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Phytoextraction and Translocation of Cadmium in Saline Soil by *Hemerocallis fulva* and *Dodonaea viscosa* Plants

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Abstract

Purpose: Cadmium contaminated saline soil has always been a problem for sustainable agriculture and environment. Cadmium (Cd) is a noxious heavy metal and its co-occurrence with high salt (NaCl) concentrations in soil decreases quality of food and quantity of crops. For this purposes to search the salinity problems in Cd contaminated soil, its uptake and accumulation and its effect on plant growth and biomass were studied in two terrestrial plants.

Materials and methods: Different concentration of salt, NaCl (1000 ppm, 3000 ppm and 6000 ppm) in combination with Cd metal (50 ppm, 100 ppm and 150 ppm) were added into pots soil, the two plants (*Hemerocallis fulva* and *Dodonaea viscosa*) were grown in it. For control (C) is used having no cadmium and salt while the remaining three with diverse concentrations of Cd (C1=50 ppm, C2=100 ppm and C3=150 ppm).

Results and discussion: Plant biomass and growth were highly reduced under variable concentrations of Cd and salt in soil. Combination of 6000 ppm NaCl and 150 ppm Cd in soil demonstrated highest significant Cd accumulation in the plants. *Dodonaea viscosa* showed high Cd-bioconcentration value (more than one) as compared to *Hemerocallis fulva* having less than one. It was noted that *Dodonaea viscosa* plant accumulate maximum concentration of Cd in sodium salt than *Hemerocallis fulva* plant.

Conclusion: *Dodoneae* plant potentially hyper accumulator and showed enough tolerance to high concentration of salt during phytoextraction of Cd. It is strongly recommended that such plants should be planted in metal contaminated saline soil and also for the conservation of barren soil.

Keywords: Terrestrial plants; Salinity; Soil; Phytoextraction

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Introduction

Water is important for existence and survival of life on earth. The demand of clean water for drinking and irrigation purposes is increasing with the ever growing world population. The rapid and unplanned utilization of fresh water resources have resulted in contamination of water with toxic pollutants. Toxic heavy metals such as cadmium enter the water resources through sewage waste, industrial effluents and mining discharge [1]. Cadmium can easily enter the human bodies through drinking of polluted water and through food chain [2]. Inside human body Cd interfere with gene expression, affect DNA repair systems, deters apoptosis and induces oxidative stress; resulting in damage to different organs such as the kidneys, liver, lung and bone marrow [3-5]. Salinization of water is another global problem that has adverse effects on sustainable agriculture and environment. Almost 953 million ha is affected by salinity; equal to about 7% of dry land on earth and 20% of total agricultural land on earth [6,7]. Because of water and soil salinity problem and their pollution with heavy metals which may be intensified in future has greatly increased the danger of heavy metals absorption in plants [8] and consequently into animals and ultimately humans, through food chain. Continuous irrigation of crops with heavy metals contaminated water not only increase concentration of these pollutants in soil but also compromise the quality and safety of food and consequently the human health [9].

The remediation of heavy metals contaminated water requires great attention from public and governing bodies to development an effective and affordable remediative technology for decontamination of heavy metal polluted water. Plants have the natural ability to absorb almost anything present in dissolved form in water and this ability of plants can be exploited for the decontamination of heavy metals contaminated water. Many scientists have based their research works on different aspects of the process of removal of metals from water, such as the degree of toxicity of heavy metals causing harm to plants, the use of plants as biofilters for polluted water, and biomonitoring of metals [10-13].

Dodonaea viscosa and Hemerocallis fulva are terrestrial and semi arid plants and were selected for the decontamination of saline watered polluted soil in the presence of Cadmium. The present investigation was carried out with the objectives to evaluate the potential of Dodonaea viscosa and Hemerocallis fulva plant for phytoremediation of cadmium from saline watered polluted soil.

Materials and Methods

Media (soil) preparation and plants transformation

Soil was collected from the herbarium of the University of Malakand, dried in sun light then grinded into fine powdered form and poured into clay pots (3 kg soil/pot). Water holding capacity (250 mL water/kg soil ± 4), electrical conductivity (814 µs ± 7) and pH (6.7 ± 2) of the soil was measured. Two different plants (*Dodonaea viscosa* and *Hemerocallis fulva*,) were used during the experiment. After germination uniform size plantlets (2 cm roots and 3 cm shoot) were selected for the experiment.

Treatments given to plants during the experiment

In the whole experiment Cadmium acetate dehydrate (Cd) solution were added to plants in three different concentrations (50 ppm, 100 ppm and 150 ppm) along with sodium chloride salt in the manner of three different concentrations (1000 ppm, 3000 ppm and 6000 ppm). Whole experiment was carried out in complete randomised design (CRD) in the manner of three replicates and one control under natural light/dark conditions with temperature 30°C/25°C. The following treatments and control (TABLE 1) were used during the experiment.

TABLE 1. **Application of Cd and NaCl during experiments. C for control is compared with all treatments to find out the effect of Cd alone and in combinations with salt (NaCl) on plant growth. While C1, C2 and C3 are compared with all other treatments for NaCl effect on Cd phytoaccumulation.**

Treatments	**Denoted**	**Treatments**	**Denoted**
Growth media Soil only	C	100 ppm Cd+1000 ppm NaCl	T4
50 ppm Cd	C1	100 ppm Cd+3000 ppm NaCl	T5
100 ppm Cd	C2	100 ppm Cd+6000 ppm NaCl	T6
150 ppm Cd	C3	150 ppm Cd+1000 ppm NaCl	T7
50 ppm Cd+1000 ppm NaCl	T1	150 ppm Cd+3000 ppm NaCl	T8
50 ppm Cd+3000 ppm NaCl	T2	150 ppm Cd+6000 ppm NaCl	T9
50 ppm Cd+6000 ppm NaCl	T3		

Measurement of plant's parameters

To measure the plant parts parameters, the experimental plants in pots were harvested. After two month and the length of their parts, roots, stems and leaves was measured through scale.

a, For fresh biomass the plants were separated into roots, stem and leaves) and weighed through physical balance. Each part was packed in envelope and labelled. The samples were kept in oven for dryness at 80°C for 48 h.

b, After complete dryness of the samples, the dry biomass were measured through digital scale. Water content for each part of a plant was calculated by subtracting dry biomass from fresh biomass. Through mortar and pestle the dried samples were crushed into powdered and packed in small polythene bags.

Analysis of Cd in plant tissues after complete degradation in acid

0.25 g from dried samples were taken in conical flask and dissolved in strong acids (Nitric acid and Sulfuric acid in ratio of 5: 1) followed the method of [14] with minor alteration. The flasks were kept on hot plat for 15 min at 300°C until the white fumes were come out. The acid dissolved solution was cooled, filtered into plastic bottles and for reaching volume up to 50 ml, distal water was added. 5 ml to 10 ml was taken from each bottle and examined by atomic absorption spectrophotometer for Cd concentration in central resource lab, Peshawar.

Statistical analysis

SPSS-16 and MS-excel (2010) and graph pad prism to analyses the data for actual value of Cd. The data was subjected to ANOVA and the mean values were compared by using Tukey's Honestly Significant Difference (HSD) test, at $P<0.05$.

