IN SITU STABILIZATION OF CADMIUM BY PHOSPHATE

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Introduction

Contamination of food chain by trace metals is being considered as a severe environmental problem. In situ stabilization has become a major remediation technique, due to its lower destructiveness and cost effectiveness.

Many studies have reported the usefulness of phosphate as an amendment to immobilize trace metals through formation of sparingly soluble precipitates (Hettiarachchi et al., 2001; Yoon et al., 2007). Since Cd is considered as a metal that has little affinity to metal sorbing phases in soils, chemical fractionation of Cd after amending with phosphate will provide useful information on *in situ* Cd stabilization.

The objective of this study was to investigate the effectiveness of Triple Super Phosphate (TSP) and Eppawala Rock Phosphate (ERP) in stabilizing Cd by employing a chemical fractionation method.

Methodology

An Immature Brown Loam (Inceptisol) soil sample was collected from Dodangolla located in Mid Country Intermediate Zone. Preliminary soil chemical properties studies have shown that total Cd concentration of the soil was 0.015 mg/kg. To meet the study objective, the soil was contaminated with Cd by adding $CdCl_2$ salt to achieve 50 mg/kg of total Cd content.

An incubation experiment was conducted by treating Cd contaminated soil with TSP and ERP. Total P content in all treatments was 3000 mg of P/kg of soil. Five treatments were established in three replicates considering total P_2O_5 content, which was 38 % and 60 % respectively for ERP and TSP. The five treatments were as follows; 1) TSP 100%, 2) ERP 100%, 3) 50 % TSP and 50 % ERP, and 4) 25 % TSP, 75 % ERP to achieve total P content and 5) Control, without P addition. Twenty percent of moisture content was maintained throughout the incubation.

Initial soil pH was determined by 1:1 soil to deionized water suspension. Total Cd contents in samples were determined by digesting soils with 4 M HNO_3 at 80^0C for 4 hrs. A sequential extraction (Tessier et al., 1979) was performed after 12 months of incubation period to quantify five Cd and Pb fractions: 1) exchangeable 2) organic matter bound 3) carbonate bound 4) iron and manganese oxide bound 5) residual. Cadmium contents in extractants were determined by Atomic Absorption Spectrophotomete -r. Available P contents by Mehlich extraction were determined after 12 months of incubation. Treatment differences were analyzed by

performing one way ANOVA using SAS.

Results

All treatments had reduced initial soil pH which was 6.25. Amendment of soils with 3000 mg P/kg soil by TSP alone had recorded the lowest pH value of 4.57. Treatments of 50% TSP and 50% ERP, 25% TSP and 75% ERP and 100% ERP had lowered soil pH by 1.23, 1.05 and 0.13 respectively.

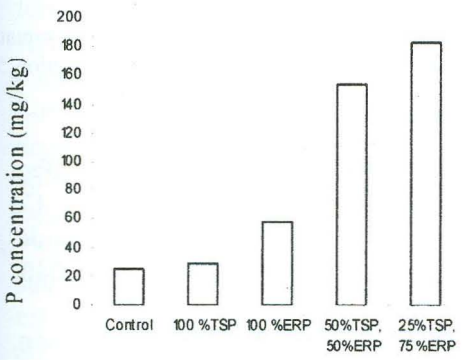

Figure 1: Available P concentrations after 12 months of incubation

Higher availability of P after 12 months was observed in treatments of TSP and ERP combinations in comparison to 100% TSP or 100 % ERP (Fig. 1). Available P content in treatment with 100 % TSP was not significantly different with the control.

Total Cd concentration varied slightly among the treatments having a variance of 7.95. Results of Cd fractionation were shown in Table 1 as a percentage of total Cd content. A significant difference among treatments was observed for the exchangeable fraction (Fraction 1) and Fe and Mn oxides bound fraction (Fraction 3). No significant difference was observed in other fractions.

Discussion

Phosphate addition had remarkably affected exchangeable, and Fe and Mn oxide bound fractions of Cd (Table 1). Higher the exchangeable Cd, lower the Fe and Mn oxide bound Cd. The exchangeable Cd content is reduced mainly due to the sorption of Cd to Fe and Mn oxides. Cadmium sorption by Al or Fe oxide can be increased by enriching oxides with phosphates (Kuo and McNeal, 1984). Soil initial pH values and Fe and Mn oxides bound Cd contents negatively correlate with a R^2 value of 0.82.

Formation of sparingly soluble cadmium phosphate has been observed by many researchers upon P addition to Cd contaminated soils (Hettiarachchci et al., 2001). In this experiment the cadmium phosphate is mainly associated with the residual fraction (Fraction 5) in all treatments, indicating the natural attenuation. Exchangeable Cd fraction has been reduced significantly in all treatments.

Available P in TSP significantly reduced after the incubation period indicating the P reactions with inorganic and inorganic constituents in soils. It is evident that the TSP contribution for the Cd remediation is only for a short term. Long lasting effect of Cd immobilization can be achieved by combinations of TSP and ERP mixtures.

Table 1. Total Cd content and sequentially extracted Cd fractions as a percentage of total Cd

Treatments	Total Cd (mg/kg)	Percentage from total Cd concentration				
		Fraction 1	Fraction 2	Fraction 3	Fraction 4	Fraction 5
Control	49.15	44.5 (a)	4.3 (a)	18.5 (c)	0.2 (a)	32.5 (a)
100 % TSP	51.18	0.2 (c)	2.5 (a)	59.5 (a)	0.3 (a)	37.5 (a)
100 % ERP	48.43	32.0 (b)	3.7 (a)	34.5 (b)	0.3 (a)	29.5 (a)
50% TSP, 50% ERP	54.46	1.5 (c)	0.3 (a)	67.5 (a)	0.2 (a)	30.5 (a)
25% TSP, 75 % ERP	54.33	0.5 (c)	2.5 (a)	59.0 (a)	0.5 (a)	37.5 (a)

Fractions of sequential extraction is as follows; Fraction 1: Exchangeable Cd, Fraction 2: Carbonate bound Cd, Fraction 3: Fe and Mn oxides bound Cd, Fraction 4: Organic matter bound Cd, Fraction 5: Residual Cd. Values that are followed by the same letter are not significantly different at $P<0.05$.

Conclusion

Addition of phosphates to contaminated soils reduced available Cd in soils. Highly soluble TSP showed the highest reduction in Cd availability while ERP showing the least reduction among the treatments. Mixing TSP with ERP showed promising results in the reduction of available Cd indicating the possibility of use of ERP mixing with TSP for remediation purposes.

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