# Characterization and classification of soils in semiarid region of Varathuru watershed area of Andhra Pradesh


ABSTRACT

Eight typical pedons representing Varathuru watershed of Chittoor district ,*viz*Pachigunta (P1 and P2), Kalepalli (P3 and P4), Ramapuram (P5 and P6) and Oogguvaripalli (P7 and P8) in semi-arid ecosystem were studied for morphological, physical, chemical characteristics and their classification. Results indicated that, the colour of the soils variedfrom dark reddish brown to strong brown with sandy loam to sandy clay loam texture. These soils were slightly acid to moderately alkaline (6.03 to 8.35) in reaction and non-saline (0.02 to 0.36 $dSm^{-1}$). The bulk density, water holding capacity, particle density, organic carbon (OC), cation exchange capacity (CEC) and base saturation were varied from 1.34 to 1.61 $Mgm^{-3}$, 28.44 to 48.96%, 2.24 to 2.58 $Mgm^{-3}$, 0.09 to 0.74 %, 3.68 to 20.32 cmol ($p^+$) $kg^{-1}$ and 51.61 % to 91.86 %, respectively. Due to the presence of ustic soil moisture regime, isohyperthermic temperature regime and low organic matter content, the soils were classified intoTypic Hapustepts (Pedons 2, 3, 4, 6 and 8),Typic Haplustalfs (Pedons 1and 7) and UlticHaplustalfs (pedon 5).



**Key words:** Characteristics, Typic Haplustepts, Typic Haplustalfs, UlticHaplustalfs,isohyperthermic, Pedon, Watershed


## 1. INTRODUCTION

Utilization of soil and water resources is the major concern in these arid and semi-arid regions accounting for more than 60 per cent of area in the country. Over 75 percent of the cropped area falls in semiarid tropical region and most of the drought prone districts are concentrated in Andhra Pradesh, Maharashtra, Tamil Nadu, Karnataka and Rajasthan. Hence, management of soil resources on scientific principles is essential to maintain the present level of soil productivity and to prevent its degradation. Comprehensive use of soil rationalizes present soil usage but also shows how they can be used and managed best for agriculture. Further, food security is a challenging task faced by the populous nations like India besides huge demand for water. Hence, concept of watershed based holistic development in rainfed areas is a potential approach, which can lead to higher productivity and sustainability.

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Characterizationandclassificationofsoilsareimportant to understand the nature of soil resources and the data generated based on the profile characteristics will serve as a benchmark for monitoring and evaluating the likely changes in soil characteristics periodically under different cropping systems because of the introduction of different soilmanagementtechniques(Ravikumar*etal*.2009).More thaneverbefore,arenewedattentionisbeinggiventosoils due to rapidly declining area for agriculture, declining soil fertility, increasing soil degradation, unsystematic land use policiesandirrationalandimbalanceduseofinputs(Kanwar 2004). Hence, studies on characterization and classification of soils is needed to realize the concept of watershed approach successfully (Sitanggang*et al.* 2006). Keeping the above facts in view, the present study was undertaken to characterize and classify the soils of Varathuru watershed of Chittoor district.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

Thestudywasconductedin2018inVarathuru watershed of Chittoor district in Andhra Pradesh situated between 13° 16´ to 13° 12´ N latitudes and 79°15´ to 79° 19´ E longitudes, with an average elevation ranging from 324 to 356 m msl. The total geographical area of watershed is about 2695 ha. The mean annual soil temperature was about 33.37ºC. The average rainfall in the watershed was 923.48mm.

### 2.2 Natural Vegetation

The natural vegetation of the study area was *Acacia nilotica, Acacia auriculata, Azadirachta indica,Palmyra palm, Parthenium hysterophorus, Pogamia pinnata, Phoenix Sylvestris, Pterocarpus santalinus, Tamarindus indica,*

### 2.3 Survey Methods

For soil resource inventorydigital cadastral map (1:10000) prepared by using Toposheet and False colour composite were used for site selection and profile excavation. Based on geomorphic-soil relationship, eight profiles were exposed and studied (Fig 1).

