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Using Wild Plant Species Grown in Wadi Al – Tib Region North East of Al – Ammara, Iraq, as Indicators of Heavy Metals Accumulation

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Abstract:

The current study included, studying the ability of eight genera of plants belong to Brassicaceae family, *Brassica tournifortii*, *Cakile Arabica*, *Capsella bursa – pastoris*,Carrichtera annua, *Diplotaxis acris*, *Diplotaxis haru* , *Eruca sativa* and *Erucaria hispanica* to accumulate ten heavy metals Cadmium, Chromium , Copper, Mercury, Manganese ,Nickel ,Lead ,and Zinc . Plant leaves samples were collected from Al-Tib area during spring of 2021.The data demonstrated that, the highest conc. of Cd was 2.7 mg/kg in *Diplotaxis acris* leaves and lower value was 0.3 mg/kg in *Cakile Arabica* leaves. For Co, the highest conc.was 1.3 mg/kg in *Capsella bursa – pastoris* leaves, whereas the lower value was 0.5 mg/kg in *Cakile arabica* leaves. As for Cr element, the highest Conc. was 14.7 mg/kg in *Capsella bursa – pastoris* leaves, and the lower value was 2.7 mg/kg in *Diplotaxis acris* leaves. The highest conc. of Cu was 100.8 mg/kg in *Capsella bursa – pastoris* leaves, whereas the lower value was 8.8 mg/kg in *Cakile arabica* leaves. For Hg element the highest Conc. was 1496.2 mg/kg in *Brassica tournifortii* leaves, and the lower value was 3.1 mg/kg in *Erucaria hispanica* leaves. *Eruca sativa* record the highest Conc. value 95.2 mg/kg for Mn element, whereas the lower value was 28.8 mg/kg in *Diplotaxis acris* leaves. The highest conc. of Pb was 26.4 mg/kg in *Capsella bursa – pastoris* leaves, and the lower conc. was 1.5 mg/kg in *Cakile Arabica* leaves, Whereas the highest Conc. of Ni was 24.2 mg/kg in *Capsella bursa – pastoris* leaves and the lower conc. was 6.1 mg/kg in *Cakile Arabica* leaves. According to these results, *Brassica tournifortii* was more capable of accumulating heavy metals, while *Erucaria hispanica* was the least compared to the rest plants.

Keywords: Accumulation, Heavy metals, Plant leaves, Pollution, Wild plants.

Introduction:

Heavy metals discharged into the environment as a result of human activities can cause significant pollution[1]. With increase urbanization, increment, and mining activities, electroplating, energy and fuel output, power transmission, intensive farming, sludge dumping, and other factors, excessive metal contamination in the environment could become a global problem, with a variety of short- and long-term consequences for the environment[2, 3]. Heavy metals such as Aluminum (Al), Arsenic (As), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Iron (Fe), Mercury (Hg), Manganese (Mn), Nickel (Ni), Lead (Pb), and Zinc (Zn), which are highly toxic to the environment and can be transferred and bio-accumulated along the food chain[4,5]. Any metal with a specific gravity of more than 5 (g/cm3)[2]. Fig. 1. depicts the pathway of heavy metal-induced toxicity in plants[4]. Plants are stationary in a terrestrial environment, and their roots are the primary contact sites for trace metal ions. Plant roots are the principal contact site for heavy metal ions, and plants absorb heavy metals predominantly through roots and also through leaf surfaces as a result of this interaction and the deposition of particles containing these metals [6].

Plants play an important role in ecosystems because they transmit elements from the abiotic to the biotic environment, they purify the air from various pollutants[7]. The use of plant leaves as bio-monitors of heavy metal pollution is extremely beneficial to the environment [8].

