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EDTA Enhanced Phytoremediation of Cadmium Contaminated Soil by Maize (*Zea mays L.*)

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Abstract: ***A pot experiment was conducted to study the effect of EDTA compound on cadmium uptake by maize variety DHM-11.This study points out that EDTA compound provided feasible conditions for plants to take metals from soil. Application of EDTA showed highest metals uptake by maize. EDTA increased uptakes of Cd 3-4 times as compared to control. EDTA was found a good chelating compound. Hence, supplementing soil with a synthetic chelating agent such as ethylene diamine tetraacetic acid (EDTA) is an efficient method to enhance cadmium uptake by plants for facilitating phytoremediation with carefully monitoring.***

Keywords: "EDTA, cadmium, maize, phytoremediation"

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1. Introduction

Cadmium (Cd) is one of the most deleterious trace heavy metals both to plants and animals. With the development of modern industry and agriculture, Cadmium has become one of the most harmful and widespread pollutants in agricultural soils, and soil-plant-environment system mainly due to industrial emission, the application of Cd-containing sewage sludge and phosphate fertilizers and municipal waste disposal..

Chelating agents have been used for the dissolution of metal-containing materials in a variety of applications. Chelates can free a heavy metal from the soil cation exchange sites by forming a complex with the heavy metal, thereby allowing the chelated metal species to migrate the cation exchange sites; it can be taken up by plant roots in the immediate vicinity. Application of EDTA to soil contaminated with heavy metals increases their uptake from the soil to more than 1 percent of shoot dry biomass.

Phytoremediation is the use of living green plants for in situ risk reduction and removal of contaminants from contaminated soil, water sediments and air. Phytoremediation is a bioremediation process that uses various types of plant to remove, transfer, stabilize and destroy contaminants in the soil and groundwater. Plant have different abilities to uptake and withstand high levels of pollutants many different plants may be used. Once the plants grown and absorbed the metal pollutants they are harvested and disposed of safely. This process is repeated several times to reduce contamination to acceptable levels. Some of plants species are used for the phytoextraction purpose e.g. maize, sunflower and marigold, upland rice, line seed, datura spp. etc. Therefore the present investigation was carried out to study the effect of EDTA application on cadmium content and uptake in maize.

2. Method and materials

A pot experiment was conducted to study the effect of EDTA compound on cadmium uptake by maize variety DHM-117during last week of 17th July to 4th October 2013 in the net house of Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences; B.H.U. Varanasi U.P Earthen pots were filled with 5 kg of air dried soil each. Aqueous solution of cadmium sulphate ($3CdSO_4$ $8H_2O$) were added to soil. Cadmium was added at the rate of 0,10,30,50 mg Kg^{-1} in different combinations in the pot and incubated in the net house for one month to allow added metal (Cd) to equilibrate before sowing.5 healthy seeds of maize were sown on 17th July, 2013. Amount of EDTA compound were added in different concentrations (0, 10, 30, 50 ppm) according to the treatment combinations. After emergence of seedlings thinning was done to maintain number of plants to 2 per pot and were allow growing up to pre-tassel ling stage. Pots were timely irrigated with deionized water at regular intervals to maintain moisture of the soil. Crop was harvest was held on 17th July to 4th October 2013. The harvested plant material was put in paper bags, washed with acid solution, air dried, fresh weight and oven dried at 65±2 °C to a constant weight. Thereafter dry weight of above ground plant parts was recorded.

Plant material was grounded in grinder, mixed and digested on a block digester till a colourless solution was obtained and analysed for N P K following standard methods (Tandon,2001) The content of Fe, Mn, Zn, Cu and Cd and in the straw digest was determined by using atomic absorption spectrophotometer (UNICAM – 969) (Sparks,1996).

