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Monitoring of heavy metals in some desert plants south of Basra province, Iraq

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Abstract

This study examines heavy metal concentrations in desert flora from two locations in Basra Province, Iraq, offering essential insights into environmental pollution. Heavy metals were analyzed at various locations to assess variability. Cadmium displayed stable levels, whereas cobalt demonstrated considerable variations, signifying an irregular distribution. Manganese was abundant although markedly inconsistent. Nickel exhibited stability. Lead had stable amounts, but zinc displayed significant presence and change. These results guide environmental evaluations and management strategies. The variability among places and plant species underscores the impact of local variables and physiological characteristics. *Erodium glaucophyllum*, *Diplotaxis harra*, and *Astragalus spinosa* exhibited unique accumulation capacities. Soil properties varied, clarifying ecological processes. This study enhances the comprehension of heavy metal accumulation patterns in Iraqi desert vegetation, supporting efforts for conservation and contamination reduction.

Keywords: Pollution, Heavy metals, Bioaccumulation, Desert plants

Introduction

Heavy metals are naturally occurring elements characterized by high atomic weights and densities, needed for life but potentially hazardous due to buildup in organisms. Heavy metals can enter the environment from several sources, including mining, industrial production, untreated sewage sludge, and atmospheric emissions, resulting in considerable environmental issues due to their potential impact on human health and ecosystems [1,2].

Desert flora have been recognized as possible indicators of heavy metal contamination due to their capacity to accumulate elevated levels of heavy metals [3]. Certain research indicate that desert flora sequester heavy metals in their senescent organs as a survival strategy in contaminated soils. Desert flora typically absorb metals from their surroundings, rendering them effective biological indicators. Although desert plants possess the capability to monitor heavy metals, there exists a deficiency in scientific study about the monitoring of heavy metals in arid regions. Further investigation is required to evaluate the function of desert flora in heavy metal buildup and to formulate suitable methodologies for monitoring heavy metals in arid settings.

Desert flora serve as indicators for heavy metals, as they tend to absorb metals from their environment, rendering them effective passive biomonitors. These plants demonstrate significant heavy metal extraction capabilities and physiological and ecological resilience to heavy metal stress [4]. The amounts of heavy metals in these plants can be associated with those in the adjacent soil. Significantly, certain plants are utilized for phytoremediation, including the mobilization of heavy metals, xylem loading, carbon sequestration, root uptake, and root-to-shoot transmission.

Nonetheless, utilizing desert flora for the assessment of heavy metals entails possible dangers. Heavy metals are extremely poisonous and can bioaccumulate in plants, posing health dangers to humans and animals who ingest them. Certain desert plants possess the capability to collect heavy metals from the soil, resulting in contamination that may render them dangerous for food. The efficacy of use desert plants for monitoring heavy metals is contingent upon several parameters, including the species of plant, soil composition, and heavy metal content in the soil [6]. Consequently, it is essential to meticulously evaluate the potential hazards and limitations of use desert plants for heavy metal monitoring prior to adopting this method. Consulting specialists in phytoremediation and environmental science is advisable to ascertain the optimal method for monitoring heavy metals in a designated area.

Numerous studies have indicated significant diversity in heavy metal deposition among various medicinal plant species, their components, and specific elements. Ryan et al. [7] examined the significant concern of regulating cadmium in the human food chain, highlighting the health hazards linked to this heavy metal. Investigate further into the topic, illustrating how cadmium expedites bone degradation, offering essential insights for comprehending its systemic effects on human health.

Schutzendubel and Polle [9] observed elevated amounts of Cd, Cu, and Zn in the roots and shoots of mycorrhizal plants, suggesting potential metal sequestration. Wang et al. [10] shown that PM2.5 dust accumulation on leaf surfaces differed among plant species and leaf characteristics. Hamza et al. [11] investigated heavy metal accumulation in *Juncus rigidus* in Basrah Province, Iraq. Lead exhibited the largest accumulation, signifying the plant's capacity for phytoextraction and phytostabilization, accompanied by noted morphological alterations in plant tissues.

