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Some heavy metals content in plants grown on serpentinitic soil from Penjwin and Mawat area at Kurdistan region – Iraq

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Abstract
Plants absorb a number of elements from soil, some of which have no known biological function and some are known to be toxic at low concentrations. There are substantial areas of serpentine soils at many locations in Iraq, but there is little information on their flora and biogeochemistry. The aim of this study was to assess the accumulation of heavy metals (Ni, Mn, Cu, Cr, Co, Cd, Fe, and Zn) in some natural plant species grown in serpentintic soils. Concentrations of heavy metals were measured also in soils, near the root of plant species. Four stations were chosen to assess the effect of growth environment in metal accumulation by each plant depending on variation in parent material composition. The plants species *Conium maculatum* L., *Euphorbia helioscopia L.*, *Scrophularia deserti, Onosma sericeum* and *Teucrium polium* were collected from Penjwin area. *Daucus carota* and *Lotus gebelia,* were collected from Mawat area (Betwat), while plants species *Lepidium draba* L. and *Salvia viridis* were collected from Kunjrin in Mawat area. The total accumulation of selected elements in studied plants species showed variation in amount of elements accumulation, and the variation in ability of studied plants to accumulate metals in their organs. The results showed that the *Euphorbia helioscopia* was able to accumulate all studied elements in their root, in contrast, it was noticed that *Salvia viridi* showed high ability to accumulate all elements in aerial parts (foliage). So, concern rose about the possibility of toxic concentrations of certain elements being transported from plants to higher strata of the food chain. All studied plants were able to accumulate very high levels of Ca, and Mg, and the values of Ca accumulated in roots were ranged between 166.62 to 4277.59 mg $kg^{-}1$, while the ranged in shoots were 367.69 to 2121.94 mg kg^{-1}. Whereas the Mg values were raned between 73.21 to 2669.98 mg kg^{-1} in roots, while in shoots were ranged from 76.79 to 1270.01 mg kg^{-1}.

1. Introduction

Serpentine (ultramafic) soils exist in many different parts of the world and are renowned for their specialist plant life. These soils have high Mg and Fe concentrations but have relatively low concentrations of Si and Ca. The amounts of Ni, Cr and Co are relatively high, while there are usually low concentrations of P and N (Proctor, 1999). Serpentine soils also tend to be shallow and dry (Proctor and Nagy, 1992). Due to these environmental stresses, the growth forms and physiognomy of some of the plant species growing in these soils can be different from those of non-serpentine areas. The concentrations of Ni in most serpentine plants are somewhat elevated, usually to about 10 - 100 mg g $^{-1}$ (Reeves, 1992). However, a number of plants growing in these soils are able to take up and accumulate high concentrations of Ni in their above-ground parts, especially the leaves. The hyperaccumulation of Ni to more than1000 mg g $^{-1}$ in leaf dry matter (Brooks et al., 1977) has so far been reported in more than 320 plant taxa from serpentines of tropical and temperate regions (Reeves and Baker, 2000). There are substantial areas of serpentine soils at many locations in Iraq, but there is little information on their flora and biogeochemistry. Some of these serpentine areas are located in the east and northeast of the country, near the borders of Iran and Turkey, respectively (Fig. 1).

