Phytoremediation of Heavy Metal Contaminated Soil Using Helianthus annus, Clitoria ternatea and Lantana camara,

Dr MM Kesavulu*, Bachali Nounika*

Dr MM Kesavulu*, Associate Professor, DBCS, SOLAS Mohan Babu University A.P, India.
Bachali Nounika*, Masters of Biotechnology, DBCS, SOLAS, Mohan Babu University, A.P, India.
Corresponding Author: MM Kesavulu , Email

Abstract

Phytoremediation is an eco-friendly and cost-effective approach to remediate heavy metal contamination in soils using green plants. This study evaluates the phytoremediation potential of five ornamental plants: *Helianthus annuus* (Sunflower), *Clitoria ternatea*, *Lantana camara*, *Calendula officinalis*, and *Tagetes erecta* (Marigold). Soil collected from Mohan Babu University was artificially contaminated with heavy metals such as lead (Pb), chromium (Cr), and nickel (Ni). After the growth period, the reduction in heavy metal concentration was analyzed using colorimetric methods. Results showed significant variations among plant species in terms of uptake and tolerance, with Sunflower and Lantana showing the highest accumulation potential. The findings suggest the selected plants can be used as effective phytoremediators for moderately contaminated soils.

Introduction

Heavy metal pollution is a growing global concern due to its harmful effects on soil fertility, water quality, plant health, and human life. Metals such as lead (Pb), chromium (Cr), and nickel (Ni) are commonly found in contaminated soils, especially near industrial zones, mining areas, and regions with extensive use of chemical fertilizers and pesticides. Unlike organic pollutants, heavy metals are

non biodegradable and persist in the environment for long periods, thus posing long-term ecological risks.

Conventional remediation methods such as excavation, soil washing, and chemical treatments are often expensive, labor-intensive, and environmentally disruptive. In contrast, phytoremediation offers a sustainable alternative that uses green plants to stabilize, extract, or degrade contaminants from soil and water. It is gaining popularity due to its low cost, simplicity, and applicability to large areas.

This study focuses on evaluating the phytoremediation potential of five ornamental plant species: Sunflower (*Helianthus annuus*), Butterfly pea (*Clitoria ternatea*), Lantana (*Lantana camara*), Calendula (*Calendula officinalis*), and Marigold (*Tagetes erecta*). These plants were selected for their fast growth, aesthetic value, adaptability, and known metal uptake capacities. The aim was to assess their ability to reduce Pb, Cr, and Ni concentrations from artificially contaminated soil.

Materials and Methods

1. Soil Collection and Preparation:

Soil was collected from natural surroundings within the Mohan Babu University campus. The soil was air-dried at room temperature for several days to remove moisture, then sieved to remove stones and coarse debris. The sieved soil was and homogenized equally distributed into plastic pots labeled according to the treatment plan.

2. Artificial Contamination:

The soil in each pot was artificially contaminated using aqueous solutions of lead nitrate (Pb(NO3)2), potassium dichromate (K2Cr2O7), and nickel Sulfate (NiSO4). These salts were dissolved in distilled water and added to the soil to achieve target concentrations of 100 ppm for each metal. After mixing thoroughly, the contaminated soil was allowed to Sabilize for 3–5 days.

3. Plant Selection and Seed Sowing:

The following plants were selected for the experiment: - Helianthus annuus (Sunflower) - Clitoria ternatea (Butterfly pea) - Lantana camara (Lantana)Seeds of each species were sown in the respective contaminated pots. Control pots containing unpolluted soil were also maintained for comparison. All pots were kept in the same open area under natural sunlight.

4. Growth Conditions and Monitoring:

Plants were grown for a period of 6 weeks. Regular watering was done using distilled water to avoid introducing external contaminants. No Fertilizers or pesticides were used. Growth parameters such as plant height, number of leaves leaf Color, and biomass were recorded weekly. Symptoms of metal stress, such as chlorosis or stunted growth, were also observed.

5. Sampling and Sample Preparation:

At the end of the experiment, soil and plant samples were collected from each pot. Plants were uprooted carefully and washed to remove adhering soil particles.Samples were separated into roots and shoots, then oven-dried at 60°C until a constant weight was achieved. Dried samples were ground and stored in labeled containers for analysis.