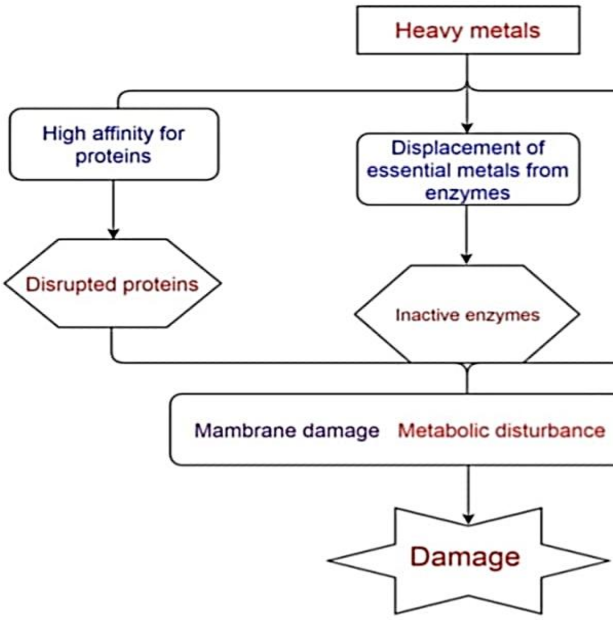

Figure 1. showed the heavy metals generated toxicity in plants. Adopted from [4]

Gaseous air pollutants are primarily removed via leaf stomata, while particulate matter pollution is removed through particle adsorption on leave [9].

Various heavy metals serve a vital function in nature since they are required for appropriate plant growth. Cu, Zn, Fe, Mn, Mo, and Ni are key heavy metals that play a role in plant biochemistry and physiology [10]. Cu and Zn are critical elements for normal plant growth because they serve as cofactors in enzyme reactions. It is vital that these necessary metals are available in growing media at a specific concentration, yet their excess concentration has a number of negative consequences [11]. These harmful metal contaminations end up in farming soil and water bodies as a result of synthetic and industrialization [2].

Many factors influence plant metal uptake, as seen in Fig. 2. Plant reactions and metabolism changes in response to heavy metals exposition depend on the type of contaminant element, plant species, stress intensity, and their duration [12].

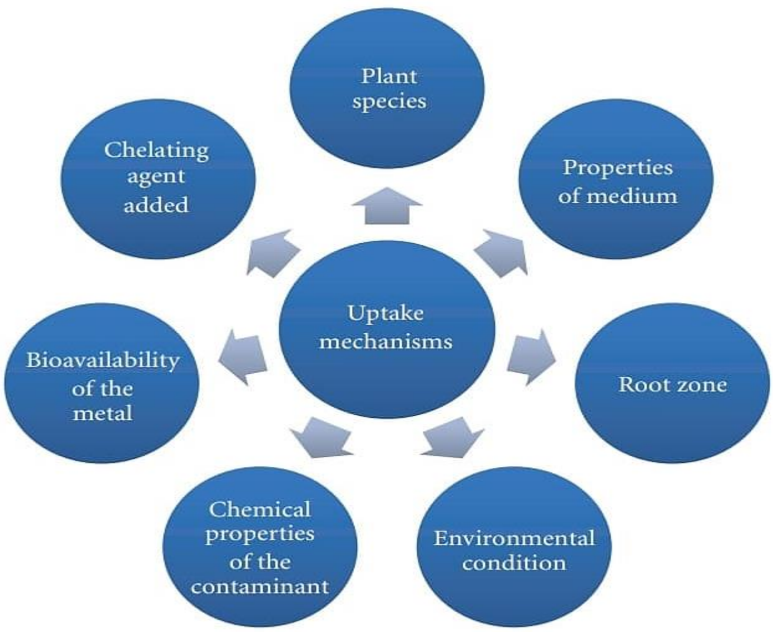

Figure 2. Factors which are affecting the uptake mechanisms of heavy metals .Adopted from [13]

Metals in plant tissues can come from two places, absorption from the soil and atmospheric deposition. Particulate matter pollution is eliminated predominantly through particle adsorption on leaves while gaseous air pollutants are primarily removed through leaf stomata [9].

