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Characterisation of Clays from South Indian Soils I. Chemical Methods*

by

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Synopsis: Eight soil samples representing the four major soil types of South India were studied for their chemical composition and base-exchange capacity and from the available data it could be concluded that black and laterite soils contain montmorillonite and kaolinite as dominant clay minerals, respectively, and the alluvial soils, a mixture of clay minerals.

Introduction: The clays, products of weathering processes, form the most active and dynamic constituents of the soil body and control all the physical, chemical and morphological properties of the soil. A thorough knowledge of the clays is indispensable for gaining a deep insight into the various intricate phenomena of the soil body. The properties of the soil as a medium for plant growth can be better understood through a better knowledge of the clays and clay minerals.

In view of the great importance of clays, many methods, techniques and tools have been evolved for characterising and identifying the clays and clay minerals. But usually no one method is found to be suitable for the complete and correct characterisation and identification of clay minerals. So, to get a fair degree of accuracy in the characterisation process, a judicious combination of all the methods is needed. The present paper discusses the use of chemical methods to characterise the clays of the typical South Indian soils employing certain of the available methods.

Review of Literature: Martin and Doyne (1927) indicated the usefulness of silica-alumina ratios for the identification of clay minerals. Marshall (1935) pointed ont the usefulness of both silica-sesquioxide and silica-alumina ratios for pure clay minerals only. Nagelschmidt *et al.* (1940), Ananthanarayanan (1940), Menon and Sankaranarayan (1957) and Parthasarathi (1959) worked out the silica-sesquioxide and silica-alumina ratios for the various soil types of India and roughly indicated the type of clay minerals.

Analysis for individual elements like non-exchangeable magnesium and potassium is found to indicate the presence of montmorillonite and illite, respectively. Menon and Sankaranarayan (1957) and Parthasarthi

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(1959) obtained a high magnesium content and reported the presence of montmorillonite in black soils. Roy and Rudra (1951) reported a high potash content indicating the presence of illite.

Total base-exchange capacity is a measure of both quality and quantity of clay minerals. Raychaudhuri *et al.* (1943) and Parthasarathi (1959) used the base-exchange data for the characterisation of clays of Indian soils. The base-exchange capacity was also determined by electrometric titrations by Roy (1951) and Das *et al.* (1952) and found to yield valuable supporting data for the characterisation of clays. Anion exchange capacity was also found to yield valuable additional informatian regarding the clay minerals present in the soils.

Materials & Methods: Two surface (0–9") soil samples each were collected to represent the four major soil types of South India in the present investigation.

Standard methods were used for the analysis of whole soils for their mechanical composition, physical constants and chemical composition (Piper 1950 and Wright 1934). The clays were separated by using 1% ammonia by weight and dried samples were used for further analysis. The clays were analysed for their chemical composition, base-exchange capacity and anion-exchange capacity by the regular procedure.

Experimental Results: The mechanical composition of the soils studied which indicated the varied nature of the soils selected.

The two black soils were found to be clayey and the red and laterite soils varied from clayey loam to loam. The alluvial soil from Cuddalore was sandy while that of Kattuputhur was clayey.

The physical constants, apparent specific gravity, true specific gravity, pore space, hygroscopic moisture, sticky point moisture, moisture equivalent, maximum water holding capacity, volume expansion and percolation rate for the different soils indicated their varied nature.

The whole soil samples were analysed for their chemical composition. The results are reported in table 1. The data indicate the varied nature of soils selected. The separated clay samples were chemically analysed and the data are presented in table 2. Clays from the black soils were found to be more siliceous than other clays. The laterite and red soil samples were found to be more ferruginous in nature than other samples. The content of non-exchangeable magnesium and potassium also revealed striking differences within the soils studied. Molar values and the ratios were calculated and are presented in table 3. The black soil clays were found to give values of more than three, the laterite samples around two and the alluvial samples between two and three. The base-exchange capacity values determined by ammonium acetate method and by titration curves are presented in table 3.

The black soil clays were found to give high base-exchange capacity, two alluvial samples and the red soil clay of Peelamedu were found to give medium values and the two laterite samples very low values.

TABLE 1

Chemical Analysis (Whole Soil)

PERCENTAGE ON MOISTURE FREE BASIS

Soil type and locality	Moisture	Loss on ignition	Acid insolubles	Alumina	Iron oxide	Lime	Magnesia	Potash	Soda	Total
Black — Coimbatore	10·37	2·54	80·92	5·08	4·47	5·20	0·99	0·41	0·20	99·81
Black — Koilpatti	10·21	14·08	60·12	11·49	9·54	3·74	0·48	0·30	0·39	100·13
Red — Peelamedu	4·29	0·79	86·13	6·36	4·81	0·22	0·79	0·73	0·07	100·51
Red — Semmanguliyur	3·93	5·44	82·71	4·76	5·99	0·31	0·31	0·23	0·11	99·86
Alluvial — Kattuputhur	9·54	3·05	63·95	14·96	14·45	1·01	1·03	1·73	0·14	100·32
Alluvial — Cuddalore	1·28	5·26	89·66	1·90	2·19	0·34	0·20	0·26	0·38	99·66
Laterite — Nanjanad	8·05	6·36	67·96	13·51	10·96	0·16	0·68	0·31	0·03	99·96
Laterite — Pattambi	3·05	7·94	69·21	9·95	11·94	0·20	0·14	0·13	0·10	99·61

