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Uptake of Arsenic (As), Cadmium (Cd), Chromium (Cr), Selenium (Se), Strontium (Sr), Vanadium (V) And Uranium (U) by Wild Plants in Khan Al- Zabib Area /Central Jordan

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Abstract

The wide distribution of Redox-Sensitive Elements (RSE) as Arsenic (As), Cadmium (Cd), Chromium (Cr), Selenium (Se), Strontium (Sr), Vanadium (V) and Uranium (U) in the top soil of Khan Al-Zabib area are related to the weathering action of alkaline surface and groundwater on the parent rocks. The bioavailability, distribution, sorption, and ecotoxicity of As, Cd, Cr, Se, Sr, V, and U of the wild plants and top soils, in the present study area, were evaluated. A total number of 10 surface soil samples and 10 plant samples were collected and analyzed for the most toxic elements. The uptake of elements by plants was dependent on the plant species and the concentration of elements in the soil. The results of the present work provide valuable knowledge for understanding the bioavailability of some toxic elements in the soil and plants of Central Jordan. The results are expected to be of great interest for the Jordanian Uranium Mining Company during their environmental risk assessments.

Keywords: Bioavailability, Central Jordan, Trace elements Uptake, Transfer Factor.

1. Introduction

Heavy metals and trace elements, such as Arsenic (As), Cadmium (Cd), Chromium (Cr), Selenium (Se), Strontium (Sr), Vanadium (V) and Uranium (U), are naturally occurring in rocks and soil environment resulted from pedogenetic processes of weathering (Pierzynsiki et al., 2000). These elements are important in contaminating surface and ground water and decreasing crop production as a result of bioaccumulation and biomagnification in the food chain. Knowledge of basic chemistry, environmental and associated health effects of these heavy metals is important to understand their speciation, bioavailability, and remedial options. Heavy metals are adsorbed onto the soil, by initial fast reactions (minutes, hours), followed by slow absorption reactions (days, years) by plants, redistributed into different chemical forms with varying bioavailability, mobility, and toxicity (Shiowatana et al., 2001). Heavy metals distribution in soils take place as a result of mineral precipitation and dissolution, ion exchange, adsorption, aqueous complexation, biological immobilization and mobilization, and plant uptake (Levy et al., 1992). Potentially toxic elements in soils and plants may come from the bedrock itself and anthropogenic sources, like solid or liquid waste deposits (Wilson and Pyatt, 2007). Plants are important components of ecosystems as they transfer elements from abiotic into biotic environments. All plants have the ability to accumulate essential elements from soil in different concentrations for growth and development. This ability also allows plants to accumulate other non-essential elements, which have not known biological function (Djingova and Kuleff, 2000). Several studies have been carried out and investigated by many authors in different regions to evaluate and describe the accumulation of toxic trace elements and its impacts on the plant diversity (Tomé et al., 2002; Chen et al., 2005). The soils and plants contain all naturally occuring radioactive elements with half-lives comparable to the age of the earth, although their concentrations in plants may be rather low (Buck et al., 1996). The uptake of heavy metals by plant parts is real and not due to contamination by aerosols and was best illustrated by higest Ni uptake index in Atriplex leuceclada (Abed and Al- Eisawi, 1994). Bzour et al. (2016) investigated the potential mobilization and accumulation of Cr, V and U in wild plants in Siwaqa area/ Central Jordan and the results indicated that the highest TF for U is (0.25) and was recorded in Onopordum transjordanicum. Top soils of central Jordan are enriched in redox sensitive trace elements, such as U, Cr, Zn, Cr, Ni, Cu, Co, As, and Cd in the form of sulphides and selenides (Nassir and Khoury, 1982; Khoury and Nassir, 1982; Khoury, 2012; Fourcade et al., 2007; Techer et al., 2006; Khoury et al., 2014, 2015). The highest concentrations of trace elements from Central Jordan are present in the altered marble, chalk marl/travertine, and top soil (Elie et al., 2007; Khoury, 2015). Limited research was carried out on the the impact of trace elements on the wild plants in central Jordan. The impact of dust and heavy metals emitted from petroleum refinery on plant diversity in Tafila / Jordan was investigated (Oran and Abu Zahra, 2014; Oran; Al- Zo'ubi, 2016). Recent work on central Jordan has indicated that redox sensitive elements are present in the structure of high and low

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temperature minerals and are adsorbed by the organic matter of the parent bituminous rocks (Fourcade et al., 2007; Techer et al., 2006; Khoury et al., 2014, 2015; Khoury et al., 2016). Heavy metals, such as U, Cd, As, Cr, Pb, Ni, Zn and V, are also enriched in the phosphate rocks of Central Jordan. (Abed et al., 2008). The lack of knowledge about the behavior of some toxic trace elements in soils and plants in Central Jordan, in addition to the planned mining activities by Jordan Uranium Minning Company (JUMCO) in the area have encouraged the authors to carry out the present work. The transfer of As, Cd, Cr, Se, Sr, V and U to the wild plants in terms of sorption, toxicity and speciation will be studied.

