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Studies on the Relationships Between Cation Exchange Capacity of Soil Clays and Certain Categories of Water from Dehydration Data

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The fifteen clay samples separated from the four major soil groups of Tamil Nadu, the black, red, alluvial and laterite soils were subjected to dehydration analysis. The ratio of adsorbed water to crystal-lattice water obtained from dehydration data served as a reliable indicator for characterization of the soil group. Besides, certain categories of water from dehydration data were found to be significantly related to cation exchange capacity of soil clays, so much so characterization of soil clay and groups from dehydration data could form a most reliable basis.

Dehydration study of soil clays is a simple method found useful to characterise the clay minerals present in soils. This technique had been employed to assess the quality aspect of soil clays, representing the four typical major soil groups, the black, red, alluvial and laterite soils from the State of Tamil Nadu. It was attempted to provide a suitable quality index of clay minerals from the dehydration data. The dehydration data by themselves were found extemely useful for the purpose of characterization of soil clay. Certain other interesting aspects of the relationships between different categories of water of dehydration data and cation exchange capacity (CEC) were also revealed.

MATERIALS AND METHODS

Fifteen soil clays were separated from the four heterogeneous major soil groups of Tamil Nadu, following the method of Dewis and Freitas (1970), clays saturated with sodium were used for dehydration analysis. The clay samples taken in platinum dishes were brought to uniform humidity level by keeping in a desiccator containing H_2SO_4 (50% R.H.). The platinum crucible with the clay sample (1 g) was heated in an electric muffle furnace and loss of weight was recorded at 100°C, 150°C, 300°C and thereafter at intervals of 100°C up to 900°C. Clays saturated with 1 N neutral ammonium acetate were used for estimation of cation exchange capacity, adopting the procedure described by Dewis and Freitas (1970).

RESULTS AND DISCUSSION

The CEC values and molar ratios such as silica-alumina and silica-sesquioxide ratios are largely used to characterise the pattern of clay mineral distribution. That highly significant relation-

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ships exist between CEC and some of the molar ratios such as silica-sesquioxide and silica-alumina ratio of the clay fractions from all the heterogeneous soil groups of Tamil Nadu had been established and reported elsewhere. Despite the divergent nature of clay minerals from the four major soil groups, close significant relationships exist between CEC and molar ratios, the two parameters ordinarily used for characterization of the clay fractions from soils.

The dehydration data of the fifteen soil clays representing the four major soil groups are presented in Table I. The dehydration curves could then be cons-

TABLE I. Dehydration data of clays. Progressive loss of moisture (Moisture loss per 100 g of clay)

Location District	Temperature in Centigrade									CEC me/100 g of clay
	100	150	300	400	500	600	700	800	900	
Black soil clays										
1. Saravanampatti, Coimbatore Dt.	11.77	15.92	17.07	17.93	18.35	21.93	22.24	22.34	22.39	84.0
2. Kallakurichi, South Arcot Dt.	10.79	15.75	16.93	19.02	20.18	21.65	22.00	22.10	22.17	86.0
3. Kovilpatti, Tirunelveli Dt.	10.94	15.33	16.38	18.17	18.51	20.36	20.82	20.92	20.97	93.0
4. Kulathur, Tirunelveli Dt.	9.45	12.78	13.91	15.73	16.26	17.25	17.82	17.87	17.93	70.0
Red soil clays										
5. Kallakadu, Tirunelveli Dt.	2.82	5.91	7.46	13.46	14.94	15.73	15.89	16.12	16.37	18.5
6. Pollachi, Coimbatore Dt.	4.48	9.01	11.62	14.75	15.40	15.97	16.22	16.70	16.77	35.0
7. Sulur, Coimbatore Dt.	3.61	7.16	10.05	13.83	14.69	15.12	15.29	16.00	16.42	30.0
Alluvial soil clays										
8. Aduthurai, Thanjavur Dt.	7.25	9.22	12.33	12.68	16.11	16.21	16.81	17.25	17.84	52.0
9. Agatheeswaram, Kanyakumari Dt.	6.06	9.04	11.21	14.36	15.08	15.25	15.72	16.31	16.52	46.5
10. Thanjavur (Kalathur series)	6.76	10.66	13.90	14.99	17.72	17.97	19.36	19.47	19.91	55.5
11. Thanjavur, (Adanur series)	6.42	7.64	9.40	15.22	15.52	16.18	16.69	17.12	18.12	52.0
Laterite soil clays										
12. Ooty, Nilgiris Dt.	3.39	11.99	22.94	24.28	28.08	28.25	29.50	29.65	30.50	31.0
13. Coonoor, Nilgiris Dt.	2.92	9.17	20.11	21.53	26.27	26.27	26.75	27.77	28.82	33.0
14. Vallam, Thanjavur Dt.	1.08	3.54	4.42	11.96	14.14	14.67	15.13	15.63	15.93	16.0
15. Red Hills, Chingleput Dt.	0.97	2.34	3.61	4.37	13.20	13.98	14.23	14.75	15.09	18.5

tructed from the values of total moisture loss against the corresponding temperature. These were also termed as weight loss curves by Barshad (1965) while Grim (1968) used the term dehydration curves. The dehydration curves so constructed were characteristic of the soil clay (Grim, 1968).