The ability of plants to eliminate and accumulate heavy metals varies by species. The plants operate as diffuse samplers, accumulating contaminants in higher concentrations than the surrounding environment. This occurs as a result of ongoing mineral absorption over time[14]. Toxic heavy metals, such as lead, cadmium, can be distinguished from other contaminants because they cannot be biodegraded but can accumulate in living beings, producing a variety of diseases and disorders at relatively low concentrations [15, 16].

Therefore, the aim of this study was to determine the concentrations of certain toxic heavy metals (Cd, Co, Cr, Cu, Hg, Mn, Pb, Ni, Zn, and V) in the leaves of green species, using these plants as a bio-indicator of these elements in the environment.

Materials and Methods:

Study area

Plant leaves samples were taken from the Al-Tib area in the Persian foothills district in the spring of 2021.The Al-Tib location is located in the upper plain and foothills Region within the Persian foothills district (FPF), with latitudes and longitudes of (N 32 27 E 47 16)[17]. Geographically, it is located in the southeastern area of Iraq (70km north of Al-Amara city) Fig. 3. It is bordered to the north and northeast by Ali Al-Gharbi township district and to the south by Al-Musharrah township. The Islamic Republic of Iran forms its eastern border, while the Eastern Alluvial Plain District forms its southern boundary (LAPD). Al-Tib area is estimated to be 2264.519 km^2.

Sampling Procedure

The plant belonging to the Brassicaceae family, Fig.4, were collected in plastic bags and transported to the laboratory for drying and pressing. The samples were classified according to the taxonomic keys in the Iraqi Botanical Encyclopedia, University of Basrah, College of Science [18]. The dried plant leaves were taken and crushed by a ceramic mortar and put into plastic vials and sent to laboratories in the Islamic Republic of Iran, Perkin – Elmer company in the laboratories of the university of Tehran for determining the concentrations of heavy elements.

Analytical Methods

The concentration of heavy metals, Table 1, had been measured according to [19]. plant leaves samples were incinerated in a silicon capsule at 480 $^{\circ}$C for 5h in a muffle furnace. After incineration, the sample was transferred to a Teflon capsule, and 5mL hydrofluoric acid (HF) was added. The HF treatment allows dissolving elements, which may be retained by the insoluble silica residue. After evaporation on a hot plate, the residue was taken up with 5mL HNO_3, filtered to a 100-mL volumetric flask, and adjusted with purified water. Approximately 1.0g of dried plant material was weighed. Then 2mL of concentrated HNO_3 was added. The acid mixture was thereafter filtered through ash-free paper filter into a 50-mL volumetric flask. The container had been cooled, filtered and centrifuged, then analyzed with inductively coupled plasma – Mass Spectrometer (ICP – MS), Model ELAN 6100 DRC – e, Perkin – Elmer company in the laboratories of the Univ. of Tehran,Iran.

