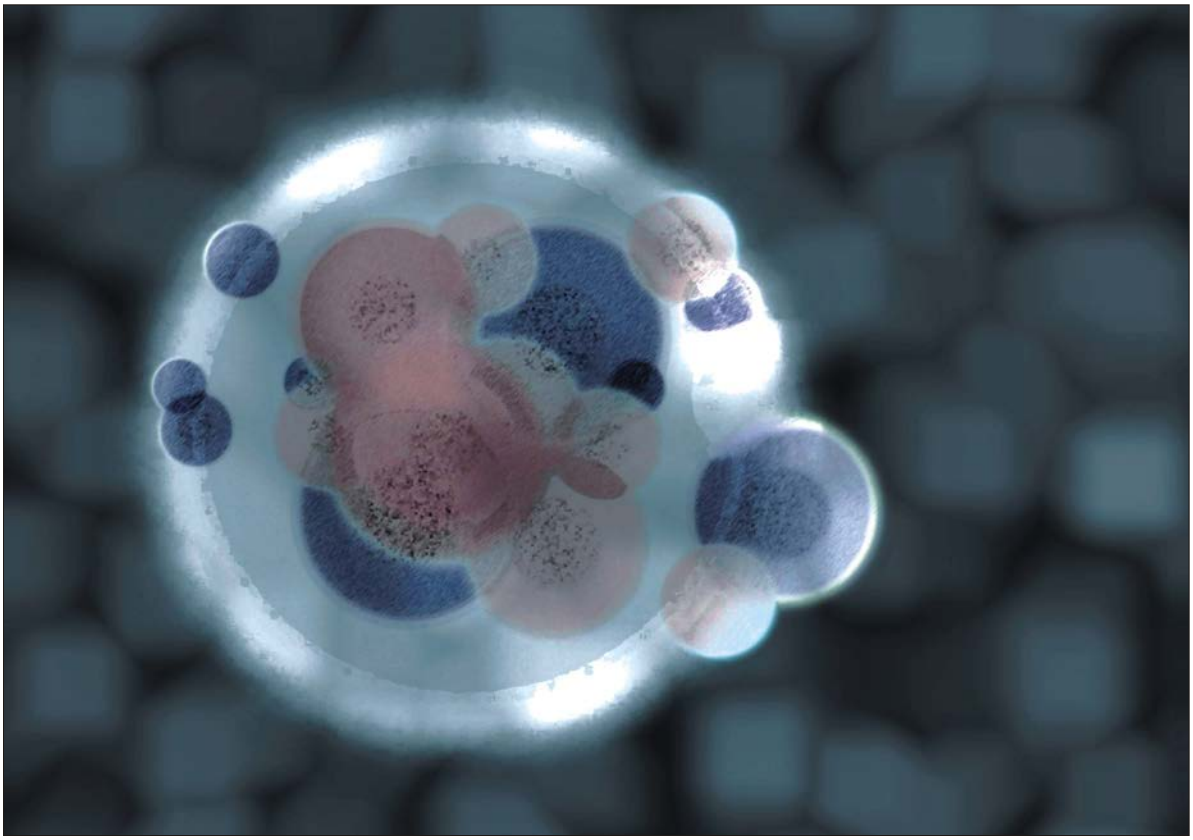

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Heavy Metals Accumulation in the Natural Vegetation of Eastern Province of Saudi Arabia

S.A. Al-Khateeb and A.A. Leilah
College of Agriculture and Food Science, King Faisal University, PO. Box 420, Al-Hassa, 31982, Saudi Arabia

