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Physico – Chemical Properties of Forest Soils in Kerala– A Review

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Abstract: *Kerala is having a rich forest cover of 29.1 % of the total land area of the state. Different forest types in the state include evergreen, moist deciduous, scrub jungle, shola and grassland systems. Studies on the nature and properties of soil of forest ecosystems are important for proper management of the environment and utilization of resources. The present study is a review which highlights the physico – chemical properties of soils in different forest types of Kerala. As part of this study the physico – chemical properties of different forest soils were collected from various published research papers. The texture of the forest soils varied from sandy to loamy. Soil reaction was found to be acidic in different forest types and ranged from 5.1 to 6.5. In general the organic carbon content of forest soils was in the high category and it varied from 1.75 to 5.7 percent. Among the primary nutrients, grassland soils were found to have relatively low nitrogen availability and high in potassium. Phosphorus content didn't differ significantly between the forest types. Scrub jungles lying in rainshadow regions of Western Ghats have very low leaching, hence were found to be rich in secondary nutrients like calcium and magnesium. XRD patterns of oriented samples of total clays showed prominent 0.7 nm peaks indicating the presence of kaolinite/halloysite in all the systems.*

Keywords: *Forests, Kerala, Physico-chemical properties, Soil*

I. Introduction

The state of Kerala is a narrow strip of land, tucked away in the southwest corner of India which lies between the high hill ranges of the Western Ghats in the east and the Arabian Sea in the west. Kerala, gifted with mountains, valleys, trees, a wide variety of plants and grasslands has a share of just 1.2% of the total area of India. This region, with a varying topography, fertile soil and an ideal climate has been an abode of man from time immemorial. Kerala state is having a rich forest cover of 11309.47 sq.km, which is 29.1% of total land area of the state. The major natural forest types of Kerala are evergreen (semi and wet), moist deciduous, scrub jungle, shola and grassland systems.

Evergreen forest receives >2000 mm annual rainfall and supports a closed canopy and thick undergrowth. Soil temperature regime is isohyperthermic and moisture regime ustic. Semi evergreen forests occur between 600 to 900 m. Wet evergreen forests are mostly confined to the windward side of the Western Ghats which extends upto1800 m AMSL. Moist deciduous forests are mixed vegetation which sheds leaves and opens canopy cover during January- April.The primary moist deciduous forest is a transition between wet evergreen and scrub jungle which generally occupy the rainfall zone of 1500 to 1800 mm. The secondary moist deciduous forests occur within the potential area of wet evergreen formations, where the rainfall is more than 2000 mm. Scrub jungle lies in the rain shadow region of the Western Ghats, which support thorny vegetation. It receives an annual rainfall of <500 mm. Thermic soil temperature with an ustic soil moisture regimes is a major feature of these systems. Shola forest is unique montane vegetation occupying temperate habitats in tropical latitudes which is generally found at elevations greater than 1500 m AMSL. It receives an annual rainfall between 2000 and 3000 mm. The area experiences a dry period for 4–5 months (December–April). Grassland receives an annual rainfall of >2000 mm and has an isohyperthermic soil temperature and ustic soil moisture regime.Soils exhibit difference in properties in relation to the vegetation changes. It has been reported that soil properties vary spatially primarily in response to rooting and litter – fall characteristics of the perennial vegetation on more or less the same soil material. Roots take up chemical constituents from a large volume of soil material and concentrate them in the biomass. Litterfall then transfers much of this biomass beneath the canopy and their decomposition releases these biophyllic chemical constituents to the soil material [Balagopalan *et.al.*, 1993]. Soils of the humid tropical region undergo intense weathering due to the prevailing conditions of high rainfall and temperature. It is well known that soil having similar parent material differ in their properties due to the difference in the vegetation component. Conversely, differences in soil properties influence both the composition of forest vegetation and the rate of tree growth. Conditions of such intense leaching provide a favourable environment for development of kaolin clays, a general group covering kaolinite, halloysite and intermediate forms along with specific minerals such as dickite and nacrite [Sandeep *et.al.*, 2014].

Studies on the nature and properties of soil of forest ecosystems are important for proper management of the environment and utilization of resources. Without adequate knowledge of the dynamic interaction

between soil, climate and forest management we cannot develop a proper soil management system. The present paper is a review which highlights the physico – chemical properties of soils in different forest types of Kerala.