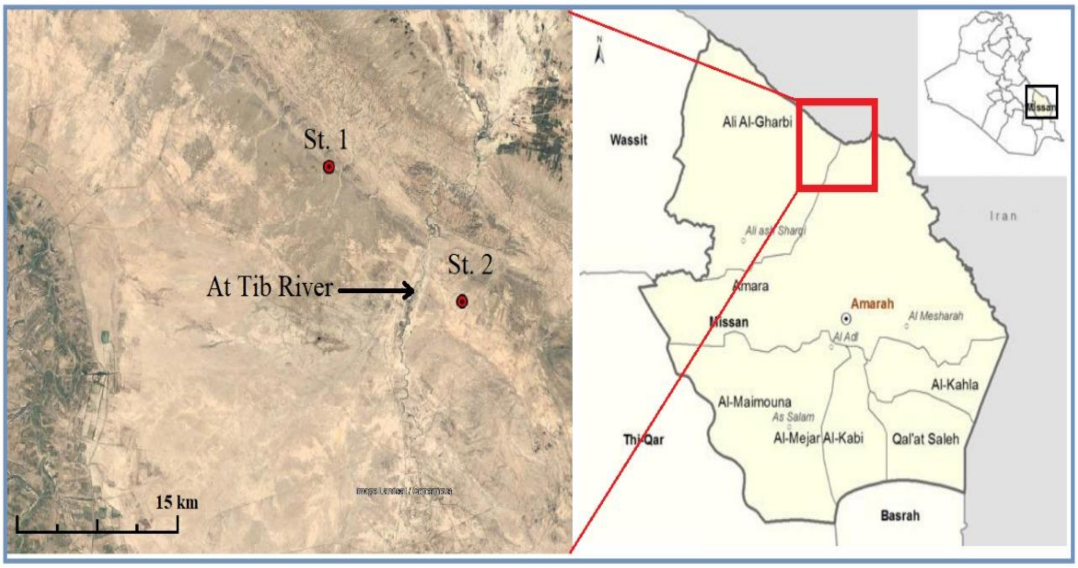

Figure 3. Map of the study area

Result and Discussion:

Heavy metal toxicity has become a global concern in recent years and poses a serious threat to both human health and the environment. The toxic effects of heavy metals on plants depend on many factors such as plant species, type and concentrations of heavy metals and time of exposure [20]. The danger lies in the accumulation of heavy elements in wild plants through their transmission in the food chain and their arrival to humans, as the study area constitutes an area for livestock grazing.

1 - *Brassica tournifortii*

2 - *Cakile arabica*

3 - *Capsella bursa – pastoris*

4 - *Carrichtera annua*

5 - *Diplotaxis acris*

6 - *Diplotaxis harra*

7 - *Eruca sativa*

8 - *Erucaria hispanica*

Figure 4. Studied plants (1 – 8)

Table 1. Fig. 5, showed the results of the current study, the results of statistical analysis using ANVOA test one way showed significant difference P<0.01 between metals accumulation in each plant, in *Brassica tournifortii, Eruca sativa* and *Erucaria hispanica* Hg was the most accumulated element and the least accumulated element was Cd. In *Cakile Arabica*, Mn was the most accumulative, whereas the least element was Co .

Table 1. Concentrations of heavy metals (mg/kg) in plant leaves

	Plants							
Element	Pt	Ca	Cbp	Can	Da	Dh	Es	Eh
Cd	0.4	0.3	2	0.6	2.7	0.8	0.5	0.6
Co	1.2	0.5	1.3	0.9	0.6	0.8	1.2	0.7
Cr	9.4	3.8	14.7	4.8	2.7	3.5	7.2	4.5
Cu	26.9	8.8	100.8	13.6	11.3	14.8	20.3	18.6
Hg	1496.2	30.6	144.1	7.8	5.5	3.4	4.5	3.1
Mn	61.4	62.0	87.3	78.3	28.8	40.2	95.2	72.3
Pb	15.2	1.5	26.4	2.8	2.5	2.5	9.1	4.2
Ni	17.5	6.1	24.2	11.8	12.0	14.6	13.4	11.6
Zn	53.0	21.1	132.4	24.2	87.9	26.6	31.6	24.9
V	3.5	1.6	3.5	2.4	0.8	1.7	3.8	1.6

Pt: *Brassica tournifortii* Ca: *Cakile arabica* Cbp: *Capsella bursa – pastoris* Can: *Carrichtera annua* Da: *Diplotaxis acris* Dh: *Diplotaxis haru* Es: *Eruca sativa* Eh :*Erucaria hispanica*

