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A Study of the Physical and Chemical Properties of High Level Soils of the Nilgiris*

by

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Introduction: Laterisation is a common soil forming process in humid tropics including India, where probably more than one fifth of the total cultivable land belongs to the laterite type. Research leading to clarification as to whether the soils of Nilgiris belong to the group laterite is necessary, as at present little is known in a systematic way regarding the chemical and physical properties of these soils. The morphology and chemistry of the soils of the Nilgiri district are not yet fully known. Earlier workers attempted sporadically to analyse the soils from this district but none of them exhaustively studied the soils present throughout the entire plateau. Hence in this piece of investigation an attempt has been made to conduct a detailed study of the soils by collecting representative samples from localities showing a wide range of elevation and rainfall. In this paper the physical and chemical properties of Nilgiris soils and the effect of rainfall and elevation on these properties are discussed and an attempt was made to classify and assign a proper class to the soils.

Experimental Details: The Nilgiris ditrict lies between 11°8′ and 11°55′ of the northern latitude and 76°13′ and 77°2′ of the eastern longitude. The district is divided into three tracts depending upon the rainfall as: 1. Pykara river tract: over 60 inches of rainfall; maximum 150″ and average 90 inches. Rains mainly during South-west monsoon; 2. Between Pykara river and West of Doddabetta hill ranges: average rainfall 60 inches. Major rains in South-west Monsoon; 3. Towards east of Doddabetta, average rainfall 50–60 inches, major rains during North-east monsoon period.

The district has a maximum temperature of 66°F and a mean annual minimum of 49°F and includes a great variation in elevation ranging from 1500 feet (Kallar) in foot hills to 8600 feet (Doddabetta peak) of the highest peak in South India.

Material and Method: Thirty eight surface (0—9″) soil samples were collected from different places representing different elevations (from 1500′ to 8600′) and different rainfall intensities (50 inches to 90 inches) on the Nilgiri region and analysed chemically for iron, aluminium, calcium, magnesium,

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total phosphorus and soluble silica and physical and moisture constants employing standard methods of analysis and Molar ratios were worked out.

Results and Discussion: From the study of the profiles, it is seen that the soils are acidic in nature, with appreciable organic matter in the surface soil and sesquioxides and kaolin in lower layers. There is a band of gravels of sesquioxide nature in most of the profiles. As the gravels are angular in shape the soils have probably been formed *in situ*. The parent rock of this region is granitic gneiss dominated by biotite.

Physical and Moisture Constants: The physical and moisture constants have been studied in detail. Among the physical constants the apparent specific gravity varied only a little from 1.00 to 1.36. The true specific gravity varied from 1.66 to 2.94. Generally the volume expansion was small and varied from 1.1 to 11.4. The pore space was markedly high and ranged from 43 to 64 per cent. The loss on ignition was comparatively high. Among the moisture constants there was a wide range of variation, the range for water holding capacity being 34.6 to 76.5, hygroscopic coefficient from 1.53 percent to 8.07 percent, moisture equivalent from 18.1 to 47.8 percent and sticky point moisture from 15.2 to 45.7 percent.

Results indicated that the porespace of soils was generally high and the soils were loose and highly permeable. This was similar to the observations of Burgess (1917) and Prescott (1931). There was a positive correlation between the loss on ignition and clay content. This relationship had also been observed by Sen and Deb (1941). There was a general tendency for the volume expansion to decrease with decreasing silica/sesquioxide ratio. The volume expansion was generally low; this was apprently due to the sesquioxidic nature of the soil as indicated also by the low cation exchange capacity. There was a tendency for the moisture absorption over 50 percent relative humidity and sticky point moisture to increase with increasing elevation but there was no relationship between the above properties and the mean annual rainfall.

Constituents: Iron and aluminium oxides were generally high among the contents of the principal constituents and were significantly correlated with elevation. Alumina was also significantly correlated with silica. Lime content was very low and ranged from 0.07 to 1.20 per cent.

