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# STRUCTURAL STATUS IN RELATION TO PHYSICO-CHEMICAL CHARACTERISTICS OF SOIL

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Soil structure is defined as mutual arrangement, orientation and organisation of particles in the soil (Daniel, 1971). It can be of decisive importance in influencing soil productivity as it greatly affects the water, air and thermal regimes in the field. In turn, it itself is known to be influenced by such factors as silt and clay content. nature and quantity of organic matter, sesquioxides etc, in soils (Yadav and Banerjee, 1968; Chakrabarti, 1971; Yadav and Singh, 1976; Tisdall *et al.*, 1978; Soong, 1980 and Patino *et al.*, 1981). In the present report an attempt has been made to study the influence of physico-chemical characteristics on the structural status of five major soil groups of Kerala namely, laterite, black, red loam,

## Materials and Methods

Five important soil groups cf Kerala viz., laterite, red loam, black, coastal alluvium and reverine alluvium were selected for the study. Three profile from each of the aforesaid group, belonging to the same series as established by the Soil Survey Unit of Department of Agriculture, Kerala, were examined for the collection of soil samples. From each profile, samples were collected at four different depths viz., 0–15, 15-30, 30-45 and 45-60 cm. A part of each soil sample was kept apart in its natural undisturbed condition for structural analysis The rest of soil sample was air-dried, powdered gently and passed through a 2 mm sieve. The samples so prepared were kept in labelled plastic containers. Particle size analysis was carried out by the international pipette method (Piper, 1942). Organic matter content and cation exchange capacity (CEC) were determined by Walkey Black and ammonium acetate methods, respectively (Jackson, 1958). The sesquioxide content was determined by digesting each soil sample with nitric acid and perchloric acid (Hesse, 1971).

The aggregate analysis was based on the technique developed by Tiulin (1928) and Yoder (1936) with modifications suggested by Dakshinamurti and Gupta (1968). Percentage of aggregates greater than 0 25 mm, mean weight diameter (MWD) and structural coefficient (SC) were evaluated as the indices of soil aggregation.

## Results and Discussion

The data on physico-chemical properties and soil structural indices are presented in Tables 1 and 2. Most of the earlier workers have used the percentage of aggregates larger than 0.25 mm as the structural index for the sake of comparison. This method suffers from the limitation that it does not utilize the entire range of

Table 1
Properties of profile soil samples

| Soil group (series) | Profile No. | Depth (cm) | Clay (%) | Organic matter (%) | CEC me/100 g of soil | Sesqui-oxide (%) |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *Laterite* (Velappaya) | I | 0—15 | 29.0 | 0.54 | 4.32 | 23.5 |
| | | 15—30 | 35.8 | 0.49 | 7.72 | 22.5 |
| | | 30—45 | 46.5 | 0.27 | 4.68 | 23.7 |
| | | 45—60 | 40.9 | 0.49 | 5.15 | 27.0 |
| | II | 0—15 | 48.3 | 1.20 | 9.33 | 24 0 |
| | | 15-30 | 50.5 | 1.99 | 9.96 | 30.1 |
| | | 30-45 | 47.6 | 1.06 | 9.25 | 29.7 |
| | | 45—60 | 38.7 | 1.03 | 8.10 | 32.9 |
| | III | 0—15 | 29.5 | 0.59 | 8.76 | 26.9 |
| | | 15—30 | 336 | 0.66 | 8.23 | 27.5 |
| | | 30-45 | 44.7 | 0.66 | 6.87 | 27.8 |
| | | 45-60 | 50.4 | 0.57 | 9.51 | 29.0 |
| *Black soil* (Valiavallampathy) | IV | 0-15 | 52.8 | 1.90 | 45.06 | 14,8 |
| | | 15—30 | 56 3 | 0.90 | 46.88 | 14.7 |
| | | 30—45 | 60.3 | 1.18 | 52.28 | 14.9 |
| | | 45—60 | 66.6 | 1.03 | 54.22 | 15.7 |
| | V | 0—15 | 49.0 | 1.63 | 45.99 | 14.0 |
| | | 15—30 | 60.3 | 0 89 | 46 66 | 17.8 |
| | | 30—45 | 69.3 | 0.99 | 51.37 | 148 |
| | | 45—60 | 74.3 | 0.95 | 51.78 | 14.2 |
| | VI | 0—15 | 62.7 | 1.37 | 52.87 | 15.6 |
| | | 15-30 | 64.5 | 0.97 | 52.87 | 17.2 |
| | | 30-45 | 65.9 | 0.90 | 52.96 | 19.3 |
| | | 45—60 | 66.1 | 0.89 | 53.09 | 17.0 |
| *Red loam* (Vellayani) | VII | 0-15 | 34.0 | 0.61 | 3.52 | 22.6 |
| | | 15-30 | 33.5 | 0.63 | 3.89 | 22.6 |
| | | 30-45 | 46.0 | 0.59 | 4.15 | 24.1 |
| | | 45—60 | 48.3 | 0.49 | 4.46 | 26.9 |
| | VIII | 0—15 | 36.9 | 0.79 | 3.85 | 22.00 |
| | | 15 - 30 | 42.0 | 0.69 | 4.02 | 28.10 |
| | | 30—45 | 456 | 0.50 | 3.22 | 27.20 |
| | | 45—60 | 47.3 | 0.46 | 4.04 | 31.70 |
| | IX | 0-15 | 30.3 | 0.84 | 3.36 | 21.30 |
| | | 15—30 | 48.5 | 0.59 | 4.27 | 29.40 |
| | | 30—45 | 42.3 | 0.60 | 3.95 | 28.20 |
| | | 45-60 | 51.1 | 0.63 | 4.27 | 30.20 |