1.1. Geology of Central Jordan

The northern boundaries of the first and second areas of Central Jordan (Daba- Khan Al-Zabib- Siwaqa) are located 25 km and 60 km south of Amman with the first area situated between E 36o 00' to 36o 15' and N31o 15' to 31o 30' and the second area between E 35o 00' to 36o 15' and N 31o 15' to 31o 30'. Figure 1a shows the location map of the studied area. The studied area was mapped in detail by the Natural Resources Authority (NRA) (Barjous, 1986; Jaser, 1986) and the geology, stratigraphy and sedimentology were described in details by Powell (1989) and Powell and Moh'd (2011).

Figure 1c is a generalized geological map of the study area (Barjous, 1986; Jaser, 1986; Khoury et al., 2014). Most of the outcropping rocks are of Upper Cretaceous age. The outcropping rocks of Central Jordan are sedimentary in origin and the exposed bed rock ranges in age from Turonian (Upper Cretaceous) to Eocene (Lower Tertiary) REF. Outcrops in central Jordan illustrate the presence of three main rock types: Bituminous marl; varicolored marble (pyrometamorphic rocks); travertine and top soil. The Bituminous Marl Unit overlies the Phosphorite Unit and underlies the varicolored marble and all are of Maestrichtian – Lower Paleocene age (Blake & Ionides, 1939; Quennel, 1956; Burdon, 1959; Barjous, 1986; Jaser, 1986; Khoury et al., 2014). In central Jordan, unusual redox-sensitive elements (RSE) cover large areas and are mainly associated with the varicolored marble, Pleistocene-Recent travertine and top soil. Yellow uranium encrustations and green Cr-rich smectites are also associated with the varicolored marble (pyrometamorphic rocks) and the underlying bituminous marl (oil shale) and phosphorites (Khoury, 2006; Khoury and Abu-Jayabb, 1995; Khoury et al., 1984; Khoury et al., 2014). The mineralogy of surficial top soil in central Jordan and RSE source rocks, transport conditions, and deposition processes were explained in detail by Khoury et al. (2014). The geochemistry of uranium and vanadium of the mineral phases was not investigated in detail. The general chronological sequence of the different lithological units is illustrated in Figure 1d. The Upper Cretaceous to Tertiary rocks in Central Jordan were deposited at the margin of the Tethys shelf-sea in environments ranging from super-tidal to deep sub-tidal (Bender, 1986). Transgression took place during Cenomanian times and marine sedimentation continued until the Late Eocene, despite fluctuations in sea level. Gentle folding, block faulting and possible strike- slip faulting were related to continued tectonic movement on the Jordan Rift structure which is located 60 Km to the west of the study area (Bender, 1986; Powell, 1989; Powell & Moh'd, 2011).

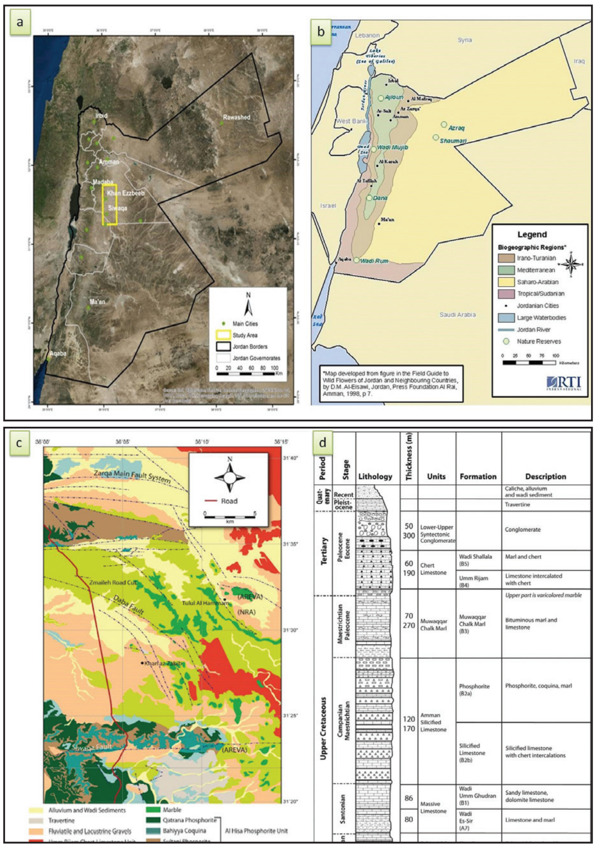

Figure 1. (a) Location map of Jordan showing the study area. **(b)** Location map of the study area showing the vegetation regions (after Al- Eisawi, 1996). **(c)** Geological map of central Jordan (modified after Barjous 1986; Jaser 1986; Khoury et al. 2014). **(d)** Simplified geologic section of central Jordan.