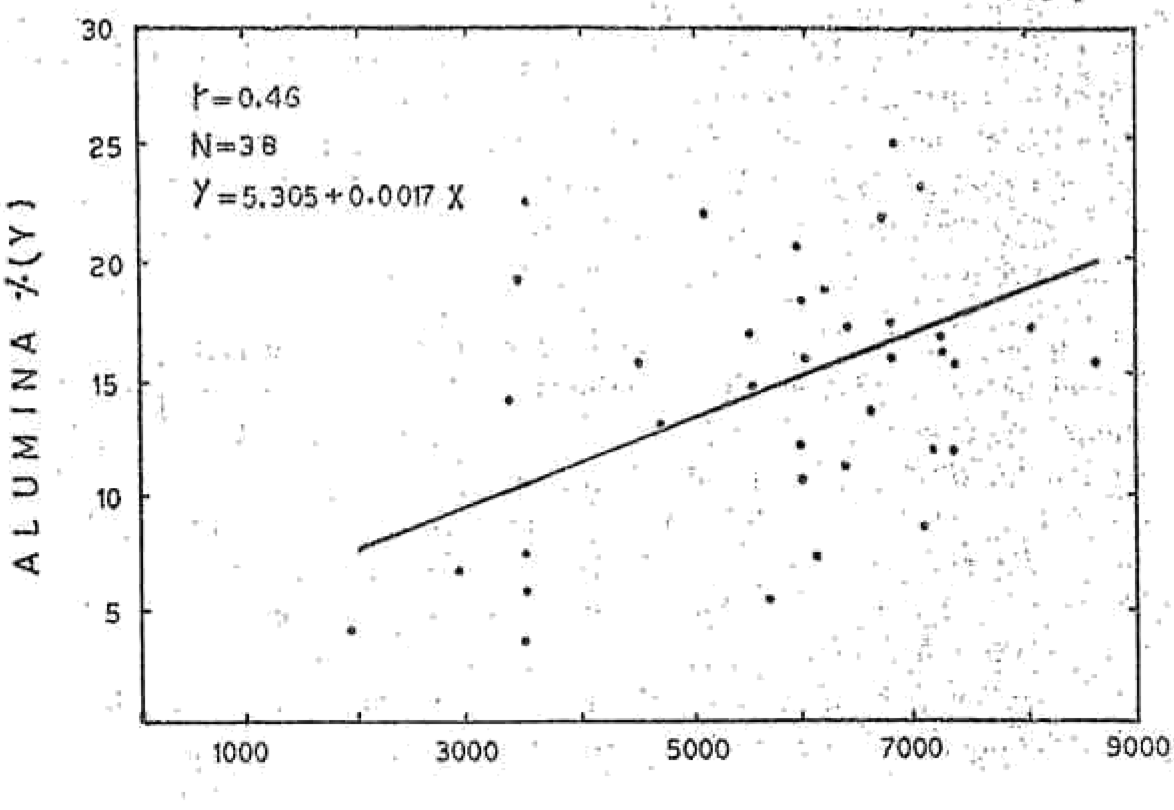
Magnesia was very low in all the samples. Generally lime and magnesia decreased with increasing rainfall and elevation. Soluble silica content was very low and ranged from 5.66 to 19 30 per cent. Positive relationship between silica and sesquioxides was obtained.

The molar ratios among the above oxides were also worked out. The silica content of the soils tended to decrease with increasing rainfall, while the sesquioxides increased slightly. There was a general tendency for the alkali and alkaline earth metals to decrease with increasing rainfall. The same conclusions were drawn by Harrassowitz (1930), Palmer (1931), Craig and Halais (1934) and Unnikrishnan (1961).

Altitude had a marked effect on the soil chemical properties. There was a significant positive correlation between elevation and alumina (r=0.46) (Fig. I) or iron oxide (r=0.59). Moreover there was a general tendency for the alkali and alkaline earth metals to decrease with increasing elevation.

REGRESSION OF ALUMINA ON ELEVATION

FIG 1



There was a general trend of decrease of silica/sesquioxide ratio and silica/alumina ratio with increasing rainfall. Martin and Doyne (1927), Crowther (1930), Brown and Byers (1935), Tanada (1951) and Unnikrishnau (1961) obtained the same results. This might be ascribed to a greater intensity of leaching of silica. Significant negative correlations were obtained between elevation and silica/alumina ratio (r= -0.52) or silica/sesquioxide ratio (r= -0.79) (Fig. II; Table 1). This was in line with the observation of Raychaudhuri and Chakraborthy (1943). There was no definite relationship between silica/ferric oxide ratio or alumina/ferric oxide ratio and mean annual rainfall or elevation.