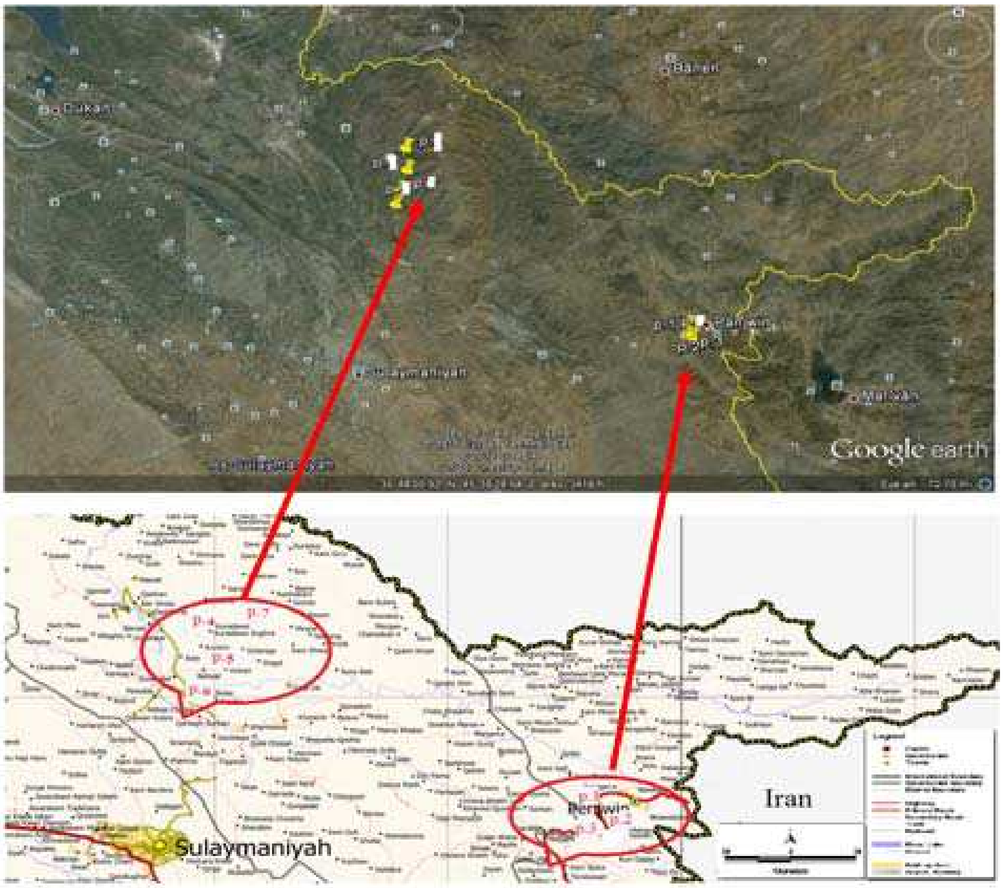

Figure 1. *Location of studied areas.*

Plants absorb a number of elements from soil, some of which have no known biological function and some are known to be toxic at low concentrations. Their availability in a soil-plant system depends on a number of factors which include pH of the soil, soil organic matter content, cationic exchange capacity as well as plant species, stage of development, and others (Farago 1994). It is known that the availability of some heavy metals decreases with rising pH of the soil, organic matter and clay content (Mengel and Kirkby 1978). Some of the absorbed elements are referred to as essentials because they are required for plants to complete their life cycle. As plants constitute the foundation of the food chain, some concerns have been raised about the possibility of toxic concentrations of certain elements being transported from plants to higher strata of the food chain.

2. Materials and Methods

Four main ultramafic rock bodies are distributed along the Iraqi Zagros Thrust Zone. They are Penjwin, Mawat, Pauza, and Qalander ultramafic bodies, in the order from southeast to northeast; The Penjwin igneous complex represents an ophiolite sequence within the larger Zagros belt. It is a northwest-southeast trending elongated body (35 km^2) within the Iraqi territories. While The Mawat igneous complex represents one of ophiolitic sequence within the Iraqi Zagros Thrust Zone. It shows north-south trending longitudinal shape, with 25 km length and 7–12 km width. It covers an area about 15 km^2 with total thickness of 1500 m. The serpentine site, Malkawa village (Penjwin Town), is located between 35^{o}35'58" N, 45^o 54' 59.8" E, and 1306 m above sea level, while the other site, Mawat town (Betwat and Kunjiren villages) was located between 39°32'106" N and 38°53'344 " E and 39°63' 001" N and 38°54'355" E respectively. Annual rainfall in the studied area ranged from 800 to1000 mm for Penjwin area, and from 250 to 350 mm for Mawat area.

During the period between, spring (April, May, June, 2009-2011), both Penjwin and Mawat areas were visited to collect the flora present on serpentine geological formation. Five to six plant species samples were collected randomly according to the most presence of plant species and these floras were grown and flourished on a serpentinite formation at both studied area (Fig 1). Identification of plant species was done with the help of botanist at the Crop Science Department at the Faculty of Agriculture Science (Table 2). These species were:

Table 1. *Identification and classification of studied plant species.*

	Scientific Name	Family Name	English Name	Generation	Notes
1	*Conium maculatum*L.	Ammiacea (Umbelliferae)	Poison Hemlock	Seeds	Winter annual
2	*Euphorbia helioscopia* L.	Euphorbiaceae	Sun spurge, wart weed	Seeds	Winter annual, toxic for animals
3	*Scrophlaria deserti*	Scrophulariaceae	Snapdragon	Seeds	Winter annual, toxic for animals
4	*Onosma sericeum*	Boraginaceae	Borage family	Seeds	Annual, toxic
5	*Teucrium polium*	Apiaceae (Umbelliferae)	Carrot family	Seeds	Annual, toxic
6	*Daucus carota*	Boraginaceae	Wild carrot Bird's nest	Seeds	Winter vegetation crop
7	*Lotus gebelia*	Fabaceae Papilionoideae	Pea family	Seeds	Winter annual
8	*Lepidium draba* L.	Brassicaceae (Cruciferеae)	Mustard family	Seeds	Winter annual
9	*Salvia viridis*	Lamiaceae (Labiatae)	Mint family	Seeds	Summer annual