Results

Effect of Cd on growth, biomass and water content of plants

The effect of different treatments on plants growth is shown in FIG. 1. The root, stem and leaf length of *Hemerocallis* and *Dodonaea* plants are given in (TABLES 2A, 2B) respectively. All the plants showed significant decrease in growth, biomass and total water content under different Cd concentrations (50 ppm, 100 ppm and 150 ppm). This decrease was highly significant at the highest concentration of Cd (150 ppm) when the control without Cd (C) was compared with Cd treated plants (C1, C2 and C3) as shown in (TABLES 2A, 2B) respectively for *Hemerocallis* and *Dodonaea* plants. At lower concentrations of Cd was not statistically significant as compared to control C (TABLE 2A). Similarly, the lowest concentration of Cd (50 ppm) shows non-significant decrease in all the above growth parameters (except the stem length) of *Dodonaea* plant as compared to the control C (TABLE 2B). The results showed a gradual decline in growth parameters in all the plants with increasing Cd concentration.

Combine effect of Cd and Salt (NaCl) on plant growth and biomass

The higher concentrations (3000 ppm and 6000 ppm) of NaCl salt in combination with Cd significantly decreased the growth, biomass and total water content of both *Hemerocallis* (TABLE 2A) and *Dodonaea* (TABLE 2B) plants when C1 (50 ppm Cd in Soil) was compared with T2 (50 ppm Cd+3000 ppm NaCl in Soil) and T3 (50 ppm Cd+6000 ppm NaCl in Soil). Similarly, when C2 (100 ppm Cd in Soil) was compared with T5 (100 ppm Cd+3000 ppm NaCl in Soil) and T6 (100 ppm Cd+6000 ppm NaCl in Soil), and C3 (150 ppm Cd in Soil) when compared with T8 (150 ppm Cd+3000 ppm NaCl in Soil) and T9 (150 ppm Cd+6000 ppm NaCl in Soil) given in (TABLE 2A, 2B). The lower concentration of NaCl (1000 ppm NaCl in Soil) in combination with Cd (T1, T4 and T7) showed no significant difference in all the growth parameters when compared C1, C2 and C3 respectively. The highest significant decrease in all the above growth parameters for *Hemerocallis* plant was recorded for the treatment T9 (150 ppm Cd+6000 ppm NaCl) as compared to control C.

Dodonaea plant showed decrease in plant growth (root and shoot length) and biomass (fresh and dry) with increasing salts (NaCl) concentration. This decrease was significant only at higher salt concentrations (3000 ppm and 6000 ppm) when T2, T3 was compared with C1, and T5, T6 was compared with C2, and T8, T9 was compared with C3 (TABLE 2B). The highest significant decrease in all the growth parameters was recorded in the treatment T9 as compared to control C.

Cadmium concentration and accumulation in plants

Hemerocallis plant showed a significant increase in tissues (Root, Stem and Leaves) Cd concentration with increasing Cd concentration (50 ppm, 100 ppm and 150 ppm) in soil, when compared C1, C2 and C3 in TABLE 3 (A). Similarly, the total Cd accumulation in different parts of the plant also increased as the Cd concentration in soil was increased, but this increase was statistically not significant. Salt (NaCl) showed positive and significant effect on Cd concentration and accumulation in various parts of the plant (TABLE 3A). Increasing Cd and sodium salt concentration in the soil increased the Cd

concentration in different parts of the plant and thus the highest significant Cd concentration (Root "25.40 ppm ± 2.30 ppm", Stem "46 ppm ± 2.86 ppm" and leaf "51 ppm ± 3.00 ppm") was recorded for the treatment T9 (150 ppm Cd+6000 ppm NaCl). The highest Cd accumulation (mg/DBM) in root (0.02 mg/DBM ± 0.009 mg/DBM), stem (0.016 mg/DBM ± 0.003 mg/DBM) and entire plant (0.127 mg/DBM ± 0.04 mg/DBM) was observed in treatment T9, while in leaves (0.104 mg/DBM ± 0.0 mg/DBM) it was observed in T4 (100 ppm Cd, without addition of NaCl salt in soil). Increasing Cd concentration in soil increased the Cd accumulation percentage in stem while decreased this percentage in roots and leaves when compared C1, C2 with C3 (TABLE 3A). The highest Cd percentage in roots (25.80% ± 1.18%) was recorded for treatment T7 (150 ppm Cd+1000 ppm NaCl in Soil), in stem (14.27% ± 3.80%) for C1 (50 ppm Cd in Soil) and in leave (72.26% ± 1.56%) for T8 (150 ppm Cd and 3000 ppm NaCl in Soil). The treatment T6 showed the highest translocation factors 2.21 root-stem and 2.29 root- leaves) and bioaccumulation factor (0.19) as shown in (TABLE 3A).

TABLE 3(B) presents the Cd concentration and accumulation in *Dodoneae* plant. The highest Cd concentration in roots (32.00 ppm ± 0.94 ppm) of the plant was found in C3 (150 ppm Cd only) while in stem (46.00 ppm ± 2.86 ppm) and leaves (51.00 ppm ± 3.00 ppm) it was recorded for the treatment T9 (150 ppm Cd+6000 ppm NaCl). Increasing the salt (NaCl) concentration in soil increased the Cd concentration in different parts of the plant (TABLE 3B). The plant accumulated more than 60% of its Cd in leaves in all treatments. The highest Cd translocation factor (2.21 roots to stem and 2.29 roots to leaves) was recorded for the treatment T6 (100 ppm Cd+6000 ppm NaCl in Soil). The bioconcentration factor of the *Hemerocallis* plant was much less than one (1) for all treatments (TABLE 3B).

The highest significant Cd concentration in roots (74.8 ppm ± 2.86 ppm and 78.4 ppm ± 1.36 ppm) and stem (62.2 ± 1.58 and 64.4 ppm ± 0.9 ppm) of *Dodonaea viscosa* plant was observed in C2 (100 ppm Cd in Soil) and C3 (200 ppm Cd in Soil) in TABLE 3 (C). The stem showed significantly high Cd concentration (62.00 ppm ± 1.54 ppm and 63.4 ppm ± 1.58 ppm) in treatments T2 (50 ppm Cd+3000 ppm NaCl in Soil) and T3 (50 ppm Cd+6000 ppm NaCl in Soil). While leaves possess significantly the highest concentration (98.2 ppm ± 1.56 ppm) of Cd in treatment T3 as shown in (TABLE 3B). The treatment T1 (50 ppm Cd+1000 ppm NaCl in Soil) showed the highest root to stem translocation factor (1.22). The root to leaves translocation factor (1.69) was highest in *Dodonaea viscosa* plant treated with 50 ppm Cd+6000 ppm NaCl in Soil (T3). Also the Cadmium bio-concentration factor (1.32) was found highest in the treatment T3 (TABLE 3C).

