Phytoremediation of Heavy Metals Contaminated Wastewater by the Plant Schoenoplectus Litoratus (L.) at Alasfar Lake in Alahsa, Saudi Arabia

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***Abstract*— *Schoenoplectus litorius* of the family *Cyperaceae* is an erect light green plant with hollow stems and tapering leaves one meter long with spikes, is used as a bio-remediating plant to aid in removing heavy metals from contaminated wastewater of Alasfar Lake in Saudi Arabia. *S.litoralis* plant accumulated heavy metals of (Cr=145.1 mg/kg), (Cu=60.15 mg/kg), (Zn=82.76 mg/kg), (Cd=0.39 mg/kg), in rhizomes, and (Cr=41.87 mg/kg), (Cu=44.19 mg/kg), (Mn=1102 mg/kg), (Cd=0.72 mg/kg) in the stem, and (Cr=205.5 mg/kg), (Cu=107.9 mg/kg), (Zn=74.99 mg/kg), (Cd=0.9 mg/kg) in the leaves and all these heavy metal concentrations are above the permissible levels suggested by the Food and Agriculture Organization and the World Health Organization (FAO/WHO, 2007). Absorption rate (TF) of elements from soil to plant parts (rhizome, stem , leaves) was high for Zn, Cu, Mn, Cd, and P, the transfer ratio (TR) between the different plant parts was high, and is high from roots to stem and leaves as regards P, K, Mn, Cd, and high to the leaves for Cr and Cu. There was a positive correlation between water and leaves in P concentration, and between soil and leaves for Cd, between soil and stem in Mg, Mn and Cd , and between soil and rhizomes as for Pb, Cd, Mn, Ca and between rhizomes and stem in contents of Mn, Cr and Mg. *Schoenoplectus litorius* is recommended as a phytoremediator for removal of heavy metals from wastewater of Lake Alasfar, and the species contains high concentrations of heavy metals so animals should be kept away from grazing on it.**

Keywords*— *Phytoremediation, Schoenoplectus litorius, heany metals

I. INTRODUCTION

Phytoremediation is a treatment in which plant species are used to remediate polluted water and soils from toxic heavy metals by the mechanism of absorption, translocation and accumulation of these toxic heavy metals in their different plant parts, roots, stems and leaves. Thus making the water and soil more favorable for production of crop plants, forages and fruit trees that can be safely used by humans and animals. It represents a cheap method of remediation of polluted water and soil. Bioaccumulation of toxic heavy metals from water and soil in food chain causes serious problems and highly dangerous to human and animal health (Islam et al., 2007). Recently the use of plants to remediate polluted water and soil has appeared as a good alternative and more reliable for improvement of polluted water and soil for agricultural use (Arthur, 2005). Bruno Pavonic (2010) estimated the content of some heavy metals absorbed by root and shoot of the plant *Schoenoplectus litoralis* that was planted in contaminated water as follows : Cd (0.16µg/L – 0.00), Cu (8.78 – 2.55 µg/L), Cr (7.05 – 0.56 µg/L), Pb (7.79 – 0.00 µg/L), Zn (48.5 – 13.29 µg/L). In a review provided by Zayed et al. (1998), *T. latifolia* is shown to be an accumulator of Cd, Cu, Ni, and Pb, while *Schoenoplectus sp.* also accumulates Cr. Moreover, Dunbabin & Browmer (1992) reported that metal concentration (Pb, Zn, Cd, Cu) in *T. latifolia* were consistently in the order roots > rhizome > non-green leaves > green leaves, so with the greater portion of the metal taken up by the plants retained in the roots. Results by (Wu et al., 2010) showed that up to 94.7 Pb mg/kg was found in shoots of *Cynodon dactylon* and it was found that Pb concentration in shoots was consistently lower than those in the roots of the plants collected from the metal- contaminated sites.

