International Journal of Advanced Technology in Engineering and Science www.ijates.com
Volume No.02, Issue No. 09, September 2014 ISSN (online): 2348 – 7550

CADMIUM CONCENTRATION AFFECTS THE ROOT BIOMASS ADVERSELY DURING PHYTOEXTRACTION EXPERIMENT

Pushpendra[1] and Raj Pal Singh[2]

[1]Department of Botany, M. M.P.G. College, Modi Nagar, U.P. (India)

[2]Principal GMN (PG) College, Ambala Cantt. -133001, Haryana (India)

ABSTRACT

Plants can be used to remove, transfer, stabilize and degrade contaminants (Ali et al., 2004 and Maiti et al., 2001) and the process is known as phytoremediation Phytoremediation is an emerging, environment friendly green technology in which plants are used to clean up the pollutants from their surrounding. Six plant species, namly Raya (Brassica juncea), Toria (B. compastris), Oat (Avena sativa), Barley (Hordeum vulgare), Bathua (Chenopodiun murale) and Rijhka (Medicago sativa) were grown in two types of cadmium spiked soils (soil-1, sandy loam soil and soil-2, sewage water irrigated soil). The pot study was conducted with five Cd levels, i. e, 0, 20, 40, 60 and 80 mg Cd Kg^{-1} soil. Root biomass of all the six species was investigated in both soils. The increased cadmium (Cd) concentration in soil results decreases in the yield of all the six species. Although the dry matter yield was greater in the soil -2 than the soil -1.

Key Words: Phytoremediation, Cadmium, Heavy Metals and Plant Species

I INTRODUCTION

Plants can be used to remove, transfer, stabilize and degrade contaminants (Ali *et al.*, 2004 and Maiti *et al.*, 2001) and the process is known as phytoremediation. Phytoremediation is environment friendly, potentially cheap, and visually undestructive technique that offers the possibility of bio-recovery of the heavy metals (Singh *et al.*, 2003 Ghosh *et al.*, 2005Wang *et al.*, 2005 and Maiti *et al.*, 2001). Previously this technique was used in constructed wetlands, reef beds and floating plant systems for the treatment of contaminated waters (Cunningham *et al.*, 2000; Ali *et al.*, 2004 and Maiti *et al.*, 2001). Khan *et. al.* (1983) observed that the low Cd concentration has some beneficial effects on plant growth. The apparent complexing and slow release of Cd to root system alleviates its toxicity even though the absolute amount may be greater in the larger and more vigorous plants (Yanai *et al.*, 2006 and Maxted *et al.*, 2007). This is probably a result of dilution of the absorbed Cd in a larger biomass of plant tissues. Severe stunting of growth and toxicity occurs when the Cd in the rooting medium is readily available in the soil solution or when the concentration exceeds the complexing capacity of the soil (Strickland *et al.*, 1979).

Large areas of Indian soils received the significant amounts of cadmium (Cd) as an impurity of phosphatic fertilizers (Pushpendra *et. al.*, 2006 and Engelen *et. al.*, 2007). Rural soils can also receive metals in manure, irrigation water, sewage sludge and from atmospheric deposition (Yanai *et al.*, 2006 and Vassilev *et al.*, 2002). Accumulation of metals in soils may affect adversely to the grazing animals, which results increase in concentrations in animal products thus pose risks to human health and other cosumers of each higher trophic

IJATES

level (Baker, *et al.*, 1989). The "itai-itai disease" in Japan in 1950s, (adverse effect of cadmium on human health due to consumption of Cd contaminated rice) has received much attention towards the heavy metal pollution (Yanai et al., 2006). A total of 2.2 x 10^4 tons of Cd has been discharged into the environment during the past half-century (Singh *et al.*, 2003a and Tanhan *et al.*, 2007). The beneficial effect of sewage waste water irrigation and adverse effect of Cd on different crops have also been reported by several workers (Narwal *et al.*, 1983; Dahiya *et al.*, 1987; Singh *et al.*, 2003 Ramachandran and D'Souza, 1999; Maiti, 2001 and Yadav, 2003). Current efforts are to remove the contaminants from the soils to preserve the nature biodiversity and other biota of soil (Cunningham *et al.*, 2000; Ali *et al.*, 2004 and Maiti *et al.*, 2001).