### 2.4 Soil Sampling andPreparation for The Laboratory Analysis

Morphological characteristics suchasdifferenthorizons,depth,soilcolour,texturewere demarked in each pedon in the field and were recorded according to Soil Survey Staff (1998)for soil profile description. Sampling of each pedon was done under pedological horizons and 2-3 kg of soil wascollected. Soil colour was determined by using Munsell colourchart. Particle size distribution, particle density and bulk densityofthesoilswasdeterminedbyInternationalpipette method (Piper 1950), Pycnometer method (Means and Parcher 1963) and core method (Blake 1965), respectively. The pH and electrical conductivity of the soils in soil: water (1:2.5) suspension was measured by glasselectrodeandconductivitymeter, respectively(Jackson 1973). Calcium carbonate in soil samples was estimated by rapid titration method (Puri 1949). CEC was determined by neutral normal ammonium acetate extraction (Bower *et al.* 1952). Exchangeable calcium and magnesium were also determinedinneutralnormalammoniumacetateextractby Versanatetitrationmethod(Chopra andKanwar1991).Thesoils of study area were classified according to Keys to Soil Taxonomy (Soil Survey Staff2014).

## 3. RESULTS AND DISCUSSION

*Morphological characteristics*: Morphological characteristics of study area are presented in Table 1. The studied pedons were moderately shallow to deep and exhibited A-B-C horizons except P2, P3 and P6 which exhibited transitional horizon (AB and BA respectively)inprofiledevelopment.Horizon boundaries of the all the pedons varied from clear to diffuse in distinctness and smooth to wavy in topography. The colour of the studied pedons varied from dark reddish brown (2.5YR)to strongbrown(10YR)withdominanthueof 10YR,value(2.5-5)andchroma(1-6).Thisvariationinthe soil colour was a function of textural makeup, topographic position, mineralogy, chemical composition and moisture regimes of the soil (Sujatha*et al.* 2021).

**3.1Physical Characteristics:**The results on physical characteristics of soils are presented in Table 1. The texture of the studied pedons varied from sandy loam to sandy clay loam. The soils of P1, P2 and P8 were sandy clay loam in texture in all horizons, whereas pedons P3, P4, P5, P6 and P7 were sandy loam at surface horizonsand sandy clay loam at sub-surface horizons. These differences were caused by topographic position, nature of parent material, *in-situ* weathering and translocation of clay and age of soils(Deepika *et al.,* 2021). The water holding capacity of the soils was higher in pedon P1 (48.96 to 46.55 %) whereas the low water holding capacity was observed in P3 (33.94 to 29.20%). Bulk density of pedons varied from 1.34 to 1.61 $Mgm^{-3}$ and increasing pattern in pedons 1, 3, 6 and 8 were observed with depth, which may be ascribed to progressive compaction and lower organic matter. However, P2, P4, P5 and P7 exhibited an irregular trend with depth. Similarly, increase in bulk density down the profiledue toloworganicmatterandcompactionofsoil aggregates in Yerpedu mandal in Chittoor district in Andhra Pradesh (Leelavathi *et al.* 2009)).The lower bulk density values in the surface horizons of pedons could be related to the structural aggregation of the soils as a result of relatively high organic matter content in surface horizons than sub-surface horizons (Meghana *et al*.,2024).

The particle density and total porosity in studied pedons of the watershed werevaried from2.40to2.58Mgm$^{-3}$and38.52to65.09%respectively. P1,P2,P3 and P7 showed an increasing trend of particle density with depth. And remained more or less same. Water holding capacity of watershed was varied from 28.44 % to 48.96 %. P1, P2, P3 and P8 were showed and increasing trend of waterholding capacity with depth. The remaining pedons showed no particular trend with depth. These differences in water holding capacity values were due to variation in the depth, clay, silt and organic carbon content of the pedons. (Lakshmi*et al.* 2020).

**3.2 Chemical Characteristics:** Data on the chemical properties are presented in the Table 2. pH of the watershed ranged from 6.03 to 8.35, according to pH classes these wereslightly acid to moderately alkaline in reaction. The P2, P3, P4 and P7 showed an increasing trend with depth whereas pedon 5, 6 and 8 which showed decreasing pattern and pedon 1 did not show any particular trend with depth. The electrical conductivity varied between 0.02to 0.36 dSm$^{-1}$ in the studied pedons indicating that the soils were non-saline. It may be due to excess leaching of salts and due to free drainage conditions, which favoured the removal of released bases by percolating and drainage water (Suguna *et al*., 2023). The soils were low in organic carbon content (0.09 to 0.74%). The low organic carbon content in these pedons may be ascribedto ustic soil moisture regime, isohyperthermic temperatureregimeandpoorvegetation (Leelavathi *et al.* 2009). Calcium carbonate content wasvaried from 1.55 to 8.68 % and could be due to ustic soil moisture regime, which is quite compatible for carbonate formation. Semi-arid climate and less rainfall as compared to annual evapotranspiration in the watershed and less available water for the leaching of insoluble carbonates and bicarbonates of the calcium, facilitated the accumulation of $CaCO_3$in these soils.