Table 1 continued

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| *Riverine alluvium* (Ponnamattom) | X | 0—15 | 27.5 | 2.60 | 13.28 | 17.60 |
| | | 15—30 | 28.2 | 2.34 | 12.27 | 18.80 |
| | | 30—45 | 33.7 | 1.78 | 19.46 | 20.90 |
| | | 45—60 | 34.9 | 1.12 | 14.00 | 26.60 |
| | XI | 0—15 | 27.1 | 1.66 | 12.61 | 17.70 |
| | | 15—30 | 27.8 | 1.70 | 14.80 | 15.20 |
| | | 30—45 | 28.5 | 1.01 | 8.49 | 15.70 |
| | | 45—60 | 34.1 | 1.50 | 12.79 | 19.90 |
| | XII | 0—15 | 14.8 | 1.35 | 5.74 | 18.76 |
| | | 15-30 | 24.3 | 1.22 | 6.73 | 15.50 |
| | | 30—45 | 24.5 | 1.03 | 15.01 | 23.90 |
| | | 45-60 | 13.1 | 0.83 | 6.75 | 20.00 |
| *Coastal alluvium* (Beypore) | XIII | 0—15 | 16.5 | 1.39 | 4.75 | 17.60 |
| | | 15-30 | 30.1 | 0.81 | 8.46 | 15.20 |
| | | 30—45 | 28.7 | 0.47 | 8.31 | 16.70 |
| | | 45—60 | 28.8 | 0.42 | 8.21 | 16.77 |
| | XIV | 0-15 | 19.6 | 0.61 | 585 | 20.30 |
| | | 15—30 | 22.5 | 0.44 | 5.86 | 15.90 |
| | | 30—45 | 27.4 | 1.00 | 8.75 | 15.70 |
| | | 45-60 | 28.3 | 0.55 | 6.10 | 15.50 |
| | XV | 0-15 | 15.0 | 0.65 | 5.15 | 17.60 |
| | | 15—30 | 20.7 | 0.41 | 5.84 | 15.60 |
| | | 30—45 | 20.1 | 0.62 | 7.26 | 24.40 |
| | | 45-60 | 22.1 | 0.34 | 6.44 | 15.50 |

aggregates. Nevertheless, in the present study this index has been observed to give a fairly reliable index of structure of soils (Table 2). Black soils were found to be superior in respect of this index. Laterite soils also exhibited satisfactory values for the index. Red loam, riverine alluvium and coastal alluvium soils showed more or less similar type of trend in respect of their index. Chakraborty *et al.* (1981) expressed similar views in respect of some soils of West Bengal.

