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Physical, chemical and biological properties of soils in Marayur Hills of Kerala, India

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Abstract
A study was carried out in Marayur Hills of Western ghats in Kerala to understand the relationship between various physical, chemical and biological properties in surface and sub-surface soils. The samples were collected from surface (0–15 cm) and subsurface (15–30 cm) layers of soils which covered major natural forest and arable lands in Marayur High Hills region. The collected samples were characterized for Physical (particle density), Chemical (electrical conductivity (EC), exchangeable acidity (EA)) and Biological (acid phosphatase activity) properties. Particle density varied from 1.65 Mg m^{-3} to 2.65 Mg m^{-3} in surface soil samples and varied from 1.73 to 2.77 Mg m^{-3} subsurface layer. Cent per cent samples in both layers comes under non saline category. Majority (90 %) of surface samples showed EA below 0.5 cmol kg^{-1} and 83.3 % samples in subsurface layer ranged EA between 0.5 to 1 cmol kg^{-1}. Surface soils showed 16.9 % more acid phosphatase activity than subsurface layer.

Keywords: Marayur Hills, Western Ghats, Particle density, Electrical conductivity, Exchangeable acidity, Acid phosphatase activity

1. Introduction

Soil is an important non-renewable natural resource which has to be kept productive and healthy as because a major part of agricultural productivity depends on it. The main objective of sustainable agriculture is to maintain or improve the productivity without hampering the soil quality. Soil quality may be defined as capacity of soil to promote plant growth and development, to maintain ecological productivity and to sustain environment. Along with the plant growth promoting properties, a good quality soil is also capable of preventing air and water pollution, soil erosion and land degradation. So, assessment of soil quality should be considered as one of the important issues to maintain both agricultural and environmental sustainability (Karlen *et al.*, 2008) [7]. In the context of agriculture, soil quality is typically characterised in terms of productivity and more particularly in terms of a soil's ability to support and foster plant growth. Land-use change causes significant alteration of soil reaction, nutrient status, soil physical quality and microbial activity in the rhizosphere. A soil's particle density quantifies the mass of a soil sample in a particular volume of particles (mass divided by volume). Particle density considers only the soil particles and not the entire volume of the soil particles and pore spaces. The chemical composition and structure of the minerals in the soil determine the density of soil particles. By comparing the particle density of soil to the known densities of minerals such as quartz, feldspar, micas, magnetite, garnet, or zircon, the chemical composition and structure of minerals in a soil sample can be determined. One of the most important processes in analysing soil salt dynamics and determining soil salinity is quantitative examination of soluble salts in soils and/or groundwater, which is measured by electrical conductivity of a soil extract (Guang-Ming *et al.*, 2006) [4]. Assessment of soil biological activity is also important to maintain the sustainability of ecology of soil. Therefore, the present study was aimed to assess some selected soil physical, chemical and biological properties in order to evaluate the quality of soil under forest and agricultural land uses of Marayur Hills in Western Ghats of Kerala which might also be able to add value to the documentation of the soil fertility status of the study area and provide future line of work.

2. Materials and methods

Soil sampling was carried out in AEU 17 (Marayur Hills) of Idukki district which covers an area of 28,968 ha (6.64%) in the Kerala state. The Marayur Hills represents the low rainfall rain-shadow region of the high hill zone comprising three panchayats *viz.*, Marayur, Kanthalloor and Vattavada of Idukki district. The climate is tropical sub humid monsoon type (mean annual temperature 23.7°C; rainfall 1276 mm). In order to delineate the soils field wise for various physical, chemical and biological characteristics in the surface and sub surface soils, 30 surface (0-15 cm) and 30 sub-surface (15-30 cm) soil samples were collected from. The major land use systems sugarcane, cool season vegetables (potato, beans, cabbage, carrot, garlic), fruits (banana, orange, jack fruit, strawberry, apple) and forest. Most of the farmers in the region use organic nutrient sources like fresh and dried FYM as nutrient sources. Inorganic fertilizers applied comprise mostly 17:17:17 mixture or 10:26:26 mixture. Complex fertilizers are applied as basal dose and two top dressings are given with urea in potato.