CEC of the soils was low (3.68 to 20.32cmol (p$^+$)kg$^{-1}$) anddepth wise distribution of CEC in soils of the profiles followed the pattern of clay distributionwhich influences, a significant positive correlation between CEC and clay (r = 0.861**) and silt (r = 0.511**) signifying that clay and silt were the principal factors that influenced CEC (Table 3). Contrarily,negativeandsignificantcorrelationwasobserved between CEC and sand content (r=-0.724**).

Theexchangeablebasesexhibiteddifferentregularand irregular trends because of topographic position. Among exchangeable cations, calcium was dominant (2.2 to 10.6cmol (p$^+$)kg$^{-1}$) in all the pedons followed by magnesium (0.4 to 6.8cmol (p$^+$)kg$^{-1}$), sodium (0.05 to 0.43cmol (p$^+$)kg$^{-1}$)andpotassium(0.03to0.22cmol(p$^+$)kg$^{-1}$).The base saturation percentage (BSP) was ranging from51.61 to91.86% and high BSP was due to the occurrence of high exchangeablecalcium (Vibha*et al.* 2019).

*Soil classification:* The soils of the watershed had usticsoil moistureregime(rainfall300-1000mm).Themeanannualsoiltemperature was much higher than 22°C and the difference between mean summer and mean winter soil temperature was less than6°C.Thus,thesoilsofthestudyarea qualify forustic soilmoistureregime andisohyperthermic soil temperature regime. Based on the CEC / clay ratio for all the pedons was recorded as <0.7. Hence, minerology class for all the pedons was mixed.

The soils of the watershed were placed under the order Alfisols and Inceptisols.P2, P3, P4, P6 and P8, which have cambic (Bw) sub-surface diagnostic horizon only were classified under Inceptisols and thesepedons were grouped under Ustepts at sub-order level due to presence of ustic soil moisture regime and Haplustepts at greatgroup level because these pedons did not have either duripan or calcic horizon and base saturation was more than 60% at a depth between 0.25 to 0.50 m from the surface and these pedons did not exhibit any intergradation with other taxa or an extra gradation from the central concept. Hence, these pedons were logically classified as Typic Haplusteptsat sub-group level(Leelavathy*et al.* 2014).P1, P5 and P7 have argillic (Bt) sub-surface diagnostic horizon which were classified under Alfisols and these pedons were grouped under Ustalfs at sub-order level due to presence of ustic soil moisture regime and Haplustalfs at great group level because these pedons did not have either duripan or calcic horizon and base saturation was more than 60% at a depth between 0.25 to 0.50 m from the surface and these pedonswere classified into Typic Haplustalfs at sub-group level because of absence of lithic or paralithic contact within 100 cm from the surface horizon and absence of pumice or pumice like fragments and volcanicash, absence of lamellae, sandy particles size except P5 which was classified under UlticHaplustalfs at sub-group level due to the base saturation of argillic (Bt) horizon in P5 was < 75%.Based on particle size distribution, these soils were classified as fine loamyat family level.

## 4. CONCLUSION:

The study indicated that there were considerable variations in the morphological, physical and chemicalcharacteristics of the soils depending on their geomorphic position in the area. The texture of soils varied from sandy loam to sandy clay loam.Among exchangeable cations, calcium was dominant followed by magnesium, sodium and potassium. Soil classification (Inceptisols and Alfisols)revealedthatsprinklerirrigationandgrowing ofcrops,*viz.*groundnut, redgram, oilseeds,millets, guava, custard apple and pomegranateare the best suggestions for these soils.