In the present study mean weight diameter and structural coefficient were preferred as the indices of soil aggregation. The mean weight diameter which is a statistical index of aggregation gives an estimate of the average size of water stable aggregates (Table 2). The maximum values for MWD was obtained in the case of black soils. A fairly high value for MWD was also exhibited by laterite soils. A wide variation was observed in riverine and coastal alluvium soils. Red loam soils had rather narrow range of variation. The relatively larger values obtained in

the case of black, laterite and to some extent in riverine alluvium soils may probably ba due **to** the presence of large quantities of such cementing agents as organic matter, sesquioxides and clay in these soils (Deshpande *et al*. 1964; Yadav and Banergee, 1968; Van Raj and Pech, 1972; Gallez *et al*., 1977 and Greenland 1979). Positive correlations were obtained between MWD and such physico-chemical characteristics as clay, organic matter, CEC and sesquioxide content in laterite and black soils (Table 3).

Table 2

Structural indices of profiie soil samples

| Soil group (series) | Profile No. | Depth (cm) | Percentage of aggregates > 0.25 mm | Mean weight diameter | Structural coefficient |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| *Laterite* | I | 0—15 | 60.99 | 1.13 | 0.31 |
| (Velappaya) | | 15-30 | 97.20 | 2.21 | 0.87 |
| | | 30—45 | 56.60 | 1.29 | 0.28 |
| | | 45—60 | 70.60 | 1.90 | 0.26 |
| | II | 0—15 | 67.70 | 1.16 | 0.44 |
| | | 15-30 | 65.35 | 1.81 | 0.48 |
| | | 30-45 | 79.42 | 1.84 | 0.61 |
| | | 45-60 | 72.80 | 1.36 | 0.52 |
| | III | 0—15 | 71.91 | 1.36 | 0 41 |
| | | 15—30 | 65.52 | 1.52 | 0.30 |
| | | 30-45 | 79.24 | 1.94 | 0.57 |
| | | 45-60 | 78.09 | 1.91 | 0.50 |
| *Black soil* | IV | 0—15 | 62.43 | 0.94 | 0.53 |
| (Valiavallampathy) | | 15—30 | 55.34 | 0.61 | 0.47 |
| | | 30—45 | 68.70 | 0.81 | 0.60 |
| | | 45—60 | 71.00 | 0.80 | 0.62 |
| | V | 0—15 | 69.39 | 1.43 | 0.60 |
| | | 15—30 | 59.83 | 0.64 | 0.50 |
| | | 30-45 | 64.92 | 0.50 | 0.54 |
| | | 45—60 | 81.38 | 1.12 | 0.68 |
| | VI | 0—15 | 86.57 | 2.20 | 0.76 |
| | | 15-30 | 80.41 | 1.35 | 0.70 |
| | | 30—45 | 76.60 | 1.66 | 0.62 |
| | | 45—60 | 91.41 | 1.33 | 0.81 |