Correlation between plant Cd concentration and dry biomass

FIG. 2 shows correlations between dry biomass of different parts (root, stem and leaves) of *Dodoneae* and *Hemerocallis* plant species with Cd concentration. Negative correlation found between the dry biomass and Cd concentration in the root, stem and leaves of *Hemerocallis* plant while the roots of *Dodonaea* plant possessed a week positive correlation between dry biomass and Cd concentration but negative correlation present in its stem and leaves. From the above results it is stated that increasing of Cd concentrations automatically decreases plant dry biomasses but certain plants showed a little tolerance to such physiological stress conditions.

TABLE 2(A). **Effect on *Hemerocallis* plant. C (Soil without Cd and NaCl addition), C1, C2, C3 (50 ppm, 100 ppm, 150 ppm Cd in Soil), T1, T2, T3 (1000 ppm, 3000 ppm, 6000 ppm NaCl+50 ppm Cd with each NaCl concentration), T4, T5, T6 (1000 ppm, 3000 ppm, 6000 ppm NaCl+100 ppm Cd), T7, T8, T9 (1000 ppm, 3000 ppm, 6000 ppm NaCl+150 ppm Cd). ± SD denote Standard deviation and different letters show the significant difference among different treatments for a specific parameter.**

	Length cm			**Fresh biomass g**			**Dry biomass g**			**Total water contents g**		
	root	**stem**	**leaves**	**root**	**stem**	**leaves**	**Root**	**Stem**	**leaves**	**root**	**stem**	**Leaves**
C	15 ± 1 a	6.25 ± 0.25 a	26.3 ± 1.75 a	10.56 ± 0.32 a	4.448 ± 0.61 a	18.5 ± 0.57 a	4.226 ± 0.13 a	1.779 ± 0.243 a	7.395 ± 0.227 a	6.3 ± 0.19 a	2.669 ± 0.365 a	11.1 ± 0.34 a
C1	12 ± 1 b	4.50 ± 0.50b	21.00 ± 1.75 b	8.65 ± 1.16 b	3.212 ± 0.19 b	15.1 ± 2.03 b	3.46 ± 0.46 b	1.285 ± 0.07 b	6.055 ± 0.813 b	5.2 ± 0.7 b	1.927 ± 0.116 b	9.08 ± 1.22 b
C2	11.75 ± 0.75 b	4.00 ± 0.05bc	20.6 ± 1.31 b	7.435 ± 0.59 bcd	2.554 ± 0.37 bcd	13 ± 1.04 bcd	2.974 ± 0.238 bcd	1.022 ± 0.14 bcd	5.204 ± 0.416 bcd	4.5 ± 0.36 bcd	1.533 ± 0.219 bcd	7.81 ± 0.62 bcd
C3	11.25 ± 1.25 bc	3.5 ± 0.5 bcd	19.7 ± 2.19 bc	6.373 ± 0.18 cde	1.974 ± 0.01 def	11.2 ± 0.32 cde	2.549 ± 0.074 cde	0.79 ± 0.003 def	4.461 ± 0.129 cde	3.8 ± 0.11 cde	1.184 ± 0.004 def	6.69 ± 0.19 cde
T1	11.5 ± 1 b	4.5 ± 0.5 b	20.1 ± 1.75 b	7.802 ± 0.18 bc	3.045 ± 0 bc	13.7 ± 0.32 bc	3.121 ± 0.073 bc	1.218 ± 0.001 bc	5.461 ± 0.128 bc	4.7 ± 0.11 bc	1.827 ± 0.002 bc	8.19 ± 0.19 bc
T2	10.5 ± 0.5 bcd	3.75 ± 0.25 bc	18.4 ± 0.88 bcd	6.116 ± 0.34 de	2.18 ± 0.08 cde	10.7 ± 0.59 de	2.447 ± 0.134 de	0.872 ± 0.031 cde	4.281 ± 0.235 de	3.7 ± 0.2 de	1.308 ± 0.047 cde	6.42 ± 0.35 de
T3	8.25 ± 0.75 d	3.25 ± 0.25 cd	14.4 ± 1.31 d	5.71 ± 0.2 e	2.297 ± 0.46 bcd	9.99 ± 0.34 e	2.284 ± 0.079 e	0.919 ± 0.184 bcd	3.997 ± 0.138 e	3.4 ± 0.12 e	1.378 ± 0.276 bcd	6 ± 0.21 e
T4	11.75 ± 1.25 b	3.6 ± 0.4bcd	20.6 ± 2.19 b	6.213 ± 0.17 cde	1.914 ± 0.52 def	10.9 ± 0.31 cde	2.485 ± 0.07 cde	0.765 ± 0.208 def	4.349 ± 0.122 cde	3.7 ± 0.1 cde	1.148 ± 0.312 def	6.52 ± 0.18 cde
T5	9.5 ± 0.5 bcd	3.2 ± 0.2 cd	16.6 ± 0.88 bcd	4.049 ± 0.81 f	1.366 ± 0.28 efg	7.09 ± 1.41 f	1.62 ± 0.322 f	0.546 ± 0.114 efg	2.834 ± 0.564 f	2.4 ± 0.48 f	0.819 ± 0.171 efg	4.25 ± 0.85 f
T6	8.75 ± 1.25 cd	2.5 ± 0.5 de	15.3 ± 2.19 cd	3.79 ± 0.14 fg	1.076 ± 0.1 fg	6.63 ± 0.25 fg	1.516 ± 0.058 fg	0.431 ± 0.042 fg	2.653 ± 0.101 fg	2.3 ± 0.09 fg	0.646 ± 0.062 fg	3.98 ± 0.15 fg
T7	12 ± 1 b	3.5 ± 0.5 bcd	21 ± 1.75 b	6.085 ± 0.62 de	1.767 ± 0.22 defg	10.6 ± 1.09 de	2.434 ± 0.25 de	0.707 ± 0.087 defg	4.259 ± 0.437 de	3.7 ± 0.37 de	1.06 ± 0.131 defg	6.39 ± 0.66 de
T8	8.5 ± 0 d	2 ± 0 e	14.9 ± 0 d	3.852 ± 0.84 fg	0.906 ± 0.2 g	6.74 ± 1.47 fg	1.541 ± 0.335 fg	0.363 ± 0.079 g	2.697 ± 0.586 fg	2.3± 0.5 fg	0.544 ± 0.118 g	4.04 ± 0.88 fg
T9	4.25 ± 0.75 e	1.45 ± 0.05 e	7.44 ± 1.31 e	2.414 ± 0.1 g	0.863 ± 0.22 g	4.22 ± 0.18 g	0.965 ± 0.041 g	0.345 ± 0.086 g	1.689 ± 0.072 g	1.4 ± 0.06 g	0.518 ± 0.13 g	2.53 ± 0.11 g

TABLE 2(B). ***Dodonaea*** **plant growth. C (Soil without Cd and NaCl addition), C1, C2, C3 (50 ppm, 100 ppm, 150 ppm Cd in Soil), T1, T2, T3 (1000 ppm, 3000 ppm, 6000 ppm NaCl+50 ppm Cd with each NaCl concentration), T4, T5, T6 (1000 ppm, 3000 ppm, 6000 ppm NaCl+100 ppm Cd), T7, T8, T9 (1000 ppm, 3000 ppm, 6000 ppm NaCl+150 ppm Cd). ±SD denote Standard deviation and different letters show the significant difference among different treatments for a specific parameter.**