Hg was the most accumulated element in *Capsella bursa – pastoris*, the least was V. In *Carrichtera annua*, Mn was the most accumulated element and the least accumulated was Cd, whereas in *Diplotaxis acris* Zn was the most accumulated element and the least accumulated was Co. In *Diplotaxis haru*, Hg was the most accumulated element and the least accumulated were Cd and Co.
The results of statistical analysis showed a significant difference (P<0.05) between plants in their ability to accumulate heavy metals, the accumulation was the highest in *Brassica tournifortii*, while *Erucaria hispanica* was the least accumulated of metals. The accumulation in plants was as the following sequence: *Diplotaxis haru* < *Cakile Arabica* < *Carrichtera annua* < *Erucaria hispanica* < *Diplotaxis acris* < *Eruca sativa* < *Capsella bursa – pastoris* < *Brassica tournifortii*.
The permissible limits of heavy metals concentrations were as shown in Table 2, according to [21], the concentration of Ni and Pb in all plant leaves were above the permissible limit, except for *Cakile Arabica* which was recorded below the limit. As for Chromium (Cr) the concentration in all plant leaves exceeded the permissible limit, the same was recorded for Cd, Cu, and Zn in all plant leaves. The concentrations of copper in all plant leaves were below the permissible limits.

Table 2. WHO (1996) permissible limits for heavy metals in plants

Elements	Permissible value of plants (mg ⁄ kg)
Cd	0.02
Zn	0.60
Cu	10.00
Cr	1.30
Pb	2.00
Ni	10.00
Co	50.00

The accumulation of heavy metals by higher plants depends on the binding and solubility of particles deposited on leaf surfaces from air, as well as on concentrations and bioavailability of elements in the soil[22]. The accumulated heavy metals in the leaves of the studied plants are due to their proximity to the fields on the Iraqi and Iranian sides, which pollute the air and soil of the region alike with various pollutants, including heavy metals.

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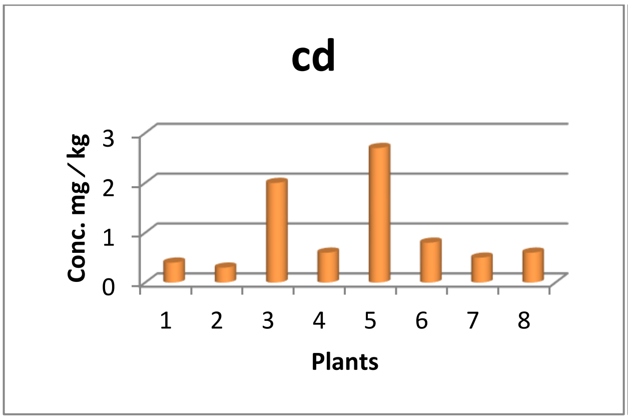

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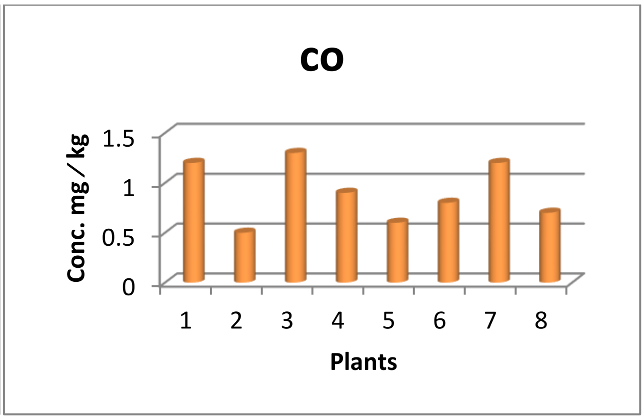

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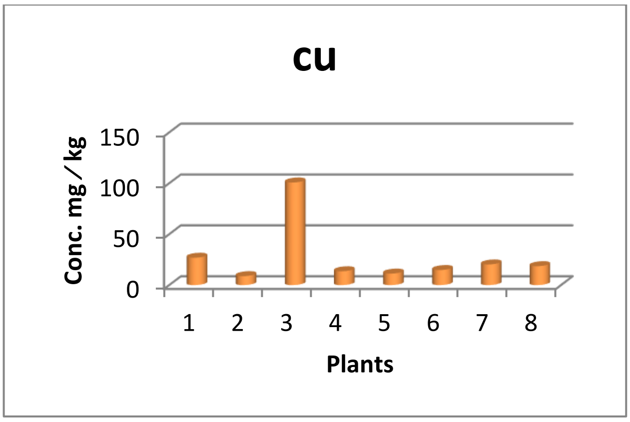