This research aimed to study the role of the plant species *Schoenoplectus litoralis* as a phytoremediator for absorption of the heavy metals polluting lake Alasfar at Al-Alhsa Province east of Saudi Arabia water. Lake Alasfar contains high concentrations of heavy metals specially Cd, Pb, Cr and plants growing in this water contain high concentrations of these metals (Fathi et al., 2013). The species *Schoenoplectus litorius* is one of the species inhabiting the water of Alasfar Lake, and the environment of this lake is changeable and needs more scientific researches.

II. MATERIALS AND METHODS

Alasfar Lake Region is in Al-Ahsa Province in the southern eastern corner of the eastern region of Saudi Arabia, 13 km east of Al-Ahsa and extends between Latitudes 25^0 05' and 25^0 40' north and between Longitudes 49^0 10' and 49^0 55' east , and rises about 109 m above sea level (Al-Taher, 1999). It is one of the shallow lakes with moistened soils and of most importance in the eastern region of Saudi Arabia. Its water is polluted by heavy metals, and a number of water plant species dominate its water, of which is *Schoenoplectus litoralis.*

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Analysis of heavy metals in plant, water and soil

Four plant samples were collected from each of the three sites chosen, and were separated into the roots, the stems and the leaves. Washed thoroughly with distilled water, and dried and ground, and plant extracts were made out of it. Then the concentration of heavy metals was determined from each of these three plant parts (roots, stems and leaves) using the absorption spectroscopy and was estimated as ppm. Soil samples were collected from three pits in each plant site, dried, digested and heavy metals were determined. Samples of water were collected from the same plant sites chosen, and heavy metal concentrations were determined.

The heavy metals and nutrients determined are Fe, Cu, Pb, Mn, Cd, Cr, Na, Ca, K, Mg and P using the absorption spectroscopy as ppm, and P was determined using An Inductively Compelled plasma-atomic emission spectrophotometer IL-Plasma200 according to method of (Allen et al., 1974).

Estimation of the Transfer Factor (TF) and Transfer Ratio (TR) for heavy metals

Heavy metals transferred from the soil to the different plant parts were estimated according to (Chamberlin, 1983) equation.

$$TF = \frac{\text{Concentration of an element in the plant body (ppm)}}{\text{concentration of the same element in the soil at the same site}}$$

The TR is estimated to determine whether the plant is capable in transferring nutrients and heavy metals from the root to the shoot according to (Kim et al., 2003).

$$TR = \frac{\text{Concentration of an element in the shoot (ppm)}}{\text{concentration of the same element in the root (ppm)}}$$

III. RESULTS

1. Heavy metals and nutritional elements in the different parts of S.litoralis plant and in soil and Lake water

The results in table (1) and figure (1) illustrate significant differences of all heavy metals and elements between t The results in table(8) of Pearson simple linear correlation coefficient (r) of the content of heavy metals and nutrients in soil and stem of *S.litoralis* illustrate a positive significant correlation (P≤0.05) for Mg (Mg=-0.726*) and for Mn (Mn=0.939*) and Na (Na=0.901*) and for Cu (Cu=0.981*) and for Zn (Zn=0.935*).

he different plant parts and soil and water. Lake soil was high in Na, Mg, K, Ca, Cr, Fe with means of 3435.3, 23598.6, 3738.56, 44824.07, 365.91 and 8793.81 ppm respectively, and registered low values in Cu (30.61 ppm.). Lake water registered high level in Cu (254.8 ppm.) and low values of P, P, Cr, Mn, Zn, Cd, Pb with 43.78, 172.9, 16.98, 2.32, 10.0 0.30, 0.17 ppm respectively. The roots (rhizome) registered high values in Zn and Pb with 82.76 and 3.84 ppm, and the stem registered high value in Mn (1102.25 ppm) and low value in Fe (165.07 ppm). The leaves registered high values in P and Cd 4333.32 and 0.90 ppm respectively, and low values in Na, Mg, Ca, giving 867.92, 3028.21 and 352.88 ppm respectively.