Treatments	Length (cm) ± SD			Fresh biomass (g) ± SD			Dry biomass (g) ± SD			Total water contents (g) ± SD		
	Root	Stem	Leaves	Root	Stem	Leaves	Root	Stem	Leaves	Root	Stem	Leaves
C	25.00 ± 1.00 ^{a}	35.00 ± 1.00 ^{a}	9.00 ± 1.00 ^{a}	1.98 ± 0.07 ^{a}	2.79 ± 0.29 ^{a}	0.72 ± 0.13 ^{a}	0.79 ± 0.03 ^{a}	1.12 ± 0.12 ^{a}	0.28 ± 0.05 ^{a}	1.19 ± 0.04 ^{a}	1.67 ± 0.17 ^{a}	0.43 ± 0.08 ^{a}
C1	22.50 ± 0.50 ^{ab}	29.50 ± 0.50 ^{b}	7.50 ± 1.50 ^{ab}	1.79 ± 0.04 ^{ab}	2.35 ± 0.06 ^{ab}	0.60 ± 0.14 ^{ab}	0.72 ± 0.02 ^{ab}	0.94 ± 0.03 ^{ab}	0.24 ± 0.05 ^{ab}	1.07± 0.02 ^{ab}	1.41 ± 0.03 ^{ab}	0.36 ± 0.08 ^{ab}
C2	21.50 ± 2.50 ^{abc}	22.50 ± 2.50 ^{c}	5.00 ± 0.01 ^{bcde}	1.54 ± 0.24 ^{bc}	1.61 ± 0.24 ^{cdef}	0.35 ± 0.01 ^{cdef}	0.61 ± 0.1 ^{bc}	0.64 ± 0.10 ^{cde}	0.14 ± 0.01 ^{cdef}	0.92 ± 0.14 ^{bc}	0.96 ± 0.14 ^{cde}	0.21 ± 0.01 ^{cdef}
C3	19.50 ± 0.50 ^{bc}	21.00 ± 1.00 ^{c}	4.50 ± 0.50 ^{cde}	1.52 ± 0.22 ^{bc}	1.63 ± 0.27 ^{cdef}	0.34 ± 0.01 ^{def}	0.61 ± 0.09 ^{bc}	0.66 ± 0.11 ^{cd}	0.13 ± 0.01 ^{def}	0.91 ± 0.13^{bc}	0.98 ± 0.16 ^{cd}	0.20 ± 0.01 ^{def}
T1	21.00 ± 1.00 ^{abc}	29.00 ± 1.00 ^{b}	7.50 ± 1.50 ^{ab}	1.65 ± 0.20 ^{ab}	2.28 ± 0.31 ^{ab}	0.57 ± 0.02 ^{abc}	0.66 ± 0.08^{ab}	0.91 ± 0.13 ^{ab}	0.23 ± 0.01 ^{abc}	0.98 ± 0.12^{ab}	1.36 ± 0.18 ^{ab}	0.34 ± 0.01 ^{abc}
T2	14.50 ± 0.50 ^{de}	15.00 ± 1.00 ^{d}	4.00 ± 0.01 ^{de}	1.43± 0.14 ^{bc}	1.47 ± 0.10 ^{cdef}	0.39 ± 0.05 ^{bcdef}	0.57 ± 0.06 ^{bc}	0.59 ± 0.04 ^{cdef}	0.16 ± 0.02 ^{bcdef}	0.85 ± 0.08 ^{bc}	0.88 ± 0.06 ^{cdef}	0.23 ± 0.03 ^{bcdef}
T3	12.50 ± 2.50 ^{ef}	13.00 ± 3.00 ^{d}	3.85 ± 0.35 ^{de}	1.17 ± 0.14 ^{c}	1.21 ± 0.18 ^{def}	0.36 ± 0.06 ^{cdef}	0.47 ± 0.05 ^{c}	0.48 ± 0.07 ^{def}	0.15 ± 0.02 ^{cdef}	0.70 ± 0.08 ^{c}	0.72 ± 0.10 ^{def}	0.22 ± 0.03 ^{cdef}
T4	18.00 ± 2.00 ^{cd}	22.52 ± 0.50 ^{c}	7.00± 2.00 ^{abc}	1.46 ± 0.11 ^{bc}	1.83 ± 0.10 ^{bc}	0.56 ± 0.14 ^{abcd}	0.58 ± 0.04 ^{bc}	0.73 ± 0.04 ^{bc}	0.22 ± 0.05 ^{abcd}	0.87 ± 0.06 ^{bc}	1.09 ± 0.06 ^{bc}	0.33 ± 0.08 ^{abcd}
T5	9.50 ± 1.50 ^{fg}	12.50 ± 2.50 ^{d}	4.00 ± 0.01 ^{de}	0.73 ± 0.01 ^{d}	0.90 ± 0.06^{fg}	0.31 ± 0.04 ^{ef}	0.29 ± 0.01 ^{d}	0.40 ± 0.02 ^{fg}	0.13 ± 0.01 ^{ef}	0.43 ± 0.02 ^{d}	0.54 ± 0.02 ^{fg}	0.18 ± 0.03 ^{ef}
T6	8.50 ± 0.50 ^{fg}	11.50 ± 0.50 ^{de}	4.03 ± 0.07^{de}	0.71 ± 0.01 ^{d}	0.95 ±0.01 ^{fg}	0.33 ± 0.01 ^{ef}	0.28 ± 0.01 ^{d}	0.38 ± 0.01 ^{fg}	0.13 ± 0.01 ^{ef}	0.42 ± 0.07 ^{d}	0.57 ± 0.01 ^{fg}	0.2 ± 0.01 ^{ef}

T7	14.50 ± 1.50 de	22.50 ± 2.50 c	6.50 ± 0.50 abcd	1.17 ± 0.19 c	1.81± 0.31 bc	0.51 ± 0.01 abcde	0.47 ± 0.08 c	0.73 ± 0.13 bc	0.20 ± 0.01 abcde	0.70 ± 0.11 c	1.08 ± 0.18 bc	0.31 ± 0.01 abcde
T8	7.50 ± 0.50 g	12.00 ± 2.00 de	3.65 ± 0.65 ef	0.65 ± 0.07 d	1.03 ± 0.13 efg	0.30 ± 0.06 ef	0.26 ± 0.03 d	0.41 ± 0.05 efg	0.12 ± 0.02 ef	0.39 ± 0.04 d	0.61 ± 0.08 efg	0.19 ± 0.04 ef
T9	7.00 ± 1.00 g	7.50 ± 0.50 e	3.10 ± 0.10 ef	0.58 ± 0.09 d	0.61 ± 0.03 g	0.25 ± 0.01 f	0.23 ± 0.04 d	0.25 ± 0.01 g	0.10 ± 0.01 f	0.34 ± 0.05 d	0.37 ± 0.02 g	0.15 ± 0.01 f