Table 1: Analytical methods followed for physical, chemical and biological analysis of soil

Sl. No.	Attributes	Method	Reference
Physical			
1	Particle density	Standard pycnometer method	Black *et al.*, (1965) [2]
Chemical			
2	EC	Conductivity meter (1:2.5) (w/v)	Jackson (1973) [5]
3	Exchangeable acidity	KCl method	Yuan (1959) [13]
Biological			
4	Acid phosphatase activity	Colorimetric estimation of PNP released	Tabatabai and Bremer (1982) [11]

3. Results and discussion
3.1 Physical attributes
3.1.1. Particle density
Soil particle density is one of the basic physical properties of soils and represents an essential element of diverse pedotransfer functions (Ruehlmann, 2020) [10]. Particle density varied between 1.65 Mg m^{-3} and 2.65 Mg m^{-3} in surface soil samples whereas in the case of subsurface soil samples particle density varied between 1.73 Mg m^{-3} and 2.77 Mg m^{-3} (Table. 2) in the study area. The main element causing a decrease in particle density is soil organic carbon, but other soil components and their composition can also influence the results (Bielders *et al.*, 1990) [1]. Ruehlmann (2020) [10] also reported soil particle density affected by soil texture and soil organic matter. The frequency distribution of particle density in the area (Fig. 1) shows that 90 per cent of the surface samples and 86.7 per cent of the subsurface soil samples had values < 2.2 Mg m^{-3}. Subsurface layer (15–30 cm) had significantly more particle density than the surface (0–15 cm) and the percent increase in bulk density of 15–30 cm layer was 4.6 per cent.

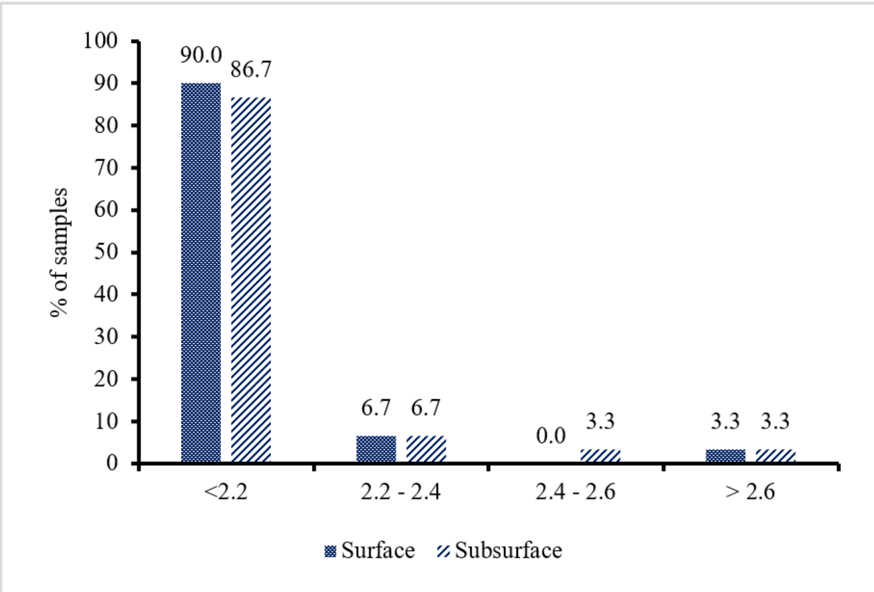

Fig 1: Frequency distribution of particle density (Mg m^{-3}) in surface and subsurface soils of AEU 17

3.2 Chemical parameters
3.2.1. Electrical conductivity
Electrical conductivity of soil is a measure of salts present in the soils and it is affected by cropping irrigation, soil texture, minerals, climate etc. (USDA,2014) [12]. The value of electrical conductivity varied from 0.02 dS m^{-1} to 0.19 dS m^{-1} in the surface soils and 0.03 dS m^{-1} to 0.21 dS m^{-1}. EC also can serve as a measure of soluble nutrients for both cations and anions and is useful in monitoring the mineralization of organic matter in soil (De Neve *et al.*, 2000) [3]. EC slightly varies from surface to subsurface and its range of variation was less in surface soils, probably due to slope of land surface and rainfall responsible to leach out alkali and alkaline bases. Similar findings were reported by Kumar *et al.* (2012) [8]. The range is very low and explains that the soil belongs to non-saline category. Low EC indicated that soluble salts were leached out of soil due to rainfall as reported by Patil *et al.* (2017) [9].

3.2.2. Exchangeable acidity
Soil exchangeable acidity ranged from 0.23 to 0.65 (cmol kg^{-1}soil) in surface soils and 0.42 to 0.87 (cmol kg^{-1}soil) in subsurface soils (Table 2) Majority of the surface samples showed exchangeable acidity below 0.5 cmol kg^{-1} soil (90 %) and 10 per cent samples with exchangeable acidity between 0.5

and 1.00 cmol kg^{-1} soil (Fig. 2) where as in the case of subsurface samples 83.3 per cent samples exchangeable acidity ranged between 0.5 and 1.00 cmol kg^{-1} soil and only 16.7 per cent samples showed exchangeable acidity below 0.5 cmol kg^{-1} soil (Fig 2).With decrease in available basic cations soil exchangeable acidity increases high availability of basic cations in surface layers compared to that of subsurface might be reason for more exchangeable acidity in subsurface soil layers than that of surface soil layers.