Table 2 continued

| 1 | 2 | 3 | 4 | b | 6 |
|---|---|---|---|---|---|
| *Red loam* (Vellayani) | VII | 0-15 | 50.12 | 0.52 | 0.26 |
| | | 15—30 | 53.10 | 0.44 | 0.26 |
| | | 30-45 | 55.64 | 0.43 | 0.41 |
| | | 45-60 | 56.74 | 0.54 | 0.44 |
| | VIII | 0-15 | 60.62 | 0.66 | 0.46 |
| | | 15-30 | 59.13 | 0.50 | 0.47 |
| | | 30 – 45 | 63.65 | 0.61 | 0.53 |
| | | 45—60 | 55.20 | 0.42 | 0.44 |
| | IX | 0-15 | 62.48 | 0.82 | 0.47 |
| | | 15—30 | 55.50 | 0.56 | 0 38 |
| | | 30 – 45 | 63.50 | 0.55 | 0.48 |
| | | 45-60 | 60.97 | 0.66 | 0.49 |
| *Riverine alluvium* (Ponnamattom) | X | 0—15 | 37.36 | 0.32 | 0.33 |
| | | 15—30 | 49.55 | 046 | 0.46 |
| | | 30-45 | 29.99 | 0.26 | 0.27 |
| | | 45—60 | 41.43 | 0.36 | 0.38 |
| | XI | 0—15 | 47.83 | 0.68 | 0.44 |
| | | 15-30 | 56.23 | 0.55 | 0.52 |
| | | 30-45 | 45.94 | 0.52 | 0.42 |
| | | 45-60 | 52.50 | 0.54 | 0.48 |
| | XII | 0-15 | 52.44 | 0.79 | 0.34 |
| | | 15-30 | 67.78 | 1.04 | 0.52 |
| | | 30-45 | 77.61 | 1.87 | 0.60 |
| | | 45-60 | 80.97 | 1.95 | 062 |
| *Coastal alluvium* (Beypore) | XIII | 0—15 | 62.33 | 0.73 | 0.47 |
| | | 15—30 | 72.64 | 1.12 | 9.63 |
| | | 30-45 | 59.40 | 0.61 | 0.57 |
| | | 45-60 | 56.33 | 0.36 | 0.41 |
| | XIV | 0-15 | 54.26 | 0.49 | 0.40 |
| | | 15—30 | 53.82 | 0.53 | 0.38 |
| | | 30-45 | 38.10 | 0.39 | 0.26 |
| | | 45—60 | 69.60 | 0.53 | 0.53 |
| | XV | 0-15 | 61.80 | 0.47 | 0.40 |
| | | 15—30 | 60.71 | 0.47 | 0.23 |
| | | 30-45 | 62.22 | 0.46 | 0.37 |
| | | 45-60 | 56.90 | 0.38 | 0.36 |

Table 3

Coefficient of simple correlation (r) between structural indices and soil properties

| Soil group | Mean weight diameter with | | | | Structural coefficients with | | | |
|---|---|---|---|---|---|---|---|---|
| | Clay | Organic matter | CEC | Sesqui-oxides | Clay | Organic matter | CEC | Sesqui-oxides |
| Laterite (n = 12) | 0.294 | 0.016 | 0.232 | 0.094 | 0.137 | 0.165 | 0.448 | —0.063 |
| Black soil (n = 12) | 0.374 | 0.210 | 0.643* | 0.002 | 0.418 | 0.203 | 0.679* | 0.196 |
| Red loam (n = 12) | -0.290 | 0.647* | —0 408 | —0.292 | 0.433 | 0 032 | —0.029 | 0.409 |
| Riverine alluvium (n=12) | —0.688* | —0.554 | —0.386 | —0.178 | -0.293 | —0.496 | —0.330 | —0.015 |
| Coastal (n = 12) | 0.410 | 0.413 | 0.125 | -0.188 | 0.410 | 0.384 | 0.458 | 0.177 |

* Significant at 5% level

Another important structural index to assess the degree of aggregation in soil is structural coefficient which when multiplied by 100 is referred to as per cent aggregate stability. Again, black soils were found to exhibit high values for *SC,* confirming thereby a better state of aggregation in these soils. These soils were followed by laterite, riverine alluvium, coastal alluvium and red loam soils. A positive correlation existed between clay and SC in all the soil groups except riverine alluvium. A similar trend was observed in relation to the organic matter content of these soils. However, the positive correlation between CEC and SC was significant only in the case of black soils. A positive correlation between sesquioxide and SC was obtained only in black and red loam soils. These results are in conformity with the work of Ameer (1970). In riverine alluvium soils, which are comparatively of recent origin, such relationship could not be observed (Antony, 1982).

## Summary

The influence of physico-chemical properties of soils on the soil structure of five major soil groups of Kerala namely leterite, black, red loam, riverine alluvium and coastal alluvium was studied. Black soils have distinctly superior aggregation in comparison to rest of the soils under investigation. Some of the physico-chemical properties like clay, organic matter, CEC and sesquioxide play an important role in building soil structure in most of the soil groups except riverine alluvium. This is because of the comparatively recent origin of riverine alluvium soils.

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