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Plant-Based Removal Of Soil Pollutants Using Ornamental Species From Public Parks

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Abstract
The present research looked at how well specific ornamental plants (Nerium Oliande and Acacia) removed soil contaminants at different concentrations of lead (Pb), zinc (Zn), and cadmium (Cd: 5, 10, and 20 ppm) in public parks in Babylon Governorate, Iraq. Time, concentration, and plant species all have a significant impact on removal efficiency. The acacia (49.94%) and nerium (51.06%) had the lowest removal effectiveness for cadmium during the first month. The maximum efficiency occurred in 20 ppm in the third month, reaching 95.92% for Acacia and 95.89% for Nerium. The effectiveness of high cadmium removal was shown by both Acacia and Nerium, particularly after two and three months of exposure. Although there was a little difference at first, both species' performance soon became equivalent. Excellent phytoremediation capabilities for lead-contaminated soils were demonstrated by Acacia and Nerium. In the first month, a minimum removal of 75 ppm of lead was noted, with nerium being removed at 41.12% and acacia at 37.5%. Over the course of three months, the effectiveness of continuous Pb removal improved, reaching the maximum lead removal of 300 ppm with acacia at 95.93% and Nerium at 96.04%. Acacia fared well in the early phases and at low concentrations, although Nerium performed somewhat better. In terms of zinc, Acacia (49.94%) and Nerium (51.06%) had the lowest levels, with 50 ppm in the second month. Acacia (95.92%) and Nerium (95.89%) had the maximum ejection effectiveness in the third month at 150 ppm. With peak performance in the third month, both plant species showed a time-free improvement in removal efficiency overall. Nerium performed exceptionally well at low concentrations in the early stages, while Acacia performed marginally better at high metal concentrations. These species have shown a high capacity for long-term phytoremediation of soil dated with Cds, Pb, and ZN. This makes them appropriate for combined use in phytoremediation strategies in a number of contaminated sites.

INTRODUCTION

According to Tang et al. (2024), heavy elements are a class of chemical elements distinguished by their high density and big atomic weight. They have the ability to accumulate these elements in soil and transport them to plants and ground water, posing a threat to ecosystems and public health (Jhao et al., 2015; Rai et al., 2022). Because they are not biodegradable, heavy metals persist in the environment and have a detrimental effect on plant development and production (Mahar et al., 2016; Wang et al., 2024). When they enter food systems, they can lead to major health problems like cancer, immunological illnesses, and neurological disorders (Jhao et al., 2015; Pandey and Singh, 2023). In light of these challenges, phytoremediation has emerged as a permanent solution, taking advantage of plants to remove or stabilize heavy elements in the soil (Tangahu et al., 2011; Liu et al., 2023). Decorative plants are promising especially due to their adaptability for harsh conditions and aesthetic value, which suit them for urban green places (Goddess et al., 2024). These plants employ mechanisms such as active absorption, bios activation and bio transforms to accumulate metals in roots, stems, or leaves (Yan et al., 2022; AL-Janabi *et al.*, 2025). The purpose of this investigation. Evaluating the ability of plants (Nerium and Acacia) to remove heavy metals (lead, zinc, and cadmium) from the soil. and Examine the impact of varying heavy metal concentrations and time periods on elimination. Plant Efficiency The results validate the feasibility of employing attractive plants for economical and environmentally beneficial soil restoration in urban and industrial settings.

MATERIALS AND TECHNIQUES

Preparation of the sample

After collecting the sandy loamy soil, it was ground and sieved to remove contaminants and plant debris. Subsequently, five kilos of earth were put into each 10-kilogram container. Three duplicates of each sample had holes in the bottom of these containers. All of the plant samples were produced with identical ages and lengths. Before planting, the Preparation Method for Heavy metals.