1.2. Bioclimatic and Vegetation Regions of Central Jordan

Central Jordan is classified as arid Mediterranean bioclimate; cool, warm and very warm varieties (Al- Eisawi, 1996). The largest area of Central Jordan is located in arid Mediterranean warm variety bioclimatic zone and located in Irano-Turanian vegetation region, while the north west of Central Jordan is in Mediterranean vegetation region and a very small part of south east of central Jordan located in Saharo-Arabian vegetation regions Figure 1b. The vegetation is mostly herbs, shrubs and bushes with no trees (Al-Eisawi, 1996).

2. Field and Laboratory Work

Field trips were conducted extensively to Khan Al-Zabib area, Central desert of Jordan. Fresh plant samples and soil samples were collected for every plant species available at the time of investigation and were placed in plastic bags according to standards. Global positioning system (GPS) records were made from the sampling sites during the period of the study. Sample locations were chosen randomly referring to the availability of plant species and sampling was based on ease of access, adequate vegetation growth to provide vegetation samples. Plant specimens were identified based on: Flora Palaestina (parts 1, 2, 3 and 4) (Zohary, 1966; Feinbrun, 1986). Field Guide to Wild Flowers of Jordan and Neighboring Countries (Al-Eisawi, 1998). Khan Al-Zabib area is dry with scare vegetation; wild plants and green grass cover the landscape during springtime that is used by locals for grazing and as folk medicine (Figure 2a). A number of 10 soil samples and 10 plant samples were collected. Figure 2b shows a general view of the landscape in Khan Al-Zabib area indicating the scarcity of vegetation cover. The top soil is porous and is mainly composed of calcite and gypsum. Secondary green Cr-rich smectite and yellow uranium minerals are common features filling voids and planes of weakness. Yellow secondary uranium minerals (source of U and V) together with green Cr- rich smectites are almost always associated together in the top soil and the underlying travertine and altered marble (Figs 2c and 2d). Figure 3 (a - h) are selected photographs of some typical wild plants from Khan Al-Zabib area.

Plant samples were carefully brush- washed with tab water and again washed and rinsed with distilled water to remove externally adhered metals and dust from the surface of the plants. The plants were oven dried at 100 ºC overnight. The samples were ground in a small coffee grinder. Finally, the samples were ground into fine powder by using Mill mix.

Soil samples were oven dried at 100 ºC overnight, then sieved through 63 microns mesh screen into fine powder. The samples were characterized using chemical methods. All the analytical work was carried out in the laboratories of the Department of Geology, University of Jordan and the Jordan Atomic Energy Commission (JAEC).

Inductively coupled plasma mass spectrometry (ICP- MS) analyses were carried out in the Chemical Analysis Section, chemical and physical analysis laboratories, Nuclear Fuel Cycle Commission (NCC- CPAL), Jordan Atomic Energy Commission (JAEC). The ICP- MS (ELAN® DRC-e, PerkinElmer SCIEX) was used to measure the amount of toxic trace elements in plants and soil particles. All samples were sent via Jordanian Uranium Mining Company (JUMCO) to ALS Arabia Co. Ltd. Jeddah, Saudi Arabia to be analyzed.

The transfer factor (TF) is defined as a factor used to describe the amount of element, which is expected to be transferred to plant from soil. It is also defined as the ratio of specific activities in plant parts and soil (in Bq kg-1 dry weight plant part divided by Bq kg1 dry weight soil). The TF was used as an index for the accumulation of trace elements by plants or the transfer of elements from soil to plants in mg. Kg-1 (Whicker et al., 1999; Yanagisawa et al., 1992).