Total water lost at 150°C for the sodium saturated clays represented adsorbed water (Barshad, 1965; Grimshaw, 1971). Water lost between 150°C and 900°C had been taken as the crystal-lattice water (Barshad, 1965). The values of these categories of water showed a certain definite trend associated with the different soil groups (Table II). The ratio of adsorbed water to crystal-lattice water was distinctly greater than 2 for black soil clays, round the value 1 for alluvial soil clay, lower than 1 for red soil clay, and clearly less than 0.5 for laterite soil clay, as revealed from the mean values (Table II). The black soil clay, red soil clay etc., were the clay samples separated from the respective soil groups. Examination of the clay samples by DTA technique (unpublished data) revealed the dominance of montmorillonite in black soil clays, kaolinite in laterite soils and a mixture of kaolinite and illite in varying proportions in alluvial and red soils. There was thus a distinct association between the values of the ratio of adsorbed water to crystal-lattice water and the soil groups, so that from the value of this ratio itself, an indication of the soil group could be inferred. Expressing the data on adsorbed water and crystal-lattice water as percentages of total water led to the same conclusion, the relative proportions of these categories of water being indicative of the major soil group with which they were associated. Thus the ratio of adsorbed water to crystal-lattice water served as reliable indicator of the nature of the soil group and could be successfully used for characterization of the soil group.

Certain other interesting relationships were revealed between CEC, a parameter used as a quality index of soil clay (Table I) and certian categories of water from dehydration data. It was noticed that CEC was closely associated with adsorbed water ($r = 0.89$; Table III). This indicated that adsorbed water as such could be used as a quality index of the clay mineral, the CEC as a reliable indicator of the nature of the clay mineral having been already established. Such close relationships could be attributed to the dependence of the magnitude of adsorbed water on the kind of the clay mineral such as montmorillonite and related minerals.

CEC was also found to be related to crystal-lattice water ($r = -0.64$; Table), in this case the relationship being inverse. The numerical value of correlation coefficient and the level of significance were, however, lesser than that of adsorbed water. The usefulness of this category of water as a quality index of the clay mineral was, therefore, indicated.

The correlation between CEC and the ratio of adsorbed water to crystal-lattice water was also marked. The coefficient of correlation was still

TABLE II. Absorbed, Crystal-lattice and total water Dehydration data for clays. Moisture loss per 100 g of clay

Soil No.	Adsorbed water	Crystal lattice water	Total water	Adsorbed water Crystal lattice water	Adsorbed water in terms of % of total water	Crystal lattice water in terms of % to total
Black soil clays						
1.	15.92	6.47	22.39	2.46	71.10	28.90
2.	15.75	6.42	22.17	2.45	71.04	28.95
3.	15.33	5.64	20.97	2.72	73.10	26.90
4.	12.78	5.15	17.93	2.48	71.28	28.72
Mean	14.95	5.92	20.87	2.53	71.63	28.39
Red soil clays						
5.	5.91	10.46	16.37	0.57	36.10	62.89
6.	9.01	7.76	16.77	1.16	53.72	46.27
7.	7.16	9.26	16.42	0.77	43.60	56.39
Mean	7.36	9.16	16.52	0.83	44.47	55.18
Alluvial soil clays						
8.	9.22	8.62	17.84	1.07	51.68	48.32
9.	9.04	7.48	16.52	1.21	54.72	45.28
10.	10.66	9.25	19.91	1.15	53.54	46.46
11.	7.64	10.48	18.12	0.73	42.16	57.84
Mean	9.14	8.96	18.09	1.04	50.53	49.48
Laterite soil clays						
12.	11.99	18.51	30.50	0.65	39.31	60.69
13.	9.17	19.65	28.82	0.47	31.82	68.18
14.	3.54	12.39	15.93	0.29	22.22	77.78
15.	2.34	12.75	15.09	0.18	15.51	84.49
Mean	6.76	15.83	22.59	0.40	27.22	72.73

greater, the value being 0.94 at 0.1 per cent probability level. In the foregoing section, it was shown that the ratio of adsorbed water to crystal-lattice water by itself indicated the major soil group. Establishment of very high degree of relationships between CEC and the ratio of adsorbed water to crystal-lattice water once again proved the usefulness of the ratio as a reliable indicator of the quality aspect of the soil clays. Thus clay characterization on the basis of the ratio of adsorbed water to crystal lattice water was firmly founded.

No relationship existed between CEC and the total water loss. But it was noteworthy that the moisture loss

TABLE III. Results of statistical analysis for correlation. Fusion analysis of clay:

Independent variable X	Dependent variable Y	Correlation coefficient r	Regression equation	No. of pairs of values
Cation exchange capacity	Adsorbed water Crystal - lattice water	0.94**	Y = -0.3213+0.0321 X	15
-do-	Adsorbed water	0.89**	Y = 2.7190+0.1452 X	15
-do-	Crystall-lattice water	0.64*	Y = 15.2404−0.1036 X	15
-do-	Water loss at 100°C	0.98**	Y = 0.6981+0.1376 X	15
-do-	Total water loss	0.20 (NS)	...	

** Significant at 1% level * Significant at 5% level NS—Not significant

at 100°c was observed to be in close range to the adsorbed water. On working out correlation coefficient, it was observed that the r value between CEC and moisture loss was still greater with a figure of 0.98 significant at 0.1 per cent probability level (Table III). Even the far easily determined value of moisture loss at 100°C was highly correlated with CEC.

Selvaseelan (1970) working on a single group, namely the red soils of Tamil Nadu, observed similar relationships between CEC and some categories of water from the dehydration data, mentioned above. The present study revealed that even when all the soil groups were considered together, a fairly well established pattern of relationships between CEC and certain categories of water as also with the ratio of adsorbed water to crystal–lattice water would be possible. This finding would greatly simplify the procedures, supplying highly reliable indicators of the pattern of clay mineral distribution in soils. The usefulness of such parameters as CEC of clays, adsorbed water, crystal-lattice water, ratio of adsorbed water to crystal-lattice water and even the ordinary moisture loss at 100°C was therefore evident in matter of characterization of soil clays.

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