Environment & Ecology 27 (3) : 994—996, 2009
 ISSN 0970-0420

Effect of Chelating Agents on Desorption of Lead in Soil

S. K. SINGH*, RAMPRAKASH AND ANOOP SINGH

Department of Soil Science, CCS Haryana Agricultural University
Hisar 125004, India
E-mail : sksingh@hau.ernet.in
**Correspondence*

Abstract

Laboratory experiments were conducted to study the effect of chelating agents on desorption of Pb. Four soil samples, viz. Pb spiked (at 180 mg Pb/kg soil), Pb spiked, FYM amended (at 3%) ; Pb spiked, sewage sludge amended (at 3%) and Pb spiked, FYM and sewage sludge amended (at 3%) soil and four chelating agents (viz. CDTA, CA, DTPA and NTA at 10 mmol kg/soil) were used and desorption study was carried out. It was observed that addition of chelating agents increased desorption of Pb from all treated soil. Maximum desorption of Pb was observed in NTA treated soils as compared to other chelates. Desorption studies also showed that amount of Pb desorbed from all four soils was the highest in the first extraction followed by second, third and fourth successive extractions. The order of effectiveness of chelating agents towards desorption of Pb was NTA>CDTA>DTPA>CA. Thus, chelating agents will be helpful in enhancing the phytoextraction of Pb by crops.

Key words : Lead, Chelating agents, Desorption, Soil.

The adsorption of inorganic pollutants on to the soil matrix of hazardous waste sites presents a formidable problem to scientists and engineers who are attempting to devise efficient and cost effective remediation strategies. Heavy metals are particularly troublesome because they can accumulate in soils through adsorption precipitation and other physico-chemical processes and their presence in even small amounts can pose a serious health risk. Increased attention has been focused on the use of chelating agents, which can dislodge and mobilize heavy metals in soils. Such chelators may be present in the soil with heavy metal contaminants or may be added specifically to assist in the soil cleanup. Over the past 20 years, environmental reclamation research dealing with metal chelation has focused on the following : The detrimental effects of chelators on the release of heavy metals from soil, sediments, and solid waste into the adjacent water phase (1), chelators as scavenging agents for removing heavy metals form sludge mud at wastewater treatment plants (2), and the use of chelating agents for *in-situ* flushing of heavy metal contaminated soils and sediments (3).

Methods

The bulk surface sample (0—15 cm) of a sandy loam soil was collected from the experimental area of the Dry land Agriculture, CCS Haryana Agricultural University, Hisar, Haryana. The processed soil sample was used for laboratory studies. The bulk sewage

Table 1. Physico-chemical characteristics of the experimental soil, sewage sludge and FYM.

Properties	Soil	Content Sewage sludge	FYM
Mechanical composition			
Sand (%)	69.70	–	–
Silt (%)	16.50	–	–
Clay (%)	13.80	–	–
Textural class	Sandy loam	–	–
pH (1 : 2)	8.10	7.20	–
$EC_{1:2}$ (dS/m)	0.50	2.10	–
Organic carbon (g/kg)	3.20	122.00	278.00
CEC [Cmol(P^+)/kg]	11.80	–	–
$CaCO_3$ (g/kg)	4.00	2.50	–
Available Nutrients in soil (kg/ha) and total nutrients in sewage sludge and FYM (%)			
Nitrogen	186.40	1.29	1.18
Phosphorus	18.10	0.41	0.70
Potassium	198.50	0.73	2.50
C/N ratio	–	9.46	23.55
Total metals (mg/kg)			
Pb	11.37	64.20	10.90
Cd	3.22	7.20	0.60
Ni	11.37	64.20	10.90

Table 2. Desorption of Pb from contaminated soil as influenced by different chelating agents.

Treat-ment	Pb desorbed (mg/kg soil) I	II	III	IV	Total	Des-orp-tion (%)
			Pb Treated			
Control	6.72	4.34	1.68	0.84	13.58	7.54
CDTA	46.62	25.76	10.64	4.76	87.78	48.77
CA	38.36	19.74	8.82	4.06	70.98	39.43
DTDA	44.52	24.64	9.66	4.34	83.16	46.20
NTA	49.14	26.88	11.76	5.32	93.10	51.72
			Pb + FYM			
Control	5.74	4.06	1.40	0.70	11.90	6.61
CDTA	44.38	27.72	10.22	4.20	86.52	48.07
CA	37.94	19.32	8.40	3.78	69.44	38.58
DTDA	43.26	23.94	8.68	3.92	79.80	44.33
NTA	48.44	26.32	11.06	4.34	90.16	50.09
			Pb + SS			
Control	5.60	3.92	1.40	0.56	11.48	6.38
CDTA	43.26	26.88	9.94	4.06	84.14	46.74
CA	37.52	18.34	7.84	3.08	66.78	37.10
DTDA	42.28	23.52	7.98	3.22	77.00	42.78
NTA	47.88	25.62	10.22	3.92	87.64	48.69
			Pb + SS + FYM			
Control	5.18	3.64	0.98	0.00	9.80	5.44
CDTA	42.14	26.32	9.66	3.50	81.62	45.34
CA	36.40	17.78	7.00	2.38	63.56	35.31
DTDA	41.58	22.68	7.42	2.66	74.34	41.30
NTA	46.90	24.78	9.66	3.22	84.56	46.98

