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Effect of Chelating Agents on Desorption of Nickel in Soil

S. K. SINGH*, RAMPRAKASH, SACHIN KUMARI 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 Ni. Four soil samples, viz. Ni spiked (at 90 mg Ni/kg soil), Ni spiked, FYM amended (at 3%), Ni spiked, sewage sludge amended (at 3%) and Ni 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 was carried out. It was observed that addition of chelating agents increased the desorption of Ni from all treated soil. However desorption was maximum in Ni treated alone as compared to FYM and/or sewage sludge amended soil. Maximum desorption of Ni was observed in NTA treated soils as compared to other chelates. Desorption studies also showed that amount of Ni 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 the desorption of Ni was NTA>CDTA>DTPA>CA. Thus, chelating agents will be helpful in enhancing the phytoextraction of Ni by crops.
Key words : Nickel, 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 seious health risk. Increased attention has 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 aspects : The deterimental 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. It was air dried, ground to pass through a 2 mm sieve and mixed thoroughly. The processed soil sample was used for laboratory studies. The bulk sewage sludge sample was collected from the Sewer Treatment Plant, Industrial Estate, Okhala, New Delhi. The bulk sample of well decomposed farmyard 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 Ni. Four soil samples, viz. Ni spiked (at 90 mg Ni/kg soil), Ni spiked, FYM amended (at 3%), Ni spiked, sewage sludge amended (at 3%) and Ni 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). All chelate-extracting solutions were prepared at concentraction of 250 μM (10 mmol/kg soil) by dissolving the chelate in NaOH at pH 7.0 in a background matrix of 0.01M $CaCl_2$. Ni desorption were carried out by placing 3g of soil in a centrifuge tube and adding 30 ml of desorbing solution. The tube were capped and shaken in an end

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 (%)	13.89	-	-
Textural class	Sandy loam		-	-
pH (1 : 2)		8.10	7.2	-
$EC_{1:2}$ (dS/m)		0.50	2.1	-
Organic carbon (%)		0.32	12.2	27.8
CEC [Cmol (P^+)/kg]		11.80	-	-
$CaCO_3$ (%)		0.40	0.25	-
Total Nutrients (%)				
Nitrogen		0.09	2.29	1.18
Phosphorus		0.01	0.41	0.70
Potassium		0.10	0.73	2.50
Total metals (mg/kg)				
	Cd	3.22	7.2	0.6
	Ni	11.37	64.2	10.9

over shaker for 16h and then centrifuged for 15 min. Supernatant was then filtered through Whatman no. 42 filter paper into plastic bottle. Soil samples were then resuspended in 30ml of the same desorbing solution by shaking vigrously by hand. The above steps were repeated three times, for a total of four desorption steps and kept for Ni analysis using Atomic absorption spectrophotometer (Avanta-932 plus).

Results and Discussion

In a fertigation-type approach to phytoextraction, chelates would be applied regularly to a contaminated soil in irrigation waters in an attempt to provide regular supply of soluble form of Ni to plants. To screen chelates for their ability to desorb soil Ni when applied in this manner, Ni desorption was measured over four consecutive extractions of the same soil sample with fresh chelate solutions.Data on desorption of Ni as influenced by different chelating agents and soil amendments are given in Table 2. The 0.01M $CaCl_2$ extractable/desorbed Ni was affected by the sewage sludge and type of the chelating agents. A perusal of the data in the table 2 clearly indicate that maximum desorption of Ni was observed in NTA treated soils. The 0.01M $CaCl_2$ could desorb only 9.70, 8.50, 8.20

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

Treatments	Ni desorbed (mg kg/Soil) I	II	III	IV	Total	Desorption %
Ni treated						
Control	4.80	3.10	1.20	0.60	9.70	9.51
CDTA	33.30	18.40	7.60	3.40	62.70	61.44
CA	27.40	14.10	6.30	2.90	50.70	49.69
DTDA	31.80	17.60	6.90	3.10	59.40	58.21
NTA	35.10	19.20	8.40	3.80	66.50	65.17
Ni + FYM						
Control	4.10	2.90	1.00	0.50	8.50	8.33
CDTA	31.70	19.80	7.30	3.00	61.80	60.56
CA	27.10	13.80	6.00	2.70	49.60	48.61
DTDA	30.90	17.10	6.20	2.80	57.00	55.86
NTA	34.60	18.80	7.90	3.10	64.40	63.11
Ni + SS						
Control	4.00	2.80	1.00	0.40	8.20	7.87
CDTA	30.90	19.20	7.10	2.90	60.10	57.70
CA	26.80	13.10	5.60	2.20	47.70	45.79
DTDA	30.20	16.80	5.70	2.30	55.00	52.80
NTA	34.20	18.30	7.30	2.80	62.60	61.34
Ni + SS + FYM						
Control	3.70	2.60	0.70	ND	7.00	6.72
CDTA	30.10	18.80	6.90	2.50	58.30	55.97
CA	26.00	12.70	5.00	1.70	45.40	43.58
DTDA	29.70	16.20	5.30	1.90	53.10	50.98
NTA	33.50	17.70	6.90	2.30	60.40	62.92

and 7.00 mg Ni/kg soil in Ni, Ni + FYM, Ni + sewage and Ni + sewage sludge + FYM treated soils, respectively. It means that about 90.49, 91.67, 92.13 and 93.28% of the added Ni (90 mg Ni/kg) could not be desorbed by 0.01M $CaCl_2$. The per cent desorption of the added Ni from NTA treated soils was 65.17, 63.11, 61.34 and 62.92 in Ni, Ni + FYM, Ni + sewage sludge and Ni + sewage sludge + FYM treated soils, respectively whereas per cent desorption by was 61.44, 60.56, 57.70 and 55.97, respectively. A major fraction of added Ni was desorbed in the first cycle of 0.01M $CaCl_2$ extraction and then it decreased with consecutive extractions. Similar results were also observed by Cooper et al. and Kandpal et al. (5).

Thus it is clear that extraction of added Ni is greatly influenced by the chelating agents and FYM and /or sewage sludge addition. Further, addition of chelating agents are helpful in increasing the available pool of Ni in soils. Thus, chelating agents will be helpful in enhancing the phytoextraction of Ni by crops. The decrease in desorption in FFM, 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 Ni (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 Ni 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.

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