Abstract: This study aimed to show the role of industrial activity on plant accumulation of some heavy metals and the possibility to use some plant species as bioindicator for heavy metals contamination. The examined plant species were *Anabasis setifera, Cyperus conglomeratus, Halocnemum strobilaceum, Haloxylon salicornicum, Panicum turgidum, Pennisetum divisum, Salsola baryosma, Seidlitzia rosmarinus, Suaeda vermiculata* and *Zygophyllum coccineum.* Cu, Mn, Zn and Fe concentration significantly varied among studied sites. Plant species grown at Al-Jubail (the area with high intensive industrial activities) accumulated higher concentrations than Al-Ugair (the area with light industrial activities), while the lowest concentrations were recorded from plant species grown at Salwa (the area with no industrial activity). Wide variations were noticed among the examined plant species in their concentrations of Cu, Mn, Zn and Fe. The ability of the examined plant species in Cu accumulation almost the same except *Anabasis setifer*a, *Suaeda vermiculata* and *Seidlitzia rosmarinus*. *Haloxylon salicornicum* accumulated the highest Mn concentration, followed by *Salsola baryosma*. The highest Zn concentration was noticed with *Salsola baryosma,* followed by *Pennisetum divisum* and *Cyperus conglomerates*. Plant species contained high levels of Fe were *Cyperus conglomerates* followed by *Halocnemum strobilaceum* and *Suaeda vermiculata*

Key words: Pollution, contamination, industrial activity, Fe, Cu, Zn, Mn, vegetation, Al-Jubail, Saudi Arabia

INTRODUCTION

A great attention should be paid to scope light on the real effects of the possible pollutants induced with the industrial capitals on forage quality of range vegetation lies near to the industrial cities. The eastern province is the largest industrial regions in Saudi Arabia. Pollution of the environment with toxic metals has increased dramatically due to the industrial revolution. The main sources of this pollution are fossil fuel burning, oil industries, mining and smelting of metal liferous ores, municipal wastes, landfill leachates, fertilisers, pesticides and sewage[1]. Industrial effluents and municipal waste waters usually contain high level of heavy metals such as As, Cd, Cr, Zn, Cu, Fe, Hg, Ni and Pb[2-5]. A number of plant species growing on metal-loading soil have been found to accumulate metals at substantial high levels in contrast to normal concentration.

The dangerous of heavy metals poising are of great concern since they enter food chain. Some heavy metals are needed in trace amount as Zn, Cu, Mn and Fe for plants[6]. High concentration of heavy metals in the ecosystems may lead to an excessive accumulation, which may be toxic to plants and cause possible health problem to animals and human. Numerous researchers have been identified some plant species with ability to develop tolerance to these pollutants, e.g. *Agrostis capillaries*[7], *Cyndon dactylon*[8] and *Ptreris vittata*[9]. Environmental pollution with heavy metals is usually assessed by physical/or chemical methods. Recently, using bioindicators, eg. plants and animals for monitoring environmental pollution have attracted attention[4]. Therefore, the present investigation aimed to study heavy metals concentrations in the evaluated naturally grown plants at Al-Jubail, Al-Ogair and Salwa sites and to distinguish the naturally grown plants which can be used as heavy metals bio-indicators.

MATERIALS AND METHODS

This investigation was conducted during 2003 and 2004 seasons at three sites in eastern province of Saudi Arabia (Al-Jubail, Al-Ugair and Salwa). The main purpose of this investigation was to evaluate concentrations of some naturally grown plants at the studied area for some heavy metals (Fe, Cu, Zn and Mn) to scope light on the influence of the industrial activities on range contamination and to detect the plant species which can be used as bioindicators for heavy metals pollution. Examined plant species were *Anabasis setifera.* Moq.,

Corresponding Author: Dr. S.A. Al-Khateeb, College of Agriculture and Food Science, King Faisal University, P.O. Box 420, Al-Hassa, 31982, Saudi Arabia

