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Availability of Added Zinc And Manganese in Relation to Adsorption Characteristics in Different Acid Soil Types of Kerala

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Three soils viz. *Karapadom**, Sandy alluvium and Lateritic alluvium having low initial levels of manganese and zinc were subjected to a study which revealed the dynamics of added zinc and manganese in relation to the adsorption - desorption characteristics. The results indicate that the adsorption of zinc and manganese in all the three soils are in conformity with the Langmuir's adsorption model. Karapadom soil with high cation exchange capacity, clay and organic matter content retained the two elements added in a higher proportion thus concluding the significantly superior residual effect. The study high lights the possibility of skipping applications in soils with high retention capacity and regulated small but frequent applications for soils with decreased residual effects.

The ecological availability of micro-nutrients to plants is governed among many factors by the process of adsorption and desorption by soil solids (Cottenie *et al.* 1979). The failure to recognise and quantify the various complex species of metalions which are adsorbed and in soil solution (Juang and Kao, 1973) and the role of soil solids especially the clay and the humus fractions in these processes have received detailed attention by various workers (Elgabaly and Jenny 1943, Thorne 1957, Hodgson 1963, Ellis and Knezek 1972). Under the rice farming situations study of adsorption-desorption characteristics of manganese and zinc and an assessment of their residual effects are particularly relevant in view of the high costs involved in continuous application as well as fear of reaching toxic levels due to heavy doses. The results of a study on the adsorption-desorption patterns in three Kerala soils deficient or marginally deficient in available manganese and zinc are reported.

MATERIAL AND METHODS

Three soils namely Karapadom* (Entisol), Lateritic alluvium (Oxisol) and Coastal sandy alluvium (Entisol) having low initial levels of manganese and zinc were selected for this study Some of the important physico-chemical characteristics of these soils are given in the Table

A stock solution containing 1000 ppm of manganese and zinc were prepared separately with manganese sulphate ($MnSO_4$ H_2O) and Zinc Sulphate ($ZnSO_4$, $7H_2O$) as the source materials. Both the elements were applied in separate lots of soils in increasing doses so as to get final concentration of 25 to 5000 ppm in 10 g of the soil. The soil : solution ratio was adjusted to be 1:5 in all cases and the

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mixture was shaken in a mechanical shaker for one hour. The suspension was filtered and manganese and zinc concentrations in the filtrate was read is an Atomic Absorption Spectrophotometer. The amounts of manganese and zinc adsorbed by the soil at each equilibrium solution concentrations was then obtained by subtracting the amounts of the elements in the equilibrium solution from the total amount added (Table 2) (Small amounts of the element originally present in the soil being neglected). The experiment was replicated thrice for averaging out the errors.

RESULTS AND DISCUSSION

Table 2 summarises data on adsorbed and solution concentrations of manganese and zinc in the three soils used for the study. The adsorption isotherm models obtained for the soils by plotting the equilibrium solution concentrations of the metals against the amount adsorbed are given in the figure.

There is considerable difference between the two elements investigated in their adsorption characteristics and also among the three soils studied. The higher doses of zinc and manganese corresponds to only 3.06 and 18.5 me / 100 g. of the soil which is far below the cation exchange capacity of the Karapadom soil, while they are nearly half in respect of zinc and exceeds full saturation in respect of manganese for the lateritic alluvium and sandy alluvium. It was observed that about 77% of the added zinc and 80% of the manganese was retained by the Karapadom soil stressing that for the highest levels of addition the adsorption complex of this soil is still not saturated with zinc and manganese and the soil possesses the capacity to retain more of these heavy metals from the soil solution; if added.

The other two soils studied however, showed much of the zinc and manganese in the solution phase after equilibrium which could be explained by the low cation exchange capacity, organic matter and clay percentage. Among the three soils studied the Onattukara Sandy alluvium soil with a very low cation exchange capacity of 4 me /100 g showed the least adsorption for both the elemente under study. This is evidenced by the steeper slope of the isotherm while a flattened curve is noticed for the Karapadom soil. It clearly indicate the greater buffering effect of the solid phase on the two elements in solution in respect of the Karapadom soil. Between the two elements studied manganese was more retained at equivalent concentrations in all the soils indicating a stronger retention for soils manganese as evidenced from the steeper slope of the manganese adsorption isotherm.

Langmuir's equation as applied to the adsorption of zinc and manganese may be written as $q(M) = KQc(M) / 1 + Kc(M)$ where 'K' is the adsorption equilibrium constant, 'Q' the total adsorption capacity and $q(M)$ and $c(M)$ the adsorbed and solution concentrations of the metal respectively. When $c(M) / q(M)$ was plotted against $c(M)$ a linear isotherm was obtained which correspond to the langmuir's model (figure not given; see Table 3 'r' values)

The statistical validity was tested for the correlation coefficients for c(M)/q(M) to understand the fit of the data to the Langmuir's model. The calculated values of correlation coefficients 'r' were all significant (Table 3) indicating that the adsorption of zinc and manganese conformed to the Langmuir's equation.