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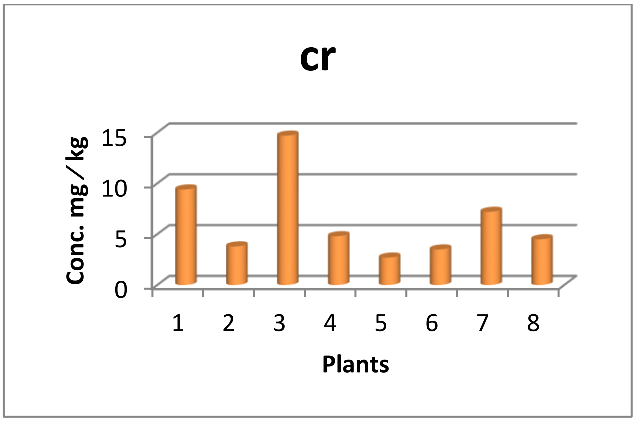

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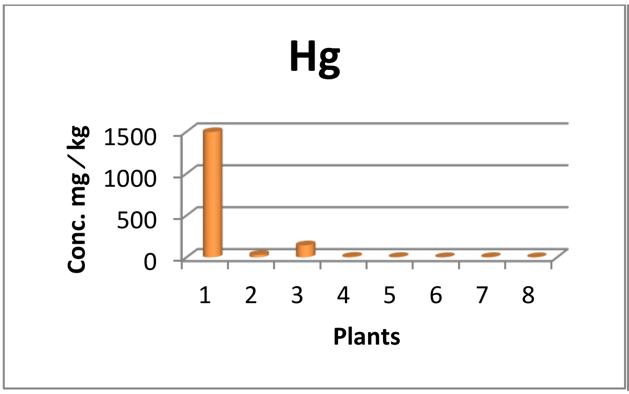

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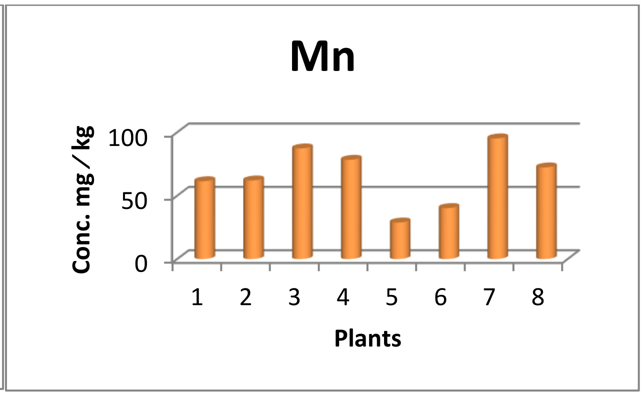

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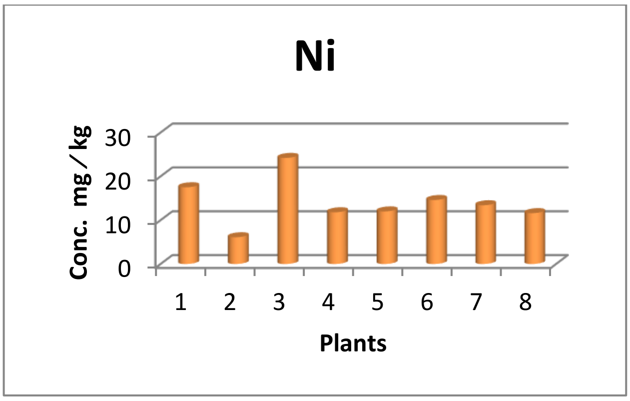