II MATERIAL AND METHODS

To evaluate the relative efficiency of different plant species for their ability to grow in Cd enriched soil. The experiment was conducted using 5 kg capacity earthen pots. The physico-chemical properties of both soils are given in table 1and 2. The collected soil of second experiment was irrigated with sewage water coming from Hisar City since 1998. The physico-chemical properties of soil are presented in table 2. The sewage water irrigated soil was taken to study the effects of sewage water with comparable levels of added Cd on the yield of seeds of all the six species. The present investigation was done; to fulfill the objectives of the present study following experiments have been conducted.

Experiment I: plant species grown in cadmium spiked, sandy loam soil.

Experiment II plant species grown in cadmium spiked, sewage water irrigated soil

Treatments:

a) **Cd levels:** Five (0, 20, 40, 60 and 80 mg Cd Kg^{-1} soil)

b) **Plant Species**

   i. **Raya** *(Brassica juncea)*
   ii. **Toriya** *(Brassica compastris)*
   iii. **Rijhka** *(Alfalfa Medicago sativa)*
   iv. **Bathua** *(Chenopodium murrale)*
   v. **Oat** *(Avena sativa)*
   vi. **Barley** *(Hordium vulgare)*

(c) **Replications:** Three

III SAMPLING AND OBSERVATIONS

All the plants species were harvested at the maturity. The seeds were separated and weighed. The following observations on all the six plant species were taken so as to assess the effects of different treatments on the growth of plants.

3.1 Visual Observation

Visual rating of the test plants were done using a scale of 0 – 100 points, where 0 = number of toxicity and 100 = complete phytotoxicity.

3.2 Root Biomass Yield

After recording, other observations were put in paper bags and kept at 65±2°C for 48 hours till constant weight was obtained and recorded as g $plant^{-1}$ after taking average.

IJATES

IV RESULTS AND DISCUSSION

Before starting the experiment, the soils were characterized. It was necessary to observe the amount of cadmium initially in the soil.The experiment with the different plant species in Cd contaminated and spiked soils was carried out to meet the objectives of the present study. The yield of the six species taken in this study was more in sewage water irrigated soil at comparable levels of added Cd. The beneficial effect of sewage waste water irrigation may be ascribed to the (i) improvement in the physico-chemical and biological environment of growth medium, (ii) additional supply of essential nutrients, (iii) and possible decrease in toxic effect of added Cd through organo-metallic complex reactions in soil. The successive additions of Cd in soils resulted in a decrease in the yield of different plant roots biomass of all species. The results of the present study are shown in the table 3.

4.1 Root biomass yield in plants grown in sandy loam soil

It was observed that the application of Cd decreased the yield of root in all the species. Application of the 20, 40, 60 and 80 mg kg^{-1} soil, decrease the dry matter 5, 13, 28 and 42 percent respectively as compared to control. The highest dry matter yield was found in Raya while it was lowest in Rijhka

4.2 Roots biomass yield in plant grown in sewage water irrigated soil:

It was observed that the application of Cd decreased the dry matter yield of root in all the species. Application of the 20, 40, 60 and 80 mg kg^{-1} soil, decrease the 3, 12, 26 and 40 percent respectively as compared to control in soil-1 (Table 3). Although results indicated that initially there was increase in the biomass yield over the sandy loam soil. The highest root biomass yield of Raya was also recorded in sewage water irrigated soil. Similar trend was observed in Toriya, Oat, Bathua, Rijhka and Barley.