The plant species (1, 2, 3, 4, and 5) were collected from Penjwin area in two positions of serpentine rocks (rock No.1and 2), while the rest of plant species were collected from Mawat area, also in two positions of serpentinite rocks (rock No. 3, (Betwat) and rock No. 4, (Kunjrin), (Table 2). All parts of plant tissue species were washed with distilled water to remove the dust, soil particles and foliar-applied materials that contained elements of interest in plant analysis determination (Jones, 2001). The plant tissues were dried in forced- air oven at temperature 60 ° C for three days, until reach a constant weight and the moisture contain in plant tissue was determined by using gravimetric method. Then the samples were ground in a Willy Mill and the ground materials was thoroughly mixed and stored in air- tight jars for further analysis. A wet digestion was carried out by taken a 1.000 g of dried plant tissue into a digestion tube and a mixture of 1:1(HNO_3, HCl) was added as described by (Jones, 2001). The extractions were stored in polyethylene tube at 4°C for determination of heavy metal by using AAS 800 Perkin Elmer according to (Margesin and Schinner, 2005). Statistical Analysis was used to evaluate the studied elements, correlation analysis and principal component analysis (PCA). IBM-SPSS Inc. (2011). SPSS Base 19 for Windows User's Guide. SPSS Inc., Chicago IL.

3. Results and Discussion

The plants species *Conium maculatum*L., *Euphorbia helioscopia L.*, *Scrophularia deserti, Onosma sericeum* and *Teucrium polium* were collected from Penjwin area. *Daucus carota* and *Lotus gebelia,* were collected from Mawat area (Betwat), while plants species *Lepidium draba* L. and *Salvia viridis* were collected from Kunjrin in Mawat area.

The results of metals total analysis of different parts of plants were indicated that the highest total Ni concentration (23.33 mg kg^{-1}) was found in *Euphorbia helioscopia L* plants collected from Penjwin area high in Ni content, and the lowest total Ni content 0.42 mg kg^{-1} was determined in *Lepidium draba* L collected from Mawat area. The second highest Ni content was also determined in *Salvia viridis* (20.03 mg kg^{-1}) collected from Mawat area, but the differences between the two species where the *Euphorbia helioscopia L* accumulated Ni in the roots, while the *Salvia viridis* accumulated Ni in the aerial parts (foliage). On the other hand, the other plant species *Lotus gebelia* accumulated Ni in the roots more than shoots. Other plants also accumulated Ni in the shoots inspite of the low Ni content. So, these plants translocate Ni in shoots through the uptake of Ni metal. Generally, Table (2) showed that most of the plant species had higher ability to accumulate metals in the aerial parts (foliage), translocated from the roots to leave and steam part, except *Euphorbia helioscopia L.* and *Lotus gebelia* plants accumulated metals in root parts (Fig 2).

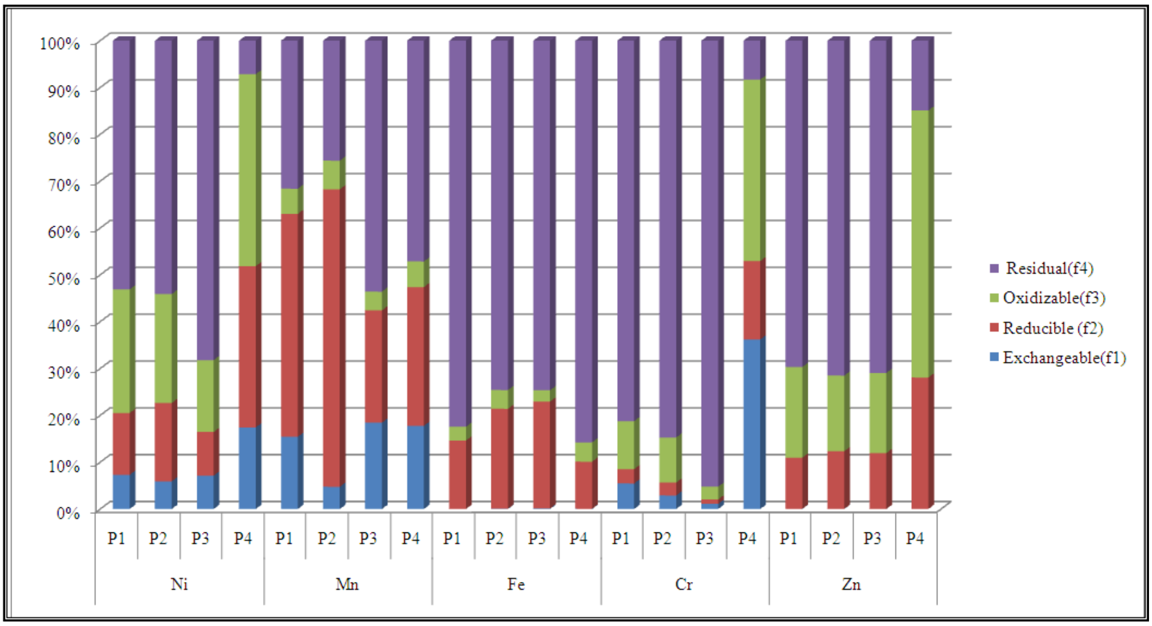

Figure 2. *Distribution of the elements fractions in pedons 1, 2, 3 and 4 from Penjwin area.*