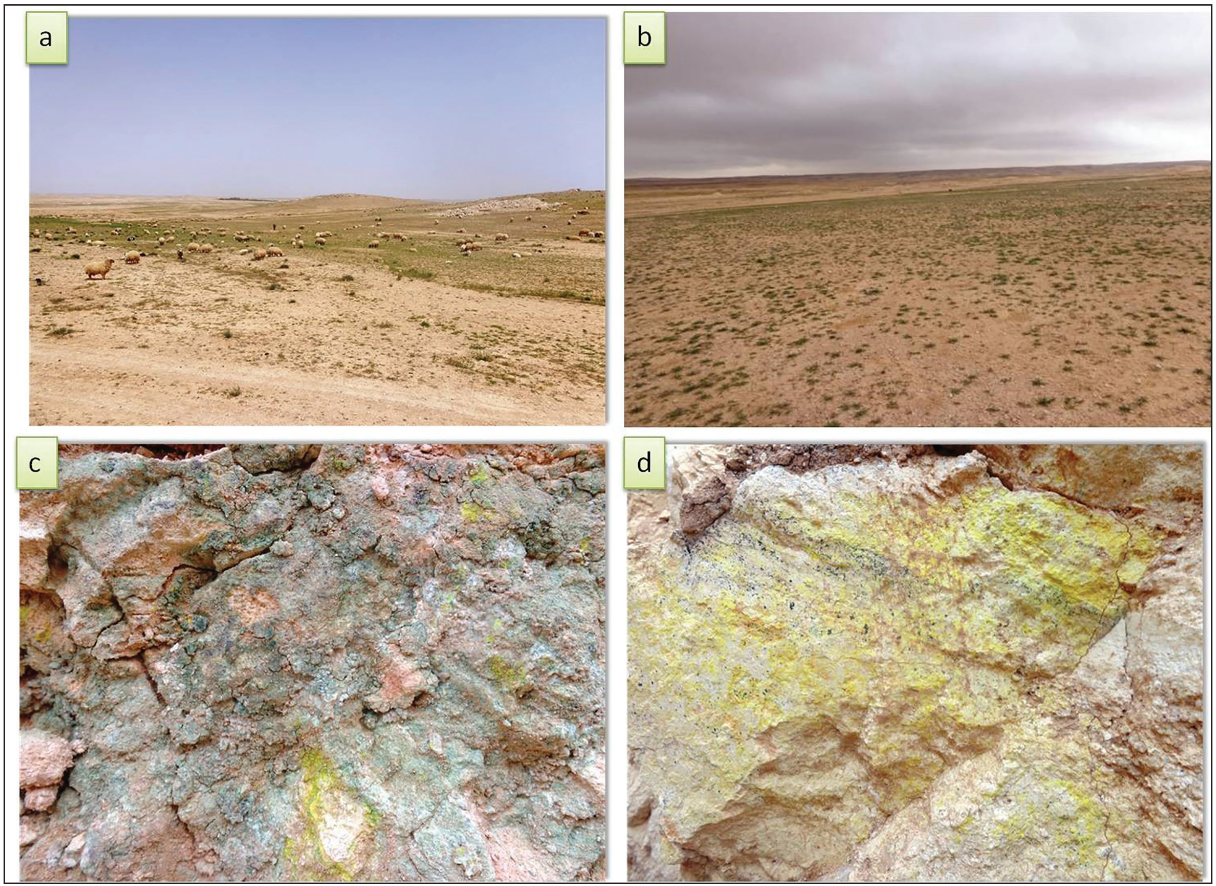

Figure 2. (a) Landscape of the study area showing grazing by herbavious animals.
(b) A Photograph showing a general view of the landscape indicating the scarcity of vegetation cover.
(c) A photograph illustrates the presence of secondary encrustations of uranium and Cr- rich smectites in the altered marble/top soil.
(d) A phtograph of yellow secondary uranium minerals filling porous rocks.

Figure 3. Photographs of wild plants **(a)** Ornithogalum trichophyllum **(b)** Malva sylvestris **(c)** Scorzonera papposa **(d)** Erodium hirtum **(e)** Astragalus sparsus **(f)** Gymnarrhena micranta **(g)** Astragalus sp. **(h)** Leopoldia longipes.

3. Result and Discussion

3.1. Mass Spectrometry Analysis (ICP- MS) Results

The mass spectrometry analysis (ICP- MS) results are given in Table 1. The table includes the concentration results of As, Cd, Cr, Se, Sr, V and U in the soil and plant samples. The calculated transfer factors TF are given in Table 2.

Table 1. Trace elements concentrations (mg/Kg) in soil and plant of Khan Al- Zabib area