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Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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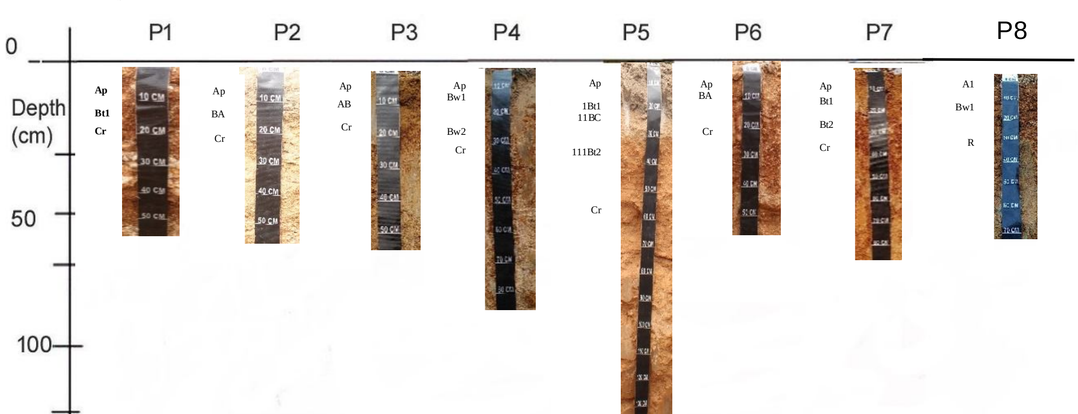