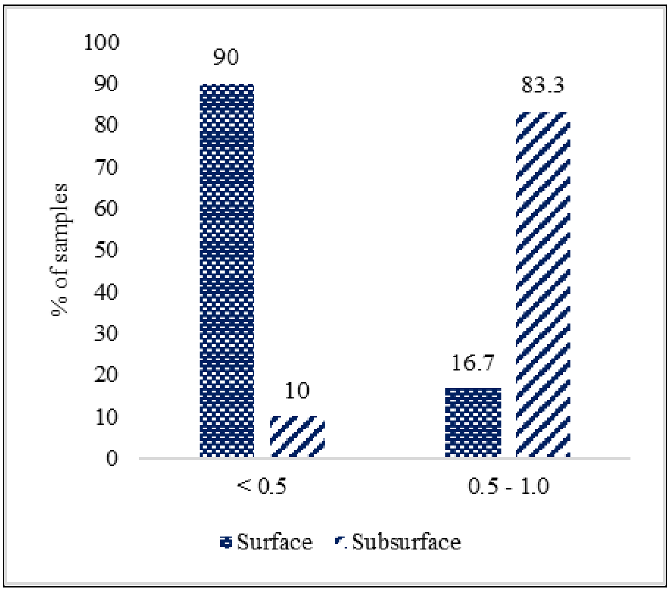

Fig 2: Frequency distribution of soil exchangeable acidity (cmol (+) kg^{-1}) in surface and subsurface soils of AEU 17

3.3. Biological Attributes

3.3.1 Acid Phosphatase Activity

The activity of acid phosphatase of surface soils varied from 16.3 to 113.2 µg nitrophenol g^{-1} h^{-1}. The mean value of acid phosphatase activity in the surface soils was found to be 54.9 µg nitrophenol g^{-1} h^{-1} and it was found to be 46.9 µg nitrophenol g^{-1} h^{-1} in subsurface samples with range 1.5 to 103.2 µg nitrophenol g^{-1} h^{-1}. About 6.7 per cent of soils were observed to have the activity of acid phosphatase in the range of 10 to 25 µg nitrophenol g^{-1} h^{-1}, 53.3 per cent in the range of 25 to 50 µg nitrophenol g^{-1} h^{-1} and 40 per cent greater than 50 µg nitrophenol g^{-1} h^{-1} in surface layer. Frequency distribution depicted in Fig. 5. shows that 16.7, 50.0 and 33.3 percent subsurface samples ranged from 10 – 25, 25 – 50 and above 50 µg nitrophenol g^{-1} h^{-1} respectively. Surface soils showed 16.9 per cent more acid phosphatase activity compared to that of subsurface soils. As surface organic deposits like leaf litter and crop residues are more when compared to subsurface layer, it might be the reason for more acid phosphatase activity in surface layer (Kalembasa and Symanowicz 2012) [6].

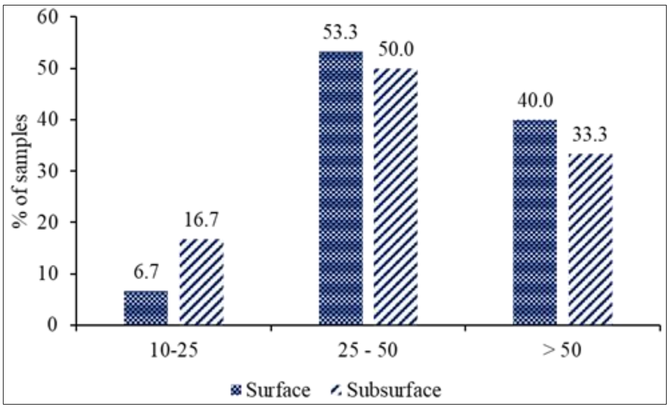

Fig 3: Comparison of frequency of acid phosphatase activity in surface and subsurface samples of Marayur Hills

4. Conclusion

Marayur Hills soils do not have alkalinity or salinity issues. Acid phosphatase activity can be increased by increasing the use of organic fertilisers. Liming should be done as per required. It was necessary to maintain higher soil fertility, improved soil aggregation and reduced surface sealing and crusting, lowered runoff and soil erosion, and increased structural stability of the soils.

Table 2: Physical, Chemical and Biological attributes of surface and sub-surface soil samples in Marayur Hills of Weastern Ghats

	Surface (0 – 15 cm)		**Subsurface (15 – 30 cm)**	
	Mean ± SD	**Range**	**Mean ± SD**	**Range**
Physical attributes				
Particle density	1.96 ± 0.20	1.65 - 2.65	2.05 ±0.21	1.73 – 2.77
Chemical attributes				
EC	0.095 ± 0.04	0.02 – 0.19	0.08± 0.03	0.03 – 0.21
EA	0.42 ±0.09	0.23 – 0.65	0.59 ± 0.10	0.42 – 0.87
Biological attributes				
APA	54.90 ± 29.22	16.30 – 113.25	46.96 ± 25.77	14.50 – 103.25

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