Soils							
SAMPLE ID	As	Cd	Cr	Se	Sr	V	U
1	26.1	62.7	256	9.4	781	177	23
2	27.3	82.1	219	17.5	849	203	29.8
3	28.2	108.5	224	10	799	190.5	20.7
4	13.6	47.9	74.4	7.1	569	94.6	6.87
5	6.73	10.2	52.3	2.1	337	62.9	4.77
6	9.21	8.54	86.3	2.1	400	59.8	5.24
7	7.07	12.95	55.9	2.5	353	66.8	4.02
8	8.9	9.44	78	1.9	392	57.4	4.91
9	6.96	7.08	65.9	1.6	374	56.8	4.5
10	12.85	5.97	111.5	2.6	464	69.5	7.47
Mean	14.69	35.54	122.3	5.68	531.8	103.8	11.13
Std. Error of Mean	2.83	11.85	24.88	1.7	64.3	19.24	3.02
Minimum	6.73	5.97	52.3	1.6	337	56.8	4.02
Maximum	28.2	108.5	256	17.5	849	203	29.8
Number of values	10						
Plants							
Plant Name	As	Cd	Cr	Se	Sr	V	U
Erodium hirtum	1.9	4.21	24.3	3.18	274	14.6	1.645
Malva sylvestris	1.34	23.2	14.6	7.32	226	10.9	1.045
Astragalus sp.	2.7	6.87	34.2	5.9	230	21.8	1.84
Arthocnemum mucronatum	0.7	2.83	4.7	0.275	166.5	4.4	0.34
Gymnarrhena micrantha	1.01	4.03	7.3	0.601	142.5	6.8	1.025
Maresia pygmaea	1.82	2.3	19.4	0.407	404	10.7	1.76
Astragalus sparsus	1.21	2.77	8.3	0.544	134	7.8	0.809
Leopoldia longipes	0.82	1.135	9.34	0.206	152	7	1.16
Gynandriris sisyrinchium	1.14	1.42	17.75	0.247	178	7.5	0.662
Convolvulus arvensis	0.88	0.32	5.14	0.2	152	3.6	0.973
Mean	1.35	4.9	14.5	1.9	205.9	9.51	1.126
Std. Error of Mean	0.2	2.1	3.02	0.9	26.3	1.71	0.154
Minimum	0.7	0.32	4.7	0.2	134	3.6	0.34
Maximum	2.7	23.2	34.2	7.32	404	21.8	1.84
Number of values	10						

Table 2. Soil- Plant transfer factor (TF) of Trace elements concentrations (mg/Kg) Khan Al-Zabib area

TF							
SAMPLE ID	As	Cd	Cr	Se	Sr	V	U
Erodium hirtum	0.07	0.067	0.1	0.3	0.35	0.1	0.07
Malva sylvestris	0.05	0.3	0.06	0.4	0.26	0.05	0.04
Astragalus sp.	0.09	0.06	0.15	0.6	0.3	0.1	0.1
Arthocnemum mucronatum	0.05	0.06	0.06	0.04	0.3	0.05	0.1
Gymnarrhena micrantha	0.15	0.4	0.1	0.3	0.4	0.1	0.2
Maresia pygmaea	0.2	0.26	0.2	0.2	1.01	0.2	0.3
Astragalus sparsus	0.2	0.2	0.1	0.2	0.4	0.1	0.2
Leopoldia longipes	0.1	0.1	0.1	0.1	0.4	0.1	0.2
Gynandriris sisyrinchium	0.16	0.2	0.2	0.15	0.5	0.1	0.1
Convolvulus arvensis	0.07	0.05	0.04	0.07	0.3	0.05	0.1
Mean	0.114	0.2	0.111	0.24	0.422	0.141	0.1
Std. Error of Mean	0.02	0.04	0.02	0.054	0.07	0.03	0.014
Minimum	0.05	0.05	0.04	0.04	0.26	0.05	0.04
Maximum	0.2	0.4	0.2	0.6	1.01	0.2	0.3
Number of values	10						

3.1.1. Arsenic (As)

Arsenic (As) is a carcinogen and is associated with human skin, lung and bladder cancers (Ng et al., 2003; ATSDR, 2005). The permissible limit of As in soil which recommended by WHO (2007) and Pendias (2000) is 10 mg/kg As. The toxic limit of As in plant species is 0.1 recommended by WHO (2007). The concentrations of (As) in the soils of Khan Al-Zabib area ranged between 6.73 to 28.2 mg/kg with a mean value of 14.69 mg/kg. Six soil samples are above the permissible limit. The highest value of (As) in the plant species of the study area is 2.7 mg/kg and is recorded in Astragalus sp. The lowest value of (As) concentration is 0.7 mg/kg and is recorded in Arthocnemum mucronatum. The mean value is 1.35 mg/kg. Figure 4 illustrates the (As) concentrations in the plant species of the study area. The mean transfer factor from soil to plant of Khan Al-Zabib area is 0.114. The highest transfer factor is 0.2 in Astragalus sparsus and Maresia pygmaea. The lowest TF is 0.05 in Arthocnemum mucronatum.

