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FORMULATION OF QUANTITATIVE EQUATIONS FOR THE RELEASE AS WELL AS ADSORPTION OF DIFFERENT CATIONS FROM THE CLAY COMPLEX OF SALT AFFECTED SOILS

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Cation exchange equilibria in two salt affected soils, namely Quingua clay, a Mg - affected soil (EMP 41) and Dadiangas clay, a Na - affected soil (ESP 45) was studied to calculate the f-values for different cations in order to seek quantitative equations for the calculation of the amounts of amendments that will go to the soil solution or adsorbed on the clay. On the basis of f-values, it was concluded that the replacing powers and/or the adsorption capacity of the cations was of the order Ca > Mg > K > Na.

INTRODUCTION

Equations dealing with the release and adsorption of cations in soils have been given by many research workers. Most of the equations have been restricted to systems of two ions, and therefore have had only limited application in the practical field. An attempt to formulate a working base - exchange equation for a system of more than two ions is found in the work of Bray (1942). He assumed the ratio of a given cation to the total cations released when a small amount of electrolyte is added as proportional to (1) the relative amount present in the exchangeable form and (2) the relative ease of release. His equation was further modified by Melstead and Bray (1947) and when expressed mathematically would give:

$$Ao = \frac{A.\,fA}{A\,fA + B\,fB + C\,fC + \ldots .N.fN} \times \text{ me of anion added} \quad \ldots . (1)$$

where Ao is the me of ion A in solution after equilibration, A,B,C,N are the total (Exch. + Soluble) me of each of these cation in the system, and fA, fB, fC, fN are the respective f-values for the ions A,B,C–N or if it is desirable to express the distribution of the ions on the colloid, the equation takes the same form, except that the reciprocal of the f-value is used, that is the ease of retention of the cation.

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$$AI = \frac{A.1/fA}{A.\ 1/fA + B.1/fB + C.1/fC + \ldots N.1/fN} \times \text{me of exchange capacity.}$$

where AI is the me of cation A (adsorbed) on the calloid.

MATERIALS AND METHODS

Two problems soils namely Quingua clay, a high magnesium soil (EMP 41), CEC, 49.6 me/100g, pH 6.7, principal mineral (by DTA) Kaolinite was collected from the Quingua soil series found in the broad nearly level geologic "alluvial" plains of the Philippines, while the other was Dadiangas clay, a highly sodium affected soil (ESP 45), CEC, 39 me/100 g, pH 7.6, principal mineral Kaolinite, and belonged to the coastal area of the Pacific Ocean. Quingua clay was equilibrated with 1, 2 and 4 me of Na and K while Dadiangas was treated with 1, 2 and 4 me of Ca and Mg. All salts added had chloride as the anion form. Fifty grams of soil sample with each treatment was equilibrated in duplicate for 24 hours and maintained at 29°C. The equilibrated soil samples were processed for the calculation of soluble cations while the exchangeable were calculated by difference. The methods followed for analysis were those as given by US Salinity Laboratory Staff (1954).

RESULTS AND DISCUSSION

A. Calculation of f-Values

The release of Mg from Quingua clay with the application of Na and K is shown in table 1. The f-values for various cations were calculated by dividing the % release of each cation by the % release of calcium. The f-values (average) for Ca, Mg K and Na were found as 1.0, 1.80, 2.23 and 8.16 respectively.

Table 1. *Exchangeable and Water Soluble Cation Status of Quingua Clay after Equilibration with Na and K.*

Treatment	Exch. cation me/100g				Soluble cation me/100g			
	Ca	Mg	Na	K	Ca	Mg	Na	K
Control	27.59	23.32	1.15	0.52	0.29	0.18	0.44	0.02
Na 1 me	27.23	19.89	1.95	0.05	0.56	0.61	0.64	0.03
" 2 "	25.93	19.35	2.81	0.49	0.86	1.16	0.77	0.04
" 4 "	24.44	18.62	4.05	0.47	1.35	1.88	1.54	0.06
K 1 me	27.22	19.84	1.01	1.50	0.57	0.66	0.57	0.04
" 2 me	26.87	19.30	0.92	2.49	0.92	0.29	0.67	0.05
" 4 me	25.21	18.27	0.67	4.43	1.58	2.23	0.92	0.11

The release of Na from Dadiangas clay with the application of Na and Mg is shown in table 2. The f-values (average) for Ca, Mg, K and Na were found as 1.0, 1.65, 2.27 and 6.73 respectively.