**Fig 1 Horizon differentiation of the profiles**

**Table 1 Morpho-physical characteristics of different pedons**

| Pedon No. & Horizon | Depth (m) | Horizon boundary | Colour (moist) | Sand (%) (2.0-0.05 mm) | Silt (%) (0.05-0.002 mm) | Clay (%) (<0.002 mm) | Textural | Bulk density (Mg/mg3) | Particle density | Water holding capacity (%) | Pore space (%) | Volume expansion (%) | WHC/ Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pedon 1 Fine loamy, mixed, iso hyperthermic, Typic Hapustalfs** | | | | | | | | | | | | | |
| Ap | 0.00– 0.23 | c-s | 2.5 YR 2.5/4 | 64.79 | 10.99 | 24.22 | scl | 1.54 | 2.26 | 48.96 | 65.09 | 11.11 | 2.02 |
| Bt1 | 0.23– 0.54 | d-w | 5 YR 3/4 | 61.12 | 12.48 | 26.4 | scl | 1.45 | 2.37 | 46.55 | 59.51 | 10.35 | 1.76 |
| Cr | 0.54 | | | Weathered gneiss | | | | | | | | | |
| **Pedon 2Fine loamy, mixed, iso hyperthermic, Typic Haplustepts** | | | | | | | | | | | | | |
| Ap | 0.00– 0.24 | c-s | 5 YR 4/1 | 63.56 | 11.53 | 24.91 | scl | 1.41 | 2.31 | 39.15 | 51.88 | 4.1 | 1.57 |
| BA | 0.24– 0.56 | d-w | 10 YR 5/4 | 66.73 | 9.22 | 24.05 | scl | 1.43 | 2.48 | 31.46 | 40.63 | 4.62 | 1.31 |
| Cr | 0.56 | | | Weathered gneiss | | | | | | | | | |
| **Pedon 3 Fine loamy, mixed, iso hyperthermic, Typic Haplustepts** | | | | | | | | | | | | | |
| Ap | 0.00– 0.23 | c-s | 10 YR 3/6 | 70.55 | 9.97 | 19.48 | sl | 1.47 | 2.45 | 33.94 | 44.18 | 7.22 | 1.74 |
| AB | 0.23– 0.55 | d-w | 10 YR 4/3 | 68.91 | 11.65 | 19.44 | sl | 1.52 | 2.58 | 29.20 | 41.49 | 3.25 | 1.5 |
| Cr | 0.55 | | | Weathered gneiss | | | | | | | | | |
| **Pedon 4 Fine loamy, mixed, iso hyperthermic, Typic Haplustepts** | | | | | | | | | | | | | |
| AP | 0.00– 0.20 | d-s | 7.5 YR 4/4 | 68.86 | 13.16 | 17.98 | sl | 1.5 | 2.5 | 28.44 | 38.52 | 2.43 | 1.58 |
| Bw1 | 0.20– 0.54 | d-w | 7.5 YR 4/6 | 57.95 | 19.49 | 22.56 | scl | 1.49 | 2.40 | 45.49 | 56.3 | 12.78 | 2.02 |
| Bw2 | 0.54– 0.86 | d-w | 10 YR 5/3 | 61.03 | 18.66 | 20.31 | scl | 1.54 | 2.45 | 39.99 | 53.04 | 8.2 | 1.97 |
| Cr | 0.86 | | | Weathered gneiss | | | | | | | | | |
| **Pedon 5 Fine loamy, mixed, iso hyperthermic, UlticHaplustalfs** | | | | | | | | | | | | | |
| Ap | 0.00– 0.23 | c-s | 10 YR 3/2 | 71.76 | 10.71 | 17.53 | sl | 1.50 | 2.42 | 31.55 | 42.62 | 6.26 | 1.8 |
| 1Bt1 | 0.23– 0.31 | c-s | 5 YR 4/4 | 65.51 | 14.18 | 20.31 | scl | 1.34 | 2.5 | 38.81 | 47.55 | 5.36 | 1.91 |
| 11BC | 0.31– 0.80 | c-s | 7.5 YR 5/6 | 89.21 | 4.03 | 6.76 | s | 1.35 | 2.57 | 48.15 | 39.91 | 2.71 | 7.12 |
| 111Bt2 | 0.80– 1.41 | c-s | 7.5 YR 4/4 | 7.84 | 42.87 | 49.29 | sic | 1.55 | 2.24 | 42.51 | 50.99 | 8.25 | 0.86 |
| Cr | 1.41 | | | Weathered gneiss | | | | | | | | | |
| **Pedon 6 Fine loamy, mixed, iso hyperthermic, Typic Haplustepts** | | | | | | | | | | | | | |
| Ap | 0.00– 0.17 | c-s | 7.5 YR 4/6 | 69.23 | 15.25 | 15.52 | sl | 1.38 | 2.46 | 31.54 | 45.68 | 3.01 | 2.03 |
| BA | 0.17– 0.54 | d-w | 5 YR 3/4 | 63.39 | 9.69 | 26.92 | scl | 1.44 | 2.41 | 34.74 | 44.09 | 5.87 | 1.29 |
| Cr | 0.54 | | | Weathered gneiss | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pedon 7 Fine loamy, mixed, iso hyperthermic, Typic Haplustalfs** | | | | | | | | | | | | | |
| Ap | 0.00– 0.27 | c-s | 5 YR 3/4 | 73.82 | 8.75 | 17.43 | sl | 1.51 | 2.36 | 29.46 | 41.88 | 3.66 | 1.69 |
| Bt1 | 0.27– 0.56 | d-w | 5 YR 3/4 | 64.77 | 12.22 | 23.01 | scl | 1.45 | 2.38 | 40.26 | 51.17 | 9 | 1.75 |
| Bt2 | 0.56– 0.85 | d-w | 5 YR 4/4 | 63.87 | 14.77 | 21.36 | scl | 1.55 | 2.44 | 36.27 | 49.33 | 7.41 | 1.7 |
| Cr | 0.85 | | Weathered gneiss | | | | | | | | | | |
| **Pedon 8 Fine loamy, mixed, iso hyperthermic, Typic Haplustepts** | | | | | | | | | | | | | |
| A1 | 0.00– 0.24 | c-s | 7.5 YR 3/4 | 71.77 | 7.05 | 21.18 | scl | 1.45 | 2.42 | 38.02 | 50.75 | 5.45 | 1.79 |
| Bw1 | 0.24– 0.71 | d-w | 10 YR 3/6 | 67.98 | 8.04 | 23.98 | scl | 1.61 | 2.41 | 33.63 | 48.49 | 6.16 | 1.4 |
| R | 0.71 | | Hard Granite Gneiss | | | | | | | | | | |
| **Min** | | | | **7.84** | **4.03** | **6.76** | | **1.30** | **2.24** | **28.00** | **39.00** | **2.43** | **0.86** |
| **Max** | | | | **89.20** | **42.90** | **49.29** | | **1.60** | **2.58** | **49.00** | **65.00** | **12.78** | **7.12** |