The research conducted by Hlail [12] examined the concentrations of heavy metals (Pb, Ni, Cr, and As) in roadside soil adjacent to fuel stations in Nasiriyah City, Iraq, in comparison to a rural control sample. The findings indicated that the concentration of heavy metals in the soil adjacent to petrol stations was markedly greater than that in rural regions. This indicates that petrol stations facilitate the buildup of heavy metals in urban soil.

This study aims to examine the accumulation patterns of heavy metals in desert flora from two locations in Basra Province, southern Iraq. This research seeks to elucidate the health and ecological hazards linked to metal bioaccumulation in arid areas, hence guiding management options for the preservation of vulnerable desert ecosystems.

Materials and Methods

Plant Material and Collection Sites

Three prevalent desert plant species were gathered for heavy metal analysis. The aerial portions of the plants were gathered from natural habitats in the Basra Desert between April and May 2023 (Figure 1). Samples were collected from mature, healthy plants devoid of any discernible disease or stress indicators. To address variability, three duplicates of each species were obtained from distinct individual plants, situated at least 10 meters apart. The geographical coordinates and elevation of each collecting site were documented. Each site represents different environmental contexts like industrial activities and plant communities.

The desert plants were identified and coded depending on Al-Mayah *et al*. [13] as follows:

A: *Erodium glaucophyllum*, [Code A]

B: *Diplotaxis harra*, and [Code B]

C: *Astragalus spinosa* [Code C]

The three plant species examined in this study are commonly occurring native plants found in desert environments of the Basra region. Choosing local plant species that naturally grow in the study area provides representative samples to investigate the ecological and environmental factors at play in this ecosystem. The collection was from two main stations: Hammar Mushrif [R1] and from Shaybah [R2].

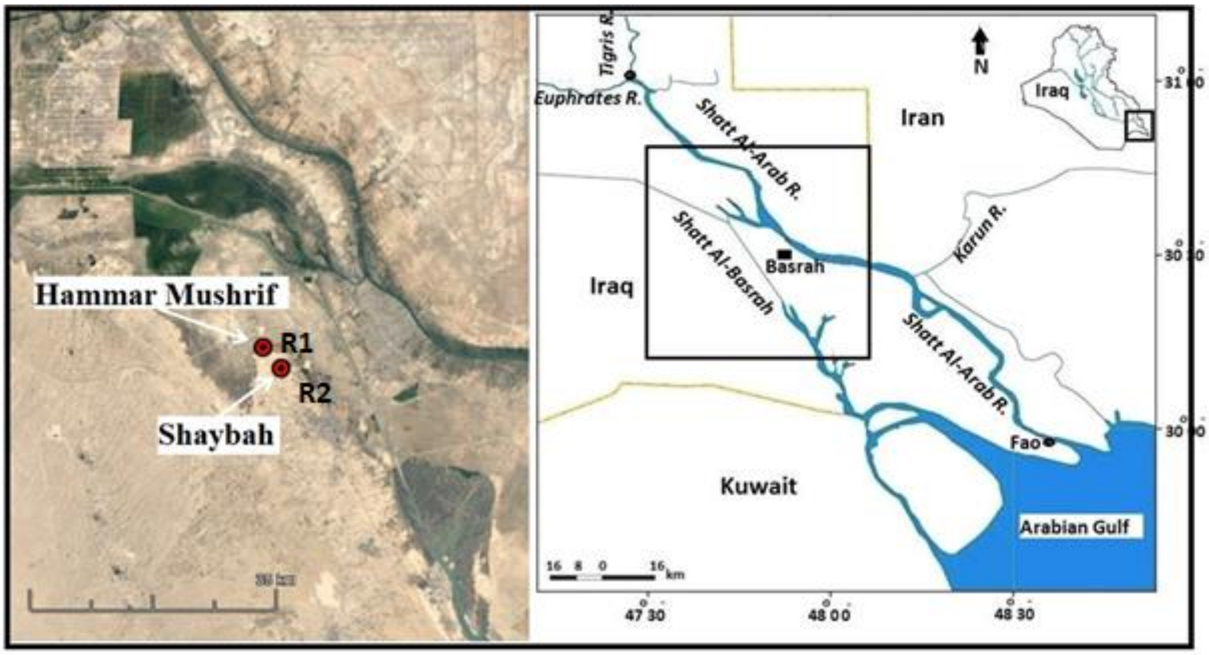

Figure 1: Map of the Study area

Sample Preparation

The collected plant samples were transported to the laboratory and thoroughly washed with tap water, followed by three rinses with deionized distilled water to remove any dust, soil, or debris. The plant materials were then spread out in trays and oven-dried for 5 d at 40°C until completely dehydrated. The dried samples were powdered using an agate mortar and stored in airtight plastic bottles at room temperature, away from direct light, until heavy metal analysis [14; 15]. Figure 2 illustrates the plant and soil samples prepared for testing.