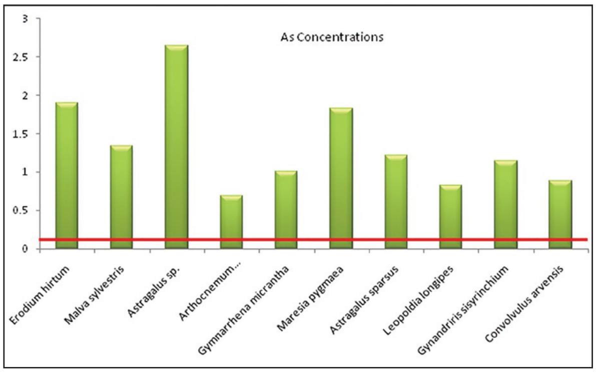

Figure 4. As concentrations in wild plant sp. in Khan Al- Zabib area

3.1.2. Cadmium (Cd)

Cadmium is an extremely toxic metal that has no known necessary function in the body. Cadmium toxicity contributes to a large number of health conditions, including the major killer diseases, such as heart disease, cancer and diabetes (Sheppard et al., 1985). The permissible limit of Cd in soil as recommended by WHO (2007) is 5 mg/kg. The toxic limit of Cd to the plant species recommended by WHO, 2007 is 0.02 mg/kg. The concentrations of Cd in soils of Khan Al-Zabib area ranged between 5.97 to 108.5 mg/kg with mean 35.54 mg/kg. All collected soil samples from this area are above the permissible limit. The highest value of Cd content is 23.2 mg/kg in plant species of Khan Al-Zabib area and is recorded in Malva sylvestris. The lowest value of Cd concentration is 0.32 mg/kg and is recorded in Convolvulus arvensis. The mean value is 4.9 mg/kg. According to WHO, 2007, all plant species of Khan Al-Zabib area are above the toxic limits. Figure 5 shows the Cd concentrations in the wild plant species of the study area. The mean transfer factor of Cd from soil to plant of Khan Al-Zabib area is 0.2. The highest transfer factor is 0.4 in Gymnarrhena micranta. The lowest TF is 0.05 in Convolvulus arvensis

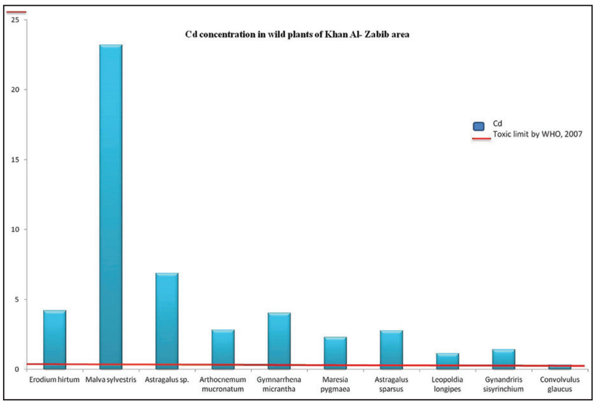

Figure 5. Cd concentrations in wild plant sp. in Khan Al- Zabib area

3.1.3. Chromium (Cr)

The abundance of Cr in the Earth's upper crust averages 100 mg/kg (Pendias, 2000). WHO (2007) and Pendias (2000) recommended that 75 mg. Kg-1 Cr in soil is critical concentration to be toxic and recommended that 1.3 mg/Kg is the toxic limit to plant species. The concentrations of Cr in the soils of Khan Al-Zabib area range between 52.3 to 256 mg/kg with a mean value of 122.3 mg/kg. Six soil samples in this area have Cr- values above the permissible limit as recommended by WHO (2007) and Pendias (2000). The highest value of Cr content in plant species of the study area is 34.2 mg/kg and is recorded in Astragalus sp. The lowest value of Cr content is 4.7 mg/kg and is recorded in Arthocnemum mucronatum. The mean value is 14.5 mg/kg. The Cr toxic limit as recommended by WHO, 2007 is below the all concentrations of Cr in all plant species collected from this area. Figure 6 shows the Cr concentrations in plant species of Khan Al-Zabib area. The mean transfer factor from soil to plant of the study area is 0.111; the highest transfer factor is 0.2 in Gynandriris sisyrinium and Maresia pygmaea. The lowest TF is 0.04 in Convolvulus arvensis.

