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Arthrocnemum Perenne As A Bio Monitor Of Heavy Metals In Brackish Lakes, North Of Benghazi, Libya

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Abstract:
Halophytes employ several mechanisms to tolerate and remediate heavy metal stress. One of the primary strategies is the restricted entry of heavy metals through the root system. This process is facilitated by root exudates that bind heavy metals, reducing their bioavailability. The present research aims to determine the potential of Arthrocnemum perenne to remediate heavy metals (Zinc, lead, cupper and cadmium) in its aerial and root tissues. over the course of a growing seasons. Samples of the species were collected from six sites from polluted lake north of Benghazi in winter and summer seasons. Oven-dried vegetation samples were digested by HNO3 and analyzed for total Zn, Pb, Cu and Cd. Significant correlations with both the roots and aerial portion of the plant were found with Zn and Pd concentrations. Cd were not much observed. Thus, Arthrocnemum perenne would appear to be a suitable tool for biomoni-toring Zn, Pb and particularly Cu.
Keyword: *Heavy metals, Bio monitoring, Arthrocnemum perenne, phytoremediation, Biofilters, Aquatic ecosystem*

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I. Introduction

The enrichment of heavy metals in the environment is a consequence of human activities, including industrial and untreated sewage effluents, fertilizers, pesticides and so forth. These metals reach the soil and sediment, where they become bound, thereby generating contamination of the atmosphere, water and soil on a global scale [1,2]. In light of these concerns, various organizations and public administrations have enacted regulations governing soil contamination by heavy metals. These regulations typically establish maximum permitted limits for metal concentrations, with the aim of safeguarding soil and environmental quality. The permitted limits are often contingent upon the soil's pH value [3].

When heavy metals accumulate to a certain concentration in soils, they can into the human body via the food chain, which is the main route for human exposure to heavy metals [4]. The ability of plants to absorb heavy metals from soil is contingent upon the bioavailability of the metal in the soil and the specific plant species in demand [5]. As vegetables constitute a significant component of the human diet, numerous studies have evaluated their levels of heavy metal contamination in various contexts and the potential health risks associated with their consumption, particularly with regard to leafy vegetables, which have been identified as having the capacity to accumulate higher levels of heavy metals than other fruit and vegetable crops [6, 7].

The genus Arthrocnemum is of significant botanical importance, belonging to the Chenopodiaceae family. All species of this genus are succulent annuals, with 25 to 30 species present in Eurasia, North America and Africa. Arthrocnemum is genus represent an excellent investment for saline agriculture due to their high tolerance to salinity. All species in this genus, are distributed in salt marshes, coastal mud flats and estuaries where the meeting of fresh water and salty sea creates unique and dynamic habitats. It is therefore distributed commonly at the brackish north lakes at the coast of Benghazi. *Arthrocnemum perenne* exhibits the capacity to maintain a higher turgor and relative water content at low leaf water potentials, accompanied by a greater capacity for osmotic adjustment [8]. Drought and salinity represent two of the most prevalent abiotic stresses encountered by plants. In plant tissues affected by drought or salinity, osmotic potentials typically decline, largely as a consequence of compatible solute accumulation in the cytoplasm or inorganic ion accumulation in vacuoles.

Vegetation can be regarded as a more appropriate tool than sediments for measuring contamination as plant–metal concentrations can reflect both chemical availability and bio accumulation potential–both of which are toxicologically significant [9,10]. A substantial degree of research into vegetation relationships with metal contamination in estuarine and coastal waters using aquatic macrophytes has been attempted.

The objective of this study was to ascertain the potential of *Arthrocnemum perenne*, a submerged halophyte that naturally occurs in the region, for use in phytoremediation of heavy metal-contaminated soils in north brackish lakes in Benghazi. To this end, the accumulation of four heavy metals (Cd, Cu, Pb and Zn) in the shoot and root systems of the plant was analyzed. These metals were selected for their abundance in the area and/or for their toxic potential. The study hypotheses were as follows: the accumulation of heavy metals would vary depending on the sampling site; and the intake of heavy metals by roots could be affected by soil pH and soil conductivity.

II. Material And Methods

Study Area and Species Studied

The northern lakes of Benghazi are a wide flat area submerged with shallow water (Figure 1). The area has been used as the city dump for many years, having all kinds of debris, old cars, oil and dangerous waste. The site has become full of slums and stands as a dangerous environmental hazard. The sampling was done from 6 sites from the littoral zones of the lakes.

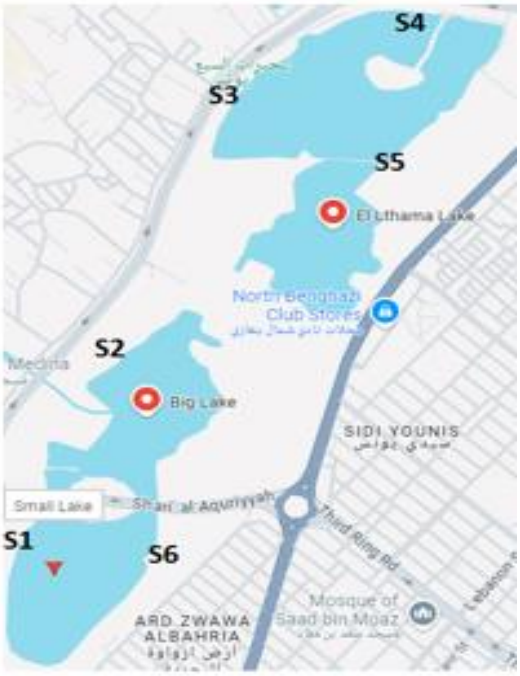

Figure 1: Google Map For The Study Area With Sampling Sites.