Table 2. *Exchangeable and Water Soluble Status of Dadiangas Clay after equilibration with Ca and Mg.*

Treatment	Exch. cation me/100g				Soluble cation me/100g			
	Ca	Mg	Na	K	Ca	Mg	Na	K
Control	12.43	7.71	17.47	2.80	0.10	0.05	1.01	0.02
Ca 1 me	13.35	7.60	16.69	2.75	0.18	0.11	1.78	0.07
" 2 me	14.35	7.73	15.92	2.71	0.28	0.18	2.79	0.11
" 4 me	16.00	7.36	14.44	2.63	0.53	0.35	4.04	0.19
Mg 1 me	12.24	8.60	16.71	2.75	0.19	0.14	1.77	0.06
" 2 me	12.16	9.48	15.97	2.71	0.27	0.24	2.51	0.10
" 4 me	12.01	11.21	14.50	2.63	0.43	0.52	3.98	0.18

B. Formulation of quantitative equations and their application in soil system.

Since these f-values were obtained experimentally, they also reflect the combined effects of ion size, charge and hydration. Thus an ion having a high f-value will be more easily replaced then an ion with a small f-value. Since K has low f-value than Na which means that the former has more replacing capacity than the later. Quantitative equations based on such f-values can predict the fate of added emendment or fertilizer in the soil system. In Quingua clay, suppose 0.5 me of K/100g soil or 380 kg K/ha or 780 kg KCl/ha was to be applied as amendment. Quantitative equations of the type (1) was used to calculate how much of the amendment will go to the soil solution.

$$\begin{array}{l}\text{Amount of cation}\\ \text{in solution me/100g soil}\end{array} = \frac{\text{(Amount of cation A) (f.A)}}{\begin{array}{l}\text{(Sum of the product of cations}\\ \text{and their respective f-values)}\end{array}} \times \text{me of anion added}$$

For K, the amount in solution was 0.015 me/100g soil or 11.70 kg/ha. Thus from 390 kg/ha only about 12 kg of K will go to soil solution and the rest will be adsorbed. The amount that will go to soil solution is subject to losses due to leaching. Using the same procedure the predicted amount of each cation under any treatment can be calculated. As regards Dadiangas clay, 1 me of Ca/100g soil or 400 Ca/ha was to be added. Using the same equation it was found that out of 400 kg Ca/ha, 0.076 me/100g of Ca or 30.4 kg Ca/ha, will go to soil solution and the rest will be adsorbed.

C. Significance of f-values in the study of salt affected soil.

The f-values for different cations calculated in both the soils were quite close to those obtained by Bray (1942) from Jenny's (1936) data for Putnam clay i.e. 1.0, 1.6, 2.2 and 6.2 for Ca, Mg, K and Na respectively. This may be attributed more to the nature of the ions than to the type of exchange material. On the basis of f-values it can be concluded that the replacing power and/or the adsorption capacity of cation was of the order as Ca > Mg > K > Na. Sodium showed a low replacing ability for Mg in Quingua clay as compared to Ca in releasing Na from Dadiangas clay. It indicated that higher is the f-value for the electrolyte that is added, the less is the replacing ability, and this rule is highly applicable when a single cation equilibrium extraction is desired, as is done in rapid soil tests. In Dadiangas clay the release of Na by Ca and Mg was more at their lower levels of amendments and this indicated that the smaller is the amount of electrolyte added, the greater is the influence of f-value on the amount of given cation released. This rule is of great practical significance in reclamation aspects of salt affected soil, especially when the amendments is costly. Once the f-values for different ions in a particular soil are established, prediction for their release as well as adsorption, can be made.

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