ORIGINAL RESEARCH PAPER

Chemistry

ROLE OF NATIVE PLANT SPECIES IN PHYTOREMEDIATION OF HEAVY METALS FROM CONTAMINATED SOIL AT ATRAULI AND PANETHI

KEY WORDS: Native Plant Species, Phytoremediation, Heavy Metals, Contaminated Soil.

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ABSTRACT

The motivation behind this study is to see if certain native plants in Aligarh, Uttar Pradesh, India, have the ability to gather and endure synthetic contamination. Two areas were picked: one near a huge modern zone and the other around 35 kilometers from modern action. The measures of cadmium (Compact disc), lead (Pb), copper (Cu), zinc (Zn), and fluoride (F) were estimated on soil and plant tests that were accumulated. The normal plants being scrutinized, Chenopodium collection and Bassia indica, gave no obvious indications of poisonousness. The higher soil layers were found to have minimal natural matter substance and to be basic. The area nearest to the modern zone has the most elevated groupings of heavy metals and fluoride. It was found that the native plants' underlying foundations, stems, and leaves had groupings of Cd, Cu, Pb, Zn, and F that were higher than their normal reaches and phytotoxic values. For each component, the natural collection factor (BAF), movement factor (TF), and bioconcentration factor (BCF) were determined. The picked plants were classified as gatherers, pointers, and excluders for every component in view of these standards. The native plants under concentrate on show a lot of commitment for phytoremediation and might be utilized as biomonitors in contaminated soils. Given its efficacy as a fluoride excluder, Bassia indica, which has been found to be an accumulator of Cd, Cu, and Pb, may be a great choice for phytoextraction and Phyto stabilization.

INTRODUCTION

When non-living factors in a specific environment injure living creatures, it's known as abiotic stress. Stressors include pesticides, heavy metals, nutritional inadequacies, cold, salinity, low or high temperatures, and other extreme weather conditions. Worldwide, abiotic stressors such heavy metals, dry season, and inordinate salt are the primary drivers of harvest misfortune. Plants are dependent upon ecological impacts at the sub-atomic, cell, tissue, physical, morphological, and physiological levels influencing the whole plant.

Heavy metals are linked to environmental issues. Human health is impacted by phytotoxicity, heavy metal pollution-induced soil degradation, and contaminated water and soil. The global public, policymakers, and scientists are concerned about their effects on the environment. Human health is harmed by heavy metal pollution in the environment. Rehabilitating contaminated soils has involved the use of ex-situ physiochemical soil cleansing and heavy metal toxin immobilization. The low cost and environmental advantages of phytoextraction make it a preferred method for removing metal pollutants from disturbed soils. Global pollution of groundwater and soil with lead. There are various methods for stopping or eliminating cadmium pollution. Reducing soil and water pollution can be achieved by limiting Cd-contaminated phosphate fertilizers, limiting landfill and mine Cd levels, and using clean wastewater. Pollution of the food chain can be avoided and soil mercury removed in a number of methods. One approach is to chemically cleanse the soil and add agricultural nutrients. High-biomass cultivars can improve root-to-shoot transfer and soil heavy metal solubility with the correct chemicals.

The non-essential element cadmium (Cd), which is present in many soils, is for both people and plants. The food chain's biota is in danger. The primary nutrient transporters, Cu, Mn, Fe, and Zn, help plants absorb Cd as well, making Cd regulation more difficult. More than two to twenty times as harmful as other heavy metals is cadmium. Stabilizers, batteries, semiconductors, and electroplating all use CD from Zn smelting. Countries with high phosphoric (P) manure use have more elevated levels of Cd in their soil. Soil Compact disc assimilation and (re)distribution among roots and shoots are constrained by root cell plasma film metal carriers, xylem and phloem stacking/dumping, leaf/shoot sequestration, and detoxification. Cadmium is consumed by plant roots, and their accessibility is affected by the rhizosphere, natural acids, and pH. Cd influences quality and protein articulation, breath, hydration and nourishment consumption, compounds, ROS, lipid peroxidation, and digestion.