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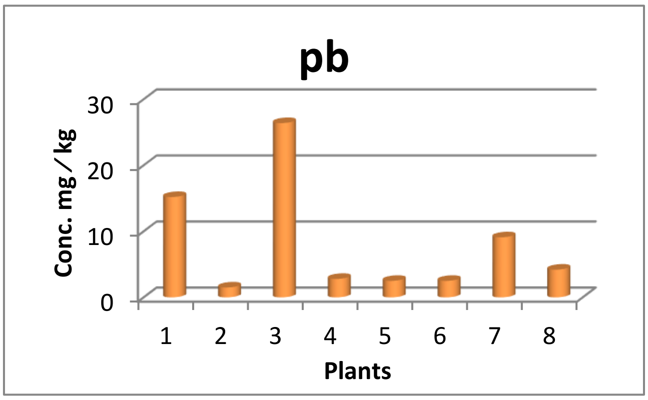

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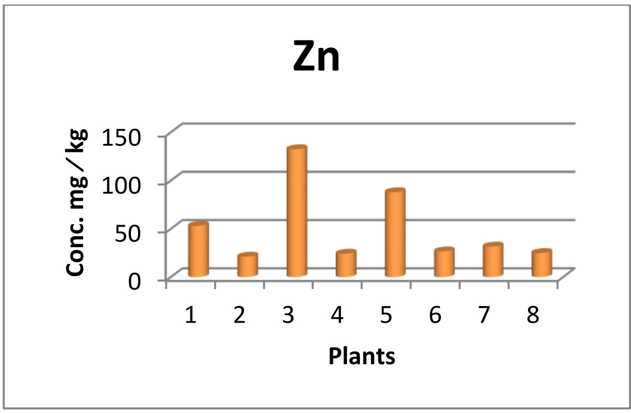

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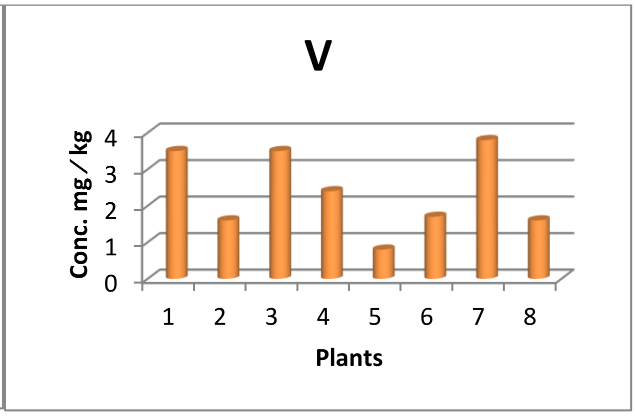

J

Figure 5. (A – J): Concentrations of Heavy metals in plant leaves.1-*Brassica tournifortii* 2 – *Cakile arabica* 3 – *Capsella bursa – pastoris* 4 – *Carrichtera annua*.5 – *Diplotaxis acris* 6 – *Diplotaxis haru* 7 – *Eruca sativa* 8 – *Erucaria hispanica*.

In the previous study[23]. estimated the concentration of heavy metals in the shoot system of desert plant *Tatraena qataranse* growing at Ras Laffan industrial area in Qatar, the concentration of heavy metals Pb, Cd, Ni, Cu, Cr, were 2.3, 0.5, 17.4, 6.2, 0 mg ⁄ kg, respectively. These values are somewhat close to the concentration of elements in some studied plants.

Ni concentrations were higher than Pb and Cd conc. in almost studied plants, an explanation for this could be that it is highly mobile and therefore can be easily moved from soil to root and through another tissue part, this is consistent with the previous study [24].

Conclusions:

This paper presents the results of research on the content of heavy metals in 8 plant leaves. The content of heavy metals (Hg, Zn, Mn) was high, the highest concentration was found in the leaves of *Brassica tournifortii*, whereas the least concentration of heavy metals was in *Erucaria hispanica* leaves. The results showed that the monitored plant species can accumulate heavy metals without serious damage to their metabolism.