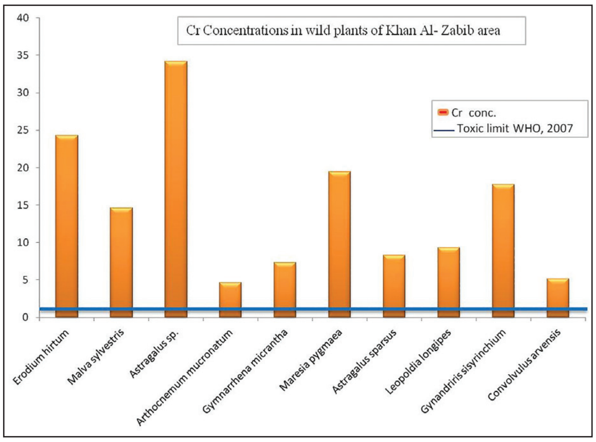

Figure 6. Cr concentrations in wild plant sp. in Khan Al-Zabib area

3.1.4. Selenium (Se)

The average content of selenium in the Earth's crust is estimated as 0.05 mg/kg (Pendias, 2000). Toxic Se concentration limit is 0.5 mg/kg soils (Pendias, 2000) and 0.05 in plants according to WHO (2007). The concentrations of Se in soils of Khan Al-Zabib area range between 1.6 to 17.5 mg/kg with a mean value of 5.68 mg/kg. All soil samples of Khan Al-Zabib area are above the permissible limit for Se as recommended by Pendias (2000). The highest value of Se content in plant species of Khan Al-Zabib area is 7.32 mg/kg and is recorded in Malva sylvestris. The lowest value of Se content is 0.2 mg/kg and is recorded in Convolvulus arvensis, the mean value is 1.9 mg/kg. Figure 7 indicates that all plant species recorded in the study area have exceeded the toxic limit as recommended by WHO. The mean value of transfer factor of Se from soil to plant of the study area is 0.24. The highest transfer factor is 0.6 and is found in Astragalus sp. The lowest TF value is 0.04 and is found in Arthocnemum mucronatum.

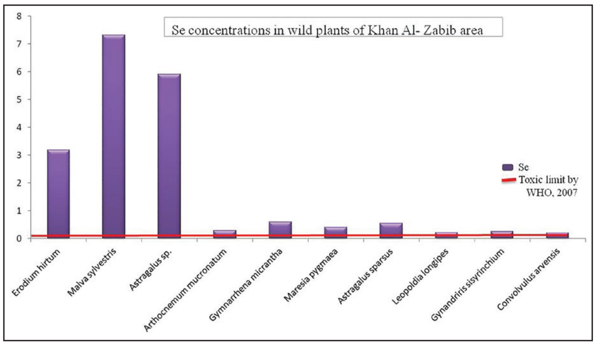

Figure 7. Se concentrations in wild plant species of Khan Al- Zabib area.

3.1.5. Strontium (Sr)

Strontium is a relatively common element in the Earth's crust and its contents range between 260 and 370 mg/kg (Pendias, 2000). According to Pendias (2000), 150 mg/kg concentration value of Sr in soils is toxic, and 50 mg/kg concentration value of Sr in plants is highly toxic referring to WHO (2007). The concentrations of Sr in the soils of Khan Al-Zabib area range between 337 to 849 mg/kg with a mean value of 531.8 mg/kg. All soil samples in this area are above the toxic limit as recommended by Pendias (2000). The highest value of Sr content in plant species of Khan Al-Zabib area is 404 mg/kg and is recorded in Maresia pygmaea. The lowest value of Sr content is 134 mg/kg and is recorded in Astragalus sparsus. The mean value is 205.9 mg/kg. The Sr toxic limit as recommended by WHO (2007) is below the all concentrations of Sr in all plant species collected from this area. Figure 8 shows the Sr concentrations in plant species of the study area. The mean transfer factor from soil to plant of the study area is 0.422. The highest transfer factor is 1.01 in Maresia pygmaea, and the lowest TF is 0.26 in Malva sylvestris.

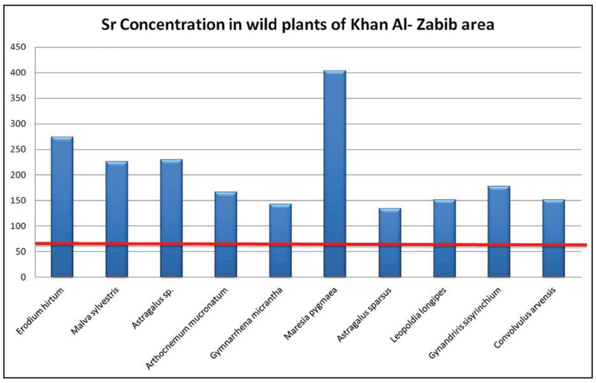

Figure 8. Sr concentrations in wild plant species of Khan Al- Zabib area.

3.1.6. Vanadium (V)

Levels of V in soils are closely related to the parent rock types. Its worldwide soil average is estimated at 129 mg/kg, within the range of 69–320 mg/kg (Pendias, 2000). WHO (2007) recommended that 2 mg/kg V concentration is toxic to plants. The concentrations of V in soils of Khan Al-Zabib area range between 56.8 to 203 mg/kg with a mean value of 103.8 mg/kg. The highest value of V content in plant species of Khan Al-Zabib area is 21.8 mg/kg and is recorded in Astragalus sp., and the lowest value of V content is 3.6 mg/kg and is recorded in Convolvulus arvensis. The mean value is 9.51 mg/kg. As shown in Figure 9, all plant species recorded in the study area are above the toxic limit according to WHO. The mean value of transfer factor of V from soil to plant of the study area is 0.1. The highest transfer factor is 0.2 in Maresia pygmaea, and the lowest TF is 0.05 in Arthocnemum mucronatum & Convolvulus arvensis.

