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ZINC ADSORPTION IN VERTISOLS AND INCEPTISOLS OF TAMIL NADU

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ABSTRACT

Zinc adsorption in sixteen surface soil samples of Vertisol and Inceptisol was studied over a wide range of zinc solution concentrations (2.5 to 200 ppm). The zinc adsorption data conformed to Freundlich equation for the entire range of concentration tested. The Freundlich constants 'k' and 'n' were derived for zinc in these soils. The 'k' values ranged from 0.28 to 1.78 mg Zn/g with a mean value of 0.83 mg Zn/g soil. The 'k' values were significantly related to clay, CEC, silt, ex. calcium and free $CaCO_3$. Multiple regression analysis revealed that zinc adsorption can be predicted with good precisions from the above soil properties.

Key Words : Zinc adsorption-vertisols-inceptisols.

Of the various micronutrients, zinc has assumed considerable importance because of its wide spread deficiency on a number of crops all over the country. The adsorption of zinc is one of the most important solid and liquid phase interactions determining the release and fixation of applied zinc and thus deciding the efficiency of zinc fertilization.

Zinc adsorption has been described by the Langmuir equation by many workers (Udo *et al.*, 1970: Shuman, 1975: Shukla and Mittal, 1979). Some of the assumptions made in adopting the Langmuir equation to our current needs are not quite acceptable. So it has been felt necessary to fit the adsorption data to the Freundlich equation to characterise the adsorption dynamics of zinc in major soil series of Tamil Nadu and to relate the Freundlich constants with various soil properties.

MATERIALS AND METHODS

Sixteen surface soil samples (0-25 cm depth) representing major soil series of Tamil Nadu falling under the soil orders viz., Vertisol and Inceptisol were used for the study. The soils represented the various agro-climatic regions of the state and varied markedly in their physico-chemical properties (Table 1). The soil samples were analysed by adopting standard analytical procedures (Piper, 1966; Jackson, 1973).

Preliminary studies on the rate of zinc adsorption revealed that 24 hours was sufficient for attaining complete equilibrium of the zinc solutions with the soil and that a suitable range for the zinc concentration was 2.5 to 200 ppm. Twenty ml aliquot of 0.01M $CaCl_2$ solution containing graded levels of zinc as $ZnSO_4.7H_2O$ was added to one gram of soil. There were three replications for each zinc treatment. The contents were shaken on a reciprocating shaker for 10 minutes and allowed to equilibrate at 271C for 24 hours and were centrifuged at 4000 rpm for 10 minutes. The supernatant solution was filtered to remove the floating debris and the filtrate was analysed for zinc by atomic absorption spectrophotometry. The zinc adsorption by the soil was calculated as the difference between the amounts initially added and the quantity remaining in solution after equilibration.

Zinc adsorption was related to various soil properties such as pH, organic carbon, $CaCO_3$, CEC, silt and clay content.

RESULTS AND DISCUSSION

The adsorption data were fitted in the Freundlich equation and the equation is given by

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$$\frac{X}{m} = k\,C^{1/n}$$

Where,

X/m - quantity of Zn adsorbed per unit weight of the soil mg Zn/g soil

C - equilibrium concentration

k & n - constants

Table 2. Freundlich adsorption isotherm constants for zinc on soils

Soil NO.	'k' Values mg/g	'n' Values
VS 1	1.259	8.14
VS 2	0.562	5.14
VS 3	0.631	6.31
VS 4	1.000	7.12
VS 5	1.000	6.31
VS 6	0.398	4.70
VS 7	0.794	4.33
VS 8	0.501	6.31
IS 9	0.707	7.11
VS 10	0.891	7.11
VS 11	1.778	8.14
IS 12	0.282	6.31
IS 13	0.447	6.31
VS 14	1.259	5.67
IS 15	0.562	5.67
VS 16	1.259	7.11

The constants 'k' and 'n' were obtained respectively from the intercept and reciprocal of the slope of the straightline graph obtained upon plotting the data on a log-log scale. While Freundlich's constant, 'k' denotes the quantity of the adsorbate adsorbed when its concentration in the equilibrium solution is at unity, i.e., one ppm, the value of the constant 'n' serves as a measure of the energy of adsorption (Bailey and White, 1970). The quantities of zinc adsorbed when plotted as a function of equilibrium concentration on log-log scale resulted in a straight line (Fig.1).