2. Means of transference factor (TF) and transference ratio (TR) of heavy metals and nutritional elements in S.litoralis

Results in table (2) showed that elements of P, Mn, Cu, Zn gave transference factor (TF) more than one between all plant parts and soil, also stem and leaves gave more than one TF of Cd, and leaves and rhizome gave more than one TF Pb. Also there are high transference ratio (TR) from roots to stem and leaves for K and Cd, and a lower TR for P and Mn, and ahigh TR of leaves as regards Cr and Cu.

Correlation between content of heavy metals and nutrients in water and leaves of S.litoralis

The results in table (3) of Pearson simple linear correlation coefficient (r) of the content of heavy metals and nutrients in water and leaves illustrate a positive significant correlation (P≤0.05), while K showed negative significant correlation.

Correlation between content of heavy metals and nutrients in water and stem of S.litoralis

The results in table (4) of Pearson simple linear correlation coefficient (r) of the content of heavy metals and nutrients in water and stem illustrate a negative significant correlation (P≤0.05) for Ca (Ca=-0.784*) and Cu (Cu=-0.749*) .

Correlation between content of heavy metals and nutrients in soil and leaves of S. litoralis:

The results in table (6) of Pearson simple linear correlation coefficient (r) of the content of heavy metals and nutrients in soil and leaves of *S. litoralis* illustrate a negative significant correlation (P ≤ 0.05) for Zn (Zn=-0.876*) and a positive significant correlation for Cd (Cd=0.789*).

Correlation between content of heavy metals and nutrients in soil and stem of S. litoralis:

The results in table (7) of Pearson simple linear correlation coefficient (r) of the content of heavy metals and nutrients in soil and stem of *S.litoralis* illustrate a positive significant correlation (P ≤ 0.05) for Mg (Mg = 0.735*) and for Mn (Mn=0.846*) and Cd (Cd=0.864*).

Correlation between content of heavy metals and nutrients in soil and rhizome of S. litoralis

The results in table(8) of Pearson simple linear correlation coefficient (r) of the content of heavy metals and nutrients in soil and stem of *S. litoralis* illustrate a positive significant correlation (P≤0.05) for Mg (Mg=-0.726*) and for Mn (Mn=0.939*) and Na (Na=0.901*) and for Cu (Cu=0.981*) and for Zn (Zn=0.935*).

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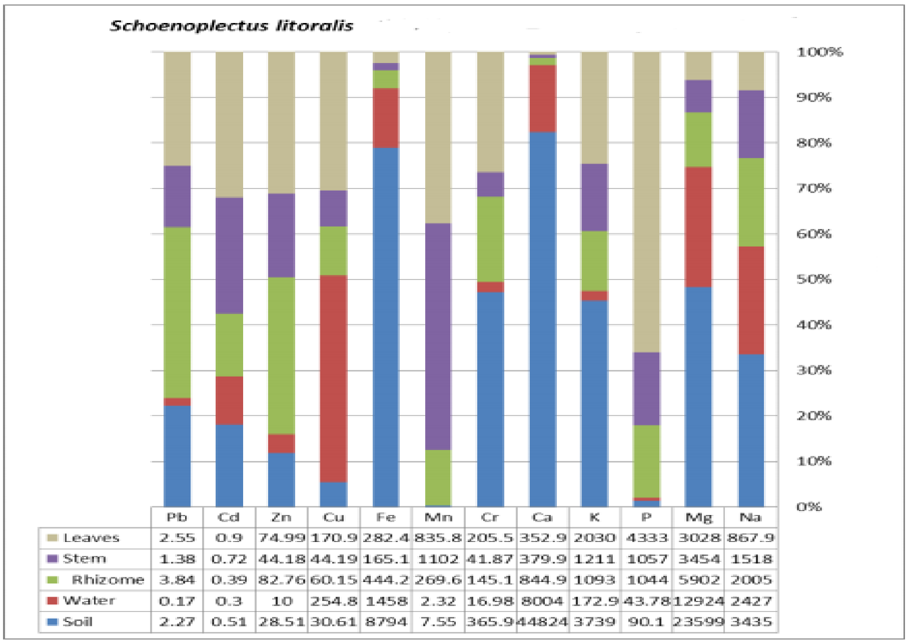