Naz, et. al. (2022) studied Hayat Abad Modern Domain in Peshawar for soil and plant cadmium (Cd). Bioconcentration Element (BCF), Movement Variable (TF), and Bioaccumulation Coefficient were determined to assess plant phytoremediation. They developed normally. At 50 areas, soil cadmium contents went from 11.54 to 89.80 mg/Kg. HIE-ST-16L Marble City and HIE-ST-7 Bryon Pharma had the most elevated cadmium values (89.80 mg/Kg) and HIE-ST-14L Imperial PVC Line and HIE-ST-11 Aries Pharma the least (12.47 and 11.54 mg/Kg). Most plant species were appropriate for phytoremediation and extraction.[1]

Leguizamo, M. A. O. (2017) focused on native herbaceous plant species from Bogota's wetlands for heavy metal phytoremediation. For such, the writers searched a bibliography using heavy metal decontamination keywords. In addition, authors collected and evaluated data to understand phytoremediation. This report advises studying 41 native or endemic species response to heavy metal exposure. Native and endemic herbaceous plants from prominent heavy metal accumulation groups were selected from a Bogota survey. These are found around the world, including Colombian wetlands. Because of their worldwide presence and phytoremediation potential, they are of incredible interest. Ebb and flow phytoremediation research recognize new herbaceous species that can purify heavy metal-dirtied foundation to concentrate on the biology and climate of nature's remainders in metropolitan wetland biological systems.[2]

Singh, S. (2022) evaluated the remediation capability of native plants in Nadia locale's Dakshin Panchpota town, which was harmed. Site soil and water tests had higher arsenic and heavy metal levels. Of the 28 plants analyzed from the contaminated locale, ten natural and seven land and water proficient plants had bioaccumulation factors (BCF) > 1, suggesting their help in as remediation and site revamping. Althernanthera ficoides had the most critical as conglomeration and development (TF > 1) of all-natural plants inspected, making it suitable for as-contaminated soil remediation. Shoots have more as than establishes in Phyllanthus amarus and Crandon dactylon, demonstrating phytoextraction potential. The best sea-going plants for as cleanup were Eicchornia crassipes and Marsilea quadrifolia. Plant tissues might endure and gather Fe, Zn, Cu, and Cr notwithstanding As. Subsequently, this investigation discovered that normally developing plant species can remediate contaminated destinations with high heavy metal fixations and assist with reestablishing the climate, however a few collectors have restorative properties.[3]

Marrugo-Negrete, J. (2016) worked at the Alacrán gold-mining site, one of Colombia's most huge ASGM objections, to perceive native plant species in Hg-contaminated rustic soils and survey their phytoremediation limit. 24 native plant species were pursued for outright Hg (THg) in roots, stems, leaves, and soils. Shoot accumulating factors (AF), root-to-shoot development (TF), and soil-to-root bioconcentration (BCF) were assessed. Roots, leaves, and starts from all plant species were situated by Hg collection. Soil THg values went from 230 to 6320 mg g□ 1. Higher TF values were found in lower Hg-contaminated soils (0.33-1.73).[4]

The purpose of this work to assess native plant toxicity and choose optimal phytoextracted species and phytoremediation methods and To compare heavy metal levels (cadmium, lead, copper, zinc) and fluoride in soil and plant tissues near an industrial zone versus a reference site distant from industrial operations.

Methodology

All collected samples were analysed, using the various techniques in the present study.

Description of the Study Area

The study region was Aligarh, which is in the Indian state of Uttar Pradesh. Its semi-arid climate is typified by monthly average temperatures of approximately 12.5°C in the winter and 35.2°C in the summer. There is erratic and heavy precipitation; the average annual rainfall is between 600 and 800 mm. Due to their separation from the industrial zone, two fields were chosen for this investigation. Site 1: The region's main source of chemical pollution is located close to a significant industrial district. This industrial area is linked to the discharge of heavy metals and fluorides from several manufacturers, among other contaminants. Site 2: A reference location that is comparatively clean and situated about 32 kilometers away from the industrial activity.