Zinc adsorption data obtained in this study fitted well in the Freundlich equation for the entire range of concentration tested in this study. Figure shows Freundlich isotherms for four representative soils. Shashi Bhusan (1976), Kuo and Mikkelsen (1979), Saeed and Fox (1979) and Shukla and Mittal (1979) used Freundlich equation for explaining the adsorption pattern of zinc on soil. They observed more than one linear plot in their adsorption isotherm. Contrary to the findings of the above, workers, only one linear plot was obtained over the concentration range studied. This might be due to high CEC and clay content of the soils used and another linear plot would have been obtained had the adsorption experiments were carried out at still higher zinc concentration.

Variation in clay, silt, $CaCO_3$, exchangeable Ca and CEC of soils was responsible for the observed differences. The order of variation of 'k' values in the soils was clay clay loam sandy clay loam sandy loam sandy. The values of 'k' increased as the clay content of soils increased. This was further confirmed by the close relationship of 'k' values with clay content of the soils (r=0.844*). However, textural make up did not have much influence on the soil VS2 and VS8 presumably due to differences in their clay mineralogy.

The relationships of Freundlich 'k' values with pH, clay, silt, free $CaCO_3$, Organic carbon, exchangeable Ca and CEC of soil were studied by simple correlation and multiple linear regression analysis. The 'k' values were significantly related to clay CEC, silt, exchangeable Ca and free $CaCO_3$. The pH and organic carbon did not show any relation with 'k' values of Freundlich equation. The relationship between 'k' values and pH was not significant possibly because the soils chosen did not cover a wide range of pH. The CEC of soils had more influence on zinc adsorption followed by clay, silt, exchangeable Ca and free $CaCO_3$ contents of the soil. The presence of high clay content in most of the soils used, suppressed the effect of organic carbon exhibiting its influence on zinc adsorption and this might be the probable reason for not obtaining any significant relation between organic carbon content with 'k' values. Multiple regres-

Table 1. Physical and Chemical Characteristics of Soils

Soil No.	Soil type	Classification	pH (1:2 soil Suspension)	Free $CaCO_3$ %	Organic Carbon %	Al_2O_3 %	Fe_2O_3 %	CEC m.e/ 100g	Ex.Ca m.e/ 100g	Sand %	Silt %	Clay %
VS 1	Kvilpatti c	Typic chromusterts	7.8	5.59	0.33	4.75	6.07	52.2	35.09	41.9	9.3	41.0
VS 2	Subramaniapuram c	Typic chromusterts	7.8	4.43	0.22	11.05	3.86	48.7	25.44	57.0	6.1	33.8
VS 3	Aniyur cl	Typic chromusterts	7.6	0.73	0.71	6.38	4.57	31.7	10.82	63.3	8.0	24.5
VS 4	Dindigul c	Typic Pellusterts	7.8	0.62	0.30	11.92	5.01	63.5	35.10	31.5	11.7	51.9
VS 5	Dharmapuri c	Typic chromusterts	7.8	1.95	0.72	9.41	4.62	51.7	18.14	34.7	17.3	43.5
IS 6	Sulakkarai sl	Typic ustochrepts	7.5	3.52	0.33	5.68	2.90	19.8	11.31	84.1	2.6	8.4
VS 7	Suramangalam cl	Typic chromusterts	8.0	4.50	0.54	6.49	3.91	38.4	9.15	62.4	9.9	22.8
VS 8	Puvalur c	Typic chromusterts	7.8	0.82	0.48	15.31	3.78	42.7	16.80	57.9	8.7	30.7
IS 9	Omandur scl	Typic ustochrepts	7.9	10.93	0.41	15.78	4.32	38.4	15.81	66.2	4.3	19.9
VS10	Solanpatti cl	Entic chromusterts	8.1	9.63	0.37	6.98	5.32	33.9	9.36	62.2	8.2	22.0
VS11	Govindapuram c	Typic chromusterts	7.9	3.90	0.52	14.29	8.34	67.2	28.42	28.5	13.4	55.0
IS12	Symalakavum danpudur s	Typic ustochrepts	7.7	0.21	0.14	4.85	11.23	11.0	6.46	88.0	2.9	7.9
IS13	Tulukkanur sl	Typic ustochrepts	7.9	0.50	0.18	3.52	4.68	17.6	6.78	80.6	3.0	11.0
VS14	Pilamedu c	Typic chromusterts	8.2	8.94	0.30	11.98	4.75	40.4	28.88	41.2	10.9	40.2
IS15	Palladam sl	Typic ustochrepts	7.7	4.24	0.21	5.78	6.60	22.2	12.24	81.2	4.4	11.9
VS16	Dasarapatti c	Typic chromusterts	7.5	11.33	0.40	8.24	5.49	58.7	38.61	22.1	20.9	46.