Fig. 1: Values of heavy metals and nutrient elements in plant parts of *S.lotiralis* and in water and soil samples:

Table (1): Means of concentrations of heavy metals and nutrients of water and soil samples and *S.litoralis* plant parts (first line) and standard error ± (second line) and F-Value based on ANOVA

Element (ppm)	Soil	Water	Rhizome	Stem	Leaves	F-Value
Na	3435.30	2427.42	2005.27	1517.63	867.92	19.979***
	±314.98	±1278.29	±451.56	±290.70	±294.48	
Mg	23598.60	12924.01	5902.28	3453.81	3028.21	140.110***
	±4174.51	±674.51	±2090.15	±1160.13	±781.70	
P	90.10	43.78	1044.37	1056.93	4333.32	738.691***
	±2.63	±21.51	±98.48	±169.84	±386.43	
K	3738.56	172.90	1092.51	1210.96	2030.20	2.658*
	±5497.19	±65.09	±170.29	±145.73	±411.05	
Ca	44824.07	8003.96	844.87	379.94	352.88	232.921***
	±8278.78	±1742.44	±99.97	±55.65	±68.36	
Cr	365.91	16.98	145.07	41.87	205.54	382.933***
	±26.48	±3.10	±27.26	±7.14	±28.56	
Mn	7.55	2.32	269.55	1102.25	835.79	96.266***
	±3.12	±1.24	±88.32	±258.43	±206.39	
Fe	8793.81	1457.69	444.17	165.07	282.40	2902.841***
	±259.41	±379.01	±29.26	±16.25	±28.38	
Cu	30.61	254.79	60.15	44.19	170.93	24.534***
	±4.50	±111.62	±18.21	±11.66	±66.14	
Zn	28.51	10.00	82.76	44.18	74.99	43.800***
	±10.23	±5.29	±25.43	±2.26	±13.61	
Cd	0.51	0.30	0.39	0.72	0.90	4.663**
	±0.21	±0.19	±0.15	±0.56	±0.41	
Pb	2.27	0.17	3.84	1.38	2.55	8.701***
	±2.02	±0.05	±1.76	±0.68	±1.43	

Table (2). Values of TF and TR in the different parts of *S. litoralis*

ppm	TF			TR	
	Leaves	Stem	Rhizome	Leaves	Stem
Na	0.25	0.44	0.58	0.43	0.76
Mg	0.13	0.15	0.25	0.51	0.59
P	48.09	11.73	11.59	4.15	1.01
K	0.54	0.32	0.29	1.86	1.11
Ca	0.01	0.01	0.02	0.42	0.45
Cr	0.56	0.11	0.40	1.42	0.29
Mn	110.70	145.99	35.70	3.10	4.09
Fe	0.03	0.02	0.05	0.64	0.37
Cu	5.58	1.44	1.97	2.84	0.73
Zn	2.63	1.55	2.90	0.91	0.53
Cd	1.76	1.41	0.76	2.31	1.85
Pb	1.12	0.61	1.69	0.66	0.36

Table (3): Pearson® Correlation between leaves and water for heavy metals and nutrients for plant S. litoralis

S. litoralis		Leaf (ppm)						
		P	K	Cr	Mn	Zn	Cd	Pb
Water (ppm)	Mg	.183	-.369	-.507	.370	.836**	.201	-.138
	P	.688*	-.003	.287	-.093	.143	-.151	-.327
	K	.315	-.752*	-.360	-.308	.536	-.410	-.693*
	Ca	-.226	-.866**	-.642	-.463	.471	-.603	-.559
	Cr	.005	-.594	-.384	-.248	.345	-.824**	-.494
	Mn	.419	-.453	.272	.050	.245	-.771*	-.663
	Fe	.770*	-.352	.216	-.759*	-.174	-.198	-.742*
	Cu	-.381	-.526	-.724*	-.016	.447	-.043	-.118
	Zn	.569	-.573	.151	-.330	.225	-.783*	-.821**
	Pb	.250	-.480	.185	-.062	.140	-.931**	-.643