II. Materials and Methods

As part of this study the physico – chemical properties of different forest soils were collected from various published research papers. The general procedures that were used in the different studies used in the present compilation are: Particle size distributions determined by Bouyoucos hydrometer method after removal of organic carbon and free iron oxides [Bouyoucos, 1962.]. pH, organic carbon, cation exchange capacity (CEC) and extractable bases determined on the total fine earth fraction (<2 mm) following standard methods (Jackson, 1958). Mineralogical analyses of the total clay (<0.002 mm) done after treatment with hydrogen peroxide and sodium citrate– bicarbonate–dithionite to remove organic matter and iron oxides respectively and subjected to X-ray diffraction (XRD) analysis using a Philips diffractometer with Ni-filtered, Cu-Kα radiation at a scanning speed of 2° 2θ/min.

III. Results and Discussion

Texture represents the proportion of sand, silt and clay in the soil. In general, the sand fractions in the forest soils varied from 78 % (moist deciduous forests) to 92 % (shola forests), silt from 4 % (shola forest) to 11 % (Evergreen forest) and clay from 4 % (shola forest) to 12 % (moist deciduous forest). The texture of the soils varied from sandy to loamy. The conversion of sand and gravel to finer silt and clay require favourable weathering conditions. Temperature and precipitation are two active soil forming factors which help weathering and soil development [Sandeep *et.al*., 2014]. Shola forests though receives a very high rainfall is limited by temperature, hence less weathering occurs. On the other hand, scrub jungles with high temperatures receives low rainfall and limits weathering and soil formation and retains much of the sand fractions intact (Table 1).

Table 1 - Soil texture of different forest types in Kerala

Forest type	**Particle size (USDA) distribution(% of <2mm)**			**Texture class**
	Sand	**Silt**	**Clay**	
Shola	92	4	4	Sandy
Evergreen	81	11	8	Loamy
Moist deciduous	78	10	12	Loamy sand
Scrub jungle	90	5	5	Sandy
Grasslands	86	9	5	Sandy

pH was found to be acidic in different forest types and ranged from 5.1 (evergreen forest) to 6.5 (scrub jungle). High rainfall in the humid tropical areas causes leaching of base ions from the soils. Soil reaction was found to be near neutral in scrub jungle due to the relatively lesser rainfall. Organic carbon percent ranged from 1.75 (evergreen and moist deciduous forests) to 5.7 (shola forests and grasslands). The combined effect of low temperature and high rainfall in shola forests and grasslands restricts biochemical decomposition of organic residues in these soils and thus help maintain high organic carbon percentage, which inturn becomes responsible for the high cation exchange capacity and base saturation of these soils [Balagopalan *et.al.,* 1993] (Table 2)

Table 2 - Selected soil chemical characters of different forest types in Kerala

Forest type	**pH**	**OC (%)**	**CEC NH4OAc (cmol (p+) kg–1)**	**Base saturation (NH4OAc) (%)**
Shola	5.2	5.7	21.7	52.7
Evergreen	5.1	1.75	13.1	32.4
Moist deciduous	5.6	1.75	17.5	49.9
Scrub jungle	6.5	1.91	20.1	40.9
Grasslands	5.4	5.7	24.8	50.2

Among the primary nutrients, nitrogen availability was found more in shola forests (307 kg/ha) and less in grassland (132kg/ha). Organic matter acts as the primary source of nitrogen in forest soils. Restricted decomposition of organic matter impairs the available nitrogen content of these soils [Balagopalan, 1995]. Potassium was found to be high in grasslands (465kg/ha) and evergreen forests (415kg/ha). Phosphorus content didn't differ significantly between the forest types. Among the secondary nutrients calcium and magnesium was found more in scrub jungle (Figures 1a and b).

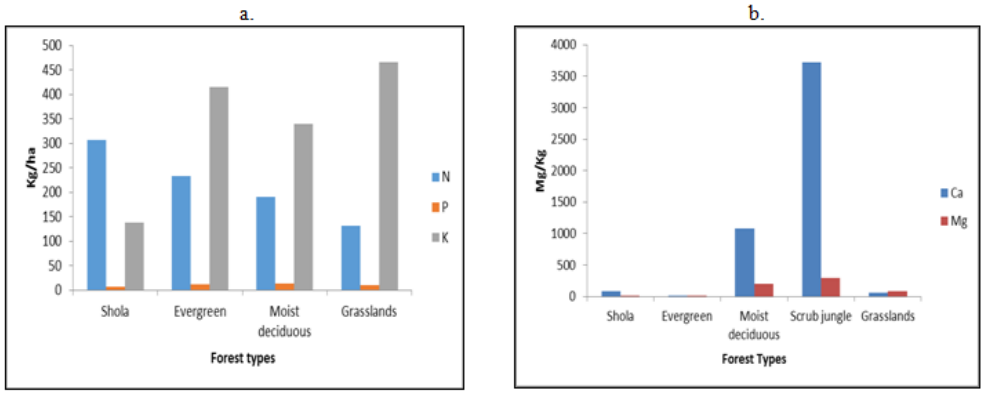

Figure 1 a and b. Primary and secondary soil nutrient status of different forest types in Kerala (a) primary nutrient contents (N,P and K) and (b) Secondary nutrient contents (Ca and Mg)

