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Exploring Phytoremediation Potential of *Lantana camara* L. for Heavy Metal Pollution

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Abstract- Industrial effluents and mining activities pose a widespread concern globally. Traditional methodology for cleaning contaminated soils have been used for a long time. Therefore, natural metal hyper accumulator plants species are important for removal of heavy metals. *Lantana camara* L. is a widespread weed and popular ornamental plant of family of Verbenaceae. It is found throughout various regions of India and is extensively used in traditional medicine for various ailments. An attempt to investigate the environmental impact of heavy metal pollution on *Lantana camara* L. was carried out to find out their heavy metal accumulation capability and phytoremediation potential. Concentration of different heavy metals such as Iron, Zinc, Manganese, Nickle, Led, Chromium and Cadmium were analysed in aerial parts viz., shoots, leaves, flowers and fruits and they were in different ranges. This approach has shown promise in remediation efforts, particularly for areas contaminated with heavy metals and by determining the heavy metals in various plant parts suggested that this plant can be used as a hyper accumulator and potential phytoremediation agent.

Key words: *Lantana camara* L., Heavy metal, Pollution, Hyper accumulator, Phytoremediation.

INTRODUCTION

Soil is a crucial environment where rock, air, and water coexist at their interface. Soil pollution can be defined as the prolonged presence of radioactive materials, toxic compounds such as heavy metals, salts, and chemicals, or disease-causing agents that have detrimental effects on plant and animal health. This pollution primarily leads to the deterioration of soil quality, texture, and its mineral and chemical content, ultimately disrupting the biological balance of the ecosystem.

Soil contamination with heavy metals is a significant global crisis due to their varied toxicity, persistence, bioaccumulation, and bio magnification throughout the food chain.[1] This contamination adversely affects soil health on a large scale, impairing vital ecosystem services. Heavy metals are particularly harmful due to their non-biodegradable nature, long biological half-lives, and potential to accumulate in various body parts. Their solubility in water makes them extremely toxic even at low concentrations, posing severe health risks to humans and animals due to the difficulty of elimination from the body. Nowadays, heavy metals are widespread because of their extensive use in industrial applications. Wastewater often contains substantial amounts of these toxic metals, leading to significant environmental problems.[2,3]

Excessive accumulation of heavy metals in agricultural soils through wastewater irrigation can lead to soil contamination and affect food quality and safety.[4] Soils polluted with heavy elements such as chromium, arsenic, lead, cadmium, copper, zinc, mercury, and nickel assess a

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significant risk to resources of groundwater through heavy elements filtering.[5,6]

Phytoremediation refers to the mechanisms by which higher plants mitigate the chemical impacts of the soil they grow in. Essentially, it is an environmentally friendly, technique to accumulate heavy metals in plant tissues, allowing for the recycling of contaminated soils. The term "phytoremediation" originates from the Greek word "Phyto," meaning plant, and the Latin word "remedium," meaning cleaning or rehabilitation.[7] This method is low-cost, safety and practical, particularly for managing soil in developing countries.[8] The plant species used for phytoremediation belong to several families, including Asteraceae, Brassicaceae, Fabaceae, Poaceae, Euphorbiaceae, Verbenaceae, and Violaceae.[9]

Plants have a selective potential to accumulate heavy metals through phytoremediation.[10] When these phyto remediator plants enter the food chain, they can impair consumer health.[11-14] These plants can grow in contaminated soils because they have developed mechanisms to minimize the effects of heavy metal exposure.[15]

Phyto-remediator plants are categorized as hyper accumulators, excluders, or indicators based on their strategy for surviving in metalliferous soils.[16, 15] Excluder species restrict the translocation of heavy metals from their roots to above-ground tissues, maintaining low concentrations of these metals in their shoots across a wide range of soils.[15, 17]

Many research studies have been conducted and published on the phytoremediation potential of certain plant species for the removal of heavy metals from contaminated soils.[16,18-25] However, limited studies have assessed the phytoremediation potential of *Lantana camara* L. Therefore, the overall purpose of this study to assess the potential of selected plant species for heavy metal accumulation at Dahej industrial estate area (SEZ, GIDC) of Dahej, Bharuch, Gujarat, India by determining the concentration of heavy metals of various plant organs of selected plant species.

MATERIALS & METHODS

Plant materials:

Various parts of *Lantana camara* L. were collected from the Dahej industrial estate area (SEZ, GIDC) of Dahej, Bharuch, Gujarat, India.

Fig. 1- *Lantana camara* L.