TABLE 3(A). **Cadmium concentration and accumulation by various parts of *Hemerocallis* grown in soil having different concentrations of NaCl and cadmium. C1, C2, C3 (50 ppm, 100 ppm, 150 ppm Cd in Soil), T1, T2, T3 (1000 ppm, 3000 ppm, 6000 ppm NaCl+50 ppm Cd with each NaCl concentration), T4, T5, T6 (1000 ppm, 3000 ppm, 6000 ppm NaCl+100 ppm Cd), T7, T8, T9 (1000 ppm, 3000 ppm, 6000 ppm NaCl+150 ppm Cd). ±SD denote Standard deviation and different letters show the significant difference among different treatments for a specific parameter. R=Roots, S=stem, L=Leaves.**

Treatments	Cd conc. (ppm)			Cd (mg/DBM)			Entire plant Cd accumulation (mg/DBM)	Cd accumulation %			Translocation factor		Bio-concentration
	R	S	L	R	S	L		R	S	L	R-S	R-S	
C1	23.00 ± 1.75 bcd	34.80 ± 0.38 cd	32.00 ± 1.00 de	0.08 ± 0.021 a	0.044 ± 0.003 a	0.194 ± 0 a	0.319 ± 0.06 a	24.9 ± 2 bc	14.27 ± 3.80 a	60.79 ± 1.80 e	1.52	1.40	0.59
C2	26.00 ± 2.48 ab	40.00 ± 0.54 bc	43.20 ± 1.00 bc	0.08 ± 0.011 ab	0.041 ± 0.002 ab	0.225 ± 0 a	0.343 ± 0.04 a	22.6 ± 1.87 bcde	11.87 ± 2.75 abc	65.57 ± 1.41 bcde	1.54	1.66	0.37
C3	32.00 ± 0.94 a	43.40 ± 2.38 ab	48.00 ± 2.00 ab	0.08 ± 0.007 a	0.0343 ± 0.007 b	0.214 ± 0 a	0.33 ± 0.04 a	24.7 ± 0.27 bc	10.39 ± 0.79 abc	64.89 ± 0.53 cde	1.36	1.50	0.28
T1	12.00 ± 1.60 e	11.40 ± 1.28 g	17.40 ± 2.00 h	0.04 ± 0.003 cd	0.0139 ± 0.001 cd	0.095 ± 0 b	0.146 ± 0.01 bc	25.6 ± 0.27 b	9.47 ± 0.26 abc	64.87 ± 0.38 cde	0.95	1.45	0.30
T2	13.00 ± 0.88 e	14.20 ± 1.42 g	24.80 ± 2.00 efg	0.03 ± 0.003 cd	0.0124 ± 0.002 cd	0.106 ± 0 b	0.151 ± 0.02 bc	21 ± 0.83 bcde	8.30 ± 0.18 bc	70.68 ± 0.78 ab	1.11	1.93	0.40
T3	16.80 ± 2.72 de	16.00 ± 1.00 g	30.40 ± 3.00 def	0.04 ± 0.007 cd	0.0146 ± 0.001 cd	0.121 ± 0 b	0.174 ± 0.03 bc	21.7 ± 1.43 bcde	8.33 ± 0.72 bc	69.92 ± 0.72 abc	0.98	1.91	0.49

T4	16.40 ± 4.86 de	24.40 ± 2.28 f	24.00 ± 1.00 fgh	0.04 ±0.01 cd	0.0186 ± 0.003 cd	0.104 ± 0 b	0.164 ± 0.01 bc	24.5 ± 4.44 bcd	11.46 ± 1.10 abc	64.02 ± 4.27 de	1.58	1.55	0.22
T5	17.60 ± 5.28 cde	36.20 ± 1.34 cd	37.40 ± 2.00 cd	0.03 ± 0.012 d	0.0197 ± 0.005 c	0.106 ± 0 b	0.154 ± 0.02 bc	18.4 ± 4.97 de	12.82 ± 3.23 ab	68.72 ± 2.94 abcd	2.07	2.13	0.31
T6	17.20 ± 1.98 de	38.00 ± 1.36 bc	39.40 ±3.00 c	0.03 ± 0.004 d	0.0164 ± 0.004 cd	0.105 ± 0 b	0.147 ± 0.03 bc	17.8 ± 0.74 e	11.13 ± 0.51 abc	71.06 ± 0.25 a	2.21	2.29	0.32
T7	22.20 ± 0.38 bcd	27.00 ± 0.50 ef	32.00 ± 4.00 de	0.05 ± 0.001 bc	0.0191 ± 0.002 c	0.137 ± 0 b	0.21 ± 0.02 b	25.8 ± 1.18 b	9.27 ± 0.66 abc	64.97 ± 1.66 cde	1.22	1.44	0.19
T8	22.00 ± 1.84 bcd	30.60 ± 0.50 de	43.40 ± 2.00 bc	0.03 ± 0.008 cd	0.0112 ± 0.002 cd	0.118 ±0 b	0.163 ± 0.03 bc	20.9 ± 0.72 bcde	6.84 ± 2.27 c	72.26 ± 1.56 a	1.39	1.98	0.23
T9	25.40 ± 2.30 abc	46.00 ± 2.86 a	51.00 ± 3.00 a	0.02 ±0.009 d	0.016 ± 0.003 cd	0.086 ± 0 b	0.127 ± 0.04 cd	19.4 ± 0.56 cde	12.44 ± 0.10 ab	68.19 ± 0.66 abcd	1.81	2.01	0.28

TABLE 3(B). **Cadmium concentration and accumulation by various parts of *Dodonaea viscosa* grown in soil having different concentration s of salt and cadmium. C1, C2, C3 (50 ppm, 100 ppm, 150 ppm Cd in Soil), T1, T2, T3 (1000 ppm, 3000 ppm, 6000 ppm NaCl+50 ppm Cd with each NaCl concentration), T4, T5, T6 (1000 ppm, 3000 ppm, 6000 ppm NaCl+100 ppm Cd), T7, T8, T9 (1000 ppm, 3000 ppm, 6000 ppm NaCl+150 ppm Cd). ± SD denote Standard deviation and different letters show the significant difference among different treatments for a specific parameter. R=Roots, S=stem, L=Leaves**

Treatment	**Cd concentration (ppm) ± SD**			**Cd accumulation (mg/DBM) ± SD**			**Entire plant Cd (mg/DBM) ± SD**	**Cd accumulation %**			**Translocation Factor (TF)**		**concentration factor (BF)**
	R	**S**	**L**	**R**	**S**	**L**		**R**	**S**	**L**	**R-S**	**R-S**	
C1	57.4 ± 2.02 b	48.8± 1.11 c	41 ± 2.5 d	0.04 ± 0.0002 ab	0.05 ± 0.0007 ab	0.0098 ± 0.0026 bcd	0.097 ± 0.0031 a	42.5 ± 1.62	47.39 ± 0.85	10.11 ± 2.46	0.85	0.71	1.02
C2	74.8 ± 2.86 a	62.2 ± 1.58 a	64.2 ± 3.54 c	0.05 ± 0.0018 a	0.04 ± 0.0014 abc	0.0091 ± 0.002 cd	0.095 ± 0.0045 ab	48.28 ± 1.15	42.03 ± 0.82	9.697 ± 1.79	0.83	0.86	0.68
C3	78.4 ± 1.36 a	64.4 ±0.9 a	96.6 ± 1.28 ab	0.05 ± 0.0076 a	0.04 ± 0.0063 abc	0.0133 ± 0.0005 ab	0.103 ± 0.0144 a	46.12 ± 0.7	40.82 ± 0.3	13.06 ± 0.98	0.82	1.23	0.49