sludge sample was collected from the Sewer Treatment Plant, Industrial Estate, Okhala, New Delhi. The bulk sample of well decomposed farm yard manure (FYM) was taken from the manure pit of Dairy Farm, CCS Haryana Agricultural University, Hisar. The physico-chemical properties of soil, sewage sludge and FYM are given in Table 1. A laboratory experiment was conducted to study the effect of chelating agents on desorption of Pb. Four soil samples, viz. Pb spiked (at 180 mg Pb/kg soil) ; Pb spiked, FYM amended (at 3%) ; Pb spiked, sewage sludge amended (at 3%) and Pb spiked, FYM and sewage sludge amended (at 3%) soil and four chelating agent (viz. CDTA, CA, DTPA and NTA at 10 mmol/kg soil) were used and desorption study were carried out as described by Cooper et al. (4) and Pb analysis were done using atomic absorption spectrophotometer (Avanta-932 Plus).

Results and Discussion

To screen chelates for their ability to desorb soil Pb, desorption was measured over four consecutive extractions of the same soil sample with fresh chelate solutions. Table 2 indicates that maximum desorption of Pb was observed in NTA treated soils. The 0.01 M $CaCl_2$ could desorb only 13.58, 11.90, 11.48 and 9.80 mg Pb/kg soil in Pb, Pb+FYM, Pb+sewage sludge and Pb+sewage sludge+FYM treated soils, respectively. The per cent desorption of the added Pb from NTA treated soils was 51.72, 50.09, 48.69 and 46.98 in Pb, Pb+FYM, Pb+sewage sludge and Pb+sewage sludge+FYM treated soils, respectively whereas per cent desorption by CDTA was 48.77, 48.07, 46.74 and 45.34 respectively. A major fraction of added Pb was desorbed in the first cycle of 0.01 M $CaCl_2$ extraction and then it decreased with consecutive extractions. Similar results were also observed by Cooper et al. (4) ; Kandpal et al. (5).

Thus extraction of added Pb is greatly influenced by the chelating agents and FYM or sewage sludge addition. Table 2 also shows that addition of chelating agents are helpful in increasing the available pool of Pb in soils. Thus, chelating agents will be helpful in enhancing the phytoextraction of Pb by crops. The decrease in desorption in FYM, sewage sludge and sewage sludge+FYM treated soil as compared to control (neither FYM nor sewage sludge) is probably due to the formation of stable complexes of Pb (6). Desorption of metals from contaminated soil using various chelating agents is a measure of its availability to plants. The chelating agents may account for the ability of a soil to buffer or replenish Pb in the solution phase. Tatiana et al.(7) also reported that the application of chelating agents enhanced the extraction/desorption of heavy metals from soil.

References

1. Garnett K., P. W. W. Kirk, R. Perry and T. N. Lester. 1986. Nitrilotriacetic acid in sludge-amended soil : Mobility and effects on metal solubility. Environ. Pollut. (Series B) 12 : 145—162.
2. Lester J. N., R. M. Harrison and R. Perry. 1979. The

balance of heavy metals through a sewage treatment work I. Lead, cadmium, and copper. Sci. Total Environ. 12 : 12—23.
3. Elliott H. A. and G. A. Brown. 1989. Comparative evaluation of NTA and EDTA for extractive decontamination of Pb-polluted soils. Water, Air and Soil Pollut. 45 : 361—369.
4. Cooper E. M., J. T. Sims, S. D. Cunningham, J. W. Huang and W. R. Berti. 1999. Chelate assisted phytoextraction of lead from contaminated soils. J. Environ. Quat. 28 : 1709—1719.
5. Kandpal G., P. C. Srivastava and K. Baliram. 2005. Kinetics of desorption of heavy metals from polluted soils : Influence of soil type and metal source. Water Air and Soil Pollut. 161 : 353—363.
6. Mishra S. 2004. Effect of chelating agents, FYM and herbicides on the phytoextractability of Indian mustard from Cd enriched soil. M. Sc thesis, Haryana Agric. Univ., Hisar, India.
7. Tatiana A., A. M. Kirpichtchikova, S. Lorenzo, P. Frederic, A. M. Matthew and J. Thierry. 2006. Speciation and solubility of heavy metals in contaminated soil using X-ray microfluorescence, EXAFS spectroscopy, chemical extraction, and thermodynamic modeling. Geochimica et Cosmochimica Acta 70 : 2163—2190.