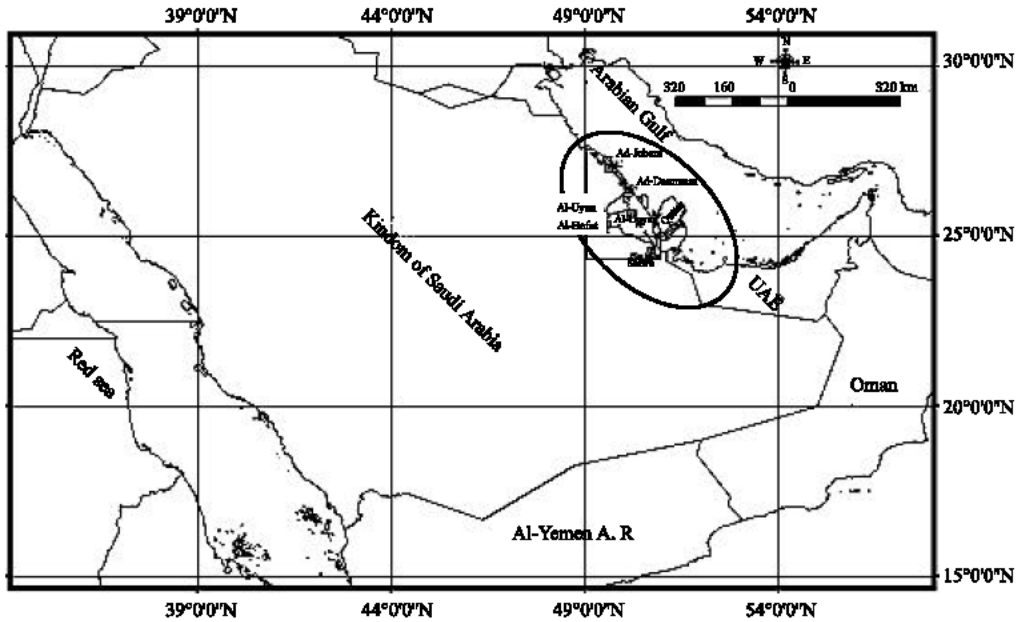

Fig. 1: Map of the study area in the Eastern Province of Saudi Arabia

Cyperus conglomeratus Rottb., *Halocnemum strobilaceum* (Pall.) M. Bieb., *Haloxylon salicornicum* (Moq.) Bunge ex Boiss, *Panicum turgidum* Forssk, *Pennisetum divisum* (J.F. Gmel.) Henrard, *Salsola baryosma* (Roem. Et schult) Dandy, *Seidlitzia rosmarinus* Bunge ex Boiss, *Suaeda vermiculata* Forssk ex J.F. Gmel and *Zygophyllum coccineum* L.

The study area: The three chosen sites were: Al-Jubail (49°31‘42.6’, 49°43’45.3’ E and 26°53‘38.6’, 27°10’51.4’N) as the nearest area for heavy industrial activities, Al-Ugair (49°45‘ 54.2’, 50°16’5.3’ E and 25°33‘36.1’, 25°45’29.4’N) as intermediate area for heavy industrial activities and Salwa (50°15’, 50°45’E and 24°40’, 25°05’N), as area with no industrial activities (Fig. 1). As in arid and semi arid zones, the study area is characterized with very hot summers and mild winters with very low rainfall.

The random samples were collected from the canopy of 10 dominated plant species which grown naturally in the studied area. The chosen plant species were taken from a transect 250 km extending from Al-Jubail (North) to Al-Ugair and Salwa (South) along the seashore of the Arabian Gulf, Saudi Arabia on the width of 50 km. Collected plant samples from each species were washed twice in the running tap water and then briefly washed with the distilled water and subjected to the chemical analysis. Metals of Fe, Zn, Cu and Mn were determined in the dry powder of these samples according to AOAC[10] using atomic absorption spectrophotometer.

Statistical analysis: Data were subjected to the statistical analysis as the technique of two way Analysis of Variance (ANOVA). The protected ANOVA LSD test was used to assess differences in heavy metal means for sites, plant species and their interaction[11]. Reading values of the 3 sites and 10 plant species were graphically illustrated, while the interaction values of plant species and sites were tabulated. Computations and statistical analysis were done using SAS[12].