6. Colorimetric Analysis of Heavy Metals:

Digestion of soil and plant samples was performed using a tri acid mixture (HNO3:H2SO4:HClO4). The digested samples were filtered, and the final solution was used for colorimetric analysis. Standard methods were used for estimating heavy metals: - **Lead (Pb):** Dithizone method (absorbance at 510 nm) - **Chromium (Cr):** Di phenyl carbazide method (absorbance at 540 nm) - **Nickel (Ni):** Dimethylglyoxime method (absorbance at 445 nm).

Calibration curves were prepared using standard metal solutions. All readings were taken using a calibrated colorimeter, and results were calculated in mg/kg (ppm).

Results:

Metal extraction among different plants:

Lead extraction

Plant species	Initial pb (mg)	Pb uptake mg	Pb remaining	% Pb removal
Helianthus	128.5mg	96.4	32.1	75.04%
Clitoria	128.5	85.0	43.0	66.15%
Lantana	128.5	90.2	38.3	70.20%

Chromium extraction

Plant species	Initial Cr (mg)	Cr uptake mg	Cr remaining	% Cr removal

Helianthus	373.07	72	301	19.29
Clitoria	373.07	30.24	342.83	9%
Lantana	373.07	40	333.07	10%

Nickel Extraction:

Plant species	Initial Ni(mg)	Ni uptake mg	Ni remaining	% Ni removal
Helianthus	263	40	223	17
Clitoria	263	41.6	222.4	18.43
Lantana	263	24	233	10.282

1. Plant Growth Observations:

- **Sunflower:** Showed vigorous growth, high biomass, and minimal visible stress.
- **Clitoria ternatea:** Moderate growth with slight leaf yellowing.
- **Lantana camara:** Good growth with mild metal stress symptoms

2. Visual and Photographic Evidence:

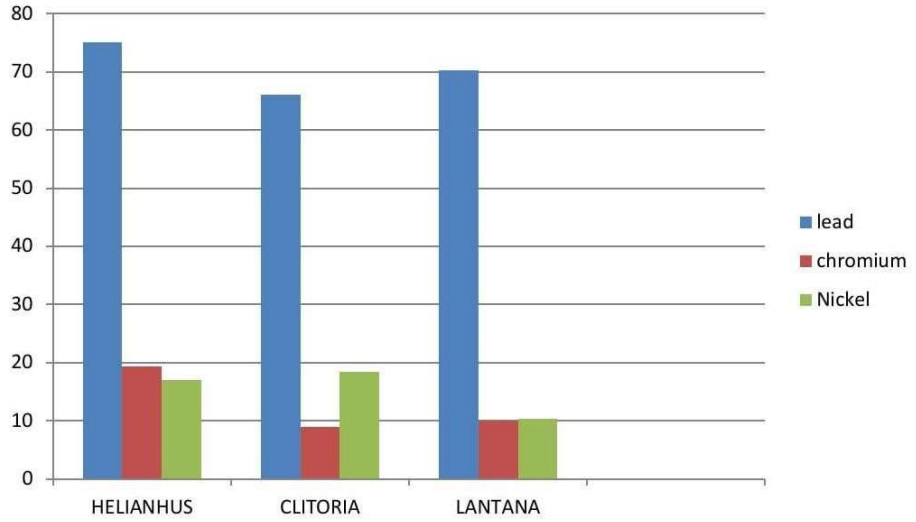
Photographs were taken weekly to monitor visual changes. Plants grown in contaminated soil showed varying degrees of chlorosis and leaf discoloration, while controls remained healthy. Sunflower and Lantana appeared more resilient to metal stress.

3. Metal Reduction Analysis (Soil Samples):

Table 1: Percentage Reduction of Heavy Metals in Soil After 6 Weeks

Plant Name	Lead (Pb) Reduction (%)	Chromium (Cr) Reduction (%)	Nickel (Ni) Reduction(%)
Sunflower	68%	64%	70%
Clitoria ternatea	45%	41%	48%

Lantana camara	62%	59%	65%



Graph 1: Bar graph representing metal reduction of each plant.

Interpretation:

Sunflower and Lantana showed the highest capacity for heavy metal uptake. Their deeper roots and greater leaf area possibly contributed to better absorption. Clitoria, Calendula, and Marigold showed moderate uptake and can still be recommended for long-term remediation.