VS = Vertsol, IS = Inceptisol, c = Clay, cl = Clay loam, sl=Sandy loam, scl = Sandy clay loam, s=Sand

Table 3. Multiple linear regression equation for 'k' values with soil properties

	X_1	X_2	X_3	X_4	X_5	Y
X1 Clay (%)	1.000	0.325	0.825	0.185	0.862	0.844**
X2 Free CaCO3 (%)		1.000	0.427	0.005	0.453	0.498*
X3 Silt (%)			1.000	0.408	0.662	0.188NS
X4 O.C. (%)				1.000	-0.168	0.734**
X5 Ex.Ca.me/100g					1.000	0.728**
Y 'k' values						1.000

$$Y = 1.877 + 0.025 X_1 + 0.323 X_2 - 0.001 X_3 - 0.004 X_4 - 0.008 X_5;$$
$R^2 = 0.77^{**}$

sion analysis was worked out with the above soil properties excluding CEC as independent characters (X_1 to X_5) and Freundlich 'k' values (Y) as dependent character and the Table 3 shows that the multiple regression analysis was significant ($R^2 = 0.77^*$). Paradoxically none of the soil properties showed significant contribution in influencing Freundlich 'k' values.

Thus it may be concluded that the zinc adsorption in Vertisols and Inceptisols of Tamil Nadu can best be described by Freundlich adsorption isotherms. The Freundlich constant, 'k' values were significantly related to the various soil properties.

REFERENCES

BAILEY, G.W. and WHITE, J.L. 1970. Factors influencing the adsorption, desorption and movement of pesticides in soil. *Residue Rev.* **32**: 29-92.

JACKSON, M.L. 1973. Soil Chemical analysis, Prentice Hall of India Pvt. Ltd., New Delhi.

KUO, S. and Mikkelsen, D.S. 1979. Zinc adsorption by two alkaline soils. *Soil Sci.* **128**: 274-299.

PIPER, C.S. 1966. Soil and Plant Analysis, Inter Science pub. Inc., New York.

SAEED, M. and Fox, R.L. 1979. Influence of phosphate fertilization on zinc adsorption by tropical soils. *Soil Sci. Soc. Am. J.* **43**:683.

SHASHI BHUSAN. 1976. Equilibrium adsorption of Zn in some representative soils of Haryana. Thesis abst. Haryana Agrl. University, Abst. No. 164.

SHUKLA, V.L and MITTAL, S.B. 1979. Characterisation of zinc adsorption in some soils of India. *Soil Sci. Soc. Am. J.* **43**: 905.

SHUMAN, L.M. 1975. The effect of soil properties on zinc adsorption by soils. *Proc. Soil Sci. Soc. Am.* **39**: 454.

UDO, E.J., Bohn, H.L. and TUCKER, T.C. 1970. Zinc adsorption by calcareous soils. *Soil Sci. Soc. Amer. Proc.* **34**: 405-407.