RESULTS AND DISCUSSION

Wide variation was observed between the evaluated sites in Cu concentration of the evaluated plant species. The highest Cu concentration (56.4 ppm) was found in the plants naturally grown at Al-Jubail, followed by Al-Ugair (52.3 ppm) while the lowest value (43.6 ppm) was noticed from plant species grown at Salwa (Fig. 2A). Mn followed the same trend of Cu. Mn concentrations were 87.9, 71.3 and 55.8 ppm at Al-Jubail, Al-Ugair and Salwa, respectively (Fig. 2B). Maximum Zn concentration (19.7 ppm) was found at plant species grown at Al-Jubail, followed by Al-Ugair (16.8 ppm) and salwa (15.3 ppm). The difference between Al-Ugair and Salwa sites did not reach the level of significance (Fig. 2C). Fe concentration significantly varied among the three studied sites (Fig. 2D). Plant species grown naturally at Salwa site recorded the lowest Fe concentration (485.5 ppm), while plant species grown at Al-Jubail (the area with high

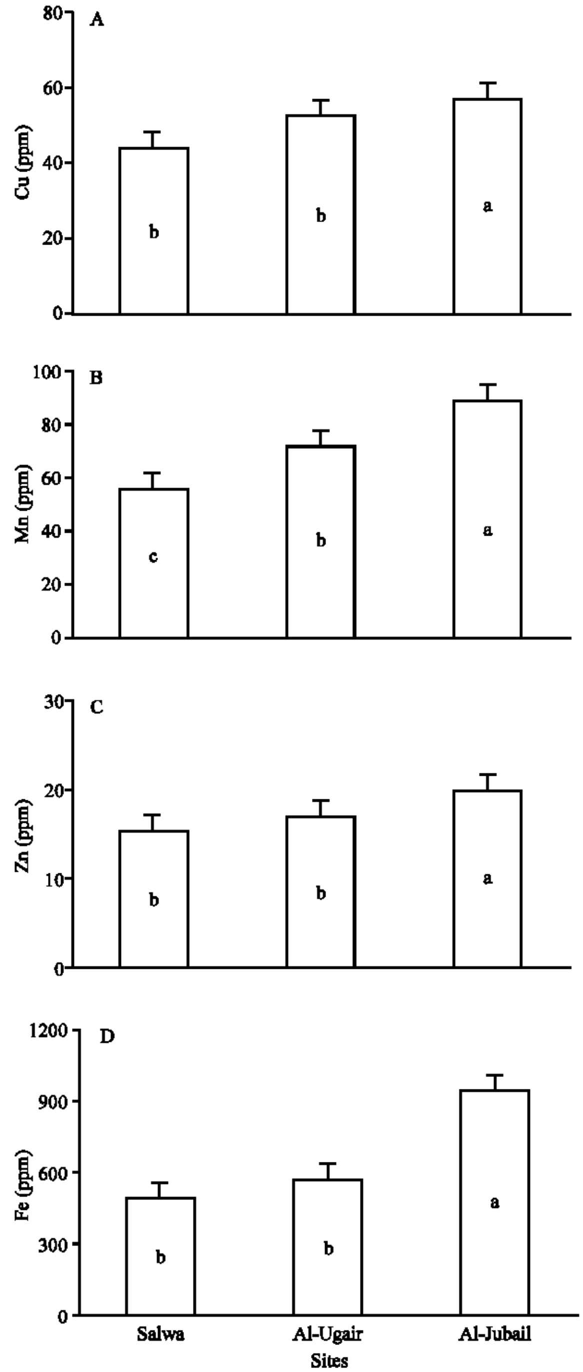

Fig. 2: Average concentrations (ppm) of Cu (A), Mn (B), Zn (C) and Fe (D) in plant species grown naturally in the different sites over all plant species. Bars = SD. Means followed by different letters differ significantly ($p < 0.5$)

industrial activities) recorded the highest value, 943.4 ppm. Plant species grown at Al-Ugair sites came in the middle with the value of 569.1 ppm. As it is expected, high concentration of many heavy metals in the industrial location have been extensively reported[5,13,14].