- Cd: 5, 10, 20 ppm- Cadmium chloride ($CdCl_2$),
- Pb: 75, 150, 300 ppm- Lead nitrate ($Pb(NO_3)_2$),
- Zn: 50, 100, 150 ppm- Zinc sulfate heptahydrate ($ZnSO_4 \cdot 7H_2O$)
- 1 ppm = 1 mg of metal per 1 kg of soil.
- Therefore, for 5 kg of soil: Required mass (mg) = concentration (ppm) × 5

Heavy Metal	Concentration required (ppm)	Heavy Metal required (mg)	Salt required (mg)
Cd	5	25	40.8
Cd	10	50	81.6
Cd	15	100	161.2
Pb	75	375	600
Pb	150	750	1200
Pb	300	1500	2400
Zn	50	250	1101
Zn	100	500	2203
Zn	200	750	3304

Using the metal percentage in salts as a foundation, calculate:
PB $(nO_3)_2$ = 62.5% PB, $cdcl_2$ = 61.3% CD, and $znso_4 \cdot 7h_2o$ = 22.7% zn.

Getting a soil sample ready

For each treatment, fill a clean plastic container with 5 kg of air and dry soil. And Each metal salt's calculated mass should be dissolved in 100–200 milliliters of distilled water. To prevent cross-power, use different utensils and containers for each metal. Then, while continually mixing, add a metal solution to 5 kg of dirt. - Make the dirt thoroughly and ensure dispersion using spatula or mechanical mixer. And than For five to seven days, cover the treated soil and let it balance at room temperature. - If required, add a tiny bit of distilled water to maintain a slight moisture level. Lastly, provide the metal type and concentration for each soil treatment.

For the purpose of calculating the concentration of elements in the soil, 0.5 g of each air-dried, finely ground, and sieved soil sample was placed in a digestion tube. The containers were divided into three groups, with plants grown in the containers and three replicates for each sample. The first group's soil element concentration was determined after one month, the second group's after two months, and the third group's after three months. After measuring and adding 6 and 1.5 milliliters of distilled water (H2O2) to the digestion tube, the sample was well mixed by gently shaking it. The digestion tubes were then placed in a digestion oven (Model: KDN-20C, China) and heated at 180°C for 3 hours. After cooling, all digested samples were filtered through Whatman No. 42 filter paper and diluted with twice-distilled water to equal 50 milliliters. Five duplicates of each sample were digested before being moved to a glass bottle that had been sealed and cleaned with acid, labeled, and kept for atomic absorption spectroscopy mineral analysis.

Where: Removal Efficiency (%)=(C1−C1/C1)×100

- C1: The metal's initial concentration in the soil or solution (before to planting), expressed in ppm or mg/L;

- C2: The metal's final concentration in the soil or solution (after treatment), expressed in ppm or mg/L

Findings and Analysis

Table (1) Removal efficiency of Acacia and Nerium plants for cadmium in contaminated soil				
Month	Concentration	Type of plant		Mean ± SD
		removal efficiency of Acacia	removal efficiency of Nerium	
First month	0	0	0	0±0
	5	49.94%	51.06%	50.50±0.79
	10	66.49%	68.35%	67.42±1.31
	20	86.14%	79.63%	82.89±4.6
	Mean ± SD	50.64±36.8	49.76±35.1	50.20±0.62
LSD(P<0.05)	Type of plant= 0.720 concentration= 1.019 interaction= 1.441			
Second month	0	0	0	0±0
	50	89.36%	89.02%	89.19±0.24
	10	90.58%	90.32%	90.45±0.18
	20	93.47%	93.45%	93.46±0.01
	Mean ± SD	68.35±46.6	68.20±45.5	68.28±0.10
LSD(P<0.05)	Type of plant= 0.224 concentration= 0.310 interaction=0.518			
Third month	0	0	0	0.00±0
	5	93.06%	93.12%	93.09±0.04
	10	94.31%	94.23%	94.27±0.04
	20	95.92%	95.89%	95.91±0.02
	Mean ± SD	70.82±47.2	70.81±47.2	70.82±0.007
LSD(P<0.05)	Type of plant= 0.204 concentration= 0.289 interaction= 0.412			

Variations in phytoextraction efficiency according to plant variety, metal content, and exposure time were shown in the results (Table). Observation during the first month In the initial month: The elimination effectiveness at 5 ppm Cd was modest, with 51.06% in Nerium and 49.94% in Acacia. Efficiency increased significantly at 10 ppm (66.49% acacia, 68.35% Nerium) and at 20 ppm (86.15% acacia, 79.64% Nerium). These results support the idea that an increase in soil metal availability boosts phytoectures' capability, as both species are capable of effectively accumulating Cd, particularly in high-risk environments (Ali et al., 2013). Perhaps as a result of their deeper root systems and higher biomass, Acacia performed marginally better in the highest concentration. Two-month observation in the second month: Removal capacity increased quickly across all concentrations. Both species achieved values over 89% at 50 ppm. - The readings increased to 90.5% at 10 ppm and more than 93% removal in both plants at 20 ppm.(Qassim and Mohammed (2019); Abbas *et al.*, 2020).

