EDTA-ENHANCED TRANSLOCATION OF HEAVY METAL FROM ROOT TO SHOOT IN INDIAN MUSTARD AND TORYIA SPECIES

Pushpendra[1] and AK Sharma[2]
[1,2] Department of Botany M. M.P.G. College, Modi Nagar,U.P(India)

ABSTRACT

A number of 'ex situ' and 'in situ' techniques have been developed to remove heavy metals from contaminated soils. Phytoremediation of heavy metal contaminated soil is a developing technology that aims to extract metals. It has attracted much attention because it is an environmentally friendly, sustainable and relatively cheap technique. EDTA is the most effective and popular reagent because it is a strong chelating agent that has potential for soil remediation applications A pot experiment was conducted to study the EDTA enhancement of the mobility of cadmium from root to shoot, to improve the phytoextraction process. Addition of EDTA to sandy loam soil experimentally spiked with Cd enhanced the mobility of Cd. EDTA increased shoot Cd concentrations in Indian mustard (Brassica juncea) and Toriya (B. compastris).

Keywords*: Heavy Metals;* Chelating Agent, *Phytoremediation; EDTA And Brassica Juncea*

I. INTRODUCTION

Soils can be contaminated with heavy metals due to various activities including mining, smelting and metal treatment operations (Chan *et al.*, 1998; Cunningham *et al.*, 2000). Due to the potential toxicity and high persistence of heavy metals, the clean up of contaminated soils is one of the most difficult tasks (Kumar *et al.*, 2010; Megan *et al.*, 2003). A number of 'ex situ' and 'in situ' techniques have been developed to remove heavy metals from contaminated soils (Hall 2002; Kumar *et al.*, 2010). There are two basic strategies under development. The first is the uses of hyper accumulator plants that have the capacity to hyper accumulate metals, and the second is chemical cheated-enhanced phytoextraction (Pushpendra *et al.*, 2010). Some chelating agents are also being used for effective metal removal. EDTA is the most effective and popular reagent because it is a strong chelating agent that has potential for soil remediation applications (Foyer *et al.*, 2001; Gupta *et al.*, 2010).

Phytoextraction of heavy metal contaminated soil is a developing technology that aims to extract metals and it becomes popular because it is an environmentally friendly and relatively cheap technique (Pushpendra *et al.*, 2006). The most promising application of this technology is for the remediation of Cd-contaminated soils using Indian mustard (*Brassica juncea*) in combination with EDTA (Pushpendra, 2010). In the present paper a pot experiment in which sandy loam soil which was spiked with Cd studied. The aim was to investigate EDTA enhancement of heavy metal (Cd) mobility in artificially spiked soil.

II.MATERIALS AND METHODS

The soil was spiked with Cd before the experiment and their mobility's remained high. Cadmium would have been readily adsorbed by soil colloids and other soil components, and its activity was always very low, so that EDTA was used to increase the activity of Cd. This is considered the reason why EDTA can enhance Cd phytoextraction efficiency. The organic chelate combined metal-complexes fraction is the portion chelated by soil organic matter and the added EDTA.

2.1. Soil sampling and spiking with Cd

Soil was taken from the surface layer (0–7 cm) of a sugar cane followed rice field. The soil is a sandy loam with the parameter range as per table-1. The soil was air-dried and spiked with five cadmium levels (0, 20, 40, 60 and 80 mg Cd Kg^{-1} soil) and mixed thoroughly into the soil.

2.2. Pot experiment

The treatments comprised the following amendments: (1) without EDTA; (2) with EDTA disodium salt. Nine seeds of Indian mustard (*B. juncea*) and Toriya *(B. compastris)*, were sown in each pot and thinned to four seedlings after 13 days of sowing. There were three replicates of each treatment. EDTA was added just before the flowering and plants were harvested after maturation.

2.3. Cadmium concentration

The various plant parts were washed with tap water and rinsed with distilled water. In order to determine Cd in various plant parts,1 g of ground and well mixed plant material was digested in a diacid mixture of nitric and perchloric acid (4:1). After digestion, the volume was made to 50 ml with double distilled water. It was filtered and stored in well washed plastic bottles. The Cd concentration was measured using the Atomic Absorption Spectrophometer (GBC 932 Plus). Analytical grade (AR) chemical were used throughout the study. Before starting the experiment, the soils were characterized (Table-1). It was necessary to observe the amount of cadmium initially in the soil. The results of the present study are shown in the table 2 and 3.