Evaluation of different plant species as bioindicators for heavy metals pollution include exposure of these plants to heavy metals. However, assessing of plant suitability as bioindicator may also monitoring by many chemical variability composition of plant species from clean and polluted sites. The ability of plant species to accumulate heavy metals have been widely reported[3,4,13]. Significant differences in Cu concentration were noticed among the examined plant species (Fig. 3A). The ability of most examined plant species in Cu accumulation was similar except in *Anabasis setifera*, *Suaeda vermiculata* and *Seidlitzia rosmarinus* showing the lowest Cu concentrations (Fig. 3A) with the highest values shown at al-Jubail site (Table 1). Concentrations of Cu shown in the present study were much higher than the toxic foliar concentration of most crop species reported by Marschner[6] which was above 20-30 $\mu g\ g^{-1}$. On the other hand, the concentration is higher than 25 $\mu g\ g^{-1}$ which considers a toxic level for sheep[15], but lower than (100 $\mu g\ g^{-1}$) the toxic level for cows [16].

Haloxylon salicornicum had the highest Mn concentrations (Fig. 3B) with the highest concentration in Al-Jubail site (Table 2), followed by *Salsola baryosma*. The lowest Mn concentrations were found with *Seidlitzia rosmarinus* (31.8 ppm) and *Anabasis setifera* (42.7 ppm) as shown in Fig. (3B) with the highest values in Al-Jubail site (Table 2). Those levels were much lower than the toxic level (1000 $\mu g\ g^{-1}$) for cows[16], sheep[15] and camels[17]. Figure 3C shows that *Salsola baryosma* had the highest Zn concentration (31.8 ppm) with the highest concentration ($p>0.05$) in Al-Jubail site and followed by *Pennesitun divisum* and *Cyperus conglomerates* (Fig. 3C and Table 3). *Zygophyllum coccineum* and *Seidlitzia rosmarinus* had the lowest Zn concentration and followed by *Anabasis setifera* and *Halocnemum strobilaceum*. *Panicum turgidum, Suaeda vermiculata* and *Halocnemum salicornicum* had the intermediate Zn concentration (Fig. 3C).

These concentrations are much lower than the toxic foliar concentration (100-300 $\mu g\ g^{-1}$) for most crop species reported by Marschuer[6]. Also, these concentrations were much lower than toxic level considers toxic for cows, 700 $\mu g\ g^{-1}$[18] and sheep, 500 $\mu g\ g^{-1}$[15].

Significant differences ($p>0.05$) in Fe concentration were noticed among plant species (Fig. 3D). Fe concentration was significantly higher ($p>0.05$) in *C. conglomerates* with the highest value in Al-Jubail site