3. Results and discussion

3.1 *Effect of EDTA compound on uptake of N P and K in maize crop*

The data pertaining to the effect of EDTA compound on nutrients uptake by maize has been presented in (Table1).The nitrogen uptake by maize varied from 0.01 to 0.06 g pot^{-1}. The maximum nitrogen uptake (0.06 g pot^{-1}) was recorded with 50ppm EDTA which was about 6 times higher than control. The lowest value (0.01 g pot^{-1}) was observed in control. There was a concomitant increase in nitrogen uptake with the application of chelating compounds. The maximum P uptake (0.04 g pot^{-1}) was found with 50ppm EDTA and minimum (0.01 g pot^{-1}) was recorded in control Hovsepyan and Greipsson (2005) reported that phosphorus uptake increase after the addition of EDTA and as P is not complexed with EDTA, it may be solely related to the increased concentrations in the soil solution due to the dissolution of P-bearing phases. It was observed that potassium uptake increased significantly with application of EDTA compound. The maximum potassium uptake (0.06 g pot^{-1}) was recorded with 50ppm EDTA which was 83% higher over 50ppm cadmium(C_{50} E_0,) The minimum value (0.01 g pot^{-1}) was recorded in treatment of C_{50} E_0, .

3.2 *Effect of EDTA compound on uptake of micronutrient and cadmium in maize.*

The data pertaining to the effect of EDTA compound on Fe uptake by maize have been presented in Table 2. The maximum uptake of Fe (8 mg pot^{-1}) was recorded with C_0E_{50} (50ppm EDTA)which was about 8 times greater than C_{50} E_0 and minimum (0.93 mg pot^{-1}) was recorded with $C_{50}E_0$ Treatments C_0E_{50} increased Fe uptake in maize by 88.37% over $C_{50}E_0$ (0.93 mg pot^{-1}), respectively. The maximum uptake of Cu (0.50 mg pot^{-1}) was recorded with Cd_0E_{50} which was 50%, respectively and about 3 times greater than control and minimum (0.16 mg pot^{-1}) was recorded with $C_{50}E_0$. The uptake of Mn by maize ranged between 0.18 to 0.42 mg pot^{-1}. The minimum uptake of Mn (0.18 mg pot^{-1}) was recorded with control and maximum (0.42mg pot^{-1}) was recorded with $C_{30}E_{50}$ which was about 3 times greater than control. The maximum uptake of Cu (0.55 mg pot^{-1}) was recorded with C_0E_{50} (50ppm EDTA)which was 61%, increased over treatment $C_{50}E_0$ respectively and about 3 times greater than control and minimum (0.21 mg pot^{-1}) was recorded with control. Cui *et al.* (2004) reported that EDTA increased soil extractable Pb and Zn and shoot Pb and Zn uptake.

Similar results were also reported by Meers *et al.* (2005) that Zn uptake in EDDS and EDTA treated pots was 150–200% than that in the untreated controls.

The data pertaining to uptake of Cd in maize as influenced by application of EDTA compound have been presented in (Table 3). A significant increase in uptake of Cd by application of EDTA compound was noticed. Interaction effect of EDTA compound was also found to be significant. The data further revealed that Cd uptake in maize varied from 0.16 to 0.62 mg pot^{-1}. The maximum uptake of Cd (0.62 mg pot^{-1}) was recorded with $C_{50}E_{50}$ (50ppm Cd +50ppm EDTA) minimum (0.16 mg pot^{-1}) was recorded with control. It increased by 68% and 73% over control, respectively.

The present study clearly indicated that application of EDTA significantly increased the concentration and uptake of Cd in maize crop. It was also reported that the addition of chelating agents enhanced the metal uptake by plants in field and pot experiments Huang *et al.* (1997). Similar result was also reported by Kirkham *et al.*(2006) that 2 g EDTA salt/kg, increased uptake of Cd, Ni, Pb, Cu, Fe, and Zn by roots of sunflower grown in the composted sludge.

4. Conclusion

This study points out that EDTA compound provided feasible conditions for plants to take metals from soil. Application of EDTA showed highest metals uptake by maize. EDTA increased uptakes of Cd 3-4 times as compared to control. EDTA was found a good chelating compound. Hence, supplementing soil with a synthetic chelating agent such as ethylene diamine tetraacetic acid (EDTA) is an efficient method to enhance cadmium uptake by plants for facilitating phytoremediation with carefully monitoring.

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Table 1.Efect of EDTA compound on N, P, and K (g pot^{-1}) uptake in maize crop.