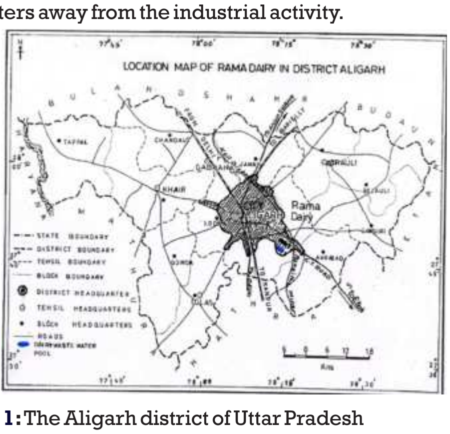

Figure 1: The Aligarh district of Uttar Pradesh

Plant inspecting and synthetic analysis

Plant species were chosen for overflow, occurrence, and availability in Aligarh, Uttar Pradesh, India's contaminated zones. This study used native Amaranthaceae Bassia indica and Chenopodium album. Dr. Rajesh Kumar from Aligarh Muslim University's Department of Botany identified B. indica and C. album voucher specimens in the university herbarium with references AMU-01/024 and AMU-02/024.

Sites were tested for complete plants aimlessly. All plant tests were washed with refined water to take out dust. The stems, leaves, and groundworks of each plant were disconnected, oven dried in paper packs at 60°C for 48 hours, and took care of into powder with an electronic blender. Test powder was taken care of at 4°C. The Buszewski et al. strategy assessed plant tissue heavy metals. A 1 g powdered example was mineralized at 550°C for 3 hours, handled with 50 cc of 1M HNO3, and filtered over a 0.44 μm cellulose acidic corrosive deduction layer. An atomic digestion spectrophotometer assessed metals. Each example was triple-analyzed. For 3 hours at 550°C, 1 g of the grounded test was lighted with 8 g of a potassium and sodium carbonate blend to choose fluoride obsession, then, handled with 50 ml of 1M hydrochloric destructive We attempted handled materials with potentiometry and molecule chromatography.[5]

Soil sampling and analysis

Both Aligarh areas gave 0-20 cm soil samples, which were fixed and moved to the lab. A 72-hour broiler drying at 60°C eliminated dampness from the soil. The ISO 10390:2005 standard was utilized to quantify pH. A soil suspension in multiple times its measure of refined water was disturbed for 1 hour and permitted to agree to 2 hours before pH was estimated with a convenient multi-boundary meter HI9828. ISO 11265:1994 was utilized to quantify electrical conductivity (EC) by dissolving soil in water at a 1/5 proportion, unsettling, sifting, and estimating EC (dS m^{-1}) at 25°C utilizing a Hanna Instruments multi-boundary meter. The ISO 11277 sifter pipette strategy estimated soil surface. The Walkley-Dark wet oxidation technique estimated soil natural carbon (SOC).

The Bernard calcimeter technique determined the extent of all out-calcium carbonate ($CaCO_3$). Water regia eliminated heavy metals. To dry a 5 g sample of dried soil, 20 ml of concentrated HCl and HNO_3 (3:1, v/v) was warmed on a plate at 150°C. Drain the buildup with 100 ml of 5% HNO_3, then, at that point, channel the concentrates utilizing 0.45 μm cellulose acetic acid derivation layer channels. Assimilation and extraction were finished in three-fold, and heavy metals were surveyed spectrochemical with a nuclear retention spectrophotometer. Fluoride was estimated potentiometrically.

Statistical Analysis

The mean worth ± standard deviation (SD) of the tree rehash tests was used to impart the data. The Quantifiable Pack for the Social sciences (SPSS) version 20.0 programming was used to play out the two-way examination of change (ANOVA) approach for the authentic examinations. Using a matched t-test, the importance of the differentiations in soil quality estimations between the reference site and the contaminated not completely settled. The India's test was used to choose if there were basic mean differences at $P<0.01$ and $P<0.05$.

RESULTS AND DISCUSSION

Soil characterization

With a sandy loam texture, Atrauli and Panethi's soil characteristics are contrasted in the table 1. The pH of Panethi's soil is 9.40, which is more alkaline than that of Atrauli's, which is 8.00. Panethi has a substantially higher electrical conductivity (EC) (4.04 mS cm^{-1}) than Atrauli (2.59 mS cm^{-1}), which suggests that Panethi is more salinized. Additionally, Atrauli has a greater total carbonate content (15.88%) than Panethi (9.75%), which could be a factor in the higher pH of the soil.

