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The occurrence, distribution, classification and management of laterite and lateritic soils

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The term laterite was originally suggested by BUCHANAN (1807) as a name for highly ferruginous deposits first observed in Malabar in India. BUCHANAN described a material that was soft enough to be cut with a knife when *in situ* but hardened in exposure; it was being quarried to make bricks, and he derived the term from the latin *later*, a brick. STEPHEN (1961) revisited BUCHANAN's type site to find that the rock-like iron stone was being packed with pickaxes—not with knife. The property of hardening of such material on exposure to the atmosphere was for some time taken as a criterion of laterite. FERMOR (1911) suggested the use of the term only for soft material that could be cut into bricks. Great interest in the study of laterites developed because of the possible use of laterite as an ore for aluminium (HOLLAND, 1903) and in some cases, for manganese (FERMOR, 1911). WADIA (1945) classified laterite as '*High level*' and '*Low level*' laterites. High level laterites never occur on situation below 2,000 ft. (Bombay, Deccan, Nilgiri mountains). *Low level* laterites are in most cases of secondary origin and are derived from the *high level* laterites and recombined after deposition in the valleys or plains. Low level laterite is thus mainly of detrital origin.

KRISHNAN (1934) reported the formation of laterite from Khondalite, a name introduced by T. L. WALKER to designate certain crystalline schists consisting of quartz, garnet, sillimanite and graphite, which he mapped in Kalahandi State, Bihar and Orissa. FOX (1936) during his visit to Malabar reported that all the laterite occurrences seen by him in Malabar, Kanara and Shimoga were associated with granite rocks below them and could be taken as always having been formed from such acid rocks and passed down into them through a zone of Kaolinised rock. He has further reported that in the Nellore quarries laterite overlies gneissic rocks. DHARESHWAR (1942) reported that laterite in Kanara rests mainly on trap which is one of the basalts.

SATYANARAYANA and THOMAS (1961) have studied the field characteristics of laterites of Malabar and South Canara. According to them, the characteristic features of laterites are the colour, consistency, structure, form and depth of the different horizons. They found that the slaglike crumbly or honeycomb structures were confined to the surface or mature horizons, and the typical laterite quarried for building purposes had a vermicular or vescicular structure. VAIDHYANATHAN (1962) described two types of laterites in the Nellore area: (i) *in situ* laterites quarried as building stone which is porous, pitted and clay like, usually yellowish brown in colour with slight pinkish tinge, and (ii) a second type undoubtedly of recent age made up of pebble gravels, shining reddish brown in colour and occasionally mixed with small pieces of vein quartz and yellowish sand. The iron occurs mainly as goethite, haematite and amorphous ferric oxides.

Laterite is usually reddish brown (typically 5 YR 5/6), has a moderately high density 2.5-3.6; usually contains secondary aluminium; may contain quartz and kaolinite but low in other forms of

silica; exchangeable bases and humus are absent.

An iron-rich mottled clay which hardens on exposure to air, or repeated wetting and drying, is called *soft laterite*.

U.S.D.A.-7th approximation has defined a new word plinthite as a sesquioxide rich clay which either changes irreversibly to hard pans on repeated wetting and drying or is the hardened relics of the soft red mottles.

Latosol was defined by KELLOG (1949) as a term to comprehend all the zonal soils in tropical and equatorial regions having their dominant characteristics associated with low silica-sesquioxide ratios of clay fractions, low base exchange capacities, low activities of the clay, low content of most primary minerals, low content of soluble constituents, a high degree of aggregate stability and some red colour. It is a collective term for zonal soils called lateritic soils.

Within the latosols there are four major groups:

(i) Ferruginous soils,
(ii) Ferrallitic soils,
(iii) Basisols (a group of soils derived from basic rocks), and
(iv) Humic latosols.

CLASSIFICATION OF LATERITES

Anthony YOUNG (1976) has distinguished the following main types and sub-divisions of laterite:

(1) MASSIVE LATERITE: Possesses a continuous hard fabric, sub-divided into:

(a) Cellular laterite—Cavities are approximately rounded.

(b) Vesicular laterite—Cavities are predominantly tubular.

(2) NODULAR LATERITE: Consists of individual approximately rounded concretions (also called pisolithic laterite) sub-divided into:

(a) Cemented nodular laterite—Individual concretions can be seen but are strongly joined together by the same iron-stone material.

(b) Partly cemented nodular laterite.

(c) Non-cemented nodular laterite—Concretions from over 60 per cent by weight of the total soil.

(d) Iron concretions—Concretions are separated by soil—but forms less than 60 per cent by weight of the total horizon.

(3) RECEMENTED LATERITE: Contains fragments of massive laterite or ferruginized rock, broken and wholly or partly cemented.

(4) FERRUGINIZED ROCK: Rock structure is still visible, but with substantial isomorphous replacement by iron.

(5) SOFT LATERITE: Mottled iron-rich clay which hardens irreversibly on exposure to air or to repeated wetting and drying.

OCCURRENCES AND CHARACTERISTICS

Laterite and lateritic soils are formations peculiar to India and some other tropical countries with intermittently moist climate. In India they cover a total area of about 248,000 sq. kilometres. Laterites are specially well developed on the summits of hills of the Deccan, Karnataka, Kerala, Madhya Pradesh, the Eastern Ghat regions of Irissa, Maharashtra, Malabar and parts of Assam. All laterite soils are very poor in lime and magnesia and deficient in nitrogen. Occasionally the phosphate content may be high, probably present in the form of iron phosphate but potash is deficient. There is occasionally a higher content of humus.

In Tamil Nadu, there are both *high level* and *low level* laterites which are formed from a variety of rock materials. The soils are rich in plant nutrients. The higher the elevation, the more acidic the soils are. In Coorg, laterite appears sporadically almost all over the country.