IV DISCUSSION

The results in table (9) showed that *S.litoralis* plant accumulated heavy metals of (Cr=145.1 mg/kg), (Cu=60.15 mg/kg), (Zn=82.76 mg/kg), (Cd=0.39 mg/kg), in rhizomes, and (Cr=41.87 mg/kg), (Cu=44.19 mg/kg), (Mn=1102 mg/kg), (Cd=0.72 mg/kg) in the stem, and (Cr=205.5 mg/kg), (Cu=107.9 mg/kg), (Zn=74.99 mg/kg), (Cd=0.9 mg/kg) in the leaves and all these heavy metal concentrations are above the permissible levels suggested by the Food and Agriculture Organization and the World Health Organization (FAO/WHO, 2007) table (11). The main source of these heavy metals is lake Alasfar polluted water where we find that concentrations of Cr, Cu, Zn, Cd and Mn in this water is above that of the permissible levels according to (FAO, 1985). We observed that the plant accumulated P in its leaves at rates above the permissible level (P=4333 mg/kg), and this is mostly due to presence of some soil fungi that enhances P absorption by plant like mycorrhizal fungi. Also it can be seen that the absorption rate of elements from the soil to the different plant parts was high for Zn, Cu, Mn, Cd, Pb and P. The transfer ratio (TR) between the different plant parts was high, and is high from roots to stem and leaves as regards P, K, Mn, Cd, and a higher transfer from root to the leaves for Cr and Cu. This is because these are movable elements inside the plant so their concentrations increase inside plant tissues (Al-Whaibi, 2005). And can be seen from table (9) the presence of a correlation between the different plant parts and water and soil as regards concentrations of some heavy metals and elements. There was a positive correlation between water and leaves in P concentration, and a positive correlation in concentrations of Cd between soil and leaves, and in Mg, Mn and Cd between soil and stem, and a positive correlation between soil and rhizomes as regards contents of Mg, MN, Na, Zn and Cu, and a positive correlation in contents of Pb, Cd, Mn and Ca between stem and leaves, and a positive correlation in contents of Mn, Cr and Mg between rhizomes and stem. So there are correlations between the different plant parts as regards (Mg=0.908 ppm), (Cu=0.981 ppm), (Zn=0.935 ppm), (Cd=0.846 ppm), (Mn=0.939 ppm), (P=0.68 ppm) concentrations.

Bruno Pavonic (2010) found *S. litoralis* to absorb Pb at a rate of 7.79 ppm in its parts, above the standards of FAO (1985). *Schoenoplectus litoralis* can thus be a good bio-remediator absorbing heavy metals from heavy metals contaminated soil and water in its different parts. The linear correlation coefficients between heavy metal concentrations in each of the parts of the plant and that in the water, can lead to the use of these plant parts to detect water contamination and pollution. The results also showed that the plant parts below soil level are the first for heavy metal accumulation. In general, in this study, roots revealed greater heavy metal concentrations than leaves, while stems had the lowest concentrations. This results are in agreement with the reports of Peverly et al., (1995), Cheng et al., (2002), Stoltz & Greger, (2002), Weis & Weis, (2004) that found higher concentration of different metals in below sediment tissues of different wetland macrophytes. Plant S. litoralis can accumulate large amount of heavy metals in its rhizomes due to the large spaces between their testa cells (Sawidis et al.,1995). Taler, 1971 and (Liu et al.,2007) suggested the use of rhizomes as filtration factor of heavy metals, thus stopping it from moving to plant parts above ground. All plant parts showed big differences in concentration of Cu, Cr, and Cd, and there is a rise in transference from rhizomes to the upper parts. Zayed et al. (1998) reported that *Schoenoplectus sp.* accumulates Cr at high rate.

Table (4): Pearson® Correlation between stem and water for eavy metals and nutrients for plant *S. litoralis*.