Table 1: Lists the metallic trace elements and soil characteristics for both study sites.

Properties	Atrauli	Panethi
Surface	Sandy loam	Sandy loam
pH	8.00 ± 0.13 b	9.40 ± 0.19 a
EC (mS cm^{-1})	2.59 ± 0.29 b	4.04 ± 0.35 a
$CaCO_3$ (total carbonate, %)	15.88 ± 0.45 a	9.75 ± 0.88 b
SOC (%)	0.95 ± 0.17 b	2.49 ± 0.23 a
Cd (mg kg^{-1})	3.39 ± 0.40 a	2.29 ± 0.17 b
Pb (mg kg^{-1})	39.35 ± 5.25 a	8.45 ± 2.84 b
Zn (mg kg^{-1})	155.00 ± 19.99 a	131.79 ± 9.35 b
Cu (mg kg^{-1})	5.28 ± 0.30 a	4.32 ± 0.22 b
F (mg kg^{-1})	1016.69 ± 172.48 a	244.90 ± 1.50 b

Atrauli has a smaller proportion (0.95%) of soil organic carbon (SOC) than Panethi (2.49%), indicating a higher organic matter content in Panethi's soil. Cadmium (Cd) levels for heavy metals are greater at Atrauli (3.39 mg kg^{-1}) than at Panethi (2.29 mg kg^{-1}). The concentration of lead (Pb) at Atrauli (39.35 mg kg^{-3}) is significantly greater than that at Panethi (8.45 mg kg^{-3}). Additionally, Atrauli's soil has a higher concentration of zinc (Zn) (155.00 mg kg^{-1}) than Panethi's (131.79 mg kg^{-1}). The values of copper (Cu) at Atrauli (5.28 mg kg^{-1}) are somewhat greater than those at Panethi (4.32 mg kg^{-1}). The concentration of fluoride (F) at Atrauli (1016.69 mg kg^{-1}) is significantly higher than that at Panethi (244.90 mg kg^{-1}).

These variations in soil characteristics may have an impact on plant uptake and environmental quality by influencing the mobility and distribution of metals in the soil.[6-8]

Water Quality Factors for Irrigation Use

The pH, electrical conductivity (EC), and metal content variations between the two sites—Atrauli and Panethi—are highlighted in the table 2 that displays soil parameters. The pH of the soil at Atrauli is 7.69, which is marginally lower than the pH of 8.16 at Panethi. There are more significant ions present in the Atrauli soil, as indicated by the higher electrical conductivity (EC) at Atrauli (4.19 mg/L) compared to Panethi (3.04 mg/L). Cadmium (Cd) values for heavy metals are comparable at Atrauli and Panethi, at 0.032 mg/L and 0.030 mg/L, respectively. In both places, the levels of lead (Pb) and zinc (Zn) are below detectable limits (BDL). The concentration of copper (Cu) at Atrauli (0.085 mg/L) is marginally more than that at Panethi (0.074 mg/L). Moreover, Atrauli has a higher concentration of fluoride (F) (2.15 mg/L) than Panethi (1.64 mg/L). The observed disparities in metal accumulation between the sites may be partially explained by these variances in soil qualities, which can also affect how plants absorb metals.[9-11]

Table 2: Study Sites' Soil Properties and Metallic Trace Elements in Soil Solutions

Properties	Atrauli	Panethi
Cu (mg/L)	0.085 ± 0.03 a	0.074 ± 0.02 b
F (mg/L)	2.15 ± 0.07 a	1.64 ± 0.03 b
Cd (mg/L)	0.032 ± 0.02 a	0.030 ± 0.02 b
Zn (mg/L)	BDL	BDL
Pb (mg/L)	BDL	BDL
EC (mg/L)	4.19 ± 0.29 a	3.04 ± 0.59 b
pH	7.69 ± 0.25 b	8.16 ± 0.03 a

Heavy Metals Contents in Plants

The research shows that Bassia indica and Chenopodium album accumulate heavy metals differently across plant organs and places. At Atrauli, Bassia indica leaves have the highest quantities of Lead (Pb), Cadmium (Cd), Copper (Cu), and Zinc (Zn). Cd, Pb, Zn, and Cu accumulate from leaves to roots to stems. Pb and Zn are highest in the stems at Panethi, while Cu is highest in the leaves. Cd, Pb, and Cu accumulation patterns change significantly, but Zn does not, demonstrating site-dependent metal intake and distribution.