Methods

The shoots, Leaves, Flowers and Fruits of selected plant organs were sun dried for a week. Ground to fine powder and stored in packed jar to protect from humidity and light. This powder was used for extraction and estimation of heavy metals. For extraction of selected metals, dry ash of plant samples was prepared. The contents of crucibles were cooled to room temperature in desiccators and 10 ml of 20% HCl was added, the mixture was heated to dissolve its content. Further it was run on Atomic Absorption Spectrophotometer under standard conditions for quantitative determination of Fe, Zn, Mn, Ni, Pb, Cr and Cd.

Statistical Analysis:

All the experiments were repeated thrice, and replicates were maintained for each experiment. The values are given as mean and standard error (SE). All the means were analyzed using one-way analysis of variance (ANOVA, $\alpha = 0.05$) followed by Tukey's test using Graph Pad Prism 6.01.

RESULTS

Shoot

Heavy metals accumulation in shoot of *Lantana camara* L. was found in different levels. Maximum accumulation has been detected for Fe (46.91±0.45 mg/kg) followed by Mn (30.17±0.09 mg/kg), Zn (17.86±0.19 mg/kg), Pb (17.47±0.15 mg/kg), Ni (4.85±0.10 mg/kg), Cr (3.26±0.01 mg/kg) and Cd (1.76±0.20 mg/kg).

Leaves

This study shows that the accumulation of different heavy metals is higher in the leaves then the shoot of *Lantana camara* L. The highest accumulation of Fe (66.91±0.45 mg/kg) and lowest accumulation of Cd (20.76±0.20 mg/kg) was found in the leaves. In the case of other metals, they were found in the ranges of Mn (50.23±0.09 mg/kg), Zn (37.86±0.19 mg/kg), Pb

(37.47±0.15 mg/kg), Ni (24.85±0.10 mg/kg) and Cr (23.26±0.01 mg/kg).

Flowers

Lantana camara L. flowers showed higher content of Zn (46.53±0.11 mg/kg), Mn (53.15±0.11 mg/kg) and Ni (25.76±0.09 mg/kg) with compared to leaves & fruits. Whereas leaves showed higher content of Fe (61.01±0.24 mg/kg) and Pb (33.46±0.05 mg/kg) compared to flowers & fruits. The proportion of Cr (23.21±0.12 mg/kg) and Cd (21.12±0.08 mg/kg) in the flowers was nearly similar in the leaves but slightly lower to fruits.

Fruits

In the fruits, the accumulation of Fe (52.03±0.12mg/kg) was higher and Cd (19.5±0.13 mg/kg) was lower than the other metals. Other metals were found in between ranges of Fe and Cd were Mn (37.37±0.04 mg/kg), Zn (35.78±0.23 mg/kg), Pb (26.23±0.10 mg/kg), Ni (22.10±0.12 mg/kg), Cr (20.99±0.12 mg/kg).

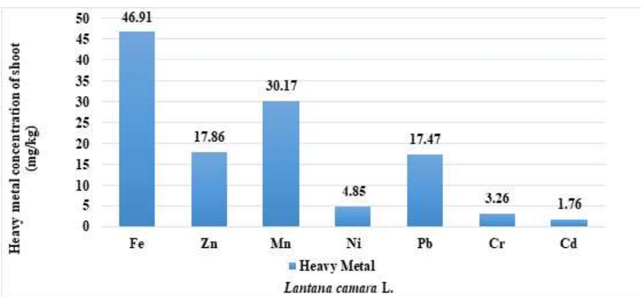

Fig. 2- Accumulation of different heavy metals in *Lantana camara* L. shoot. Each bar shows the mean values (n = 3) and error bar as standard error. Bars having same letters are not significantly different (p ≤ 0.05) according to Tukey's test.

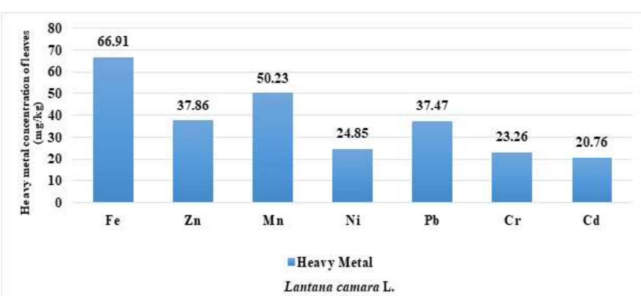

Fig. 3- Accumulation of different heavy metals in *Lantana camara* L. leaves. Each bar shows the mean values (n = 5) and error bar as standard error. Bars having same letters are not significantly different (p d" 0.05) according to Tukey's test.