S. litoralis		Stem (ppm)							
		Mg	K	Ca	Cr	Fe	Cu	Cd	Pb
Water (ppm)	Mg	.186	-.032	.008	-.635	-.698*	.124	.196	-.256
	P	-.152	.682*	.440	.160	.477	.817**	.399	-.202
	K	.642	.206	-.095	-.147	.033	.360	-.302	-.715*
	Ca	.716*	.020	-.784*	.014	-.270	-.212	-.788*	-.442
	Cr	.283	.096	-.310	-.036	.078	-.429	-.688*	-.433
	Mn	.150	.805**	.053	.148	.502	.461	-.308	-.575
	Fe	-.134	.094	.070	.677*	.135	.238	-.071	-.420
	Cu	.476	-.669*	-.408	-.419	-.699*	-.749*	-.493	-.283
	Zn	.146	.705*	-.063	.335	.424	.438	-.353	-.596
	Cd	.479	.745*	-.328	-.079	.152	.513	-.377	-.473

Table (5): Pearson® Correlation between rhizome and water for heavy metals and nutrients for plant *S. litoralis*.

Schoenoplectus litoralis		Rhizome (ppm)									
		Na	K	Ca	Cr	Mn	Fe	Cu	Zn	Cd	Pb
Water (ppm)	Mg	.726*	-.877**	.823**	-.691*	.353	-.031	.146	-.868**	-.570	-.652
	K	.668*	-.111	.537	-.248	-.590	.774*	.758*	-.599	-.884**	-.684*
	Ca	.580	-.037	.226	-.214	-.524	.656	.841**	-.398	-.551	-.315
	Pb	.270	.219	.020	.291	-.682*	.491	.476	-.148	-.180	.051

Table (6): Pearson® Correlation between leaves and soil for heavy metals and nutrients of *S. litoralis*.

Schoenoplectus litoralis		Leaf (ppm)				
		K	Cr	Zn	Cd	Pb
Soil (ppm)	Na	-.931**	-.592	.759*	-.453	-.706*
	Mg	-.828**	-.219	.112	-.814**	-.775*
	P	-.722*	-.801**	.759*	-.029	-.356
	Ca	.856**	.250	-.157	.812**	.788*
	Cr	.714*	.596	-.812**	.298	.533
	Mn	.548	-.068	.186	.771*	.627
	Fe	.913**	.596	-.780*	.422	.684*
	Cu	-.952**	-.414	.366	-.744*	-.824**
	Zn	.714*	.602	-.876**	.149	.473
	Cd	.929**	.338	-.303	.789*	.823**
	Pb	.613	.026	.166	.785*	.640

Table(7): Pearson® Correlation between stem and soil for heavy metals and nutrients for plant *S. litoralis*

Schoenoplectus litoralis		Stem (ppm)				
		Mg	Mn	Fe	Cd	Pb
Soil (ppm)	Na	.687*	-.265	-.363	-.504	-.740*
	Mg	.735*	-.856**	.300	-.871**	-.737*
	P	.568	-.111	-.757*	-.304	-.423
	Ca	-.750*	.839**	-.263	.871**	.753*
	Mn	-.560	.846**	-.609	.742*	.607
	Fe	-.667*	.220	.391	.468	.724*
	Cu	.784*	-.747*	.056	-.821**	-.812**
	Cd	-.787*	.763*	-.146	.846**	.803**
	Pb	-.598	.908**	-.498	.831**	.580

Table (8): Pearson® Correlation between rhizome and soil for heavy metals and nutrients for plant S. litoralis