V CONCLUSION

Laboratory studies were carried out into two soil, sandy loam soils and sewage water irrigated soil. The soils were characterized for background concentration of Cd and different chemical parameters and they are shown in Table 1 and 2. The Raya is widely used crop and it also shows tolerance in contaminated soil. So such type of plants may be used for the removal of the contamination from soil and showed better results in the remediation of contaminated soil. Although plant species show reduced biomass when grown in highly Cd contaminated soil. In the sandy loam soil, Cd_0, to in Cd_{80} treatment the mean root dry matter yield decrease from 5 to 42 percent, 18 percent, leaf dry 3 to 25 percent and seed yield decreased from, while in the sewage water irrigated soil, the decreases in the root, from 3 to 40, percent in Cd_0 to Cd_{80} treatments respectively. The maximum decrease in the mean root matter yield was at Cd_{80} treatment as in sandy loam soil and sewage water irrigated soil. Species showed variability in their mean root yield, irrespective of soils and Cd levels.

The efficacy of this technique as a viable remediation technology is still being explored, though the results are positive. This study provides a promising start for biomass-based phytoextraction. Phytoextraction as well as agronomic practices for sustaining high shoot biomass production should be further explored. The potential for phytoextraction depends upon the interaction of soil contaminants with plants. This complex interaction affected by a variety of factors such as, climatic conditions, soil properties, site hydrogeology etc. Thus an understanding of basic plant mechanisms and the effect of agronomic practices on plant, soil and contaminant interaction would allow practitioners to optimize phytoextraction by customizing the process to site specific conditions.

Table 1: Physicio-Chemical Characteristic of the sandy loam soil

Characteristics	Contents
*pH	7.67
*EC (dSm^{-1})	0.39
Mechanical Composition (%)	
i) Sand	76.3
ii) Silt	12.3
iii) Clay	1.4
Organic carbon (%)	0.36
Olsen's P (mg kg^{-1})	12.0
CEC (m.e/100 g)	7.2
Metal contents (mg kg^{-1})	
i) Lead	2.78
ii) Cadmium	0.80
iii) Nickel	0.25
iv) Zinc	3.1
v) Iron	14.4
vi) Manganese	5.1
vii) Copper	3.4

*** 1:2 Soil: Water suspension**

Table 2: Physicio-Chemical Characteristic of the sewage water irrigated soil

Characteristics	Contents
*pH	7.35
*EC (dSm^{-1})	0.84
Mechanical Composition (%)	
i) Sand	74.4
ii) Silt	12.6
iii) Clay	13.2
Organic carbon (%)	0.82
Olsen's P (mg kg^{-1})	22.7
CEC (m.e/100 g)	8.5
Metal contents (mg kg^{-1})	
i) Lead	2.97
ii) Cadmium	13.4
iii) Nickel	0.32
iv) Zinc	16.1
v) Iron	36.4
vi) Manganese	3.3
vii) Copper	11.8

- **1:2 Soil: Water suspension**

IJATES

Table 3: Root Biomass Yield of Different Plant Species (g Plant^{-1}) as Influenced by Cd Application in Sandy Loam Soil & Sewage Water Irrigated Soil

Species		Cd Levels (mg kg^{-1} soil)						
		0	20	40	60	80	Tot	mean
Raya	soil -1	1.33	1.29	1.19	1.06	0.92	5.79	1.158
	soil -2	1.44	1.42	1.35	1.19	1	6.4	1.280
Toriya	soil -1	1.26	1.24	1.15	0.99	0.86	5.5	1.100
	soil -2	1.32	1.27	1.17	1.03	0.92	5.71	1.142
Rijhka	soil -1	0.92	0.93	0.79	0.55	0.4	3.59	0.718
	soil -2	0.97	0.95	0.83	0.58	0.43	3.76	0.752
Bathua	soil -1	1.39	1.2	1.1	1.03	0.79	5.51	1.102
	soil -2	1.43	1.4	1.27	1.07	0.87	6.04	1.208
Oat	soil -1	1.02	1.01	0.88	0.65	0.56	4.12	0.824
	soil -2	1.07	1.03	0.92	0.7	0.62	4.34	0.868
Barley	soil -1	1.09	1.08	0.9	0.79	0.53	4.39	0.878
	soil -2	1.13	1.1	0.96	0.84	0.59	4.62	0.924

REFRENCES

[1] Ali, N.A.; Ater, M.; Sunahara, G.I. and Robidous, P.Y. (2004). Phytotoxicity and bioaccumulation of copper and chromium using barley (*Hordeum vulgare* L.) in spiked artificial and natural forest soils. *Ecotox. and Environ. Saf*. **57**: 363-374.

