Characterization, classification and evaluation of major soils in Sollapura sub-watershed of Chikmagalur district in Karnataka for sustainable crop production

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ABSTRACT

The morphological, physical and physico-chemical characteristics of soils in Sollapura sub-watershed of Chikmagalur district in Karnataka have been studied. The district comprises of 7 taluks of which Tarikere comes under southern transition zone. Tarikere talu have wide range of climate variation from perhumid to semi-arid. The study revealed that the soils had colours in the hue of 10YR to 5 YR, well to poorly drained, slightly acidic to moderately alkaline, low to high in organic carbon and low to medium in cation exchange capacity with wide textural variations. The soils on gently sloping topography exhibit the development of argillic horizon (Bt). The soils have been classified as Alfisols soil or der and Ustalfs at sub-order level due to the presence of ustic soil moisture regime. On the basis of the major soil constraints, sustainable land use plan for the micro-watershed has also been suggested for their better management.

Key words: Argillic horizon, Land use, Soil classification, Watershed.

INTRODUCTION

Land and water are the most vital natural resources of the country and these are under tremendous stress due to ever increasing biotic pressure (Wani and Sidhu, 2009). The optimal management of these resources with minimum adverse environmental impact is essential, not only for sustainable development but also for human survival. This decline was attributed to periodic droughts, poor management and exploitative agriculture coupled with soil degradation processes. The potential of land for crop production to satisfy the demand for the ever increasing population is declining as a result of severe soil degradation. In the study area nearly 25 per cent of area is affected by soil erosion.

Watershed is a “geo-hydrological” entity or piece of land that drains at a common outlet. This natural unit is evolved through the interaction of the rainwater and land mass and normally comprises of arable and non-arable lands along with drainage lines. Thus, the watershed area is delineated based on distribution and flow of rainwater, which facilitates scientific developments of natural resources like soil, water and vegetation.

Land Resource Inventory and mapping are plays a vital role in natural resource management. It assists to planning land use, particularly agriculture, because it assesses the land resource and its potential for sustainable agricultural production. Assessing of soil resources, in case of variable properties like physical, chemical and biological, of which results showed that the success in soil management to maintain soil quality (Wakene, 2001). This implies that understanding the characteristics of soils is a prerequisite for designing appropriate management strategies, thereby solving many challenges faced in crop and livestock production sectors and in their efforts towards natural resource conservation and management for sustainable development. Keeping these factors in mind the study has been undertaken to characterize and classify the soils of Sollapura sub-watershed and to suggest the land use plan to protect the natural resources for sustainable crop production.

MATERIALS AND METHODS

The study area Sollapura sub-watershed is located in Chikmagalur district of Karnataka state. Chikmagalur district is situated in the Malenadu region of Karnataka in the Deccan Plateau in the foot hills of the Western Ghats. It lies in the south central part of Karnataka, between 12° 54’42” - 13° 53’53” N latitudes and 75° 04’46” - 76° 21’50” E longitudes, with a geographical area of 7201 km². The district comprises of 7 taluks of which Tarike comes under southern transition zone No.7 and rest of the taluks comes under Hilly Zone No.22. Tarike is located at 13.72°N 75.82°E. It has an average elevation of 698 metres above MSL. Tarike borders 3 taluks in its own district. The mean annual rainfall varies from lowest 600 mm in Kadur taluk to more than 4000 mm in Srinageri taluk. Sollapura sub-watershed is covering four mini-watersheds viz. Mallenhalli-1 (674 ha), Mallenhalli-2 (546 ha), Sollapura (661 ha) and

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Tommaladdhalli (566 ha) in Tarikere taluk of Chikmagalur district. Location map is given in Fig 1.

The detailed morphological description of these fourteen pedons was studied as per the procedure outlined in soil survey manual (Soil Survey Staff, 2003). The soil samples representing each added horizon of the pedons were collected and characterized for important physical and physico-chemical properties using standard procedures. The soil samples collected from the control section (25 to 100 cm) of each pedon were analyzed by sedimentation technique (Jackson, 1973). The soils were classified according to Keys to Soil Taxonomy (Soil Survey Staff, 2003). Considering limitations and potentials of the soils, land capability classification was evaluated up to sub-class level (Klingebiel and Montgomery, 1966) and based on that a suitable land use plan has also been suggested.

RESULTS AND DISCUSSION

**Morphological characteristics:** Seven soil series identified viz. Balliganur, Nagadevanahalli, Thimmappura, Koranahalli, Tadaga, Hanumapura and Aldahalli are coming under Alfisols soil order. Varying soil morphological characteristics are soil depth shallow (<50 cm) to very deep (>150 cm). The soils had colours in the hue of 10YR to 5 YR. The colour grades to redder hues with depth. The values ranged between 1 to 3 and chromas between 3 to 6 (Table 1). Schwertman and Taylor (1977) believed that 5YR colours might be due to the presence of both lepidocrocite and ferrihydrite. Childs and Wilson (1983) proved that haematite was associated with 5YR colours while goethite with 7.5YR and 10YR colours. Free iron oxides played an important role in imparting red color to soil. The soil horizons had single grain structure and weak to moderate, fine to medium and granular to sub-angular blocky structures with soft to slightly hard (dry) and loose to friable (moist) consistence. The bottom layers were grading from weak to moderate, fine to medium sub-angular blocky structure and soft to hard (dry) and friable to firm (moist) in consistence. Low clay content and kaolinitic type of clay mineral are responsible for the consistence in red soils (Sehgal et al., 1987).