In *Euphorbia helioscopia L.* plants the amount of Ni accumulated in their shoots was 2.69 mg kg^{-1}, while in the roots was 20.64 mg kg^{-1}. Similar study performed for the same plant species grown in serpentinitic soil from Penjwin and Mawat area by (Hossain, 2007), the results showed accumulating of very high concentration of Ni in all parts of this plant (5975, , 2110, 3060 mg kg^{-1} dry plant) in leaves, stem and fruit respectivelly, it was concluded that *E. helioscopia L.* was hyperaccumulative of Ni and other heavy metals, so, these results were in disagreement with those reported by (Hossain, 2007), but these results were in agreement with those found by (Khan *et al*.,2008), they found low concentration of Ni accumulation, when they studied accumulation of heavy metals in *E. helioscopia L.* in polluted soil (anthropogenic pollution) and un polluted soil in Pakistan.

The results also showed that low concentration of Ni in *Schrophuloria deserti* organ, and similar content of Ni was noticed in root (2.57 mg kg^{-1}) and shoot (2.77 mg kg^{-1}), while (Hossain, 2007) obtained very high concentration of Ni in the same plant species collected from the same area, the levels were 8020, 3200 mg kg^{-1} for leaves and stems respectively. Low amount of Ni were also accumulated in *Onosma sericeum*, *Teucrium polium*, *Daucus carota* and *Lepidium draba L* (Table 2). These results were disagreed with those found by (Hossain, 2007), he recorded up to 8140 mg kg^{-1} in leaves and (2300 mg kg^{-1}) in stem for *Teucrium polium* and (7980, 2450 mg kg^{-1}) in leaves and stem respectively for *Daucus carota.* The variation in Ni contents may be due to the variation in plant species, different of Ni contents in rocks, and soils position. These results were in agreement with those reported by (Hajiboland and Manafi, 2007), when they studied accumulation of heavy metals (Ni, Mn. Zn, and Cu) in plant species belong to 39 families, collected from two positions of serpentine rocks and soils (high and low levels of mentioned metals) on north west in Iran, and they reported that the Ni concentration in plant, varied from 3 to 186 mg kg^{-1} depended on plant species and collection site. While (Ghaderian *et al*., 2007) studied the concentration of Ni in seven *Alyssum* species that collected from two positions of serpentine soils (low and high Ni contents) in Iran, and they indicated that *Alyssum bracteatum* can contain up to 2300 mg kg^{-1}, the other species contain much lower concentration of Ni and other studied elements, also they indicated that the *A.Bracteatum* is endemic to Iran and the first Ni hyperaccumulator reported from this species.

Lotus gebelia, belonging to the legume family (Papilionoideae), the Ni content levels in the root were 6.90 mg kg^{-1} and 3.78 mg kg^{-1} in shoot part, this means the Ni was concentrated much more in the root than the shoot, also weak ability to translocate to the aerial part of plant, no data were obtained to explain the ability of legume plant species to grow on serpentine rocks and soils. *Salvai Viridis* plant recorded high levels of Ni in their shoot part (18.76 mg kg^{-1}), and (1.27 mg kg^{-1}) in their root, that means that the translocation of Ni from root to the aerial part was higher than that of all plants species studied. As (Hossain, 2007) reported that *Salvai sp.* was able to accumulate more than (1000 mg kg^{-1}dry weight) of Ni in their leaves and stems.

Generally, the results indicated that the both plant species *E. helioscopia L* and *Scrophularia deserti* accumulated large amount in their roots, while the other plant species accumulated large amount of Ni in the shoots part, this was may be due to histidine chelates Ni, suggesting that might assist root uptake of Ni (Peer *et al*., 2007). Andrew *et al*., (1995) suggested that the Ni hyperaccumulation trait in *Alyssum* was associated with the ability of the root system to produce substantial amounts of histidine as a Ni complexing ligand. These results were in agreement with those found by Oze *et al*., (2008), they determined the mean total Ni contents (0.10 -10.30 mg kg^{-1})

in vegetation that grow in two sites of serpentine and non serpentine. Similar results were also found by (Zehra *et al*., 2009, Malik *et al*., 2010, and Mohammad, 2011), while our results disagreed with Altinözlü *et al*., (2012), where the Ni contents in dried foliage were (100-13778 mg kg^{-1}), and they concluded that *Brassicaceae* **(***Alyssum Caricum Dudley***)** was classified as a hyperaccumulator of Ni.