Author's declaration:

- Conflicts of Interest: None.
- We hereby confirm that all Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission attached with the manuscript.
- Authors sign on ethical consideration approval
- Ethical clearance: The project was approval by the local ethical committee in University of Basrah.

Author's contribution statement:

This work was carried out in collaboration between all authors, I A. A-G and S T. A - K diagnosis the cases then collected the samples and doing the test. I A. A-G wrote and edited the manuscript with revisions idea. R Z K analysis the data with revisions idea. All authors read and approved the final manuscript.

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إستخدام أنواع من النباتات البرية النامية في منطقة وادي الطيب شمال شرق محافظة العمارة، العراق، كمؤشرات على تراكم المعادن الثقيلة

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قسم البيئة، كلية العلوم، جامعة البصرة، البصرة، العراق.

الخلاصة:

تضمنت الدراسة الحالية دراسة قدرة ثمانية أنواع من النباتات التي تنتمي الى العائلة الصليبية و هي *Brassica tournifortii* , *Cakile arabica* , *Capsella bursa – pastoris* , *Carrichtera annua* , *Diplotaxis acris* , *Diplotaxis haru* , *Eruca sativa* and *Erucaria hispannica* على مراكمة 10 عناصر ثقيلة هي الكادميوم و الكروم و النحاس و الزئبق و المنغنيز و النيكل و الرصاص و الزنك . جمعت عينات أوراق النبات من منطقة الطيب خلال ربيع 2021 م . أظهرت النتائج ام أعلى تركيز لعنصر الكادميوم بلغ 2.7 ملغم / كغم في أوراق نبات *Diplotaxis acris* و أقل قيمة كانت 0.3 ملغم / كغم في أوراق نبات *Cakile arabica* , فيما يتعلق بعنصر الكوبلت فقد كانت اعلى قيمة 1.3 ملغم / كغم في أوراق *Capsella bursa – pastoris* , بينما بلغت أقل قيمة لهذا العنصر 0.5 ملغم / كغم في أوراق نبات *Cakile arabica* . أما بالنسبة الى عنصر الكروم فقد كانت أعلى قيمة 14.7 ملغم / كغم في اوراق نبات *Capsella bursa – pastoris* , بينما كانت أقل قيمة 2.7 ملغم / كغم في أوراق نبات *Diplotaxis acris* . أعلى قيمة لتركيز عنصر النحاس 100.8 ملغم / كغم في أوراق نبات *Capsella bursa – pastoris* , بينما أقل قيمة 8.8 ملغم / كغم في أوراق نبات *Cakile arabica* . أما بالنسبة بعنصر الزئبق فقد كانت أعلى قيمة 1496.2 ملغم / كغم , بينما أقل قيمة كانت 3.1 ملغم / كغم في أوراق نبات *Erucaria hispanica* . سجل نبات *Eruca sativa* أعلى قيمة لتركيز عنصر المنغنيز , اذ بلغت 95.2 ملغم / كغم , بينما كانت أقل قيمة 28.8 ملغم / كغم في أوراق نبات *Diplotaxis acris* . بلغت أعلى قيمة لعنصر الرصاص 26.4 ملغم / كغم في اوراق نبات *Capsella bursa – pastoris* , بينما بلغ أقل تركيز 1.5 ملغم / كغم في أوراق نبات *Cakile arabica* . بلغ أعلى تركيز لعنصر النيكل 24.2 ملغم / كغم في أوراق نبات *Capsella bursa – pastoris* , بينما أقل تركيز له في أوراق نبات *Cakile Arabica* , اذ بلغ 6.1 ملغم / كغم . تبعا للنتائج فإن نبات Brassica tournifortii كان الاكثر قدرة على مراكمة العناصر الثقيلة , بينما كان نبات Erucaria hispanica هو الاقل قدرة مقارنة مع باقي النباتات .

الكلمات مفتاحية: أوراق النباتات، تراكم، تلوث، عناصر ثقيلة، نباتات برية.