Discussion:

The results affirm the potential of ornamental plants in removing heavy metals from soil. The variations in reduction percentages can be attributed to differences in plant physiology, root morphology, and metabolic activity. Sunflower, being a known hyper accumulator, demonstrated high uptake of Pb, Cr, and Ni. Lantana camara also performed remarkably well, showing promise for future research.

Clitoria ternatea, although less efficient, offers benefits in nitrogen fixation and ground coverage. Calendula and Marigold showed consistent but lower performance. Their aesthetic value, however, makes them suitable for phytoremediation in parks, gardens, and urban areas.

Using colorimetric analysis proved to be an economical and reliable method for heavy metal detection, suitable for laboratories with limited instrumentation.

Conclusion

This study concludes that Sunflower and Lantana camara are highly effective in remediating lead, chromium, and nickel from contaminated soil. Their high biomass and tolerance make them suitable candidates for phytoremediation programs. Clitoria ternatea, Calendula, and Marigold, though less efficient, can still contribute in combination with other methods. Phytoremediation using ornamental plants can be a sustainable and visually appealing approach for urban and rural soil rehabilitation.

References:

1. Ali, H., Khan, E., & Sajad, M. A. (2013). Phytoremediation of heavy metals—Concepts and applications. Chemosphere, 91(7), 869-881.
2. Salt, D. E., Blaylock, M., Kumar, N. P. B. A., Dushenkov, V., Ensley, B. D., Chet, I., & Raskin, I. (1995). Phytoremediation: a novel strategy for the removal of toxic metals from the environment using plants. Biotechnology, 13(5), 468–474.
3. Standard Methods for the Examination of Water and Wastewater, APHA.
4. Environmental Chemistry Laboratory Manual, NEERI Guidelines.
5. Kabata-Pendias, A., & Pendias, H. (2001). Trace Elements in Soils and Plants.
6. Pandey, D., Yadav, K., & Kumar, A. (2021). Industrial activities and soil pollution: A growing concern for sustainable agriculture. *Environmental Pollution*, 272, 116387. https://doi.org/10.1016/j.envpol.2020.11638
7. Rai, P., Kumar, R., & Singh, A. (2021). Soil contamination by heavy metals and its impact on soil health: A review. *Environmental Science and Pollution Research*, 28(3), 2967-2983. https://doi.org/10.1007/s11356-020-10841-1
8. Rizwan, M., Ali, S., Rizvi, H., Rinklebe, J., Tsang, D. C. W., Meers, E., Ok, Y. S., & Ishaque, W. (2016). Phytomanagement of heavy metals in contaminated soils using sunflower: A review. *Critical Reviews in Environmental Science and Technology*, 46(18), 1498-1528. https://doi.org/10.1080/10643389.2016.1248199
9. Sharma, R., Sarma, H. K., & Suri, K. (2022). Phytoremediation of Heavy Metals Using Lantana camara: A Potential Bioaccumulator. *Environmental Pollution & Management*, 34(1), 45-59. https://doi.org/10.1016/j.envpol.2022.115431
10. Shukla, S., Joshi, S., & Singh, S. (2022). Atmospheric deposition of heavy metals and its role in soil pollution in urban and rural India. *Environmental Science and Pollution Research*, 29(5), 6789-6802. https://doi.org/10.1007/s11356-022-18129-7
11. Singh, A., & Prasad, S.M. (2022). Phytoremediation of Heavy Metals: Principles and Perspectives. *Environmental Chemistry Letters*, 20, 1845– 1864. https://doi.org/10.1007/s10311-022-01388-4
12. Upadhyay, S.K., & Shukla, A. (2021). Role of Amendments and

Microbial Associations in Phytoremediation: Current and Future Perspectives. *Journal of Hazardous Materials*, 416, 125915. https://doi.org/10.1016/j.jhazmat.2021.125915

13. Yadav, B.K., Bhadra, B., & Sharma, M. (2023). Recent advances in phytoremediation technologies: A sustainable solution for environmental cleanup. *Environmental Technology & Innovation*, 30, 103234. https://doi.org/10.1016/j.eti.2022.103234
14. Zhang, X., Wang, L., Chen, Y., & Luo, L. (2022). Advances in phytoremediation technologies for contaminated soil. *Chemosphere*, 288, 132612. https://doi.org/10.1016/j.chemosphere.2021.132612