https://doi.org/10.29321/MAJ.10.A03624

Study of East Coast Laterite Soils of Tamil Nadu
II. Physical Properties (Profile Soil Samples)*

by
P. PILLAIYAR[1] and D. DURAIRAJ[2]

Introduction: The productive capacity of any soil is directly related to its physical properties. The profile development, degree of erosion, eluviation, illuviation, pan formation, moisture retentivity and aeration can be examined from the point of view of crop growth by studying the physical characteristics of the profile. The laterite soil has advanced to a stage of weathering where the finer particles are reconstituted, with the formation of concretions and gravels rich in sesquioxides, which considerably alter the physical conditions governing water movement. In the present paper an attempt has been made to study in detail, the physical properties of East Coast laterite profile samples.

Materials and Methods: Six representative profiles were selected for morphological description and laboratory analysis. The details of places wherefrom the samples have been collected and the morphological description have been given in a previous paper (Pillaiyar and Durairaj, 1964). The air dry samples were gently powdered with a wooden mallet and sieved through 2 mm sieve. The material passing through the sieve was taken up for analysis and the material remaining in the sieve, consisting mostly of ferruginous gravel and concretions was weighed, but not taken up for analysis. The samples were examined for moisture content, mechanical fraction, apparent density, absolute specific gravity, pore space, volume expansion on wetting and water holding capacity.

Moisture was determined by desiccation of soil at 105°C. Mechanical analysis was performed by International pepette method (A.O.A.C., 1955). The apparent density, absolute specific gravity, pore space, volume expansion on wetting and water holding capacity were determined by Keen-Raczkowski method using brass cups (Piper, 1950).

Simple correlation was worked out among the physical properties of the horizons of all the profiles put together.

Results: *Gravel and Mechanical Analysis:* The results of the gravel determination and the mechanical analysis expressed on oven dry basis are given in Table 1. There is no characteristic pattern of distribution of properties down the profile. In three profiles (P_I, P_{II} and P_{III}), the gravel content

* Formed part of the M.Sc. (Ag) dissertation submitted to the University of Madras by the senior author.

1. Asst. Manager, Food Corporation of India, Thanjavur and 2. Professor of Soil Science, Agricultural College and Research Institute, Coimbatore-3.

decreased with the depth and in the other three cases, it increased uniformly with the depth. The gravel content in the first two horizons of the Sivagangai profile (P_I) was found to be more than 70 %. The gravel was found to be smooth, with considerable size variation.

TABLE 1. *Gravel and mechanical fractions* (Percentages on moisture free basis)*

Location	Depth in inches	Gravel	Clay	Silt	Coarse sand	Fine sand	Loss on solution	Total
Profile I	0-28	76.9	66.1	2.1	23.0	8.0	0.8	100.0
Sivagangai	28-51	73.1	61.7	2.4	25.6	9.9	0.4	100.0
	51-55	36.8	27.5	1.4	57.4	13.0	0.7	100.0
	55-58	28.9	21.4	11.0	46.0	21.1	0.5	100.0
Profile II	0-36	59.7	28.6	9.4	51.6	10.2	0.2	100.0
Tiruppattur	36-44	67.9	29.0	7.6	47.6	14.9	0.9	100.0
	44-60	67.2	13.0	4.6	61.4	19.4	1.6	100.0
Profile III	0-25	65.4	42.6	9.5	30.7	17.2	—	100.0
Pallatoor	25-38	87.1	50 7	4.5	24.6	19.1	1.1	100.0
Profile IV	0-18	54.0	59.9	3.6	21.8	13.2	1.5	100.0
Vallam	18-36	68.9	36.6	3.0	35.7	23.6	1.1	100.0
Profile V	0-18	62.0	37.2	14.0	35.5	12.9	0.4	100.0
Capper Quarry	18-84	35.0	41.1	5.9	46.4	6.3	0.3	100.0
Profile VI	0-24	69.0	31.1	6.2	35.0	27.6	0.1	100.0
Puzhal	24-48	62.9	19.8	2.9	46.3	29.3	1.7	100.0