T1	44.4 ± 1.34 cd	54.2 ± 1.8 b	43.8 ± 0.6 d	0.03 ± 0.0065 c	0.05 ± 0.0065 a	0.01 ± 0.0001 bcd	0.089 ± 0.0131 abc	32.95 ± 0.5	55.61 ± 1.16	11.44 ± 1.61	1.22	0.99	0.99
T2	54 ± 1.02 b	62 ± 1.54 a	48.4 ± 1.6 d	0.03 ± 0.0033 bc	0.04 ± 0.0061 bcd	0.0077 ± 0.0006 cde	0.075 ± 0.009 bcd	41.11 ± 0.43	48.7 ± 1.29	10.19 ± 1.69	1.15	0.9	1.14
T3	58 ± 0.9 b	63.4 ± 1.58 a	98.2 ± 1.56 a	0.03 ± 0.0029 c	0.03 ± 0.0022 cde	0.0145 ± 0.0009 a	0.072 ± 0.006 cd	37.4 ± 0.65	42.34 ± 1.05	20.27 ± 0.43	1.09	1.69	1.32
T4	40.6 ± 0.58 d	45 ± 0.86 d	48.6 ± 1.8 d	0.02 ± 0.0033 cd	0.03 ± 0.0047 cd	0.0109 ± 0.0024 abc	0.067 ± 0.0057 cde	35.02 ± 1.63	48.9 ± 3.28	16.08 ± 4.90	1.11	1.2	0.44
T5	47.6 ± 0.86 c	49 ± 1.02 c	53.6 ± 3 cd	0.01 ± 0.0016 de	0.02 ± 0.0023 fg	0.0068 ± 0.0024 de	0.039 ± 0.0024 fg	35.3 ± 1.45	47.55 ± 4.6	17.15 ± 3.19	1.03	1.13	0.49
T6	54.2 ± 2.86 b	52.2 ± 1.04 bc	83.6 ± 1.34 b	0.02 ± 0.0008 de	0.02 ± 0.0008 efg	0.0111 ± 0.0011 abc	0.046 ± 0.0014 efg	33.04 ± 0.78	43.09 ± 2.81	23.87 ± 2.52	0.96	1.54	0.58
T7	48.2 ± 1.58 c	36.4 ± 1.18 e	24.2 ± 14.3 e	0.02 ± 0.0006 cde	0.03 ± 0.0005 def	0.0051 ± 0.0018 e	0.054 ± 0.0028 def	41.7 ± 0.89	48.86 ± 1.55	9.44 ± 2.34	0.76	0.5	0.26
T8	55 ± 1.84 b	43.4 ± 0.92 d	52.4 ± 1.2 cd	0.01 ± 0.0041 de	0.02 ± 0.0049 fg	0.0067 ± 0.0002 de	0.039 ± 0.0091 fg	36.77 ± 0.7	46.13 ± 0.86	17.1 ± 1.48	0.79	0.95	0.32
T9	55.8 ± 1.3 b	51 ± 1.4 bc	64.6 ± 1.22 c	0.01 ± 0.0013 e	0.01 ± 0.0026 g	0.0066 ± 0.0013 de	0.032 ± 0.0009 g	40.05 ± 3.34	39.35 ± 6.79	20.6 ± 3.45	0.91	1.16	0.37

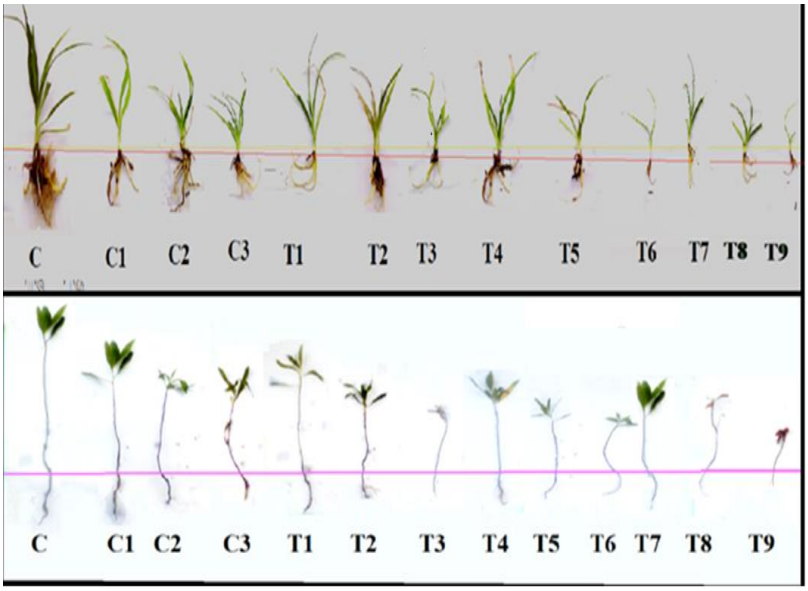

FIG.1. **Effect of different treatments on plants growth. C (Soil without Cd and NaCl addition), C1, C2, C3 (50 ppm, 100 ppm, 150 ppm Cd in Soil), T1, T2, T3 (1000 ppm, 3000 ppm, 6000 ppm NaCl+50 ppm Cd with each NaCl concentration), T4, T5, T6 (1000 ppm, 3000 ppm, 6000 ppm NaCl+100 ppm Cd), T7, T8, T9 (1000 ppm, 3000 ppm, 6000 ppm NaCl+150 ppm Cd).**

