed to improve the use of phytoremediation to reduce the amount of heavy metals in contaminated soils has begun to emerge (Adriano et al 2004).

Essential processes involved in phytoremediation:

1. Phytoaccumulation: The uptake and concentration of contaminants (metals or organics) within the roots or aboveground portion of plants.

2. Phytoextraction: Element accumulating plants are established on contaminated soil and later harvested in order to remove the specific elements from the soil.
3. Phytoextraction: The use of plants at waste sites to accumulate metals into the harvestable, above-ground portion of the plant and, thus, to decontaminate soils
4. Phytoextraction coefficient: The ratio of metal concentration in the plant (g metal/g dry weight tissue) to the initial soil concentration of the metal (g metal/g dry weight soil) for phytoextraction of metals.
5. Phytomining: Use of plants to extract inorganic substances from mine ore.
6. Phytoremediation: Use of plants to remediate contaminated soil or water.
7. Phytostabilisation: Plants tolerant to the element in question are used to reduce the mobility of elements, thus, they are stabilized in the substrate or roots.
8. Phytovolatilisation: The uptake and transpiration of a contaminant by a plant, with release of the contaminant or a modified form of the contaminant to the atmosphere from the plant.
9. Rhizofiltration/ Phytofiltration: Roots or whole plants of element accumulating plants absorb the element from polluted effluents and are later harvested to diminish the metals in the effluents
10. Rhizosecretion: A subset of molecular farming, designed to produce and secrete valuable natural products and recombinant proteins from roots (M.N.V. Prasad, 2000).

The success of phytoextraction, as an environmental cleanup technology, depends on several factors including the extent of soil contamination, metal availability for uptake into roots (bioavailability), and plant ability to intercept, absorb, and accumulate metals in shoots (Ernst, 1996). Lead is a major metal contaminant notorious for posing a significant risk to humans, especially children. To date, approximately 400 plant species from at least 45 plant families have been reported to hyperaccumulate metals (Baker et al., 2000).

Plants exhibit 3 main strategies for managing potentially toxic metals. They can be classified as: (i) excluders, when elemental concentration in the shoot is maintained constant over a wide range of soil-metal contents; (ii) indicators, when uptake and transport of metals to shoots increase along with soil content; and (iii) accumulators, when metals accumulate in above-ground parts regardless of the soil concentration (Baker, 1981).

METHODOLOGY



Ruellia is commonly known as ruellias or wild petunias. Ruellias are popular ornamental plants. Some are used as medicinal plants, but many are known or suspected to be poisonous. *Ruellia tuberosa*, also known as Minnie Root, Fever Root, Snap dragon Root and Sheep Potato, is a species of flowering plant in the Acanthaceae family. It grows often as a weed even in ruderal habitats. Its names Popping Pod, Duppy Gun and Cracker Plant come from the fact that children like to play with the dry pods that pop when rubbed with spit or water. Its native range is in Central America but presently it has become naturalized in many countries of tropical South and Southeast Asia. It is a small biennial plant with thick fusiform tuberous roots and striking funnel-shaped violet-colored flowers. It reaches an average height of about 25 cm in moist and shady environments. In animal models, this plant has antinociceptive and anti-inflammatory properties. (Alam *et al*., 2009). In folk medicine and Ayurvedic medicine (Panda, 2002) it has been used as a diuretic, anti-diabetic, antipyretic, analgesic, antihypertensive, gastroprotective, and to treat gonorrhea. It is also used as a natural dye for textiles (Gamble, 2008e).

Results and Discussion

Accumulation of Heavy Metals in *Ruellia Tuberosa*

The metal concentration, transfer and accumulation of metals from soil to roots and shoots was evaluated in terms of Biological

Concentration factor (BCF) or Bioconcentration Factor (BCF) and Translocation Factor (TF). The Bioconcentration factor (BCF) of metals was used to determine the quantity of heavy metals absorbed by the plant from the soil. This is an index of the ability of the plant to accumulate a particular metal with respect to its concentration in the soil. Translocation factor (TF) was described as ratio of heavy metals in plant shoot to that in the plant root. TF was calculated to evaluate the potential of the species for phytoextraction or phytostabilzation. TF is an indication of the ability of the plant to translocate metals from the roots to the aerial parts. The TF value will be higher for those plants which retain the metal in roots without translocating to aerial parts. The TF value increases with increasing ability of the plant to translocate metals to stem and leaves. Thus the plants showing high BCF and TF values (greater than one) are suitable for phytoextraction. While the plants showing TF value less than one can be used for phytostabilization. Phytoextraction ensure elimination of the metal from the soil, as the plant absorbs the metals and store them in the roots, stem and leaves. Phyto stabilisation ensures adsorbtion metals on roots, concentration or agglomiration or precipitaion of metals in rhyzosphere. The plant which fails to translocate the metals can be used for phytostabilization. In the present study the plants have shown varied BCF and TF for each metal.

Accumulation of Lead (mg/kg) in *Ruellia tuberosa*:

A total of 96.54 mg/kg of lead had accumulated in Ruellia tuberose by 60th day. The absorption was highest in all the plant parts during the first 20 days. The stem and roots accumulated marginal qualities from 20-60 days where as leaves have accumulated consistently higher quantities of lead during 20-40-60 days. The trend of accumulation of lead revealed that the lead concentrations reached saturation by 20th day itself and hence the increase of concentrations from 20-40 and 40-60 was less than 1 mg/kg of lead. After 20th day whatever the lead the plant has absorbed is tanslocated to leaves. The total accumulation was highest in stem followed by roots and leaves (Table 1) the difference of total accumulation between the roots and stem in meagre.

Table 1: Accumulation of Lead (mg/kg biomass) in different plant parts of *Ruellia tuberosa* during the experimental period.

Plant part	Control	20th day	40th day	60th day	Total accumulation
Leaf	19.71±0.48	36.45±0.19	40.73±0.21	44.02±0.08	24.3
Stem	24.7±0.21	69.07±0.08	69.19±0.07	70.19±0.15	45.48
Root	34.56±0.11	59.94±0.16	60.21±0.13	60.31±0.16	25.75
Total Accumulation	78.98	165.46	170.13	174.52	96.54

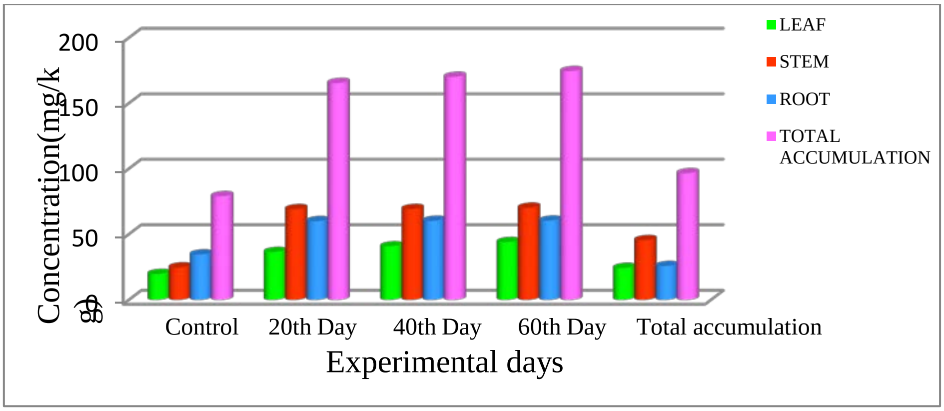

Fig 1: Accumulation of Lead in *Ruellia tuberosa* during the experimental period

Conclusion

Ruellia tuberosa was good accumulator of lead. The species can be recommended for the remediation of lead contaminated soils.