* Gravel is on whole soil basis. Mechanical analysis is on 2 mm soil basis

In most of the profiles there was a gradual decrease of clay content with depth. The profiles at Pallatoor (P_{III}) and Capper Quarry (P_V) recorded a definite increase of clay with depth. The surface horizons of the profiles were found to be clayey in texture. Depth function curve for clay is given in the Figure. Except in Sivagangai profile (P_I), the silt fraction decreased uniformly with depth. The silt content in most of the cases was found to be less than 10 %. The scond horizon of the Vallam profile (P_{IV}) recorded the least amount of silt (3.0 %). The coarse and fine sand fractions increased in appreciable proportion with depth. The third horizon of the Tiruppattur profile (P_{II}) recorded 1.6 % of loss on solution, the highest amount in all the profiles studied, while there was no loss on solution in the case of the surface horizon of Pallatoor profile (P_{III}). The percentage loss on solution in different horizons was more or less uniform. A significant positive correlation between clay (expressed on 2 mm soil basis) and gravel (expressed on whole soil basis) ($r=0.573$) and significant negative correlation between clay and coarse sand ($r=-0.764$) were obtained (Table 3).

The data regarding the moisture content, apparent density, absolute specific gravity, water holding capacity, pore space and volume expansion on wetting are furnished in Table 2.

TABLE 2. *Moisture content and physical constants*

Location	Depth in inches	Moisture %	Apparent Specific gravity	Absolute Specific gravity	Water holding capacity %	Pore space %	Volume Expansion on wetting %
Profile I	0–28	2.70	1.00	2.15	45.8	59	9.8
Sivagangai	28–51	3.75	1.21	2.72	42.9	63	4.7
	51–55	3.76	1.06	1.98	39.2	50	3.9
	55–58	3.03	1.26	2.57	45.9	53	15.9
Profile II	0–36	2.24	1.14	2.24	32.9	36	13.5
Tirupattur	36–44	1.85	1.15	2.04	37.6	37	13.2
	44–60	0.89	1.31	2.42	21.9	30	12.5
Profile III	0–25	1.60	1.44	2.47	36.6	46	12.9
Pallatoor	25–38	1.68	1.25	2.27	46.7	51	17.5
Profile IV	0–18	1.95	1.30	2.32	35.0	54	8.5
Vallam	18–36	1.21	1.12	2.11	44.5	47	6.7
Profile V	0–18	0.78	1.28	2.33	36.7	47	6.2
Capper Quarry	18–84	1.34	1.32	2.37	35.6	46	4.1
Profile VI	0–24	1.77	1.42	2.47	29.5	50	4.9
Puzhal	24–48	1.18	1.57	2.50	33.5	44	10.1

Air-dry moisture: In most cases the air-dry moisture content increased with depth. The second and third horizons of the Sivagangai profile recorded 3.75 and 3.76 % which were the highest, while the least was recorded by the first horizon of the Capper Quarry profile (0.78 %).