III.RESULTS AND DISCUSSION

3.1. Plant growth and heavy metal uptake

There were no visible symptoms of heavy metal toxicity in Indian mustard during germination and growth. However, about 4 days after EDTA addition there were numerous brown dots on the leaves, and the whole leaf became yellow and died slowly. This indicates phytotoxicity of Cd metals. Table 2 & 3 also shows the increased Cd concentrations in shoots. Applied EDTA significantly increased both the mobility of soil Cd and the concentrations of Cd in the shoots of all the plants. Table 3, shows that shoot Cd uptake by plants growing in soil treated with EDTA was higher than that of the control and without EDTA (Table-2).

Cadmium uptake in the EDTA treatment was many-fold higher than the control. The Cd concentration in the shoots was also higher in the EDTA treatment than the others. These results may be attributed to the contamination of the soil with Cd-rich. EDTA (disodium salt, 3 mmol kg-1) added to a soil significantly enhanced the mobility of soil Cd. Concentrations of Cd in shoots of Indian mustard were also increased by EDTA addition.

IV. CONCLUSION

Experiments, in which soils used rather than solution, approximately are more closely to the natural conditions, where the effect of soil buffering capacity influences nutrient availability to plants. The goal was to assess to develop the heavy metal removal technique in natural conditions of the soil with and without chelators. It was observed that Cd affects all the growth parameters. However, it could be used to remediate the Cd contaminated soil without the application of any chemical. The results indicated that there was increase in the cadmium concentration in various plant parts after application of EDTA. The highest cadmium concentration in Raya was also recorded. Similar trend was observed in Toriya. In this study, the response of different plant species, in the sandy loam soil has been observed.

Phytoextraction efficiency is related to both plant metal concentration and dry matter yield. Thus, the ideal plant species to remediate a contaminated site should be a high yielding crop that can both tolerate and accumulate the target contaminants. The efficacy of phytoextraction as a viable remediation technology is still being explored, though the results are positive. This study provides a promising start for biomass-based phytoextraction as it includes high biomass producing species and growing these species is practically easier than producing hyper accumulators. Phytoextraction as well as agronomic practices for sustaining high shoot biomass production should be further explored.

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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: Cd Concentration (μ g g^{-1}) in Root, Stem and Leaf of Different Species as Influenced by Cd Application in Sandy Loam Soil

Cd levels (mg kg^{-1})	Different species	
	Raya	**Toriya**
	Root	
0	2.53	2.15
20	41.64	30.09
40	65.81	42.03
60	83.75	51.25
80	95.31	69.35
Mean	**57.81**	**38.97**
C.D.(0.05)		Cd levels= 19.63
	Stem	
0	5.21	5.35
20	49.92	31.29
40	88.14	49.90
60	96.89	62.27
80	110.09	69.53
Mean	**70.05**	**43.67**
C.D.(0.05)		Cd levels= 44.71
	Leaf	
0	3.27	1.62
20	12.49	12.64
40	33.52	23.51
60	40.88	28.65
80	51.24	41.61
Mean	**28.28**	**21.61**
C.D.(0.05)		Cd levels = 15.02

Table 3: Cd concentration (μg g^{-1}) in Root, Stem and Leaf of Different Species as Influenced by Cd and EDTA Application in Sandy Loam Soil

Cd levels (mg kg^{-1})	Different species	
	Raya	**Toriya**
	Root	
0	4.92	5.14
20	18.62	26.30
40	48.64	59.80
60	55.39	64.29
80	61.21	69.79
Mean	**37.76**	**45.06**
C.D.(0.05)		Cd levels= 18.31
	Stem	
0	3.57	2.46
20	65.64	74.29
40	97.15	91.15
60	105.89	102.10
80	119.51	107.34
Mean	**78.35**	**75.47**
C.D.(0.05)		Cd levels= 42.14
	Leaf	
0	4.28	6.14
20	83.84	66.41
40	117.55	87.29
60	125.35	96.74
80	138.73	109.31
Mean	**93.95**	**73.18**