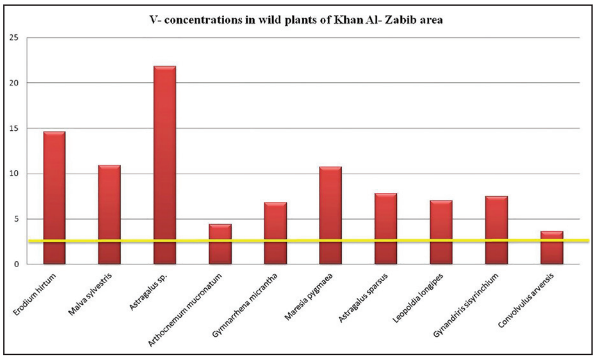

Figure 9. V concentrations in wild plant species of Khan Al- Zabib area.

3.1.7. Uranium (U)

The toxicity of U can be caused by breathing air containing uranium dusts or by eating substances containing uranium, which then enters the bloodstream. Once in the bloodstream, the uranium compounds are filtered by the kidneys, where they can cause damage to the kidney cells (ATSDR, 2005; Sheppard et al., 1985). The toxic limit for U concentrations in soils and plants are 1 & 0.3 mg/kg, respectively, recommended by WHO (2007). The concentrations of U in soils of Khan Al-Zabib area range between 4.02 to 29.8 mg/kg with a mean value of 11.13 mg/kg. All soil samples in this area are above the toxic limit as recommended by WHO (2007). The highest value of U content in plant species of Khan Al-Zabib area is 1.84 mg/kg and is recorded in Astragalus sp. The lowest value of U content is 0.34 mg/kg and is recorded in Arthocnemum mucronatum. The mean value is 1.126 mg/kg. The U toxic limit as recommended by WHO (2007) is below all the concentrations of U in all plant species collected from this area. Figure 10 shows the U concentrations in plant species of the study area. The mean transfer factor from soil to plant of the study area is 0.141. The highest transfer factor is 0.3 and is found in Maresia pygmaea. The lowest TF is 0.04 and is found in Malva sylvestris.

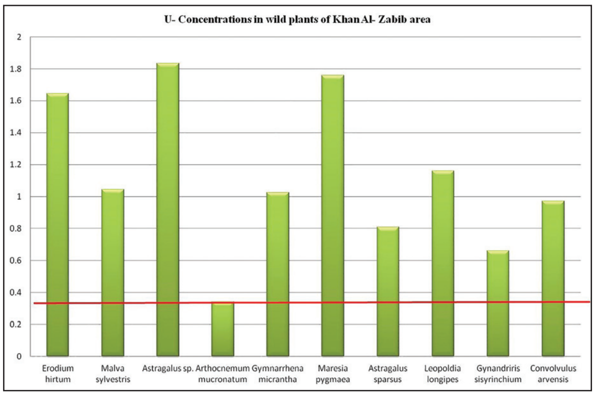

Figure 10. U concentrations in wild plant species of Khan Al- Zabib area.

Conclusions

The present work aims to characterize the soil and the ability of wild plant species in Khan Al-Zabib area/ Central Jordan to absorb different hazardous trace elements chemically and mineralogically. The behavior of toxic heavy metals and trace elements (As, Cd, Cr, Se, Sr, V and U) in soils and plants was investigated. The ability to assess of wild plant species in Khan Al-Zabib area/ Central Jordan for the absorption of different hazardous trace elements. The environmental geochemical survey has revealed variations of trace elements concentrations in soils and plant species. The sources of trace elements are related to the leaching processes from the parent rocks of the area. The potential mobilization of As, Cd, Cr, Se, Sr, V and U seems to decrease as follows: Sr > Cr >V> Cd > Se >As > U. The absorption of these elements in plants is variable from one species to another, but the majority of plants shows that the accumulation of metals followed this order: Sr > Se > Cd > V > As > Cr > U, indicating that the metal release in the soils correlates with their absorption by the plants. The concentration of these elements was depend on climatic geologic events in Central Jordan. Differences between trace elements TFs values for various plant species are related to the different characteristics and behavior of the wild plants. In general, the comparative uptake of trace elements is affected by numerous physical, chemical and biological conditions of the soil. The uptake of elements by plants depends on the plant species and the concentration of elements in the soil. The values are above the permissible limits according to world health organization (WHO). The information on the concentration level and transfer of (As, Cd, Cr, Se, Sr, V and U) from soil to plant will provide important information during the environment risk assessment that is expected to be carried out by JUMCO in the near future. Further studies and investigations are needed to assess and evaluate the ecotoxicity of heavy metals on plant species by the different RSE in the different soils of Central Jordan.

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