**Table2. Chemical properties of different pedons**

| Pedon No. & Horizon | Depth (m) | pH (1:2.5) | | EC (dS m$^{-1}$) | OC (%) | $CaCO_3$ (%) | CEC | $Ca^{2+}$ | $Mg^{2+}$ | $Na^{+}$ | $K^{+}$ | BSP (%) | ESP (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $H_2O$ | 1*N*K Cl | | | | [cmol (p$^+$) kg$^{-1}$] | | | | | | |
| **Pedon 1** | | | | | | | | | | | | | |
| Ap | 0.00– 0.23 | 6.57 | 5.46 | 0.12 | 0.65 | 4.4 | 16.01 | 8.1 | 4.7 | 0.24 | 0.19 | 82.69 | 1.53 |
| Bt1 | 0.23– 0.54 | 6.03 | 5.24 | 0.1 | 0.18 | 2.98 | 12.14 | 5.1 | 3.8 | 0.19 | 0.11 | 75.86 | 1.61 |
| Cr | 0.54 | | | | Weathered gneiss | | | | | | | | |
| **Pedon 2** | | | | | | | | | | | | | |
| Ap | 0.00 –0.24 | 7.51 | 6.67 | 0.33 | 0.74 | 5.83 | 16.48 | 9.2 | 5.5 | 0.22 | 0.22 | 91.86 | 1.34 |
| BA | 0.24 –0.56 | 8.14 | 7.61 | 0.25 | 0.15 | 7.25 | 14.96 | 6.5 | 3.7 | 0.22 | 0.08 | 70.16 | 1.46 |
| Cr | 0.56 | | | | Weathered gneiss | | | | | | | | |
| **Pedon 3** | | | | | | | | | | | | | |
| Ap | 0.00 –0.23 | 6.88 | 6.18 | 0.02 | 0.46 | 2.5 | 11.45 | 6.4 | 3.4 | 0.21 | 0.11 | 88.39 | 1.80 |
| AB | 0.23– 0.55 | 7.18 | 6.15 | 0.19 | 0.09 | 3.45 | 10.38 | 5.2 | 3.2 | 0.25 | 0.08 | 84.14 | 2.44 |
| Cr | 0.55 | | | | Weathered gneiss | | | | | | | | |
| **Pedon 4** | | | | | | | | | | | | | |
| Ap | 0.00– 0.20 | 6.11 | 5.47 | 0.1 | 0.53 | 2.03 | 11.61 | 6.2 | 2.4 | 0.33 | 0.16 | 78.32 | 2.87 |
| Bw1 | 0.20– 0.54 | 7.14 | 6.41 | 0.08 | 0.37 | 3.93 | 13.83 | 8.2 | 3.6 | 0.24 | 0.22 | 88.61 | 1.72 |
| Bw2 | 0.54– 0.86 | 7.57 | 6.79 | 0.13 | 0.32 | 2.98 | 12.57 | 6.6 | 3.6 | 0.32 | 0.16 | 84.98 | 2.55 |
| Cr | 0.86 | | | | Weathered gneiss | | | | | | | | |
| **Pedon 5** | | | | | | | | | | | | | |
| Ap | 0.00– 0.23 | 8.12 | 7.34 | 0.36 | 0.44 | 6.3 | 10.06 | 5.2 | 2.6 | 0.19 | 0.17 | 81.09 | 1.89 |
| 1Bt1 | 0.23– 0.31 | 8.35 | 7.52 | 0.27 | 0.32 | 8.68 | 12.13 | 6.9 | 2.1 | 0.17 | 0.12 | 76.66 | 1.44 |
| 11BC | 0.31– 0.80 | 8.14 | 7.36 | 0.06 | 0.19 | 5.83 | 3.68 | 2.2 | 0.4 | 0.05 | 0.03 | 72.84 | 1.34 |
| 111Bt2 | 0.80– 1.41 | 7.92 | 6.56 | 0.21 | 0.12 | 3.45 | 20.32 | 10.6 | 6.8 | 0.25 | 0.14 | 87.56 | 1.22 |
| Cr | 1.41 | | | | Weathered gneiss | | | | | | | | |
| **Pedon 6** | | | | | | | | | | | | | |
| Ap | 0.00– 0.17 | 6.21 | 5.56 | 0.23 | 0.34 | 2.5 | 9.67 | 3.8 | 2.4 | 0.19 | 0.17 | 67.86 | 1.97 |
| BA | 0.17– 0.54 | 6.14 | 5.35 | 0.19 | 0.28 | 5.35 | 17.33 | 5.5 | 4.8 | 0.15 | 0.12 | 61.00 | 0.85 |
| Cr | 0.54 | | | | Weathered gneiss | | | | | | | | |
| **Pedon 7** | | | | | | | | | | | | | |
| Ap | 0.00– 0.27 | 6.81 | 5.93 | 0.17 | 0.25 | 1.55 | 11.04 | 3.2 | 1.9 | 0.43 | 0.16 | 51.61 | 3.94 |
| Bt1 | 0.27– 0.56 | 6.09 | 5.64 | 0.09 | 0.34 | 2.98 | 15.07 | 5.1 | 2.7 | 0.42 | 0.13 | 75.43 | 2.79 |
| Bt2 | 0.56– 0.85 | 6.67 | 5.92 | 0.12 | 0.21 | 2.5 | 13.61 | 6.9 | 3.5 | 0.18 | 0.12 | 78.63 | 1.34 |
| Cr | 0.85 | | | | Weathered gneiss | | | | | | | | |
| **Pedon 8** | | | | | | | | | | | | | |
| A1 | 0.00– 0.24 | 6.51 | 5.66 | 0.21 | 0.34 | 3.93 | 13.63 | 4.7 | 3.5 | 0.21 | 0.19 | 63.09 | 1.53 |
| Bw1 | 0.24– 0.71 | 6.23 | 5.75 | 0.29 | 0.11 | 6.78 | 15.81 | 6.2 | 3.4 | 0.13 | 0.12 | 62.28 | 0.82 |
| R | 0.71 | | | | Hard Granite Gneiss | | | | | | | | |
| **Min** | | **6.03** | **5.24** | **0.02** | **0.09** | **1.55** | **3.68** | **2.2** | **0.4** | **0.05** | **0.03** | **51.61** | **0.82** |
| **Max** | | **8.35** | **7.61** | **0.36** | **0.74** | **8.68** | **20.32** | **10.6** | **6.8** | **0.43** | **0.22** | **91.86** | **3.94** |