According to Baker and Brooks, (1989), the results of the studied plant species indicated that these plants can be defined as non hyper accumulators for Ni. The ability of studied plant species to accumulate Mn was more than the Ni accumulation (Table 2). The highest Mn concentration (15.20 mg kg^{-1}) was found in roots of *Euphorbia helioscopia L.* plants; while the lowest Mn content (0.55 mg kg^{-1}) was determined in roots of *Daucus Carota* plants. The results also indicated that the plant species *Conium maculatum*, *Euphorbia helioscopia L., Scrophularia deserti*, *Teucrium polium,* and *Lotus gebelia* accumulated Mn in root part more than in shoot , while *Salvia viridis, Onosma sericeum*, and *Daucus carota* had an ability to translocate Mn in the aerial (foliage) parts, (Fig 2). *Euphorbia helioscopia L.* plant species accumulated Mn (15.20 mg kg^{-1}) in roots, while much lower (1.47 mg kg^{-1}) accumulated in shoot, this explained no translocation through the plant was noticed. Also *Teucrium polium* and *Lotus gebelia* accumulated Mn in roots more than shoots, but *Lepidium draba L.* showed low differences between Mn amount that accumulated in shoots (1.11 mg kg^{-1}) and roots (1.16 mg kg^{-1}).

The variations in Mn contents may be due to the variation in plant species and the different of Mn contents in rocks and soils position (Ghaderian *et al*., 2007). These results were in agreement with those reported by (Hajiboland and Manafi, 2007) in North West Iran. They explained that the Mn concentrations in plant species varied from 3 to 186 mg kg^{-1}, depending on plant species and collection site, while high concentration of Mn (20 – 145 mg kg^{-1}) was found by (Ghaderian *et al*., 2007), when they studied concentration of metals in *Alyssum* (Brassicaceae) in serpentine soil in Iran. While Mohammad, (2011) determined the uptake of (Ni, Mn, Cr, and Co) in wheat and grass that cultured in serpentine and non serpentine soil derived from ultramafic rock in Penjwin area, it was found that the highest amount of Mn uptake occurred in wheat and grass. It was emphasized that roots accumulated higher amount than shoots in all soils, since Mn was well known as immobile metals in root than shoots (Kabata-Pendias and Pendias, 2001). Based on (Baker and Brooks, 1989, and Market, 2003), the studied plant species could be defined as non Mn hyperaccumulators.

The concentrations of Fe determined in studied plant species showed the highest levels of accumulation, much more than that accumulated in Ni and Mn (Table 2). The highest Fe (540.18 mg kg^{-1}) was found in roots of *Euphorbia helioscopia L.*, while the highest Fe content (350.95 mg kg^{-1}) was found in leaves of *Salvia viridis* plant. Generally, the Fe content values in roots of these plants were ranged from 17.58 to 540.18 mg kg^{-1} found in roots of *Daucus carota* and *Euphorbia helioscopia L.*plants respectively (Fig 2).

The plant species, *Onosma sericeum*, *Daucus carota,*and *Salvia viridis* accumulated Fe in their aerial parts much more than Fe accumulated in roots, and these values were (119.12, 24.49, and 350.95 mg kg^{-1}) respectively. This indicated that high ability of these plants to translocate Fe through their plant parts, but in *Conium maculatum* accumulated similar levels of Fe (75.12 and 75.48 mg kg^{-1}) in shoots and roots respectively. Whereas *Euphorbia helioscopia L.*, *Scrophularia deserti, Teucrium polium* and *Lotus gebelia* showed high concentration of Fe accumulated in roots, these mean no translocation of Fe was noticed (Table 2). Both Fe uptake and transport between plant organs were highly affected by several plant and environmental factors, like soil pH, concentrations of Ca and P, and ratios of several heavy metals were the most pronounced (Kabata-Pendias and Pendias, 2001). The variation in Fe contents may be due to the variation in plant species and the different concentration of Fe presents in studied area (Oze *et al*., 2008). The same rang of Fe accumulation (2160-230 mg kg^{-1}) was found in seven species of *Alyssum*, collected from two sites of serpentine soil on west and northwest of Iran (Ghaderian *et al*., 2007). On the other hand, Oze *et al*., (2008) studied uptake and distribution of major and minor elements into the biomass of vegetation growing on serpentine and non serpentine soils, and they explained the presence of numerous factors (climate, relief, time, water availability, etc.) controlling and affecting plant growth. In contrast Khan *et al*., (2008) obtained low concentrations accumulated in *Euphorbia helioscopia L.* that growing in polluted and unpolluted area.

Table 2. *Concentration of heavy metals in plant species.*

Plant species	Organ	Concentration mg kg^{-1} Plant									
		Ni	Mn	Fe	Cr	Co	Cd	Ca	Mg	Cu	Zn
Conium maculatum	Shoot	1.18	2.21	61.19	0.44	0.10	0.001	351.87	228.57	0.30	1.57
	Leave	2.32	4.31	116.33	0.91	0.20	0.002	966.91	506.12	0.30	1.45
	Steam	1.06	1.66	47.83	0.44	0.09	0.002	405.30	248.45	0.22	1.04
	Root	2.50	2.93	75.48	0.98	0.22	0.003	495.70	345.87	0.45	1.47
Euphorbia helioscopia L.	Leave	1.39	1.79	20.69	0.15	0.18	0.001	577.64	274.92	0.24	0.92
	Steam	1.30	1.14	23.79	0.15	0.08	0.002	367.59	196.77	0.22	0.83
	Root	20.64	15.20	540.18	4.28	1.64	0.009	1619.29	2669.98	0.92	2.53
Scrophularia disert	Leave	1.79	3.43	102.46	0.61	0.14	0.007	768.45	371.65	0.45	2.32
	Steam	0.98	2.42	77.33	0.46	0.09	0.011	536.46	289.98	0.37	2.22
	Root	2.57	3.18	110.02	1.09	0.21	0.014	322.40	355.85	0.41	1.96