Nitrogen					
	E_0	**E_{10}**	**E_{30}**	**E_{50}**	Mean
C_0	0.03	0.04	0.05	0.06	0.04
C_{10}	0.03	0.04	0.05	0.05	0.04
C_{30}	0.02	0.03	0.04	0.05	0.03
C_{50}	0.01	0.02	0.03	0.04	0.02
Mean	0.022	0.03	0.04	0.05	0.04
Phosphorous					
	E_0	**E_{10}**	**E_{30}**	**E_{50}**	Mean
C_0	0.02	0.03	0.03	0.04	0.03
C_{10}	0.02	0.02	0.02	0.04	0.03
C_{30}	0.02	0.02	0.02	0.03	0.02
C_{50}	0.01	0.01	0.02	0.02	0.02
Mean	0.02	0.02	0.02	0.03	0.02
Potassium					
	E_0	**E_{10}**	**E_{30}**	**E_{50}**	**Mean**
C_0	0.10	0.19	0.27	0.34	0.23
C_{10}	0.09	0.17	0.23	0.32	0.20
C_{30}	0.07	0.14	0.20	0.28	0.17
C_{50}	0.05	0.12	0.15	0.23	0.14
Mean	0.08	0.16	0.21	0.29	0.18

	N		**P**		**K**	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
E	0.001	NS	0.0005	0.0015	0.006	0.017
C	0.002	0.007	0.0006	0.0019	0.008	0.023
ExC	0.004	NS	0.0011	0.0033	0.013	0.040

Table 2:Effect of EDTA compound on Fe, Cu, Zn and Mn (mg pot^{-1}) uptake in maize crop

	Fe					Cu				
	E_0	**E_{10}**	**E_{30}**	**E_{50}**	**mean**	**E_0**	**E_{10}**	**E_{30}**	**E_{50}**	**Mean**
C_0	1.81	4.93	6.76	8	5.38	0.36	0.4	0.48	0.5	0.43
C_{10}	1.77	3.7	6.6	7.74	4.95	0.33	0.37	0.38	0.43	0.38
C_{30}	1.15	3.41	5.97	6.4	4.23	0.28	0.27	0.31	0.37	0.31
C_{50}	0.93	3.02	4.6	5.59	3.53	0.25	0.27	0.29	0.31	0.26
mean	1.41	3.77	5.98	6.93	4.53	0.26	0.38	0.36	0.4	0.33
	Zn					**Mn**				
	E_0	**E_{10}**	**E_{30}**	**E_{50}**	**mean**	**E_0**	**E_{10}**	**E_{30}**	**E_{50}**	**mean**
C_0	0.3	0.4	0.47	0.55	0.43	0.18	0.27	0.36	0.33	0.28
C_{10}	0.28	0.33	0.38	0.4	0.34	0.33	0.29	0.34	0.4	0.33
C_{30}	0.25	0.31	0.37	0.37	0.32	0.21	0.35	0.36	0.42	0.35
C_{50}	0.21	0.27	0.27	0.25	0.25	0.39	0.37	0.4	0.37	0.35
Mean	0.23	0.33	0.35	0.39	0.32	0.26	0.3	0.37	0.38	0.33

	Fe		**Cu**		**Zn**		**Mn**	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
N	0.15	NS	0.008	0.023	0.008	0.022	0.012	0.029
C	0.16	0.52	0.009	0.028	0.011	0.027	0.013	0.035
NxC	0.30	0.86	0.016	0.048	0.018	0.048	0.024	0.063

Table 3: Effect of EDTA compound on Cd content and uptake in maize

Cadmium										
Content in maize (mg kg^{-1})						Uptake in maize (mg pot^{-1})				
	E_0	E_{10}	E_{30}	E_{50}	Mean	E_0	E_{10}	E_{30}	E_{50}	Mean
C_0	16.28	19.15	20.66	23.13	19.80	0.16	0.32	0.46	0.48	0.35
C_{10}	25.86	28.08	30.26	36.45	30.16	0.19	0.39	0.49	0.51	0.36
C_{30}	29.02	34.37	38.17	44.38	36.48	0.22	0.44	0.53	0.57	0.44
C_{50}	34.26	39.34	44.25	50.90	42.13	0.24	0.59	0.58	0.62	0.55
Mean	26.34	30.24	33.34	38.71	32.16	0.20	0.43	0.51	0.54	0.42

	Content in maize (mg kg^{-1})			Uptake in maize (mg pot^{-1})		
	EDTA	Cd	EDTA*Cd	EDTA	Cd	EDTA*Cd
SEm±	1.02	1.30	2.27	0.01	0.01	0.02
CD(P=0.05)	2.85	3.68	6.53	0.03	0.04	0.07