XRD patterns of oriented samples of total clays showed prominent 0.7 nm peaks indicating the presence of kaolinite/halloysite in all the systems. Shola forest lying at an altitude of 1600– 2100 m AMSL has a cool climate restricting weathering and transformation of minerals common in humid tropics. As activation energy for kaolinite to halloysite transformation is temperature-dependent, climatic conditions which fail to provide sufficient activation energy for reaction mechanisms may slow down the process and along with ecosystem-supported geochemical conditions will retain metastable mineral phases for relatively longer geological time periods [Sandeep *et.al*., 2014].

Scrub jungle lies in the rain shadow area of the Western Ghats. Geologically the area is comprised of gneissic metamorphic rocks from the Archean shield. Rainfall acts as a limiting factor for weathering in the region. Studies show that crystallization of kaolinites and halloysites occurs only in leaching solutions containing silica in excess of about 5 ppm. Scrub jungles with a low leaching environment could easily maintain these silica concentrations in their soil solutions for longer periods and thereby support halloysite–kaolinite coexistence. Kaolin minerals in grassland soils were characterized as hydrated halloysites and well-ordered kaolinites. No halloysites were detected in moist deciduous and evergreen forests. However, clays from these soils were rich in disordered kaolinites. Ecosystems with metastable phases of minerals can be considered as young systems which provide valuable inputs of early mineral conversions while developing models of soil genesis in the tropics. Knowledge of soil physico-chemical conditions and ion balances supported by these systems for formation and maintenance of metastable phases like halloysites will help us in the scientific management of highly utilized and exposed soils of the humid tropics.

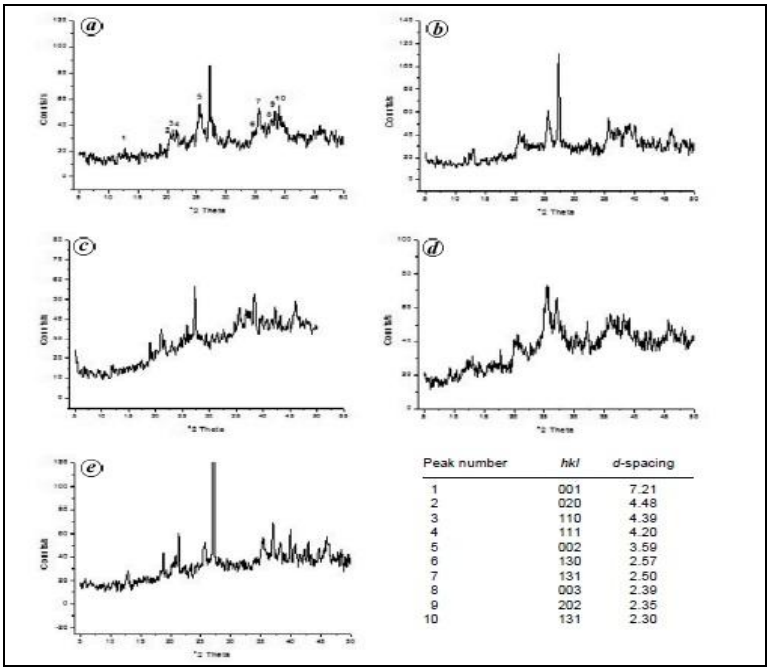

Fig 2 - Mineralogy of soil clay fractions in different forest types of Kerala a) Moist deciduous forests *b*) Shola forests *c*) Evergreen forests *d)* Scrub jungle *e*) Grasslands.

IV. Conclusion

Kerala has a rich forest cover which is more than one fourth of total land area of the state. Most of the physico – chemical properties of soil were found varying with forest types. Climatic factors including rainfall and temperature and vegetation type can be considered the main factors for these variations in soils. The soils in general had a sandy to loam texture, acidic pH, high organic carbon, and available nitrogen and potassium contents. Extractable phosphorus was medium and available calcium and magnesium contents were low in all forest soils except scrub jungles. Presence of metastable minerals such as halloysites in these soils indicates that the forest soils in the region remain still young even under intense tropical weathering conditions. Unlike agricultural soils, forest soils being pristine unaltered by anthropogenic influences will help us generate knowledge of the natural physico-chemical conditions of the soils in humid tropics.

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