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Retention of Zinc by Coarse and Medium Textured Soils of Semi-Arid Tract in Western Uttar Pradesh

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Abstract In coarse and medium textured soils, retention of Zn followed Langmuir isotherm. Retention capacity and the bonding energy constant varied from 632 to 1587 Zn g^{-1} soil and 0.151 to 0.280 mL μg^{-1} Zn, respectively. The Zn retention capacity correlated very well with organic C, CEC, clay and sand. Soils extremely rich in sand but poor in clay and organic matter had relatively lower capacity to fix Zn.

Key words Sandy soils, Zn absorption, Langmuir isotherm

Physico-chemical characteristics of soils regulate the availability of Zn to plant roots by affecting its retention and release (Chatterjee & Mandal 1985). Information on the behaviour of soils of western UP for Zn retention was lacking, therefore the present investigation was undertaken to study the retention pattern of Zn by coarse and medium textured soils of the area.

Materials and Methods

Surface soil samples of coarse and medium textured soils were collected from seven locations (Table 1) in alluvial plains of western UP having semi-arid climate.

Zinc retention was studied by equilibrating 1 g soil, in a series of centrifuge tubes, with 20 mL of $ZnSO_4$. $7H_2O$ containing Zn concentrations ranging from 2 to 128 μg mL^{-1}. After shaking for 10 min, these were kept in incubator at 25°C for 20 h. The suspensions were then centrifuged for 10 min and supernatant was filtered and analysed for Zn by atomic absorption spectrophotometer. The amount of Zn retained by the soils was computed by subtracting the equilibrium Zn concentration from the initially added Zn level. The retention data were fitted to Langmuir equation.

Results and Discussion

Regression equation and the Langmuir constants for the retention of Zn by different soils are presented in Table 2. The significant correlation coefficients (r = 0.970 to 0.992) between C/x/m vs C indicated the fit of the data to the Langmuir isotherm. Joshi and Sharma (1986) had also reported similar isotherms for sandy soils of Rajasthan.

Retention capacity (b) and the bonding energy constant (k) computed from regression equations of Zn retention varied from 632 to 1587 μg g^{-1} soil and 0.151 to 0.280 mL μg^{-1} of Zn, respectively.

Relatively higher values of the retention capacity (1388 to 1587 μg Zn g^{-1} soil) and bonding energy constant (0.222 to 0.280 mL μg^{-1} Zn) in Kamora, Babralla and Rathonda soils, as compared to soils of Kalakhera, Malpura, Morna and Sahaswan ('b' = 632 to 980 μg Zn g^{-1} soil and 'K' = 0.151 to 0.191 mL g^{-1} Zn), is attributed to comparatively higher value of pH (8.1 to 9.6), organic matter (0.76 to 0.96% org.C) and clay (12.5 to 18.6%) in former soils. Shuman (1975) also reported higher absorption capacity and higher bonding energies for Zn in soils high in clay and organic matter.

The pH of these soils is alkaline, therefore Zn might be retained in hydrolysed form or precipitated as $Zn(OH)_2$ (Bingham *et al.* 1964). Due to higher amount of $CaCO_3$ in these soils (2.5 to 4.0%), formation of $ZnCO_3$ at high levels of added Zn may also be expected (Misra & Tiwari 1966) leading to unavailability of Zn. Zinc may be

Table 1 *Physico–chemical characteristics of the soils*

Location	Great Group	pH	Org.C (%)	CEC [Cmol (p+) kg^{-1}]	$CaCO_3$ (%)	Sand (%)	Silt (%)	Clay (%)	Soil texture
Morna	Ustipsamment	7.7	0.40	9.9	0.40	70.5	20.0	9.5	Loamy sand
Kalakhera	Ustipsamment	7.9	0.32	9.0	0.52	77.5	17.5	5.0	Loamy sand
Malpura	Hapludoll	7.6	0.40	10.9	0.45	72.5	18.0	9.5	Sandy loam
Kamora	Eutrochrept	8.3	0.88	13.9	2.50	50.0	37.5	12.5	Loam
Rathonda	Hapludoll	8.1	0.96	15.6	2.80	50.8	30.7	18.5	Loam
Babralla	Eutrochrept	9.6	0.76	16.5	4.00	50.0	31.4	18.6	Loam
Sahaswan	Haplumbrept	7.8	0.40	13.0	0.25	70.0	19.7	10.3	Sandy loam

Table 2 *Regression equation and Langmuir constants for the retention of zinc*

Location	'r' Values[a]	Regression equation[b] C/x/m =	Retention capacity 'b' (μg Zn g^{-1} soil)	Bonding energy constant 'K' (mL μg^{-1} Zn)
Morna	0.984*	0.00115 C + 0.00675	868	0.170
Kalakhera	0.992*	0.00158 C + 0.00827	632	0.191
Malpura	0.977*	0.00118 C + 0.00777	347	0.151
Kamora	0.974*	0.00072 C + 0.00324	1388	0.222
Rathonda	0.973*	0.00063 C + 0.00265	1587	0.237
Babralla	0.970*	0.00067 C + 0.00239	1492	0.280
Sahaswan	0.978*	0.00102 C + 0.00618	980	0.165

Significant at P = 0.01

a–r values between C/x/m and C

b–E [Equilibrium Zn concentration ($\mu g\ mL^{-1}$)]

x/m = Amount of Zn retained by soil ($\mu g\ g^{-1}$)

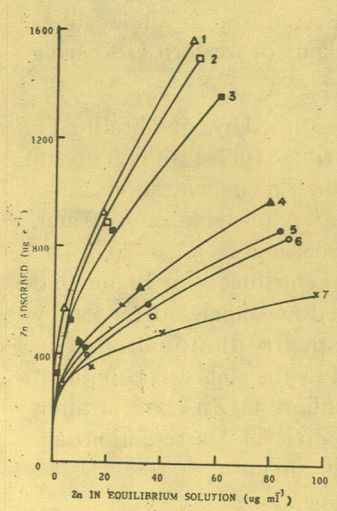

Fig. 1 Zinc adsorption isotherms of (1) Rathonda (2) Babralla (3) Kamora (4) Sahaswan (5) Morna (6) Malpura (7) Kalakhera soils

entrapped physically in the wedge zones or fixed with stronger forces on the exchange sites by clay minerals (Reddy & Perkins 1974). It might also be immobilized by organic matter due to the formation of insoluble Zn-organic matter complexes owing to the retention of Zn by COOH and phenolic-OH groups of humic acid (Randhawa & Broadbent 1965).

In soils of Kalakhera, Malpura, Morna and Sahaswan the concentration of Zn in equilibrium solution increased faster (Fig. 1)than that retained by soils with increase in the addition of Zn to the system. Consequently, the slopes of the isotherms were less steeper in these soils as compared to those of Kamora, Babralla and Rathonda soils. This is ascribed to minor buffering effect of the solid phase on the Zn in solution.

The Zn retention was significantly positively correlated with organic C, CEC and clay (r = 0.959, 0.945 and 0.951) and negatively with sand (r = -0.979). The values of the correlation coefficient with bonding energy constant were positive for pH, organic C, CEC and clay (r = 0.907, 0.777, 0.823 and 0.791) and negative with sand (r = -0.840).

Thus, it can be inferred that in semi-arid region soils of western Uttar Pradesh, low in clay and organic matter had low capacity to retain Zn.

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