Figure 2: The Plant Species Of The Study.

Plants Sampling and Analysis

Fresh aerial parts and root parts of the submerged *Arthrocnemum perenne* (Figure 2) from those growing naturally in the brackish lakes at the north coast of Benghazi, were collected from 6 sites in late January 2023 (winter season) and late July 2023 (summer season). Soil pH, temperature and electron conductivity were measured in triplicates in the field at sampling time.

Upon sampling, both aerial and root parts were sealed into airtight plastic bags before being transported to the laboratory. Samples were washed individually with deionized water to avoid any cross contamination. Samples were then oven dried at 105◦C for 24 h. Dried samples were ground to a fine powder using an electric mill and then a suitable portion (5 mg) of a powdered sample were mixed with 5 ml HNO_3 in 25 ml conical flasks and shacked for 24 h and then the solution volume was completed with distilled water to 25 ml [11]. Digested samples were kept in sterile transparent blank plastic containers for analysis. All analyses were performed in triplicates, and three measures of each heavy metal in each plant part were taken for each site. The standard solutions were 1ppm, 3ppm, 5ppm and 10ppm. The measurement of heavy metals concentration was carried out using Shimadzu AA-68OO Atomic Absorption Spectrometer.

Statistical Analyses

Significant differences in the measured parameters between the three zones were tested for using one-way ANOVA at $p<0.05$. Relationships between the measured variables were tested using Pearson's correlation. All statistical tests were performed using IBM SPSS version 25 (IBM Corporation, New York, USA).

III. Result And Discussion

Halophytes have evolved a variety of physiological and biochemical mechanisms to cope with and remediate heavy metal stress. These mechanisms range from reducing metal uptake to compartmentalizing and detoxifying metals within their cells. The primary mechanisms include restricted uptake, synthesis of osmolytes, and intracellular sequestration of heavy metals. The availability of heavy metals is contingent upon a number of factors, including the quantity and source of metals, the organic matter content, the pH, the quantity and type of clay, the cation exchange capacity, the competitiveness of other elements, and the plant uptake mechanisms.

Firstly, pH, EC and temperature of lake water were fluctuated by seasonal changes as presented in (Table 1). pH value ranged from (6.7) during summer to (8.7) during winter. Electrical conductivity ranged from (11010 to 18990) mS/m. It was greatly increased in summer season and the highest value recorded at site 6. That because of increasing the soluble cations and anions in summer. Lake water temperature ranged from 14.2 to 30.3 °C.

Table 1: Mean ± Standard deviation of Physico-chemical parameters of sampling sites

Seasons	Sampling sites	pH	Conductivity (mS/m)	Temperature °C
Winter	Site 1	7.5 ± 0.00^{e}	14100 ±0.00	14.2±0.00
	Site 2	8.6 ± 0.00^{g}	11150±0.00	15.3±0.00
	Site 3	8.0 ± 0.00^{f}	11010±0.00	16.4±0.00
	Site 4	8.6 ± 0.00^{h}	11280±0.00	16.5±0.00
	Site 5	8.7 ± 0.00^{g}	11990±0.00	17.8±0.00
	Site 6	8.7 ± 0.00^{h}	12020±0.00	20.7±0.00
Summer	Site 1	6.7 ± 0.02^{b}	17820±0.00	30.3±0.00
	Site 2	6.7 ± 0.01^{a}	15100±0.00	30.6±0.00
	Site 3	6.8 ± 0.00^{cd}	18810±0.00	29.0±0.00
	Site 4	6.8 ± 0.00^{c}	15890±0.00	28.3±0.00
	Site 5	6.7 ± 0.00^{b}	12740±0.00	29.5±0.00
	Site 6	6.8 ± 0.00^{d}	18990±0.00	28.2±0.00

Heavy metal concentrations in the aerial and root parts of *Arthrocnemum perenne* are presented in Table 2. The concentration of Zn was higher in aerial part during summer season and in the root parts during winter season. Its range varied from 0.30 to 0.84 μg/L in the aerial parts during winter, and 0.36 to 1.40 μg/L in the aerial parts during summer. While in the root parts, its range varied from 0.69 to 1.25μg/L during winter and 0.47 to 0.78μg/L during summer.