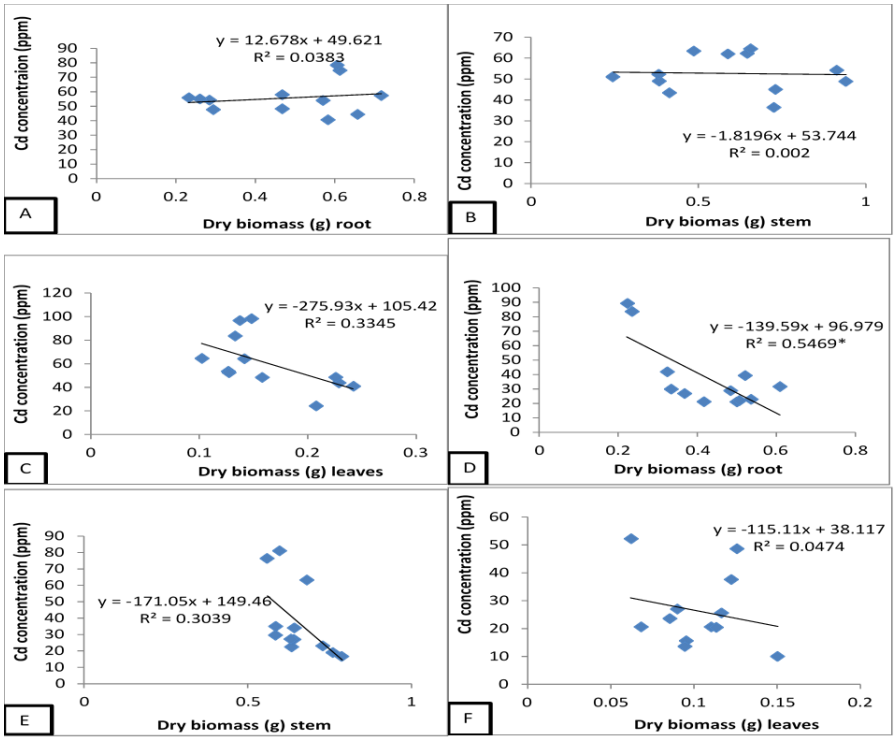

FIG. 2. **Correlation between dry biomass and Cd concentration within different parts of *Dodonaea viscosa* (A,B,C) and *Hemerocallis* (D, E, F) plants.**

Discussion

Cadmium contaminated soil decreases the plant growth, and it could be the negative effect of cadmium on uptake of nutrient and their distribution in the plant cells [15]. Its accumulation in plants cell may negatively affect the growth and development of a plant by causing a decrease in the enzymatic activities [16] and [17] disturb respiration, photosynthesis [18], stomatal closure [19] and reduction of nutrient uptake [20] The present result showed a decrease in plant growth and biomass due to Cd toxicity. Similar effects of Cd were reported by various investigators on different plants such as on *Cucumus sativus* [21] *Lemna polyrrhiza* [22] and on *Glycyrrhiza uralensis* [23]. Cadmium may affect the root elongation by reducing water and nutrient absorption, decreasing the transpiration rate and consequently decreasing growth rate [24].

Salinity in soil and water produces stress condition for plants and may lead to reduction in growth and biomass of a plant [25]. It affects plant in three ways, i.e. by decreasing its water potential, ionic imbalance or disturbances in ion homeostasis and its toxicity. Salinity cause physiological drought condition in plants and causes both osmotic as well as ionic stress, thus induce a reduction in growth [26]. The suppression of growth is directly related to the total concentration of soluble salts [27]. In current experiment salt (NaCl) showed an increasing effect on Cd absorption and accumulation within plant tissues. This increase in Cd content of plant might be due to two mechanisms i.e. exchange of metals from sorption sites in soil by the cationic component and formation of stable metal complexes with the chloride anion [28]. Addition of NaCl increased Cd concentration in the soil solution and accumulation in the leaf of Swiss chard [29]. It demonstrate that bioavailability of Cd is enhanced under saline conditions. Human-induced salinization and trace element contamination are widespread and increasing rapidly. Phyto-accumulation, as the crucial entry pathway for bio-toxic Cd into the human food stuffs, correlates positively with rhizosphere salinity. Organic matter decreases the bioavailable Cd^{2+} pool and therefore restricts its phytoextraction. Sodium salt (NaCl) showed reduction in plant growth and biomass compared to other treatments which might be due to its negative effect on production of endogenous plant growth regulators [30].

In the present result, Cd significantly reduced the plant growth, total water content (TWC) and biomass, the same result have been presented by [31] who reported that plant growth was reduced by Cd uptake and its distribution within cells. According to [32], Cd affects plant growth by damaging membrane permeability and elongation of cell. Current result showed that NaCl increased uptake of Cd at low concentration up to certain level while maximum amount of NaCl salt did not increase the Cd phytoextraction. Similar results were found in the work of [24], where sodium salt enhanced phytoextraction of Cd in optimum condition and cause toxicity to plants that ultimately affected the growth parameter. In this result specially in hydroponic condition growth parameter were reduced gradually with increase of sodium salt, because salt enhanced the translocation factor of Cd. [33] stated that sodium chloride is a biological dilution and improved the Cd concentration with increasing sodium salt concentration. [34], suggest that increasing salinity increases cadmium uptake and the reduction of growth has direct proportion to the sodium salt concentration [35].

Salt (NaCl) addition to growth media showed an increasing effect on the Cd concentration in different parts of the plant. Cd concentration was enhanced by the gradual increase of salinity [36]. Salinity enhanced the chloro-complex with Cd which may lead to increase the translocation of Cd in the cell [37]. A Similar increase in Cd concentration in relation with the

increase in the NaCl concentration in soil has been reported in potato and sunflower [38]. The Cd accumulation increased with the increase of salinity and maximum concentrations were reported in plant roots due to Cd elevation through salt [39].

These results are in general agreement with previous studies in which *Tamarix ramosissima* showed a marked diminution in growth in response to salinity but no diminution in photosynthesis over a salinity gradient from 0 mM to 200 mM NaCl and it was concluded that growth was negatively affected by salinity due to diversion of energy for increased respiration and salt pumping [40]. Phytoremediation is a right choice which is applicable to multi-contamination. Laboratory and field trials have proven successful, but this ideal technique is in all cases dependent on plant growth ability on low-fertility soil. While contaminant concentration has often been proposed as an explanation for plant growth limitation, other factors, commonly occurring in industrial soils, such as salinity, should be considered. In order to achieve the goal, the accumulation of Cd via root uptake at different saline conditions were investigated as there is notable evidence that salinity is a key factor in the translocation of metals from roots to the aerial parts of the plant.

Conclusion

Dodoneae plants grown in soil as well as in acidic and sodic soil too but show tolerance and were found as Cd hyperaccumulators, while *Hemerocallis* plants was not hyperaccumulators of Cd. The salt of sodium, although, increased the cadmium concentration in the plant tissues but showed negative effect on plant growth and biomass. Increasing the sodium salt concentration decreased biomass of the plants but showed an increasing effect on the Cd uptake and concentration within different parts of plant. From the results it is clear that the use of saline soil/water containing cadmium metal should be avoided to use for agricultural purposes because of higher absorption of Cd by plants in saline soil/water. It is strongly recommended that plantation and cultivation of *Dodoneae* plant is very important for phytoextraction of metals in saline soil and conservation of barren rocks.

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REFERENCES

1. Ali N, Hadi F. Phytoremediation of cadmium improved with the high production of endogenous phenolics and free proline contents in Parthenium hysterophorus plant treated exogenously with plant growth regulator and chelating agent. Environ Sci Pollut Res. 2015;22:13305-18.
2. Hadi F, Ali N, Ahmad A. Enhanced phytoremediation of cadmium-contaminated soil by *Parthenium hysterophorus* plant: Effect of gibberellic acid (GA3) and synthetic chelator, alone and in combinations. Bioremed J. 2014;18:46-55.
3. Huang D, Zhang Y, Qi Y, et al. Global DNA hypomethylation, rather than reactive oxygen species (ROS), a potential facilitator of cadmium-stimulated K562 cell proliferation. Toxicol Lett. 2008;179:43-7.
4. Joseph P. Mechanisms of cadmium carcinogenesis. Toxicol Appl Pharm. 2009; 238:272-79.