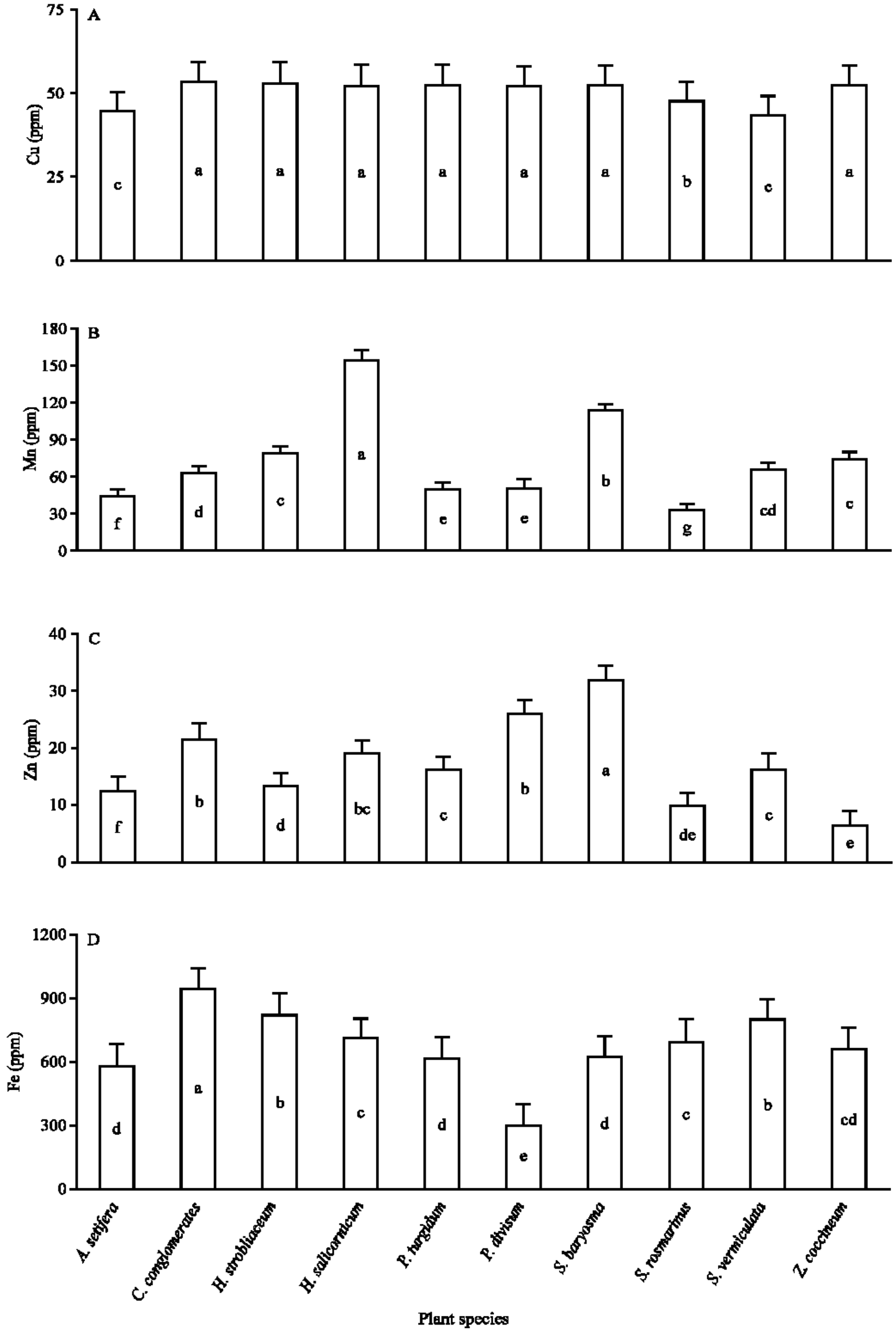

Fig. 3: Average concentrations (ppm) of Cu (A), Mn (B), Zn (C) and Fe (D) in plant species grown naturally in the study area over all sites. Bars = SD. Means followed by different letters differ significantly ($p<0.05$)

Table 1: Cu concentration ±SD (ppm) of plant sp. in the different sites

Plant sp.	Salwa	Ogair	Jubail
A. setifera	23.4±2.9^{c}	51.9±4.0^{b}	58.9±4.5^{a}
C. conglomerates	52.7±2.9^{b}	52.6±5.2^{b}	56.1±3.9^{a}
H. strobilaceum	54.9±3.4^{b}	53.4±3.9^{a}	53.0±2.1^{a}
H. salicornicum	50.1±3.2^{b}	52.8±2.1^{ab}	55.2±2.1^{a}
P. turgidum	51.9±3.5^{b}	51.4±2.2^{b}	54.3±3.0^{a}
P. divisum	48.5±285^{c}	52.7±2.3^{b}	56.0±2.5^{a}
S. baryosma	49.5±3.0^{b}	51.2±3.4^{b}	57.1±2.7^{a}
S. rosmarinus	37.2±3.3^{c}	50.5±2.4^{b}	56.6±3.2^{a}
S. vermiculata	24.6±2.6^{b}	53.1±3.9^{a}	53.7±3.1^{a}
Z.coccineum	43.2±3.5^{c}	53.0±4.4^{b}	62.1±5.2^{a}

Values in the same row with the same superscript letter or in the last column (Average) with the same capital letters are not significantly different ($p \geq 0.05$)