TABLE 2

Chemical Analysis - Clays (Con. Hydrochloric acid digestion)

PERCENTAGE ON MOISTURE FREE BASIS

Soil type and locality	Moisture	Loss on ignition	Acid insolubles	Soluble silica	Alumina	Iron oxide	Lime	Magnesia	Potash	Soda	Total
Black—Coimbatore	9·60	8·18	59·30	43·21	13·15	10·09	4·11	2·80	1·09	0·80	99·52
Black—Koilpatti	8·77	12·97	50·87	42 28	15·17	11·43	2·69	3·56	2·18	0·93	99·80
Red—Peelamedu	7·00	7·53	55·92	33·13	18·92	13·34	1·43	0·48	2·30	0·28	100·92
Red—Semmanguliyur	2·29	8·39	50·93	35·21	18·83	16·53	1·00	1·66	1·69	0·31	99·84
Alluvial-Kattuputhur	13·40	8·20	56·91	41·01	16·00	14·32	1·61	0·39	2·10	0·47	99·53
Alluvial—Cuddalore	5·53	12·17	52 94	34·65	14·98	14·08	1·48	2·25	2·06	0·53	100·49
Laterite—Nanjanad	4·05	19·22	42·74	30·21	18·83	16·69	0·60	0·35	0·61	0·13	99·17
Laterite—Pattambi	1·56	12·19	41·91	33·05	20·75	22·21	0·49	1·42	1·09	0·12	100·18

TABLE 3

Molar Ratios and Base-exchange capacity of Clays

Soil type and Locality	Molar Ratios - Clays				Base - exchange capacity-m. e./ 100 gms. of Clay			
	Silica-Sesquioxide ratio	Silica-Alumina ratio	Silica-iron oxide ratio	Alumina-iron oxide ratio	By ammonium acetate method	From Titration curves at pH 7: Sodium hydroxide	Potassium hydroxide	Calcium hydroxide
Black — Coimbatore	3·73	5·55	11·44	2·06	67·0	50	56	82
Black — Koilpatti	3·03	4·49	9·35	2·08	69·5	64	66	76
Red — Peelamedu	2·23	3·23	7·26	2·24	27·0	22	28	23
Red — Semmanguliyur	2·06	3·14	5·94	1·88	13·0	16	18	20
Alluvial — Kattuputhur	2·82	4·41	7·80	1·77	34·0	26	24	28
Alluvial — Cuddalore	2·46	3·93	6·55	1·67	35·0	37	39	40
Laterite — Nanjanad	1·75	2·74	4·90	1·80	9·0	12	13	15
Laterite — Pattambi	1·61	2·71	3·96	1·46	10·5	14	12	17

Discussion: The mechanical composition, physical constants and chemical composition of the whole soil samples revealed striking differences. High variability with regard to moisture constants, mechanical composition and chemical appeared to indicate that the soils were formed through widely differing soil forming factors.

The clays isolated from the two black soils were found to be very siliceous and to have a high silica - sesquioxide and silica - alumina ratio, high non-exchangeable magnesium content and high base-exchange capacity. These features pointed to the presence of montmorillonite as the dominant clay mineral in them. Similar results were obtained by Menon and Sankaranarayanan (1957) and Parthasarathi (1959) for the South Indian black soils.

Parthasarathi (1959) indicated the presence of illite in the red soils of Madras State. In the present investigation, the clay sample from Peelamedu red soil was found to give a high silica - sesquioxide and silica-alumina ratio, high non - exchangeable potassium content and fairly high base-exchange capacity and to indicate the presence of illite as a major mineral. It was found that the data obtained were higher than those which could have been brought about by kaolinite alone. So it may be concluded that the particular soil contains a mixture of kaolinite and illite, the latter probably being the dominant one.

The red soil clay from Semmanguliyur and the two laterite samples were found to be less siliceous. They did not have appreciable amounts of non-exchangeable magnesium or potassium. The silica-sesquioxide ratios were found to be less than two and the base-exchange capacity was observed to be low. These observations indicate the presence of kaolinite as the dominant clay mineral in these soil and corroborate the findings of Raychaudhuri *et al.* (1943) and Sen *et al.* (1941).

Both the alluvial clay samples were found to give intermediate molar values and ratios between kaolinite and montmorillonite. The same feature was observed with regard to base-exchange capacity also. These features can be attributed to the presence of a mixture of minerals like montmorillonite, kaolinite and illite. Since the soils are of alluvial origin, there is every possibility of mixing up of various soil types, resulting in a mixture of clay minerals in the soil.

Summary and Conclusions: Eight soil samples representing the four major soil types of South India were taken for the study. The clay samples were analysed chemically for their composition and their base-exchange capacity. From the available data it can be concluded that black soil clays contain montmorillonite, red soil clay of Peelamedu a mixture of illite and kaolinite, alluvial soil clays a mixture of kaolinite, montmorillonite and illite and the red soil clay of Semmangaliyur and the laterite samples, kaolinite as the dominant clay minerals.

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