These findings imply that extended exposure to Cd increases absorption, maybe as a result of increased root-metal contact duration and metal transporter protein activation (Yadav, 2010 ; Mohammed *et al.*, (2019) ;Qassim *et al.*, (2021).

Since the two species' performances were nearly identical at this point, it was proposed that they should both have access to effective internal sequence schemes and uptake systems. Observation for the third month Following three months, both species showed near-maximum efficiency across all treatment levels, ranging from 93% to 96% across all concentrations. - The little difference between nerium and acacia (95.92% vs. 95.89% 20 ppm, for example) suggests a plateau effect. These findings point to the Cd uptake system reaching saturation, when plants are able to eliminate cadmium to the fullest extent possible. Salt et al. (1998) found similar results, observing quicker rates of stability in hypercumulator plants under extended danger.

Comparison of nerium with acacia: Possibly as a result of the metal's quick initial sharpness, nerium enhanced acacia in low concentrations during the first month. But at the greatest concentration, Acacia performed better (86.15% vs. 79.64%). - Both species showed nearly the same efficiency in the second and third months, indicating similar long-term adaptation and acute processes.
More biomass and a sophisticated routing system might help Acacia by improving the metal sequence. Conversely, nerium may exhibit rapid initial uptake because to its high transpiration rate and root surface activity. Under these real-world circumstances, both species may be categorized as an efficient Cd phytoremediator. A statistical perspective The three-month plant kinds, concentrations, and interactions (e.g., interaction = 1.441, 0.518, 0.412) at LSD value p <0.05 verify that all parameters have a significant impact on the effectiveness of Cd removal. Specifically, the statistical variance reduced with time, suggesting that both plant species may be able to adjust to cadmium strain and operate well.
This study's findings are consistent with those of Ali et al. (2013), who discovered that deep-rooted, high-biomass plant species, such as acacia, may extract a substantial amount of cd from polluted soil. – and research Yadav (2010) emphasized the significance of metal transport proteins in enhancing phytoxtraction as well as long-term danger. - According to Salt et al. (1998), once plants achieve their phytoxtuction capability, the plateau may gradually perform the metal absorption. Prasad and Freetas (2003) categorized Acacia and Nerium as prospective metal-stamped plants appropriate for phytormediation, citing similar findings.

Table (2) Removal efficiency of Acacia and Nerium plants for Lead in contaminated soil

Month	Concentration	Type of plant		Mean ± SD
		removal efficiency of Acacia	removal efficiency of Nerium	
First month	0	0	0	0±0
	75	37.51%	41.12%	39.31±2.55
	150	59.53%	59.49%	59.51±0.02
	300	70.47%	69.68%	70.08±0.55
	Mean ± SD	41.88±31.1	42.57±30.7	42.22±0.49
LSD(P<0.05)	Type of plant=0.429 concentration=0.607 interaction=0.858			
Second month	0	0	0	0±0
	75	73.06%	72.34%	72.70±0.50
	150	79.21%	79.35%	79.28±0.10
	300	87.79%	87.51%	87.65±0.20
	Mean ± SD	60.01±40.4	59.80±40.3	59.91±0.15
LSD(P<0.05)	Type of plant= 0.780 concentration= 1.079 interaction= 1.481			
Third month	0	0	0	0±0
	75	89.11%	92.72%	90.91±2.55
	150	95.64%	95.39%	95.52±0.17
	300	95.92%	96.04%	95.98±0.08
	Mean ± SD	70.17±46.8	71.04±47.3	70.60±0.61
LSD(P<0.05)	Type of plant=1.28 concentration= 1.88 interaction= 2.62			