Plant species	Organ	Concentration mg kg^{-1} Plant									
		Ni	Mn	Fe	Cr	Co	Cd	Ca	Mg	Cu	Zn
Onosma sericeum	Leave	0.50	6.87	114.67	0.49	0.11	0.003	2783.49	199.09	0.80	2.16
	Steam	0.44	8.30	123.57	0.49	0.10	0.003	1460.39	140.42	1.11	2.63
	Root	0.18	3.02	50.70	0.23	0.05	0.001	633.15	61.85	0.04	1.49
Teucrium Polium	Leave	0.29	1.75	76.43	0.32	0.07	0.001	423.40	89.32	0.27	1.72
	Steam	0.21	1.24	57.94	0.22	0.05	0.001	311.98	64.25	0.20	1.43
	Root	0.37	3.30	122.25	0.58	0.11	0.006	743.82	122.25	0.97	3.88
Daucus Carota	Shoot	0.19	0.89	8.40	0.04	0.02	0.000	422.22	146.87	0.26	1.20
	Leave	0.18	1.20	36.07	0.13	0.03	0.001	667.33	93.79	0.21	1.13
	Steam	0.55	1.80	29.02	0.22	0.04	0.001	1395.52	328.85	0.76	3.01
	Root	0.42	0.55	17.58	0.13	0.03	0.000	166.62	74.16	0.21	0.51
Lotus Gebelia	Leave	2.00	6.87	39.79	0.17	0.09	0.001	2141.60	412.39	0.34	1.74
	Steam	1.78	1.98	23.92	0.15	0.05	0.002	1341.34	233.96	0.36	1.12
	Root	6.90	7.90	219.52	1.52	0.52	0.004	4277.59	575.47	0.62	2.13
Lepidium draba L.	Shoot	0.07	0.97	21.46	0.10	0.02	0.002	316.66	95.26	0.24	1.28
	Leave	0.15	1.34	49.43	0.18	0.05	0.004	809.73	220.84	0.29	1.17
	Steam	0.07	1.02	17.44	0.09	0.02	0.004	413.01	119.31	0.28	1.39
	Root	0.13	1.16	42.94	0.20	0.05	0.002	194.03	73.21	0.33	1.46
Salvai viridis	Leave	18.62	23.60	696.39	6.53	1.75	0.005	2842.23	2428.13	2.56	4.04
	Steam	0.14	0.55	5.50	0.06	0.03	0.000	271.27	111.88	0.21	0.34
	Root	1.27	1.71	44.90	0.54	0.11	0.000	292.25	285.24	0.31	1.32

Low concentration of Cr was found in plants that collected from both Penjwin and Mawat area. Table (2) showed the lower concentration of Cr in roots (0.13 mg kg-1) was found in *Daucus carota*, while the highest concentration (4.28 mg kg-1) was found in roots of *Euphorbia helioscopia* L. The highest accumulation in shoots (3.29 mg kg-1) was found in *Salvia viridis*, while the lowest Fe accumulated in shoots (0.12 mg kg-1) was found in *Lepidium draba* L. The results also showed that plant species *Onosma sericeum* and *Salvia viridis* accumulated higher values of Cr in their aerial parts, while *Conium maculatum, Euphorbia helioscopia L, Scrophularia deserti, Teucrium polium, Lotus gebelia* and *Lepidium draba* L accumulated the highest levels of Cr in their roots, whereas the same distributions were found in roots and shoots of *Daucus carota* (0.13 mg kg-1), (Fig. 2).

Plant species differed significantly in Cr uptake capacity and distribution within the plant (Grubinger *et al.*, 1994). Although the high concentration of Cr, found in four rocks positions (especially rocks No. 1, 2, and 3 Table 9), low amounts of Cr were found in studied plant organs, this may be due to the variation in plant species and the nature of Cr where exists predominantly in the Cr+3 oxidation state, very insoluble and much less available for plant uptake, so few Cr hyperaccumulator were identified (Hossner *et al.,* 1998). Under normal conditions, the concentrations of Cr in the plant were < 1 mg kg^{-1}. Chromium uptake by plants is mainly non-specific, probably as a result of plant uptake of essential nutrients and water. These results were in agreement with those obtained by (Ghaderian *et al.,* 2007; and Oze *et al.,* 2008). Low concentration of Cr were also found by Khan *et al*., (2008) in *Euphorbia helioscopia* L. growing in polluted and unpolluted area in Eslamabad, Pakstan, and the values were (0.12, 0.08, 0.18, 0.05 mg kg^{-1}) for roots, stems, leaves, and seeds respectively. While (Mohammad, 2011) determined the uptake of Cr in wheat and grass that cultured in serpentine and non serpentine soil derived from ultramafic rock in Penjwin area, and it was found that the means amount of Cr uptake in wheat and grass was similar in shoots and roots, but were lesser in roots (22.22 mg pot^{-1}) than in the shoots (5.64-4.04 mg pot-1) of the wheat and grass. The results of the studied plant species identified that the plants cannot be defined as Cr hyperaccumulators (Baker and Brooks, 1989, and Market, 2003).