[2] Arduini, I.; Ercoli. L.; Mariotti, M. and Masoni, A. (2004). Response of *Miscanthus* to toxic cadmium applications during the period of maximum growth. *Environ. Expt. Bot.* **55**: 29-40.

[3] Baker, A.J.M. and Brooks, R.R. (1989). Terristial higher plants which hyperaccumulate metal elements. A review of their distribution, ecology and phytochemistry. *Biorec*. **1**: 81-126.

[4] Cunningham, S.D. and Berti, W.R. (2000). Phytoextraction and phytostabilization: technical economic, and regulatory considerations of the soil-lead issue. In: *Phytoremediation of Contaminated Soil and Water*. Terry, N., Banuelos, G. (Eds.), CRC Press, Boca Raton, FL, **pp**. 359–376.

[5] Engelen, D.L.V., Sharpe-Pdler, R. C. and Moorhead, K. K. (2007). Effect of celating agents and solubility of cadmium complexes on uptake from soil by *Brassica juncea*. Chemosphere. **68**, 401-408.

[6] Foy, C.D.; Chaney, R.L. and White, M.C. (1978). The physiology of metal toxicity in palnts. *Ann. Rev. Pl. Physiol*. **29**: 511-566.

[7] Ghosh, M. and Singh, S.P. (2005). A comperative study of cadmium phytoextraction by accumulator and weed species. *Env. Poll*. **133**: 365-371.

[8] Maiti, D. (2001). Effect of sweage sludge on relative toxicity of Zn, Ni and Cd to *Brassica juncea* L. *M.Sc. Tehsis*, CCS Haryana. *Environ. Poll*. **124**: 375-370.

IJATES

[9] Narwal, R.P.; Singh, B.R. and Panwar, A.R. (1983). Plant availability of heavy metals in sewage sludge treated soil. I. Effect of sewage sludge and pH on chemical composition of grape. *J. Environ. Qual*. **12**: 358-365.

[10] Singh, O.V.; Labana, S. and Pandey, G. (2003a). Phytoremediation: an overview of metallic ion decontamination from soil. *Appl. Microbol. Biotech*. **61**: 5–12.

[11] Tanhan, P., Kruatrachue, M., Pokethitiyook, P. and Chaiyarat, R. (2007). Uptake and accumulation of cadmium lead and zinc by Siam wee (Chromolaena *odorata*, *L.*). Chemosphere. **68**, 323-329.

[12] Vassilev, A.; Vangronsveld, J. and Yordanov, I. (2002). Cadmium phytoextraction: Present state, biological back grounds and research needs. *Bulg. J. Pl. Physiol*. **28**(3-4): 68-95.

[13] Wang, M.E. and Zhou, Q.X. (2005 a). Single and joint toxicity of chlorimuron-ethyl, cadmium and copper acting on wheat *Triticum aestivum*. *Ecotoxicol. Environ. Saf*. **60**: 169–175.

[14] Yadav, J.M. (2003). Behaviour of nickel and cadmium in soil and plant as influenced by farmyard manure. *Ph.D. Thesis*, CCS Haryana Agril. Uni., Hisar, Haryana.

[15] Yanai, J.; Zhau, F.; Mc Grath, S.P. and Kosaki, T. (2006). Effect of soil characteristics on Cd uptake by the hyperaccumulator *Thlaspi caerulescens*. *Environ. Poll*. **139**: 167-175.

IJATES