The concentrations of lead were higher during winter in both the aerial and the root parts. In the aerial parts, its range varied from 0.04 to 0.58 μg/L during winter, and 0.09 to 0.43 μg/L during summer. While in the root parts, its range varied from 0.03 to 0.66 μg/L and 0.04 to 0.50 μg/L. Sharma *et al.*, (2007) stated that Pb concentrations in soil and plant is higher during winter while Zn is higher during summer. The concentrations of cupper were higher during winter in both the aerial and the root parts. In the aerial parts, its range varied from 0.18 to 0.67 μg/L during winter, and 0.03 to 0.32 μg/L during summer. While in the root parts, its range varied from 0.01 to 0.85μg/L during winter and 0.03 to 0.32 μg/L during summer.

The concentrations of cadmium were very low to not defined in both aerial and root parts during winter and summer. That is due to effects of salinity on the bioavailability of cadmium (Cd) in soils and water, and Cd accumulation in plants [13, 14].

Table 2: Mean ± Standard deviation of heavy metals concentrations (µg/L) in collected samples.

Seasons	Sampling sites	Zn		Pb		Cu		Cd	
		Aerial	Root	Aerial	Root	Aerial	Root	Aerial	Root
Winter	Site 1	0.40 ±0.05b	0.84 ±0.01fg	0.57 ±0.27c	n.d	0.18 ±0.06bc	0.85 ±0.00h	n.d	0.05 ±0.00a
	Site 2	0.72 ±0.02e	0.82 ±0.02f	0.34 ±0.00abc	0.38 ±0.00e	0.22 ±0.00cd	0.07 ±0.00b	n.d	n.d
	Site 3	0.46 ±0.01c	0.69 ±0.01b	0.58 ±0.01c	0.66 ±0.02g	0.67 ±0.00f	0.01 ±0.00a	n.d	n.d
	Site 4	0.30 ±0.00a	0.81 ±0.01ef	0.31 ±0.01abc	0.03 ±0.00b	n.d	0.47 ±0.00g	n.d	n.d
	Site 5	0.84 ±0.00f	0.86 ±0.00g	0.48 ±0.00bc	0.11 ±0.00cd	0.35 ±0.00e	n.d	0.05 ±0.00b	n.d
	Site 6	0.56 ±0.00d	1.25 ±0.00h	0.04 ±0.00a	0.13 ±0.00d	n.d	n.d	n.d	n.d
Summer	Site 1	0.55 ±0.00d	0.48 ±0.00a	n.d	n.d	0.15 ±0.00b	0.22 ±0.00e	n.d	n.d
	Site 2	0.71 ±0.00e	0.47 ±0.00a	0.43 ±0.00abc	0.50 ±0.00f	0.32 ±0.00e	0.29 ±0.01f	0.03 ±0.00a	n.d
	Site 3	0.69 ±0.01e	0.73 ±0.04bc	0.20 ±0.00abc	n.d	0.25 ±0.01d	n.d	n.d	0.13 ±0.00b
	Site 4	0.36 ±0.00b	0.76 ±0.00cd	0.35 ±0.45abc	n.d	n.d	n.d	n.d	0.21 ±0.00c
	Site 5	0.99 ±0.01g	0.78 ±0.00de	0.09 ±0.01ab	0.10 ±0.00c	0.03 ±0.00a	0.13 ±0.00c	n.d	n.d
	Site 6	1.40 ±0.00h	0.74 ±0.19c	0.11 ±0.01ab	0.04 ±0.00b	0.20 ±0.00c	0.19 ±0.00d	n.d	n.d

Nil readings = are readings below the mean of the plank solution

From the data that presented in Table 3, there was positive moderate relation between Zn concentration in the root parts and pH values, and negative relations with EC and temperature. while there was negative relation of Zn concentration in the aerial parts with pH and EC, and positive relation with temperature. Study conducted by Fritioff *et al.,* (2005) stated that Zn and Pb in the aerial and root parts increased with increasing of temperature, which is agree with result of the current study. The temperature of the water may exert an influence on a number of factors, including the chemistry of the water, the solubility of metals, the uptake of metals by plants, and the growth of plants. In accordance with the findings of Kumar *et al.,* (2013), there is no discernible impact of seasonal fluctuations in water temperature on the solubility of metals in water. However, it should be noted that cool water contains a greater concentration of dissolved oxygen than warm water. Consequently, the concentration of metals in the interstitial water of the sediment may decline with a reduction in temperature, as a greater proportion of metals are bound to sediment colloids at high rather than low redox potentials.

Some heavy metals, including copper (Cu) and Zinc (Zn) are essential as micronutrients for plant growth and development. Conversely, other heavy metals, such as lead (Pb) and cadmium (Cd) are regarded as highly toxic for plants [17].

IV. Conclusion

Heavy metals are not biodegradable, unlike the majority of pollutants (both organic and inorganic). As a result, they can be accumulated in aquatic habitats and undergo a global ecological cycle via natural waters, which serve as the main pathway. Chronic inputs of heavy metals from ship breaking, hydrocarbons, and related activities, as well as seaport and industrial activities, have led to the development of highly contaminated sediments in coastal environments. Consequently, metal pollution has raised concerns about the potential toxic effects on marine organisms and ecosystems, as well as the possibility of bioaccumulation along the food chain, which could pose human health risks.

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