TABLE I. *Results of Statistical Analysis for correlation.*

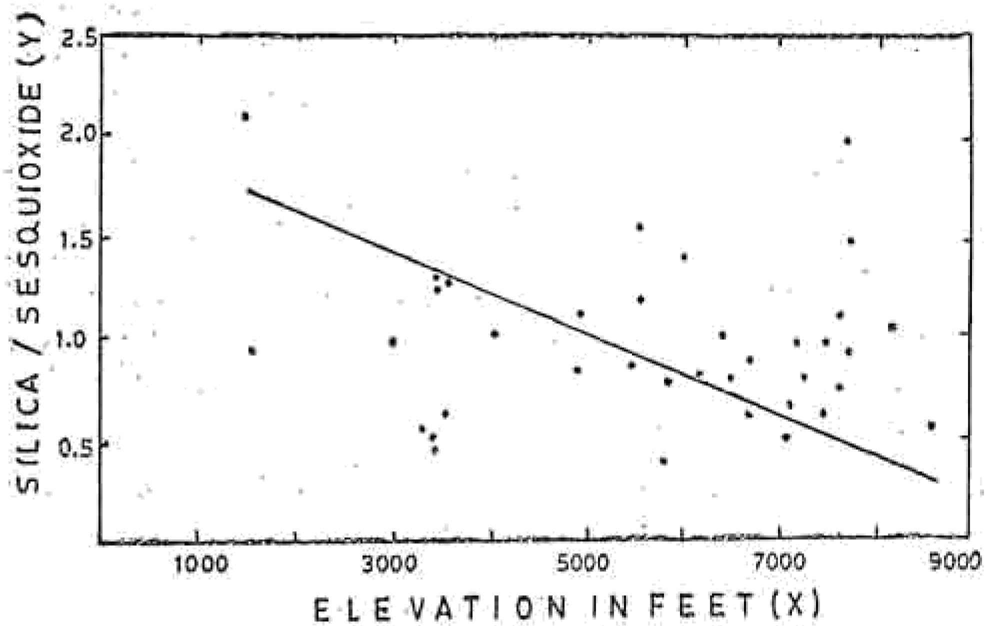
S. No.	Relationship between X	Y	Correlation co-efficient	Regression equation	No. of pairs
1.	Elevation	Silica/alumina	−0.516**	y=2.05−0.00013x	27
2.	Elevation	Silica/Sesquioxides	−0.794***	y=2.03−0 0002x	30
3.	Elevation	Alumina	+0 460**	y=5.31−0 0017x	38
4.	Elevation	Iron oxide	+0.590***	y=6 10−0.0011x	37
5.	Silica	Alumina	+0.543***	y=4.48+0.902x	38
6.	Silica	Sesquioxides	+0 783***	y=6.44+1.85x	38

Note: *** Significant at 0.1 per cent level.
** Significant at 1.0 per cent level.

REGRESSION OF SILICA/SESQUIOXIDE ON ELEVATION

FIG 2

r = −0.794
N = 30
Y = 2.026 − 0.0002 X



Position of Nilgiri soils in the laterite class: Oldham (1903) defined laterite as one having an illuvial horizon largely of iron oxides with a slag like cellular or pisolitic structure and possessing such a degree of hardness that it may be quarried out for building purposes. But in the present study no cellular structure was found but only a pisolitic one and it could not be quarried for building purposes.

Depending on the silica/alumina ratio Martin and Doyne classifiep the soils of Sierra Leone as follows:

	Silica/alumina ratic
Laterite	1.33 or less
Lateritic	1.33 — 2 0
Non-lateritic	2.00 and more

Classifying the soils of Nilgiris according to the above basis in the present study, 20 samples could be placed under laterite group, 13 under lateritic group and the remaining five under non-laterite. In this connection, it may be mentioned that Raychaudhuri and Subramaniam (1941) analysed Nilgiri soils from three different elevations, *viz.*, 3000 ft., 5000 ft. and 7000 ft., and concluded that they come under the group 'laterite.'

Pendleton and Sharasuvana (1940) distinguished two types of laterites in Siam. Vesicular and cellular and also described an incipient laterite horizon which was too soft and crumbly to be quarried. Such an immature laterite horizon had a typical variegated colouring (mottling) with red, purplish or brown iron oxide deposits. When viewed from this angle, Nilgiris soils appear to come under the category 'Pisolitic incipient lateritic with mottled horizons.'

According to the recent Seventh approximation of soil classification of U. S. D. A. (1960), Nilgiri soils may be placed under 'Oxisols', sub order 'Acrox' (with very low silica/sesquioxide ratios) and great group 'Haplocrox.'

Summary and Conclusions: Thirty eight surface soil samples were examined for their physical constants like apparent and real specific gravity, pore space and volume expansion, and moisture constants like water holding capacity, moisture equivalent, sticky point moisture and hygroscopic moisture and complete chemical composition and molar ratio worked out. The effects of elevation and rainfall on these properties are discussed. The followin conclusions were drawn.

The moisture constants tended to increase with increasing rainfall and definite sets of soil properties were associated with individual altitudes.

The contents of iron and alumina increased significantly with elevation. The molar ratio like silica/alumina and silica/sesquioxides were negatively correlated with increasing elevation. There was a general increase of iron oxide and alumina and decrease of silica/alumina and silica/sesquioxide ratios with increasing rainfall, and an inverse relationship between rainfall and silica. A general tendency for the alkali and alkaline earth metals to decrease with increasing elevation and mean annual rainfall was observed. There was an indication of higher intensity of weathering and leaching at higher altitudes.

From the available data of chemical properties and molar ratios it can be concluded that part of Nilgiri soils come under the laterite group and part under the lateritic one.

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