Figure 2: Photos of the Plant and soil samples collected from different sites.

Heavy Metal Analysis

Triplicate 1 g samples of the dried, homogenized plant material were precisely weighed into porcelain crucibles. The samples were dried in a muffle furnace at 540°C for 6 h. The ash was dissolved in 5 mL of 10 M hydrochloric acid [HCl] and incubated for 15 min. The HCl extracts were transferred into 50 mL volumetric flasks and made up to volume with deionized distilled water. The solutions were filtered through 0.42 μm Millipore membrane filters before analysis [16,17].

Concentrations of zinc [Zn], cadmium [Cd], lead [Pb], Cobalt [Co], Manganese [Mn] and Nickel [Ni] were determined using a Perkin-Elmer 1100 B atomic absorption spectrophotometer equipped with hollow cathode lamps and an air-acetylene flame. All reagents used were of analytical grade. Standard solutions of each element were used for calibration and quantification. Data were recorded in mg/kg on a dry weight basis for triplicate measurements for each plant species. The percentage coefficient of variation was calculated to assess variability between replicates.

Soil Analysis

Surface soil samples were collected from each site randomly, air-dried, and passed through a 2 mm sieve. Heavy metal concentrations were estimated by acid extraction followed by atomic absorption spectrophotometry [18].

Statistical Analysis

All statistical analyses were conducted using SPSS software version 20. The mean and standard deviation of the soil metal concentrations were calculated. Differences between the soil, and plant concentrations for each metal were evaluated using the Wilcoxon signed-rank test. Differences between the groups were considered statistically significant at $p < 0.05$.

Results and Discussion

In examining the heavy metal concentrations across the studied stations, the mean values revealed key insights (Table 1) expressed as mg/kg. Cadmium (Cd) exhibited an average concentration of 0.4353, indicating a relatively consistent presence within the samples. Cobalt (Co) shows a mean of 1.9872, with moderate variability, suggesting a more diverse distribution. Manganese (Mn) presents a notably higher mean of 7.0925, indicating a prevalent presence across the samples, but with substantial variability. Nickel (Ni) displayed an average concentration of 4.968, indicating a relatively stable presence within the dataset. Lead (Pb) exhibited a mean of 3.4223, indicating a relatively consistent concentration. Zinc (Zn) presented the highest mean at 19.7734, signifying a significant presence but with substantial variability. The standard deviations provide further context, with Cd having the lowest deviation, indicating less variability, while Mn and Zn displayed higher standard deviations, suggesting more diverse concentration patterns across samples. These statistics help to characterize the central tendencies and variations in heavy metal concentrations, which are vital for environmental assessments and management strategies.

Table 1: Heavy Metal Concentrations in whole different desert plants in the study area (mg/kg)

Heavy Metal	Mean	Median	Std. Deviation	Minimum	Maximum
Cadmium (Cd)	0.4353	0.365	0.2533	0.059	0.634
Cobalt (Co)	1.9872	2.117	0.7129	0.90565	2.971
Manganese [Mn)	7.0925	6.1225	2.5058	3.291	11.6885
Nickel [Ni)	4.968	4.511	1.4145	3.329	6.843
Lead [Pb)	3.4223	3.312	0.8525	2.076	4.221

Heavy Metal	Mean	Median	Std. Deviation	Minimum	Maximum
Zinc [Zn)	19.7734	17.4855	6.8184	11.0355	27.663

Figure 3 shows that site R2 has a slightly higher average value of 7.4801 than site R1, which is 5.1084, indicating that there is variability between these two sites and the likelihood of site-specific factors contributing to these differences. Among the three plants, species A featured the highest average, boasting an average of 6.0497, while species B and species C scored 4.7423 and 4.5333, respectively. These differences are on average in the physiological traits exhibited by these plants or may reflect underlying differences in response to environmental circumstances [19]. A notable finding is that site R2 and species A co-occurrences have the highest-class averages, prompting an interesting investigation of possible interactions between site-specific environmental factors required contains promise to deliver.