The present study thus is in agreement with the work of Cottenie *et al.* (1979) who identified that adsorption of heavy metals in soils generally conformed to the Langmuir. adsorption model.

From the afore-mentioned facts it is clear that the adsorption of heavy metals like manganese and zinc by soils is largely affected by the soil properties, cation exchange capacity. clay content and organic matter status. Among the three soils studied only the Karapadom soil retained the two elements added at a higher proportion. So the residual effect of the applied micronutrients will generally be significantly higher in such soils. In the lateritic and sandy alluvium a major portion of the applied nutrients remain in the soil solution phase without being adsorbed into the exchanger. This decreased adsorption of the heavy metals into the exchanger especially under the humid tropical soil situations suggests the possible leaching losses and decreased residual effect from single applications. In such soils regulated small, but frequent applications depending on the pattern of uptake by the crop in question may have to be advocated after further detailed work.

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Karapadom* - Riverine alluvium of the Kuttanad region where four major rivers of Kerala empty into the Vembanad lake.

TABLE 1 Soil Characteristics

	Karapadem	Lateritic alluvium	Sandy alluvium
pH	4.2	4.6	5.4
E. C. (millimhos / cm)	0.640	0.140	0.053
Organic matter (Per centage)	6.8	1.9	0.7
C. E. C. (me. / 100g)	26.47	8.73	4.20
*Available Mn	35	6	1
*Available Zn	4	3	2

*0.1N Hcl extractable.

TABLE 2 Quantities of Mn and Zn in the equilibrium solution and adsorbed by the three soils used for different addition levels

Element	Soil sample	ppm added	Quantity in equilibrium solution		Quantity adsorbed	
			ppm C(M)	Percentage of added	ppm q(M)	Percentage of added
ZINC	Lateritic alluvium	25	0.1	0.4	24.8	99.6
		50	2	4	48	96
		100	5	5	95	95
		250	34	13.6	216	86.4
		500	127	25.4	373	74.6
		1000	493	49.3	507	50 7
	Karapadom	25	0.1	0.4	24.9	99 6
		50	0.1	0.2	49.9	99.8
		100	1.5	1.5	98.5	98.5
		250	12	4 8	238	95.2
		500	63	12.6	437	87.4
		1000	231	23.1	769	76.9
	Sandy alluvium	25	0.1	0.4	24.9	99.6
		50	1	2	49	98.0
		100	12	12	88	88.0
		250	62	24.8	188	75.2
		500	229	45.8	271	54.2
		1000	663	68.3	317	31.7

Contd...2.

TABLE 2 (Contd.)

Element	Soil sample	ppm added	Quantity in equilibrium solution		Quantity adsorbed	
			ppm c(M)	Percentage of added	ppm q(M)	Percentage of added
MANGANESE	Lateritic alluvium	25	0.1	0.4	24.9	99 6
		50	0 2	0 4	49.8	99.6
		100	1.0	1.0	99.0	99 0
		250	16	6.4	234	93.6
		500	89	17.8	411	82.2
		1000	407	40.7	593	59.3
		5000	3979	79.58	1021	20.4
	Kerapsdom	25	0.1	0.4	24.9	99 6
		50	0.1	0.2	49.9	99 8
		100	0.2	0 2	99.8	99 8
		250	0.3	0.12	249.7	99 8
		500	6.0	1.2	494	98 8
		1000	69	6.9	931	93.1
		5000	973	19 46	4027	80.5
	Sandy alluvium	25	0.2	0 8	24.8	99.2
		50	0.4	0.8	49.6	99 2
		100	2.0	2.0	98.0	98.0
		250	32	12.8	218	87.2
		500	176	35.2	324	64.8
		1000	531	53.1	469	46.9
		5000	4110	82.2	890	17.8

TABLE 3 Langmuir coefficients for the equation describing the adsorption of Zn and Mn.

Element	Soil sample	Correlation coefficients	Regression equation
	Lateritic alluvium	0.9920 **	$\frac{c\ (M)}{q\ (M)} = 0.0019c(M) + 0.565$
Zn	Karapadom	0.9614 **	$\frac{c\ (M)}{q\ (M)} = 0.0013c(M) + 0.0203$
	Sandy alluvium	0.9950 **	$\frac{c\ (M)}{q\ (M)} = 0.0031c(M) + 0.0728$
	Lateritic alluvium	0.9943 **	$\frac{c\ (M)}{q\ (M)} = 0.0010c(M) + 0.0802$
Mn	Karapadom	0.9748 **	$\frac{c\ (M)}{q\ (M)} = 0.0002c(M) + 0.0122$
	Sandy alluvium	0.9906 **	$\frac{c\ (M)}{q\ (M)} = 0.0011c(M) + 0.1584$