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COO-1495-1

CONF-660820-1

OCT 11 0 1966

Investigations of Ca-Sr Adsorption Selectivity in Clays and Soils **CFSTI PRICES**

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*Purdue Research Foundation*H.C. \$ 1.00 MN. .50

A growth chamber experiment has indicated that a sizeable fraction of plant uptake of strontium takes place by mass flow, where the soluble ions move along with soil water to the absorbing surfaces of plant roots. Since ionic concentrations in the soil solution are controlled by ion exchange reactions, then it is necessary to understand the reactions that affect the Sr ion in the soil. Such a parameter is needed to incorporate in any expression for describing ion uptake by plant roots in a quantitative manner (slide 1).

The exchange of Sr and Ca has been investigated by several workers, but the data is not in agreement and deals mostly with clays. The results of Lewis and of Heald indicated that Sr was preferentially adsorbed by clay minerals and soils with a selectivity coefficient ranging from 1.1 to 1.2 (Lewis) and from 1.0-1.4 (Heald). Polyakov on the other hand reported that measurements of ΔH , ΔF , and ΔS for the exchange reaction of Sr and Ca on soils showed greater stability of the soil-Ca system than of the soil-Sr system. Schroeder reported a preferential adsorption of Ca and attributed this to a hysteresis effect that lead to weaker sorption of Sr. This paper reports the results of work done to reexamine Ca-Sr exchange reaction with emphasis on soils.

Exchangeable Ca and exchangeable Sr were measured on 64 soils from Indiana, representing 16 different soil series. Sr and Ca in the saturation extract were also measured, and a selectivity coefficient was calculated for each soil. Thirty of the above soils were then selected and selectivity coefficients were determined by equilibrating these soils

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with a 0.1 N chloride solution of Ca and Sr in the ratio of 186 to 1, respectively. Selectivities that were calculated from exchangeable and saturation extract ions will be referred to as selectivities of untreated soils, and those measured by the equilibration procedure will be referred to as selectivities of treated soils. This slide shows the frequency distribution of selectivity coefficients of treated and untreated soils. *decide*
For the untreated soils, K_c ranged from 0.355 for a Chelsea sand to 2.11 for a Parke subsoil, with a considerable dispersion around the mode of 1.0. For the treated soils, however, the range of K_c was considerably narrower, (0.69 to 1.17), and the dispersion considerably less. The wider range and larger dispersion of K_c for the untreated soils was attributed to the presence of other exchangeable ions, and also to the effect of the level of soluble salts in the untreated soils.

Several soil properties were measured like pH, CEC, percent clay, and percent organic matter. A multiple regression analysis of the measured selectivities against these soil properties indicated that K_c was negatively correlated with percent organic matter and CEC. (0.83, 0.76 corr. coef.)

The relationship between K_c and organic matter was pursued further. Two Brookston silty clay loams and a Blount silty clay loam were selected. Both of the Brookston soils were high in organic matter, while Blount was relatively lower, while other properties were more or less similar (slide). Samples of these soils were treated extensively with H_2O_2 to destroy organic matter, and then K_c was measured on the o.m. - free soil. This slide shows K_c for these soils. The destruction of organic matter had resulted in a pronounced change in K_c to favor the preference for

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Sr over Ca by all of these soils. This confirmed the negative correlation between K_c and organic matter, and indicated that soil organic matter possessed a preference for Ca over Sr. Next, humic acid fractions from these soils were obtained using two extracting procedures, one using 0.5 N NaOH after pretreatment with HF, and the other using a Na-saturated resin. K_c was measured on these humic acid fractions as well as on a muck soil (slide). K_c of the muck soil indicated a preference for Ca over Sr, while K_c of the humic acid fractions varied considerably according to the method of extraction for each given soil. These measurements on humic acid indicated that soil organic matter was sufficiently altered by the extracting procedure to confound its behavior in regards to preference for Ca or Sr, and no conclusion can be drawn from results on the humic acid extracts.

To summarize, the following conclusions are made:

1. The range in selectivity of Ca-Sr exchange reaction in untreated soils is wider than has been reported so far. A six fold range is reported, 0.36-2.11.
2. This range is narrowed down considerably by eliminating the effect of other exchangeable ions and of different levels of soluble salts.
3. There is a negative correlation between K_c and organic matter content and between K_c and CEC.
4. Destroying the organic matter of soil by H_2O_2 treatment resulted in a pronounced increase in Sr selectivity. Selectivity of a muck soil also indicated preference for Ca. The preference of soil organic matter for Ca over Sr is important in modifying the overall preference of soil for either of these ions.

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References Cited

1. Choudhri, M. B. and F. J. Stevenson, 1957. Chemical and physicochemical properties of soil humic colloids: III. Extraction of organic matter from soils. Soil Sci. Soc. Am. Proc. 21:508-515.
2. Heald, W. R., 1960. Characterization of exchange reactions of strontium and calcium on four clays. Soil Sci. Soc. Am. Proc. 24:103-106.
3. Lewis, R. J., 1961. Some aspects of the chemistry of radio-strontium in soils. Diss. Abstracts XXII No. 6, 1763.
4. McHenry, J. R., 1955. Adsorption and retention of strontium by soils of the Hanford Project. Hanford Atomic Products Operation. Richland, Washington. HW - 34499.
5. Polyakov, Yu. A., 1960. Determination of thermodynamic characteristics of the exchange adsorptions of calcium and strontium ions in soils. Dokl. Sovet. Pochvovedov 7 Mezhdunarod. Kongr. 100-105. (Abs. in Soils and Fertilizers, 25:2487, 1962).
6. Schroeder, D. and G. Freiherr von dem Bussche, 1962. Die Konkurrenz von Calcium-, Wasserstoff- und Strontium- Ionen bei der Sorption von Aktivem und Inaktivem Strontium im Boden. Landwirtsch. Forsch. 15:190-195. (Abs. Soils and Fertilizer 26:587, 1963).
7. Tensho, K., K. L. Yeh and S. Mitsui, 1961. Absorption of radioactive strontium by soil, especially in relation to native calcium. Soil Sci. Plant Nutrition, 7:152-156.

$$K_c = \frac{[\text{Sr-Soil}]}{[\text{Ca-Soil}]} \times \frac{(\text{Ca}^{++})}{(\text{Sr}^{++})}$$

Soil Properties

Soil	pH	CEC me/100 g	O.M. %
Blount Silty Clay Loam	5.5	14.8	2.4
Brookston Silty Clay Loam (1)	6.6	37.2	7.1
Brookston Silty Clay Loam (2)	6.9	33.8	6.0

Effect of Treatment on Sr/Ca Selectivity
Coefficients

Soil	Treatment		
	None	Equilibration	H ₂ O ₂ + Equilibration
Blount	1.28	1.08	2.08
Brookston (1)	0.76	0.69	1.96
Brockston (2)	0.89	0.70	1.54

Sr/Ca Selectivity Coefficients on
Humic Acid Fractions and a Muck Soil

Method of extraction	Blount	Brookston (1)	Brookston (2)	Muck
Alkali extracted	1.12	1.70	1.46	
Resin extracted	0.84	0.93	1.04	
				0.575