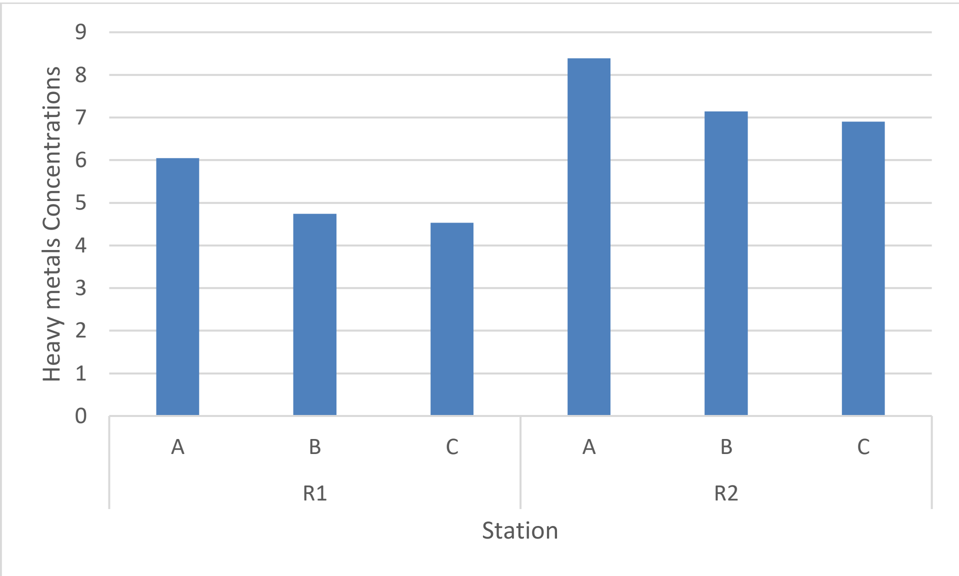

Figure 3: Average values of Heavy metals in different plants across different study sites [mg/kg]

The mean metal concentrations for the specified plant species (Figure 4) were as follows. *E. glaucophyllum* demonstrated a mean metal concentration of 7.2202 mg/kg, indicating a relatively higher metal content within its tissues. *D. harra*, with an average metal concentration of 5.9437 mg/kg, exhibits a moderate metal presence. *A. spinosa* displayed a mean metal concentration of 5.7266 mg/kg, which is slightly lower than that of *E. glaucophyllum*. These values offer precise measurements of metal uptake or accumulation in these plant species, which have ecological and environmental relevance [20,21].

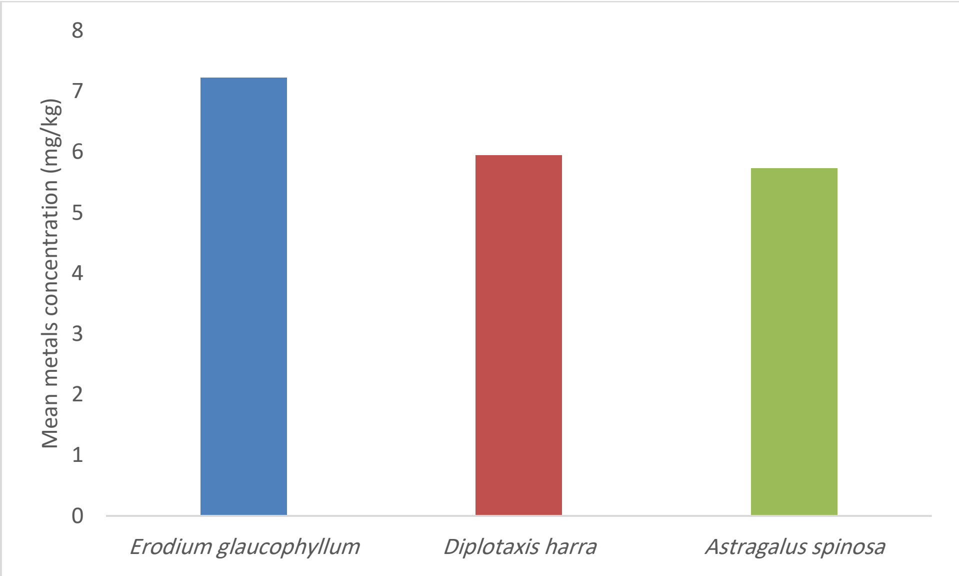

Figure 4: Average Concentration of Heavy metals in different desert plants in the study area