The capacity of both plants to eliminate lead at different concentrations (75, 150, and 300 ppm) over a three-month period is found and compared in the study (Table 2). Observation during the first month Acacia had a removal skill of 37.5% at 75 ppm, although Nerium did marginally better at 41.12%. Both plants achieved nearly uniform removal (~59.5%) at 150 ppm. Nerium reached 69.68% and Acacia 70.47% at 300 ppm. According to these findings, the two species

may initiate lead absorption rapidly and with increasing efficiency, and the PBb concentration rises proportionately. Nerium's low concentration increased somewhat, either as a result of its roots' large surface area or its quick early growth. These patterns are consistent with the results of Sharma and Dubey (2005), who noted that plants' reception of lead is frequently concentrated and originates from the metal-collecting roots. Observation during the second month The elimination capacity increased by 72.34% (Nerium) and 73.06% (Acacia) at 75 ppm. Both achieved around 79.3% at 150 ppm. They both reached around 87.6% at 300 ppm. This adequate improvement is a result of cumulative uptake over time, which keeps absorbing lead from the roots and transferring it to the air. Pour Rut et al. (2011) and Qassim *et al.*, (2023).
Claim that extended exposure to enzymatic activity and metal transport protein expression prolongs metal buildup. Plants have successfully adapted to lead stress at this stage. Observation for the third month Nerium slightly enhanced Acacia in ppm (92.72% vs. 89.1%). Both plants increased their efficiency by about 95.5% to 96% at 150 and 300 ppm. The two species reached their maximal phytoremediation capability by the third month, and they did so quite effectively at all concentrations. This implies that these plants can be used in long-term phytormediation initiatives. The large fibrous root structure of Nerium may have contributed to its minor advantage at low concentrations, but Acacia's biomass and routing depth allowed it to perform well under high Pb loading. The same saturation thresholds in metal-stamped plants during the prolonged exposure time were also found by Suhad *et al.*,2018; Qassim and Hind (2024).
A comparison between Nerium and Acacia Month 1: At 75 ppm, Nerium did somewhat better. Month 2: Acacia was present in higher concentrations and both plants performed better, nearly identifying each other. Month 3: With little change, both were able to eliminate over 95%. While Nerium might be preferred when quick initial lift is desired and the sites require entrance into deep roots and increased biomass buildup, overall, both species demonstrated statistically comparable performance and good effectiveness (as shown by LSD values). Statistical significance The increasing LSD values for concentration, concentration, and interaction are suggested by plant kinds, concentration, and months 1 (0.429–0.858) through 3 (1.28–2.62). Focus and the impact of time on removal effectiveness are crucial. Over time, the relationship between plant type and Pb levels becomes increasingly evident, revealing species-specific responses to prolonged Pb exposure. Comparison of scientific literature - Dubey and Sharma (2005): In plants exposed to lead, antioxidant responses and their function in tolerance were emphasized. Pourrut et al. Ali et al. - Prasad and Freetas (2003): Because of their capacity to accumulate heavy metals, both species were found to be perfect for phytoremediation. According to Salt et al. (1998), Pb accumulation in plant tissues reaches saturation over a prolonged exposure time.
In conclusion, Excellent phytoremediation capabilities for lead-contaminated soils were demonstrated by Acacia and Nerium. After three months, he improved the continuous Pb removal effectiveness to almost 95%. Acacia had powerful, long-lasting effects in every circumstance, although Nerium performed somewhat better at low doses and in the early phases. They can be used together in phytoremediation techniques in a number of polluted settings because of their complementary strengths.

Table (3) Removal efficiency of Acacia and Nerium plants for Zinc in contaminated soil				
Month	Concentration	Type of plant		Mean ± SD
		removal efficiency of Acacia	removal efficiency of Nerium	
First month	0	0	0	0±0
	50	71.28	72.54	71.91±0.89
	100	79.53	77.69	78.61±1.3
	150	87.88	88.045	87.96±0.11
	Mean ± SD	59.67±40.3	59.57±40.2	59.62±0.07

LSD(P<0.05)	Type of plant= 0.274 concentration= 0.387 interaction= 0.548			
Second month	0	0	0	0±0
	50	49.94	51.06	50.50±0.79
	100	66.49	68.35	67.42±1.31
	150	86.145	79.635	82.89±4.6
	Mean ± SD	50.64±36.6	49.76±35.1	50.20±0.62
LSD(P<0.05)	Type of plant= 2.54 concentration= 4.02 interaction=6.08			
Third month	0	0	0	0±0
	50	93.06	93.12	93.09±0.04
	100	94.3	94.23	94.27±0.04
	150	95.92	95.89	95.91±0.02
	Mean ± SD	70.82±47.2	70.81±47.2	70.82±0.007
LSD(P<0.05)	Type of plant= 0.278 concentration= 0.394 interaction=0.556			