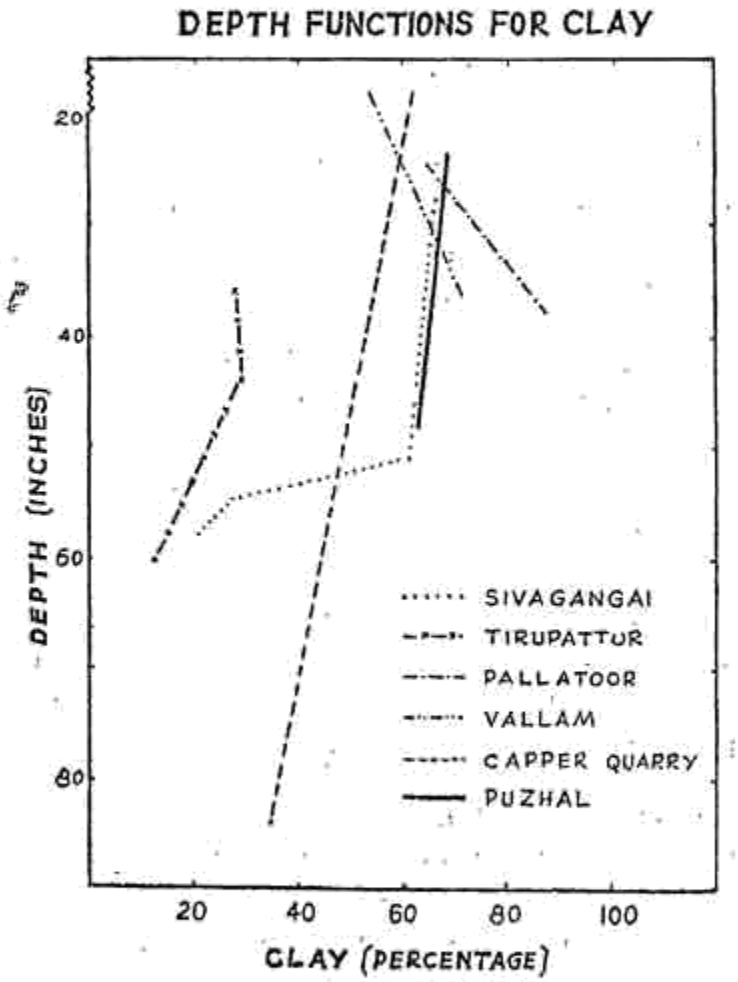
Apparent and real specific gravity: In the case of Pallatoor (P_{III}) and Vallam (P_{IV}) profiles, the density figures (apparent and real) were found to decrease with depth, while in other profiles the lower horizons were high in apparent and real specific gravity. The apparent density varied from 1.00 to 1.57 and the real specific gravity from 1.98 to 2.72.

Water holding capacity: In the Capper Quarry profile (P_V) water holding capacity was found to be more or less uniform throughout the profile. It increased with depth in Pallatoor (P_{III}), Vallam (P_{IV}) and Puzhal (P_{VI}) profiles. In the first and fourth horizons of the Sivagangai profile (P_I) it was found to be more or less uniform. The maximum value (46.7%) was recorded by the second horizon of Pallattoor profile (P_{III}). Significant positive correlation was observed between clay and water holding capacity ($r = 0.746$))Table 3).

TABLE 3. *Results of statistical analysis*

Independent variable X	Dependent variable Y	Correlation coefficient	Regression equation	No. of pairs of values
Clay	Gravel	+0.573*	Y=38.61+0.565X	14
Clay	Coarse sand	−0.764***	Y=60.42−0.529X	13
Clay	Fine sand	−0.38	—	15
Clay	Water holding capacity	+0.746**	Y=22.73+0.395X	13
Clay	Pore space	+0.343	—	15

Significance : *: 0.05 **: 0-01 ***: 0.001 levels



Pore space: The percentage of pore space was found to decrease with the depth in Vallam (P_{IV}), Capper Quarry (P_V) and Puzhal (P_{VI}) profiles. In the case of Pallatoor profile (P_{III}), there was an increase of pore space with depth, while an increase was observed in the middle horizone of the Sivagangai (P_I) and Tiruppattur (P_{II}) profiles.

Volume expansion on wetting: A decrease of volume expansion with depth was observed in Tirupattur (P_{II}), Vallam (P_{IV}) and Capper Quarry (P_V)

profiles, with an increase in Pallatoor profile (P_{III}). The third horizon of the Sivagangai profile (P_I) recorded the least volume expansion (3.9%), while the second horizon of the Pallatoor profile (P_{III}) recorded 17.5%, the highest for all the horizons studied.

Discussion: The high content of ferruginous gravel and concretions suggests that the profiles in this study have reached an advanced stage of laterisation. Only after maturation the gravel would have been formed. As constrasted to the observations made by Drosdoff and Nikiforoff (1940) in Dayton soils, the larger gravel were not irregular but nearly spherical. The surface of the gravel was found to be smooth. The above workers observed the zone of accumulation of concretions to be usually just above the surface of the B horizon. In East Central Java, Dames (1955) observed the concretions to accumulate in a distinct horizon at a depth of about 1.5 to 2 metres, forming beds of pellets usually 20–80 cm thick. Durairaj (1964) has also reported the occurrence of distinct quartz layer in a particular zone in Nilgiri profiles. But such an accumulation of gravel confined to a specific horizon was not traceable in the East Coast laterite tract.