Within this study area, comprising two distinct sites, it can be observed from Figure 5 that there are variations in both plant and soil characteristics. At site R1, the mean value for the plants was 5.1084, indicating a moderate level of the parameter being measured. In terms of soil, the mean value was 4.4648, suggesting a relatively low concentration or content of the specific parameter in the soil at this site. The average value of the soil at site R2 was 5.0951, signifying a somewhat elevated concentration of the soil characteristics. The findings underscore the unique attributes of both locations, encompassing plant responses and soil composition, so offering significant insights into the ecological dynamics of the studied area [22].

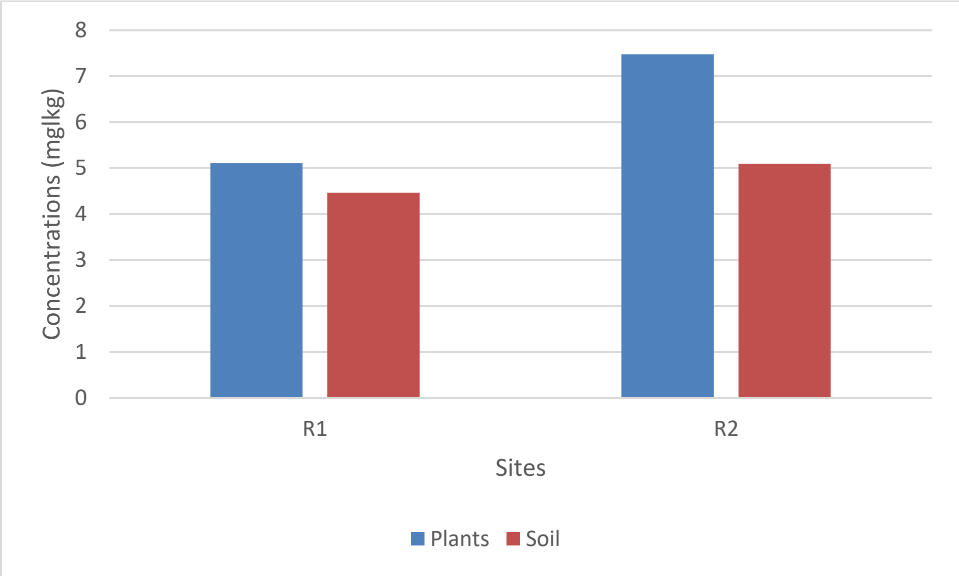

Figure 5: Average Concentration of Heavy metals [plants and soil] in different sites in the study area

The Wilcoxon signed-rank test indicated a statistically significant difference in heavy metal concentrations between plants and soil at the respective site. The test results reveal substantial differences in heavy metal concentrations between plants and soils at the respective locations, enhancing our comprehension of metal dynamics in desert ecosystems.

Figures 3-5 illustrate the mean concentrations of heavy metals in several plant species across multiple study sites, highlighting the average amounts of heavy metal accumulation in distinct desert plant species. Moreover, these data illustrate the mean amounts of heavy metals in both vegetation and soil at different research sites. These findings highlight the substantial influence of local environmental factors and plant physiological traits on heavy metal accumulation.

Conclusion

This study of heavy metal concentrations in desert flora of Basra, Iraq, demonstrated significant heterogeneity, underscoring the impact of local environment and physiological characteristics on accumulation patterns. Cadmium and lead exhibited a stable presence, whereas manganese and zinc shown significant variability among sites and species. These findings highlight the necessity of meticulously assessing potential health and ecological concerns linked to metal bioaccumulation in dry ecosystems. This study offers significant insights into management measures designed to safeguard vulnerable desert ecosystems.

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