Cobalt displayed very low accumulation in all studied plant species for both areas. The highest Co accumulated in roots (1.46 mg kg-^{1}) was found in *Euphorbia helioscopia* L.plant, collected from Penjwin area, and the lowest Co accumulated (0.03 mg kg^{-1}) was found in *Daucus carota* that collected from Mawat aea. Whereas the highest Co content in shoots (0.45 mg kg^{-1}) was determined in *Salvia viridis* collected from Mawat area, while the lowest (0.03 mg kg^{-1}) was found *in Lepidium draba* L that collected also from Mawat area. On the other hand, the other plant species that accumulate Co in the roots more than shoots were *Conium maculatum, Scrophularia deserti, Teucrium polium* and *Lotus gebelia*. The other plants also accumulated Co in the shoots in spite of the low Co content. So, these plants can translocate Co to the aerial parts through the uptake of Co metal (Fig 2).

The variation in Co contents may be due to the variation in plant species and the different of Co contents in rocks and soils position. So the Co content in all plant species was low and could not be hyperaccumulators for Co (Baker and Brooks, 1989). These results were in agreement with those found by (Khan *et al*., 2008; and Oze *et al.,* 2008). Higher amounts of Co were reported by (Malik et al., 2010) accumulated in 16 plant species collected in soils from industrial site contaminated of Islamabad, Pakstan. But Mohammad, (2011) obtained higher values of Co in wheat and grass cultured in serpentine soils, the values were (1.23 mg pot^{-1}), while Co values were lesser in plants cultured in non serpentine soils.

Plant species accumulated very low concentrations of Cd in both studied area, this may be due to the low levels of Cd, found in soils and rocks. The plant species *Conium maculatum, Euphorbia helioscopia L, Scrophularia deserti, Teucrium polium* and *Lotus gebelia*, accumulated high Cd in their roots, while the *Onosma sericeum, Daucus carota, Lepidium draba* L and *Salvia viridis* accumulated Cd in their shoots (Fig. 2). On the other hand, no Cd was detected in the roots of *Daucus carota* and *Salvia viridis*.

As it is known that the amount of Cd accumulated within the plant is limited by several factors, including: Cd bioavailability within the rhizosphere, rates of Cd transport into roots via either the apoplastic or symplastic pathways, the proportion of Cd fixed within roots as a Cd phytochelatin complex, accumulated within the vacuole, and rates of xylem loading and translocation of Cd (Hossner *et al.,*1998). Similar results were found by Khan et al., (2008), they reported that Cd could not be detected in plant samples, and this may be due to a very low level (below detection limit) (Nath, 1986). But Tanga *et al*., (2009) found high concentration of Cd (457 - 452 mg kg^{-1}) in native plant Arabis paniculata growing in mining area in China, and they emphasized that this species was identified as hyperaccumulator for Cd. The results of the studied plant species identified that the plants cannot be defined as Cd hyperaccumulators (Baker and Brooks, 1989, and Market, 2003).

Very high concentration of Ca that found in studied plants represented the highest element accumulated compared with the other elements. Generally, the concentration of Ca varied between plant species and plant organs. The highest Ca accumulation in the roots (4277.59 mg kg^{-1}) was found in *Lotus gebelia*, while the lowest Ca (166.62 mg kg^{-1}) was determined in the roots of *Daucus carota*. Whereas the highest Ca content in shoots (2121.94 mg kg^{-1}) was determined in *Onosma sericeum* collected from Penjwin area, while the lowest (367.69 mg kg^{-1}) was found in *Teucrium polium* that collected also from Penjwin area. The plants species *Conium maculatum, Scrophularia deserti, Onosma sericeum, Daucus carota, Lepidium draba L and Salvia viridis* accumulated much highest Ca in their shoots, while the plants species *Euphorbia helioscopia L, Teucrium polium,* and *Lotus gebelia* accumulated more Ca in their roots than shoots (Fig. 2). The highest levels of Ca that found in all plant were due to high concentrations of Ca that determined in soils and rocks. Also Ca has been known as passively absorbed by plants, so it is easily up taken. High levels of Ca accumulated in seven Alyssum species growing in serpentine soils in Iran were found by Ghaderian et al.,(2007)., and the Ca content ranged from 21830 to 54285 mg kg^{-1}.