Although zinc is a necessary element for plant growth, high soil concentrations brought on by mining, industrial processes, and waste water discharge can be harmful to both plants and microbes. A long-term solution for eliminating more zinc from the polluted environment is phytoremedation. (Table 3) The effectiveness of removing zinc from acacia and nerium oliander (Nerium) at three concentrations (50, 100, and 150 ppm) during three time periods (one, two, and three months) is assessed in this study.

Observation during the first month Both Acacia and Nerium started to show signs of phytoramdiation within the first month. Acacia and Nerium eliminated 71.28% and 72.54% of the zinc in 50 ppm, respectively. Acacia and Nerium eliminated 79.53% and 77.69% of the zinc in 100 ppm, respectively, whereas both species eliminated more than 87.9% in 150 ppm. These findings demonstrate a definite concentration-dependent rise in removal efficiency. LSD = 0.274 for plant type indicates that the minimal difference across species at this time is statistically insignificant. The pattern is consistent with EBBS and Kochian's (1997) results, which emphasize that certain plants may withstand elevated zinc levels as their performance improves.

The Zn removal patterns changed a little in the second month of monitoring. Efficiency decreased to 49.94% for Acacia and 51.06% for Nerium at 50 ppm. 50 ppm, the capacity dropped to 51.06% for Nerium and 49.94% for Acacia. Curiously, both plants grew at 100 and 150 ppm, with Acacia removing 66.49% and 86.15% and Nerium removing 68.35% and 79.64%, respectively. According to Zaid et al. (1998), when ZN Uptake Plant is modulated by Defense Mechanism, the variance in mid-term outcomes may be due to physical stress or saturation effects. This month's high LSD values (plant type = 2.54, interaction = 6.08) indicate that the plant's reaction is becoming more variable.

Observation for the third month The two species reached their maximal elimination capacity by the third month. Nerium demonstrated similar removal: 93.12%, 94.23%, and 95.89%, but Acacia removed 93.06%, 94.3%, and 95.92%50, 100, and 150 ppm, respectively. Both plants achieved close-saturation in ZN uptake and functioned similarly, as seen by the extremely low standard deviations and LSD values. The study by Vangronsweld et al. (2009), which emphasized the long-term accumulation capacity of woody and ornamental plants in phytoremedy efforts, is supported by these findings.

A comparison between Nerium and Acacia Nerium and Acacia had comparable effectiveness in extracting zinc from polluted soil throughout the research. Nerium benefitted somewhat in the first stage at the lowest concentration. Acacia outperformed 100 ppm in the second month, but by the third month, the two species' efficiency had altered. According to this convergence, both species can be used for long-term phytormediation. While acacia offers stability at modest dosages, nerium may be recommended for quick awakening during first therapy.

The notion that, under most circumstances, there are no appreciable differences between two plants is supported by statistical LSD values. Particularly in the second month, statistically significant LSD levels rose, indicating a brief change in plant behavior under mild Zn stress.

Nonetheless, stability and at least a statistical difference were observed in the third month. Nonetheless, there was stability and a reduction in statistical disparities in the third month.
- First month: LSD (plant) = 0.274; interaction = 0.548
- Second month: LSD (plant) = 2.54; interaction = 6.08
- Third month: LSD (plant) = 0.278; interaction = 0.556

These results imply that both plants consistently retain their sharp Zn capacity throughout time, despite minor variations under stress.

CONCLUSIONS:

- When it comes to phytoremediation of Cd, Pb, and Zn, Acacia and Nerium are both quite efficient, and their efficacy grows with time.
- *Acacia is superior for long-term accumulation, particularly at high metal concentrations, whereas nerium is better for quick initial absorption.*
- Because of their versatility and aesthetic appeal, the study backs the use of ornamental plants for environmentally responsible soil restoration.

Recommendations:

- Additional molecular research to comprehend the processes behind metal absorption.
- Testing more plant species to improve methods for phytoremediation.
- Examining how soil characteristics and climate affect removal effectiveness

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