5. Hadi F, Ali N, Fuller MP. Molybdenum (Mo) increases endogenous phenolics, proline and photosynthetic pigments and the phytoremediation potential of the industrially important plant *Ricinus communis* L. for removal of cadmium from contaminated soil. Environ Sci Pollut Res. 2016;23:20408-30.
6. Sairam RK, Tygai A. Physiology and molecular biology of salinity stress tolerance in plants. Current Science. 2004;86:407-21.
7. Abdel fattah MA, Shahid SA, Othman YR. Soil salinity mapping model developed using RS and GIS-A case study from Abu Dhabi, United Arab Emirates. Eur J Sci Res. 2009;26:342-51.
8. Helal HM, Haque SA, Ramadan AB, et al. Salinity-heavy metal interaction as evaluated by soil extraction and plant analysis. Community Soil and Plant Analysis. 1996;27:1355-61.
9. Arora M, Kiran B, Rani S, et al. Heavy metal accumulation in vegetables irrigated with water from different sources. Journal of Food Chemistry. 2008;111:811-15.
10. Cardwell A, Hawker D, Greenway M. Metal accumulation in aquatic macrophytes from southeast Queensland Australia. Chemosphere. 2002;48:653-63.
11. Hassan SH, Talat M, Rai S. Sorption of cadmium and zinc from aqueous solutions by water hyacinth (*Eichhornia crassipes*). Bioresour Technol. 2007;98:918-28.
12. Drost W, Matzke M, Backhaus M. Heavy metal toxicity to *Lemna minor*: Studies on the time dependence of growth inhibition and the recovery after exposure. Chemosphere. 2007;67:36-43.
13. Dunbabin JS, Bowmer KH. Potential use of constructed wetlands for treatment of industrial waste water containing metals. Science of Total Environment. 1992;111:151-68.
14. Allen SE, Grimshaw AH, Parkinson JA, et al. Chemical analysis of ecological materials. Blackwell Scientific Publications, Oxford, UK. 1974.
15. Hernandez LE, Carpena-Ruiz R, Garate A. Alterations in the mineral nutrition of pea seedlings exposed to cadmium. J of Plant Nutrition and Soil Sci. 1996;19:1581-98.
16. Ouarili O, Boussama N, Zarrouk M, et al. Cadmium and copper- induced changes in tomato membrane lipids. Phytochem. 1997;45:1343-50.
17. Van Assche F, Clijsters H. Effects of metals on enzyme activity in plants. Plant Cell Env. 1990;13:195-206.
18. Vassilev A, Lidon F, Matos MDC, et al. Photosynthetic performance and content of some nutrients in cadmium- and copper-treated barley plants. J of Plant Nut. 2002;25:2343-60.
19. Barcelo J, Poschenrieder C. Plant water relations as affected by heavy metal stress: A review. J of Plant Nut. 1990;13:1-37.
20. Sanità DI, Toppi L, Gabbrielli R. Response to cadmium in higher plant. Environ Exp Bot. 1999;41:105-130.
21. Abu-Muriefah SS. Growth parameters and elemental status of cucumber (*Cucumus sativus*) seedlings in response to cadmium accumulation, Int J Agri Biol. 2008;10:261-66.
22. John R, Ahmad P, Gadgil K, et al. Effect of cadmium and lead on growth, biochemical parameters and uptake in *Lemna polyrrhiza* L. Plant Soil Env. 2008;54:262-70.
23. Zheng G, Lv HP, Gao S, et al. Effects of cadmium on growth and antioxidant responses in *Glycyrrhiz auralensis* seedlings. Plant Soil Env. 2010;56:508-15.

24. Chen ZS, Lee GJ, Liu JC. The effects of chemical remediation treatments on the extractability and speciation of cadmium and lead in contaminated soils, Chemosphere. 2000;41: 235-42.
25. Sirguey C, Ouvrard S, Contaminated soils salinity, a threat for phytoextraction. Chemosphere. 2013;91:269-74.
26. Hayashi H, Murata N. Genetically engineered enhancement of salt tolerance in higher plants, Molecular Mechanisms and Molecular Regulation. Elsevier Amsterdam. 1998;133-48.
27. Flowers TJ, Troke PF, Yeo AR. The mechanisms of salt tolerance in halophytes. Annual Review of Plant Physio.1977;28:89-121.
28. Schmidt U. Enhancing phytoextraction: The effect of chemical soil manipulation on mobility, plant accumulation and leaching of heavy metals. J Envi Qual. 2003; 32:1939-54.
29. Smolders E, Lambregts RM, Mclaughlin MJ, et al. Effect of soil solution chloride on Cd availability to Swiss chard. J Env Qual. 1998;27:426-31.
30. El-Khallal SM, Hathout TA, Abd-El-Raheim A, et al. Brassinolide and salicylic acid induced growth, biochemical activities and productivity of maize plants grown under salt stress. Rese J of Agri and Biolog Sci. 2009;5:380-90.
31. Rubio MI, Escrig I, Martínez-Cortina C, et al. Cadmium and nickel accumulation in rice plants: effects on mineral nutrition and possible interactions of abscisic and gibberellic acids. Plant Grow Regul. 1994;14:151-57.
32. Khatamipour M, Piri E, Esmaeilian Y, et al. Toxic effect of cadmium on germination, seedling growth and proline content of Milk thistle (*Silybummarianum*). Ann Biol Res. 2011;2:527-32.
33. Chai MW, Shi FC, Li RL, et al. Effect of NaCl on growth and Cd accumulation of halophyte *Spartina alterniflora* under CdCl2 stress. *S*outh African J of Bot. 2013;85:63-69.
34. Manousaki E, Kalogerakis N. Phytoextraction of Pb and Cd by the mediterranean salt bush (*Atriplex halimus* L.): metal uptake in relation to salinity. I J Env Sci poll Res. 2009;16: 844-54.
35. Greenway H, Munns R. Mechanism of salt tolerance in non-halophytes. Ann Rev of Plan Physiol. 1980;31:149-90.
36. Helal HM, Upenov A, Issa GJ. Growth and uptake of Cd and Zn by *Leucaena leucocephala* in reclaimed soils as affected by NaCl salinity. J of Plan Nutr and Soil Sci.1999;162:589-92.
37. McLaughlin MJ, Tiller KG, Beech TA, et al. Soil salinity causes elevated cadmium concentrations in field-growth potato tubers. J Env Sci. 1994;23:1013-18.
38. Pedro C A, Santos MSS, Ferreira SMF, Gonçalves SC. The influence of cadmium contamination and salinity on the survival, growth and phytoremediation capacity of the saltmarsh plant *Salicornia ramosissima*. J of Marine Env Res. 2013;92:197-205.
39. Gabrijel O, Davor R, Zed R, et al. Cadmium accumulation by muskmelon under salt stress in contaminated organic soil. Sci of total env. 2009;407:2175-82.
40. Otte ML. Contamination of coastal wetlands with heavy metals: Factors affecting uptake of heavy metals by salt marsh plants, In: Rozema J, Verkleij JAC, editors. Ecological Response to Environmental Stresses. Kluwer Academic.1991.