Table 2: Mn concentration ±SD (ppm) of plant sp. in the different sites

Plant sp.	Salwa	Ogair	Jubail
A. setifera	8.9±2.0^{b}	57.5±6.4^{a}	61.5±7.6^{a}
C. conglomerates	41.2±3.6^{b}	48.5±5.7^{b}	97.6±8.6^{a}
H. strobilaceum	71.9±4.1^{b}	75.6±8.6^{b}	85.0±7.5^{a}
H. salicornicum	130.9±8.1^{c}	158.6±8.5^{b}	172.6±8.5^{a}
P. turgidum	37.8±3.8^{c}	45.6±5.8^{b}	62.8±6.9a
P. divisum	36.9±3.0^{c}	45.6±4.3^{b}	67.9±5.6^{a}
S. baryosma	98.5±8.1^{b}	117.6±9.3^{a}	120.9±5.6^{a}
S. rosmarinus	12.4±2.3^{c}	20.5±2.4^{b}	62.4±7.5^{a}
S. vermiculata	52.1±5.7^{c}	69.6±9.9^{b}	71.4±8.4^{a}
Z. coccineum	66.9±7.5^{b}	74.3±7.3^{a}	78.1±7.9^{a}

Values in the same row with the same superscript letter or in the last column (Average) with the same capital letter are not significantly different ($p \geq 0.05$)

Table 3: Zn concentration ±SD (ppm) of plant sp. in the different sites

Plant sp.	Salwa	Ogair	Jubail
A. setifera	11.2±1.5^{a}	13.2±2.3^{a}	13.4±2.0^{a}
C. conglomerates	18.9±3.6^{b}	19.1±3.0^{b}	26.4±4.5^{a}
H. strobilaceum	12.6±3.7^{b}	12.8±4.2^{b}	14.0±2.7^{a}
H. salicornicum	17.7±2.8^{b}	18.5±3.1^{ab}	19.8±3.5^{a}
P. turgidum	15.1b±7.9^{b}	15.4±2.5^{b}	17.8±2.1^{a}
P. divisum	22.2±3.0^{c}	26.2±3.5^{b}	28.9±2.5^{a}
S. baryosma	28.6±3.2^{b}	31.0±3.9^{ab}	35.8±3.5^{a}
S. rosmarinus	8.8±7.1^{b}	10.1±2.0^{a}	11.1±2.1^{a}
S. vermiculata	11.4±5.0^{b}	14.9±2.8^{b}	22.2±4.8^{a}
Z. coccineum	6.3±4.1^{b}	6.5±3.9^{a}	6.9±2.4^{a}

Values in the same row with the same superscript letter or in the last column (Average) with the same capital letters are not significantly different ($p \geq 0.05$)

Table 4: Fe concentration ±SD (ppm) of plant sp. in the different sites

Plant sp.	Salwa	Ogair	Jubail
A. setifera	350.5±67.9^{b}	394.1±23.2^{b}	978.7±78.4^{a}
C. conglomerates	574.4±69.1^{b}	637.8±96.1^{b}	1592.0±84.6^{a}
H. strobilaceum	701.4±68.7^{b}	855.9±57.6a	885.5±50.6^{a}
H. salicornicum	580.9±70.2^{c}	698.7±65.0^{b}	820.4±75.8^{a}
P. turgidum	293.6±41.7^{c}	628.8±19.8^{b}	891.4±71.0^{a}
P. divisum	164.6±15.4^{a}	180.9±19.8^{a}	531.3±39.0^{a}
S. baryosma	438.9±22.4^{b}	456.3±35.6^{b}	937.5±52.8^{a}
S. rosmarinus	602.5±24.1^{b}	649.4±48.0^{b}	812.8±48.5^{a}
S. vermiculata	686.7±69.3^{b}	702.5±30.8^{b}	971.6±63.8^{a}
Z. coccineum	461.2±71.5^{b}	486.7±59.9^{b}	1012.1±87.6^{a}

Values in the same row with the same superscript letter or in the last column (Average) with the same capital letter are not significantly different ($p \geq 0.05$)

(Table 4) while the lowest was in *P. divisum*, but with highest value also in Al-Jubail site (Table 4). The concentration was lower than the toxic (1000 $\mu g\ g^{-1}$) in cows[18] and chamels[17], but higher than the toxic level (500 $\mu g\ g^{-1}$) reported for sheep[15] except on *P. divisum*.