Martin and Doyne (Anon, 1932) observed in many profiles an increase of clay with depth. Such an increase of clay content was observed in this study in a few cases only. It was not possible to point out clearly the zones of eluviation and illuviation. Prismatic structure was not observed in any case in the present study. The profile maturation might have taken place by eluviation and illuviation processes. But due to the sloping nature of the land, torrential rain and poor vegetative cover, severe erosion appears to have taken place. The varying nature of the clay content can be ascribed to such erosion and further deposition in other places. In most of the cases the lower horizons were found to be comparatively low in clay content. This is presumably due to progressively increasing weathering, while proceeding from the lower to upper horizons. The apparent increase of clay in some of the lower horizons is not due to illuviation but is illusory in that the clay content of the superficial horizon is being eroded away.

Manickam (1964) has observed low bulk density, high water holding capacity and pore space of the superficial horizons in most of the profiles of the Nilgiris. Since the superficial horizons were not found to be rich in organic matter, the phenomena observed by Manickam (1964) was not present in East Coast laterite soils. There was no distinct decrease or increase of volume expansion with depth in East Coast laterite soil profiles as was observed by Manickam (1964) in Nilgiri soil profiles. The varied nature of the profiles studied indicated that the profile characteristics were determined by the erosion but not by rainfall or elevation.

It is found that there is a fair degree of homogeneity within profile samples as inferred from the high correlation obtained between physical properties, in spite of including lower depth materials also in correlation studies. This shows that there is considerable similarity of behaviour of the soil from all the horizons. Such correlation between clay and coarse sand and water holding capacity were observed for the surface samples of other laterite soils and Nilgiri soils by Durairaj (1961) and Mahalingam (1962) respectively.

Summary and Conclusions: Soil samples from six representative profiles of the East Coast laterite tract of Tamil Nadu were examined for mechanical composition, moisture content and physical constants. The observations made during the study have been presented and discussed. No two profiles examined in the present study were similar in all characteristics. In three profiles, the gravel and clay contents decreased consistently with depth. The varying nature of the prime particles and the physical properties may be due to the differences in the intensity of erosion and subsequent deposition. It was further found that there was a fair degree of homogeneity of soil material from all horizons in a profile as inferred from the high correlations between certain components even though the lower depth materials were included in correlation studies.

Acknowledgement: The first author wishes to express his deep sense of gratitude to the financial help rendered by the Indian Council of Agricultural Research during the tenure of his study. The permission accorded by the University of Madras for publishing this part of the M. Sc. (Ag.) dissertation is gratefully acknowledged.

REFERENCES

Anon. 1932. *Laterite and Laterite soils.* Imperial Bureau of Soil Science. Tech. Commn. No. 24, London.

Anon. 1955. *Methods of Analysis* (U.S.A.) Association of Agricultural Chemists.

Dames, T. W. G. 1955. *The Soils of East Central Java.* Contribution of the General Agricultural Research Station, Bogor.

Drosdoff, M. and C. C. Nikoforoff. 1940. Iron-Manganese concretions in Dayton soils. *Soil Sci.*, 49 : 333–45.

Durairaj, D. J. 1961. Study of relationship between mechanical components of South Indian Soils. *J. Indian Soc. Soil Sci.*, 9 : 14–28.

———. 1964. Profile characteristics of certain Nilgiri soils. *Madras agric. J.*, 51 : 145–55.

Mahalingam, P. K. 1962. A study of physical and chemical properties of the High Level Nilgiri soils. Diss. M. Sc. (Ag.) Univ. Madras.

Manickam, T. S. 1965. Study of the profile morphology and physico-chemical properties of Nilgiri soils. *Madras agric. J.*, 52 : 297–310.

Pillaiyar, P. and D. J. Durairaj. 1968. Study of East Coast Laterite soils of Madras State. I. Profile Characteristics. *Madras agric. J.*, 56 : 20–7.