Schoenoplectus litoralis		Rhizome (ppm)									
		Na	Mg	K	Ca	Mn	Fe	Cu	Zn	Cd	Pb
Soil (ppm)	Na	.901**	.666*	-.459	.684*	-.397	.605	.812**	-.856**	-.831**	-.695*
	Mg	.414	.726*	.351	.026	-.922**	.829**	.918**	-.190	-.441	-.164
	P	.827**	.384	-.565	.718*	-.060	.397	.611	-.799**	-.748*	-.700*
	K	-.595	-.484	.415	-.648	.160	-.162	-.211	.748*	.537	.598
	Ca	-.456	-.740*	-.308	-.069	.910**	-.834**	-.934**	.237	.477	.201
	Cr	-.857**	-.476	.642	-.743*	.096	-.370	-.548	.877**	.762*	.723*
	Mn	-.071	-.604	-.631	.278	.939**	-.707*	-.713*	-.175	.112	-.165
	Fe	-.909**	-.649	.498	-.708*	.355	-.572	-.783*	.876**	.829**	.705*
	Cu	.625	.764*	.092	.253	-.813**	.828**	.981**	-.435	-.615	-.366
	Zn	-.875**	-.439	.740*	-.803**	.014	-.307	-.520	.935**	.772*	.745*
	Cd	-.586	-.776*	-.156	-.212	.857**	-.837**	-.967**	.392	.585	.321
	Pb	-.134	-.596	-.597	.239	.935**	-.744*	-.767*	-.113	.196	-.079

Table (9): Rate of concentration of nutrient elements and heavy metals in *S. litoralis* in(mg/kg) and the standards permissible by (WHO/FAO,2007), and the toxic limits for water (in mg/L) suggested by FAO,1985) and soil (in mg/kg) and toxic limits by (EU,2002).

Elment	Water ASafer lake (mg/l)	FAO standard Cytotoxi Range (mg/l)**	Soil ASafer lake (mg/kg)	Eu Standards Cytotoxi Rang (mg/kg)***	Leafs (mg/kg)	Stem (mg/kg)	Rhizome (mg/kg)	FAO standard Cytotoxi Rang (mg/kg) *
Na	2427	-	3435	-	867.9	1518	2005	-
Mg	12924	-	23599	-	3028	3454	5902	-
P	43.78	-	90.1	-	4333	1057	1044	2000
K	172.9	-	3739	-	2030	1211	1093	10000
Ca	8004	-	44824	-	352.9	379.9	844.9	-
Cr	16.98	0.1	365.9	150	205.5	41.87	145.1	5
Mn	2.32	0.2	7.55	-	835.8	1102	269.6	1000
Fe	1458	5	8794	-	282.4	165.1	444.2	-
Cu	254.8	0.2	30.61	140	107.9	44.19	60.15	40
Zn	10	2	28.51	300	74.99	44.18	82.76	50
Cd	0.3	0.01	0.51	3	0.9	0.72	0.39	0.2
Pb	0.17	0.5	2.27	300	2.55	1.38	3.84	5

Table (10): Pearson® Correlation between heavy metals and nutrients in soil and water and plant parts of S. litoralis

	Leaf (ppm)	Stem (ppm)	Rhizom (ppm)
Water (ppm)	P, K	(Cu, Ca)	-
Soil (ppm)	Cd , Zn	(Cd, Mn, Mg)	(Zn, Cu, Mn, Mg, Na)
Leaf (ppm)	-	(Pb, Cd, Mn, Ca)	(Zn) , +(Cr, Mg)
Stem (ppm)	-	-	(Mn, Cr, Mg)

CONCLUSION

Schoenoplectus litorius plant accumulated heavy metals of Cr, Cu, Zn, Cd and P in its different parts at concentration levels above the permissible levels suggested by the Food and Agriculture Organization and the World Health Organization (FAO/WHO, 2007). Absorption rate (TF) of elements from soil to plant parts was high for Zn, Cu, Mn and P, stem and leaves absorbed Cd at a higher rate, and leaves and rhizomes absorbed Pb at a higher rate. The transfer rate (TR) between the different plant parts was high, and is high from roots to stem and leaves as regards P, K, Mn, Cd, and a higher transfer to the leaves for Cr and Cu. There was a positive correlation between water and leaves in P concentration, and between soil and leaves for Cd, between soil and stem in Mg, Mn and Cd , and between soil and rhizomes as for Pb, Cd, Mn, Ca and between rhizomes and stem in contents of Mn, Cr and Mg. Heavy metal concentration is the sequence rhizome < leaves < stem. *Schoenoplectus litorius* is recommended as a phytoremediator for water and soils contaminated with heavy metals.

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