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REFERENCES

1. Forstner, U., 1995. Land Contamination by Metals Global Scope and Magnitude of Problem. In: Allen, H.E., C.P. Huang, G.W. Baley and E.R. Bowers (Eds.), Metal Speciation and Contamination of Soil. CRC Press, Boca Raton, FL.
2. Abdukashem, M.D. and P.R. Singh, 1999. Heavy metal contamination of soil and vegetation in the vicinity of industries in Bangladesh. Water, Air and Soil Pollu., 115: 347-361.
3. Del, R.M., R. Font, C. Almela, D. Velez, R. Montoro and A.D.H. Bailon, 2002. Heavy metals and arsenic uptake by wild vegetation in the Guadiamar river area after the toxic spill of the Aznalcollar mine. J. Biotechnol., 98: 125-137.
4. Piczak, K., A. Lesniewicz and W. Zyrnicki, 2003. Metal concentrations in deciduous tree leaves from urban areas in Poland. Environ. Monitoring and Assess., 86: 273-287.
5. Cuny, D., F.O. Denayer, B. Foucault, R. Schumacker, P. Colein and C.V. Haluwayn, 2004. Patterns of metal soil contamination and changes in terrestrial cryptogamic communities. Environ. Pollu., 129: 289-297.
6. Marschner, H., 1995. Mineral Nutrition of Higher Plants. 2nd Edn. London: Academic Press: pp: 889.
7. Watkins, A.J. and M.R. Macnair, 1991. Genetics of arsenic tolerance in *Agrostis capillaries* L. Heredity, 66: 47-54.
8. Jonnalagadda, S.B. and G. Nenzou, 1997. Studies on arsenic rich mine dumps. II: The heavy element uptake by vegetation. J. Environ. Sci. Health, 32: 455-464.
9. Ma, L.Q., K.M. Komar, C. Tu. W. Zhang, Y. Cai and E.D. Kennelley, 2001. A fern that hyperaccumulates arsenic. Nature, 409: 579.
10. A.O.A.C., 1984. Official Methods of Analysis. 14th Edn., Association of Official Analytical Chemists, Arlington, USA.
11. Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. 2nd Edn., John Wiley and Son Ltd., New York, pp: 680.

12. SAS, 2001. Statitistical Analysis System Institute for Windows, SAS User's Guide: Statistics. Version 8.0 e. SAS Inst., Inc., Cary, North Carolina.
13. Saleh, M., E. Ewane, J. Jones and B.L. Wilson, 2000. Monitoring Wadi El-Riyan Lakes of the Egyptian desert for inorganic pollutants by lon-selective electrodes, ion chromatography and inductively coupled plasma spectroscopy. Ecotoxicol. Environ. Safety, 45: 310-316.
14. Salemaa, M., J. Derome, H.S. Helmisaari, T. Nieminen and I.V. Majamaa, 2004. Element accumulation in bryophytes, lichens and vascular plants exposed to heavy metal and sulfur deposition in Finland. Sci. Total Environ., 324: 141-160.
15. NRC, 1985. Nutrient Requirements of Sheep. 6th Edn., The Natl. Acad. Sci., pp: 2-25.
16. NRC, 2001. Nutrient Requirements of Dairy Cattle. 7th Edn., The Natl. Acad. Sci., pp: 105-161.
17. Wardeh, M.F., 1997. The Nutrients Requirements of the Dromedary Camels. The Arab Ceter for the Studies of the Arid Zones and Dry Lands. The Camel Applied Research and Development, ACSA/CARDN/ Camel /P29 /1997, Damascus.
18. NRC, 2000. Nutrient Requirements of Beef Cattle. 7th Edn., The Natl Acad. Sci., pp: 102-112.