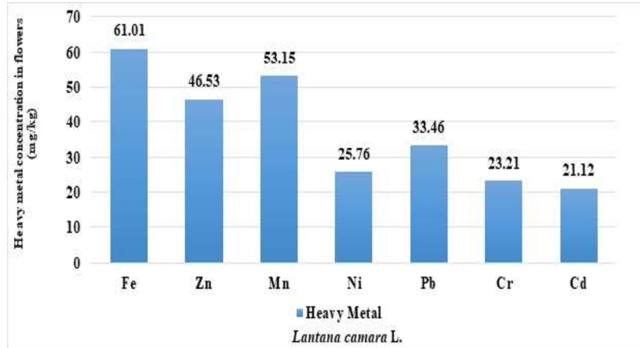

Fig. 4- Accumulation of different heavy metals in *Lantana camara* L. flowers. Each bar shows the mean values (n = 5) and error bar as standard error. Bars having same letters are not significantly different (p d" 0.05) according to Tukey's test.

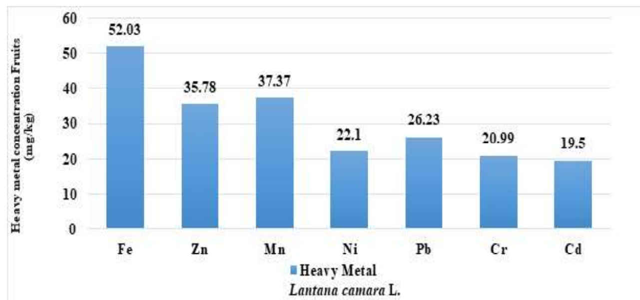

Fig. 5- Accumulation of different heavy metals in *Lantana camara* L. fruits. Each bar shows the mean values (n = 5) and error bar as standard error. Bars having same letters are not significantly different (p d" 0.05) according to Tukey's test.

DISCUSSION

The normal heavy metal contents of terrestrial plants growing in uncontaminated soils were found to be in range of 50 mg/kg for Pb, 0.5-2 mg/kg for Cr, 0.01-1 mg/kg for Cd, and 1-5 mg/kg for Ni. The present study showed that concentrations of Cr, Pb, Cd and Ni metal studied in the *Lantana camara* L. growing in Dahej industrial estate area were higher than the plant growing in normal soil. Thereby these plants have a strong ability to tolerate and accumulate these heavy metals. It is also found that, leaves, flowers and fruits of *Lantana camara* L. accumulated more metals concentration then shoot. Similar type of investigation by using four heavy metals Cr, Pb, Cd and Ni was also carried out in *Lantana camara* L. by Waoo *et al.* (2014)[26] and reported that the concentration of these heavy metals was higher in the plant growing industrially polluted area in Bhopal.

The normal range of heavy metals for Fe, Mn and Zn are 10.0 mg/kg. In this study the range of heavy metals concentration is comparatively also higher for these metals in *Lantana camara* L. Kahangwa *et al.* (2021)[27] suggested that there is a higher accumulation of heavy metals in organs of *Melinis repens*, *Lantana camara*, *Leucaena leucocephala* and *Blepharis Maderaspatensis*. They suggested that these plant species can act as hyper accumulator.

Phytoremediation mechanism of *Lantana camara* L. for the various metals like Hg, Ni, Pb, Cd, Cu, Cr, Fe and Zn were also evaluated by Panhekar *et al.* (2015)[28], Fang *et al.* (2014)[29], Pandey *et al.* (2015)[30], Pandey & Bhattacharya (2018)[31].

CONCLUSION

Now a day, heavy metal in the soil is a serious problem and a danger to both the human health and environment. Long-term exposure to contaminated environments can cause several health problems, including dizziness and cancer. Phytoremediation is an emerging technology of implementing green plants to reduce the toxic effect of heavy metals in the environment, which is cost-effective and an alternative to the conventional remediation approaches. Phyto-remediator plants have been categorized as hyper accumulators, excluders or indicators according to their strategy for surviving metalliferous soil. This study was conducted to assess the potential of phytoremediation technology, focusing on the efficacy of *Lantana camara* L. plant. Results revealed that the heavy metals concentrations in the investigated plant species exceeded normal values, indicating higher accumulation, particularly in plant like *Lantana camara* L. in the area under study. The results also showed that the accumulation of heavy metals in medicinal plants depends upon the climate of locality, air pollution, soil contamination and other environmental factors where the plants grow. In order to revegetate in soil polluted by metals, the physiological impact of the pollution on plant species should be studied in further details. As the heavy metals fluctuate in plant as well as in soil sample from site to site therefore each medicinal plant should be analyzed before utilization for pharmaceutical or traditional medicinal purposes.

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