The accumulation and distribution of Mg in studied plants approximately were high. The concentrations of Mg varied between plant species and plant organs. The highest accumulation of Mg in roots (2669.98 mg kg^{-1}) was determined in *Euphorbia helioscopia* L, while lowest accumulation of Mg (61.85 mg kg^{-1}) was found in the roots of *Onosma sericeum*. Whereas the highest Mg content in shoots (1270.01 mg kg^{-1}) was determined in the shoots of *Salvia viridis* collected from Mawat area, while the lowest (76.79 mg kg^{-1}) was found *in Teucrium polium* that collected also from Penjwin area. On the other hand, most studied plant species showed high levels of Mg accumulated in roots parts except *Onosma sericeum, Daucus carota, Lepidium draba L.* and *Salvia viridis* where the highest Mg was determined in their aerial parts; these indicated the high ability of this plant to translocate of Mg through the plant (Fig. 2).

These results were disagreeing with those found by Oze *et al*., (2008), they determined the total Mg contents (13-202 mg kg^{-1}) in native vegetation that grow in two sites of serpentine and non serpentine. Very high levels of Mg accumulated in seven Alyssum species growing in serpentine soils in Iran, and the ranges of 400 to 9640 mg kg-1 was found by Ghaderian *et al., (*2007).

Cupper displayed low accumulations in all studied plant species for both areas. The highest concentration of Cu in roots (0.97 mg kg^{-1}) was found in *Teucrium polium,* while the lowest concentration of Cu (0.04 mg kg^{-1}) was found in the roots of *Onosma sericeum* (Table 2). While the highest Cu content in shoots (1.39 mg kg^{-1}) was determined in the shoots of *Salvia viridis* collected from Mawat area, while the lowest (0.23 mg kg^{-1}) was found in the shoots of *Euphorbia helioscopia* L that collected from Penjwin area. The results showed that the plant species *Conium maculatum, Euphorbia helioscopia L, Teucrium polium, Lotus gebelia,* and *Lepidium draba* L. accumulated high amounts of Cu in their roots, this showed low ability of these plants to translocate Cu to the aerial parts while, *Onosma sericeum, Daucus carota* and *Salvia viridis* accumulated Cu in their shoots much more than the roots, this indicated that high ability of these plant to translocate Cu from roots to the aerial parts (Figures 27, 28, and 29), whereas the same distributions were found in roots and shoots of Scrophularia diserti (0.41 mg kg-1).

The variation in plant species may be the major reason explaining the variation in Cu contents in these plants. Similar results were obtained by (Yoon *et al.,* 2006), when they studied accumulation of (Pb, Cu, and Zn) in 36 native plants (17 species) growing on contaminated site in north Florida. They emphasized that none of these plants were suitable for phytoextraction. While Hajiboland and Manafi, (2007), obtained very high levels of Cu when they studied accumulation of heavy metals in plant species belong to 39 families, collected from two positions of serpentine rocks and soils in North West Iran, and they indicated that the accumulation of metals depended on plant species and collection site. Similar results were found by (Oze *et al.,* 2008; Zehra *et al.,* 2009; and Malik *et al.,* 2010). Based on these results the studied plant species were classified as non hyperaccumulators for Cu (Baker and Brooks, 1989; and Market, 2003).

Zinc displayed higher accumulation in all studied plant species for both areas compared to accumulation of Cu (Table 2). The results showed that the highest Zn (3.88 mg kg^{-1}) accumulated in the roots of *Teucrium polium*, while lowest Zn (0.51 mg kg-1) was determined in the roots of *Daucus carota,* while the highest Zn accumulated in shoots (2.39 mg kg-1) was found in Onosma sericeum, whereas the lowest Zn (0.88 mg kg-1) accumulated in the shoot parts was found in *Euphorbia helioscopia L*. On the other hand, the plant species *Scrophularia deserti, Onosma sericeum, Daucus carota* and *Salvia viridis* accumulated Zn in their shoots much more than the roots, this indicated that high ability of these plant to translocat Zn, while Conium *maculatum, Euphorbia helioscopia L., Teucrium polium, Lotus gebelia,* and *Lepidium draba* L. accumulated high amount of Zn in roots (Fig. 2).

The rate of Zn uptake differed greatly among both plant species and growth media, so, this may cause the variation in Zn contents in studied plant. These results were in disagree with those found by (Yoon et al., 2006; Hajiboland and Manafi, 2007; Malik *et al.,* 2010; and Cheraghi *et al.,* 2011), while they were in agreements with those found by (Oze *et al.,* 2008; and Zehra *et al.,* 2009). The results of studied plant species showed low ability to accumulate higher levels of Zn, so, these plants cannot be defined as huperaccumulator for Zn (Baker and Brooks, 1989, and Market, 2003).

Generally, the plant species *Onosma sericeum*, and *Salvia viridis* showed high ability to accumulat ten studied elements in their aerial parts (shoots), while *in Euphorbia helioscopia*, L ten studied elements were accumulated in the roots.

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