Atrauli data shows that Chenopodium album roots have the highest Zn, leaves the highest Pb, and roots the highest Cd, with accumulation patterns of Roots > Leaves > Stems for Cd, Pb, Zn, and Cu. Stems have the most Pb and roots the most Zn at Panethi. Panethi had no Cd, and Pb, Zn, and Cu patterns were similar to Atrauli, demonstrating that environmental conditions may affect metal availability and uptake differently.[12-15]

Table 3: Heavy Metal Aggregation (mg kg^{-1}) in Native Plant Organs at Various Sites

Site	Plant Organ	Cd	Pb	Zn	Cu
Bassia indica					
Atrauli	Leaves	5.60 ± 0.14	56.60 ± 0.49	116.0 ± 8.0	9.39 ± 1.6
	Roots	3.65 ± 0.3	54.18 ± 1.3	76.89 ± 3.7	4.59 ± 0.4
	Stems	2.39 ± 0.2	66.0 ± 1.1	95.58 ± 0.9	3.55 ± 0.2
	Aggregation	L > R > S	S > R > L	L > S > R	L > R > S
Panethi	Leaves	1.10 ± 0.15	1.30 ± 0.09	76.7 ± 1.3	7.45 ± 0.3
	Roots	1.95 ± 0.10	1.59 ± 0.3	59.7 ± 1.5	3.5 ± 0.27
	Stems	1.40 ± 0.14	5.65 ± 0.13	84.35 ± 3.0	2.5 ± 0.3
	Aggregation	R > S > L	S > L > R	S > L > R	L > R > S
Site X Organ	p-value	<.002	<.001	0.070 (NS)	<.001
Chenopodium album					
Atrauli	Leaves	0.45 ± 0.09	6.35 ± 0.14	49.69 ± 1.4	7.79 ± 0.7
	Roots	0.58 ± 0.05	2.6 ± 0.3	80.65 ± 0.4	3.45 ± 0.6
	Stems	0.37 ± 0.10	3.87 ± 0.17	59.35 ± 2.2	4.89 ± 0.2
	Aggregation	R > L > S	L > S > R	R > S > L	L > S > R
Panethi	Leaves	BDL	2.05 ± 0.03	28.13 ± 1.7	4.0 ± 0.4
	Roots	BDL	0.8 ± 0.04	62.7 ± 1.1	1.6 ± 0.2
	Stems	BDL	1.17 ± 0.2	32.14 ± 1.4	2.4 ± 0.3
	Aggregation	---	L > S > R	R > S > L	L > S > R
Site X Organ	p-value	NS	<.001	0.004 (NS)	<.001

CONCLUSION

This research demonstrates the important role that native plant species Chenopodium album and Bassia indica play in the phytoremediation of fluoride and heavy metals from contaminated soils in Aligarh, Uttar Pradesh. The findings suggest that both plant species significantly absorb zinc (Zn), fluoride (F), lead (Pb), copper (Cu), and cadmium (Cd) from contaminated locations, with Bassia indica demonstrating the greatest potential for cadmium, copper, and lead accumulation. Both plant species showed hyper-accumulation levels in spite of the high concentrations of these pollutants, suggesting that they do not reach excessive levels of metal deposition. Using their bioconcentration, translocation, and accumulation factors, the researchers categorized Chenopodium album and Bassia indica as accumulators, indicators, or excluders in the study. According to this classification, these indigenous plants may be useful as biomonitors for contaminated soil and in phytoremediation processes. The results highlight the possibility of utilizing these plants in environmental remediation plans to deal with fluoride and heavy metal contamination in areas impacted by industry.

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