**Table.3. Correlation matrix among physico-chemical properties**

| Parameter | pH | EC | OC | $CaCO_3$ | CEC | $Ca^{2+}$ | $Mg^{2+}$ | $Na^{+}$ | $K^{+}$ | BSP | ESP | Sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | 1 | | | | | | | | | | | | | |
| **EC** | 0.97** | 1 | | | | | | | | | | | | |
| **OC** | -0.08 | -0.09 | 1 | | | | | | | | | | | |
| **$CaCO_3$** | 0.56** | 0.62** | -0.03 | 1 | | | | | | | | | | |
| **CEC** | -0.17 | -0.25 | 0.09 | 0.07 | 1 | | | | | | | | | |
| **$Ca^{2+}$** | 0.20 | 0.10 | 0.29 | 0.13 | 0.77 | 1 | | | | | | | | |
| **$Mg^{2+}$** | 0.00 | -0.13 | 0.18 | -0.01 | 0.88** | 0.82** | 1 | | | | | | | |
| **$Na^{+}$** | -0.24 | -0.25 | 0.18 | -0.57** | 0.21 | 0.06 | 0.07 | 1 | | | | | | |
| **$K^{+}$** | -0.20 | -0.25 | 0.67** | -0.20 | 0.39* | 0.42* | 0.40* | 0.36* | 1 | | | | | |
| **BSP** | 0.45* | 0.36* | 0.38* | 0.03 | 0.08 | 0.65** | 0.42* | -0.18 | 0.23 | 1 | | | | |
| **ESP** | -0.15 | -0.14 | 0.09 | -0.60** | -0.32* | -0.37* | -0.38* | 0.84** | 0.15 | -0.23 | 1 | | | |
| **Sand** | -0.12 | 0.03 | 0.16 | 0.12 | -0.72** | -0.75** | -0.75** | -0.17 | -0.22 | -0.32* | 0.21 | 1 | | |
| **Silt** | 0.21 | 0.07 | -0.16 | -0.21 | 0.51** | 0.67** | 0.59* | 0.19 | 0.22 | 0.42* | -0.08 | -0.95** | 1 | |
| **Clay** | 0.01 | -0.13 | -0.15 | -0.02 | 0.86** | 0.75** | 0.83** | 0.13 | 0.19 | 0.19 | -0.31* | -0.95** | 0.79** | 1 |