In Maharashtra, laterites are found only in Ratnagiri and Kanara. The soils of Kanara are coarse, poor in lime and P_2O_5 but fairly good in organic matter and nitrogen and potash. In the soils of Ratnagiri, coarse material is found in large quantities. These are rich in plant food constituents, except lime. In Kerala, both high level and low level laterites are met with; high level laterites growing plantation crops are rich soils because of their proper management. The laterites on lower elevations have a poor nutrient status.

The soils are generally poor in plant nutrients and organic matter. The laterite soils in Karnataka occur in the western parts of the districts of Shimoga, Hassan, Kadur and Mysore. All the soils are comparable to the laterites and to similar formations found in Malabar, the Nilgiris, etc., of the Tamil Nadu State. These soils are very low in bases like lime, due to severe leaching and erosion. These also are poor in phosphate.

In West Bengal, the area between the Damodar and the Bhagirathi is interspersed with some basaltic and granitic hills with a laterite capping. The soils of the region are differentiated into two distinct groups; to the first group belong the soils of Midnapur, Bankura, Burdwan and Birbhum. Bankura district is known to be located in the lateritic soil zone. The

contents of potash, phosphorus and nitrogen are also low. In Bihar, laterite occurs principally as a cap on the higher plateaus but is also found in fair thickness in some valleys. The laterites of Orissa are found largely capping hills and plateaus occasionally in considerable thickness. Large areas in Khurda are occupied by laterites, those of Balasore are gravelly and appear to be detrital. Two types of laterites have been distinguished in Orissa: (i) the laterite murrum and (ii) the laterite rock. These types are also found to occur together.

FACTORS OF LATERITE FORMATION AND CHEMICAL AND MINERALOGICAL COMPOSITION

RAYCHAUDHURI and CHAKRAVORTY (1940) studied the influence of rainfall and altitude above sea level on the chemical composition of clay fractions of Indian red soils and lateritic soils and concluded that both annual rainfall and altitude give significant negative correlation with the SiO_2/Al_2O_3 ratios of the clay fractions of Indian lateritic soils.

RAYCHAUDHURI and MUKHERJEE (1942) studied the mineralogical composition of Indian red soils and lateritic soils and found iron oxide, zircon, tourmaline, staurolite, chlorite, hornblende, epidote, and rutile among the heavy fractions, while in the light fractions the minerals consisted of feldspars and quartz. ROY and LANDEY (1962) have found the occurrence of illitic mineral with some kaolinite and quartz in red and laterite soils of Mand watershed in Rajgarh district in Madhya Pradesh.

The leaching processes responsible for the removal of silica in the formation of lateritic soils also remove a large portion of the bases originally present in the rock and soil, thus having a residue rich in iron and aluminium and poor in potash and phosphoric acid. Alkali and alkaline earth bases do not, as a rule, exceed 1.0 per cent. As part of the phosphorus compounds in the soils are insoluble, the mobility of phosphorus is hindered and it accumulates in the surface horizon. Nitrogen deficiency is not so much as that of potash and phosphoric acid. The nitrogen content of laterites of Goa is between 0.01 and 0.1 per cent while that of Assam soils averages 0.1 per cent.

To summarise, the laterite soils are poor in available nutrients of phosphorus, potassium and calcium. The nitrogen content generally varies from 0.03 per cent to 0.06 per cent. The pH ranges from 4.8 to 5.5 and base exchange capacity is low. Consequently, they give a high response to application of lime and potash.

MANAGEMENT

Cultivators' field trials have been conducted on paddy. The response to combination of nitrogen, phosphorus and potassium was quite high in Kerala, Karnataka and Chhota Nagpur region of Bihar, Orissa and Assam. At Kharagpur, potato showed small response to nitrogen but the response was appreciable when a balanced dose of nitrogen, phosphorus and potassium was applied. Green gram and gram gave significant increased yields by application of phosphate but little response to nitrogen and potassium or their combination. Under lowland conditions, bronzing and root rot occur which can be corrected by the addition of lime, nitrogen, phosphate and potash. In lowland laterites, iron and manganese often causes toxicity, which results in bronzing and root rot due to reduction of ferric into ferrous oxide and of tetravalent manganese to the divalent form. The addition of lime corrects this condition and the uptake of nitrogen and phosphate becomes normal. The dose of lime ranges from 2470 kg/hectare to 3700 kg/hectare. In most of the laterite regions, the annual rainfall exceeds 177.8 cm and heavy erosion occurs every year.

The agricultural value of soils with laterite depends largely on the thickness of the overlying soil. With laterite at more than about 50 cm depth, soils can be moderately productive for paddy and other cereal crops and for plantation crops like rubber.

Ferruginous soils are suited to annual crops, like maize, tobacco, cotton and yams. Ferruginous soils usually give good response to fertilizers. There is a substantial erosion hazard on ferruginous soils, particularly because they often occur on slopes. Conservation works and the maintenance of a good organic matter status are necessary.

Both physically and in respect of nutrients, weathered ferrallitic soils are poor for agriculture. The compact B horizon inhibits root penetration. Moisture retention is relatively low. The organic matter content is low. Short fallowing (with a fallow: cultivation ratio of at least 1:1) is necessary, together with green manuring, a rotation that includes legumes, and application of manures or fertilizers.

Humic latosols are freely to imperfectly drained acid soils, relatively rich in organic matter, which occur at high altitudes. These occur at altitudes above 1500 m. Nitrogen levels are high, but leaching results in potash deficiency. Phosphates suffer from fixation under the strongly acid conditions. Where depth is sufficient the soils is suitable for perennials, tolerant of acidity but requiring lower temperatures and free drainage, such as tea, coffee and tung.

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