**Physical characteristics:** The per cent coarse fragments increased with depth in all major soils. The coarse fragments were mainly quartz gravel in all the soils (Table 2). Medium deep and deep soils had insignificant amount of gravels (10-60 %) in B horizons of Balliganur and Nagadevanahalli series. The sand content is varied between 9.7 to 77.3 per cent, the sand content decreasing with depth and clay content ranged from 10.0 to 51.7 per cent which is increasing with different depths. This can be partial attribution of vertical migration of clay and translocation of clay from the surface to lower horizons (Torrent et al., 1980; Klich et al., 1990). The surface enrichment of sand fraction is due to the removal of finer particles by clay eluviation and surface runoff. Water holding capacity of soils in different location is varied based on clay content. The water holding capacity of the soils ranged between 24 to 61 per cent. These differences were due to the variation in the depth, clay, silt and organic carbon content of the pedons. These results are in line with those of Thangaswamy et al. (2005) in soils of Sivagiri watershed in Chittoor district of Andhra Pradesh.

**Chemical characteristics:** There was a general trend of increasing pH with depth in all the pedons. All the soil series are in range of strongly acidic (<5.5) to neutral (6.5 -7.5) except Balliganur series which are mildly to moderately alkaline (7.3-8.5) or strongly alkaline (8.5-9.0). The lower pH values in sub-soil, indicate the high degree of development of the soil from acid parent materials (Shrikant et al., 1993). The electrical conductivity values ranged between 0.01 and 0.44 dS m$^{-1}$ indicating that the soils are non-saline. Organic carbon content was found to decrease with depth. Organic carbon followed irregular distribution in all the series, it may due to transported soil materials. Organic carbon content ranged from 0.21 to 0.84 per cent but high in Balliganur series (0.68-1.47 %) respectively, which in general accumulated in surface layers. The lower contents of organic carbon apparently resulted because of
Table 1: Morphological and physical characteristics of the soils.

| Depth(cm) | Horizon | Colour (Moist) | Sand (2.0-0.05) | Silt (0.05-0.002) | Clay (<0.002) | Texture | Graveliness (Vol. %) | WHC (%) | Structure | Consistency |
|-----------|---------|----------------|----------------|------------------|--------------|----------|---------------------|---------|-----------|-------------|
|           |         |                | (Vol. %)       | (mm)             |              |          |                     |         | S G T D M W |             |
|           |         |                |                | (mm)             | Gravelliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | Graveliness |          |                     |         |           |             |
|           |         |                |                | (Vol. %)         | WHC (%)      |          |                     |         |           |             |
high temperature which might have induced its rapid oxidation. Observations in the line with the present findings have been reported by Basavaraju et al. (2005). The cation exchange capacity (CEC) values varied from 6.6 to 35.2 cmol (p+) kg⁻¹ in different soils, overall low content, it may due to leaching of cations from surface soils and influence of primary minerals (Buol et al., 1998). Exchange complex was mostly saturated with Ca²⁺ followed by Mg²⁺, Na⁺ and K⁺. This order of abundance was in accordance with Jenny’s (1941) view that the leaching caused preferential losses of Na⁺ and K⁺. Higher values of exchangeable Ca and Mg indicated the decrease in extractable magnesium content in soils.

Table 2: Physico-chemical characteristics of the soils.

| Depth (cm) | Horizon | pH (1:2.5 H₂O) | EC (dS m⁻¹) | OC (%) | Ca (1 N NH₄Ac, pH 7.0) cmol (p+) kg⁻¹ | Mg (1 N NH₄Ac, pH 7.0) cmol (p+) kg⁻¹ | Na K | Sum of cations by sum of cations | CEC | CEC/Clay Ratio | BS (%) | K₂O (kg ha⁻¹) |
|-----------|---------|----------------|-------------|--------|-----------------------------------|-----------------------------------|------|-----------------------------------|------|---------------|--------|--------------|
| 0-13      | Ap      | 7.55           | 0.34        | 0.68   | 9.25                              | 4.50                              | 0.39 | 14.14                            | 15.18| 184           |
| 13-34     | BA      | 8.31           | 0.40        | 1.20   | 17.2                              | 6.75                              | 0.51 | 24.46                            | 26.39| 395           |
| 34-59     | Bt1     | 8.50           | 0.42        | 1.38   | 19.0                              | 9.20                              | 0.55 | 28.75                            | 31.22| 372           |
| 59-83     | BC      | 8.68           | 0.44        | 1.47   | 23.0                              | 10.7                              | 0.38 | 34.28                            | 35.25| 345           |
|           |         |                |             |        |                                   |                                   |      |                                   |      |               |
|           |         |                |             |        |                                   |                                   |      |                                   |      |               |
|           |         |                |             |        |                                   |                                   |      |                                   |      |               |
|           |         |                |             |        |                                   |                                   |      |                                   |      |               |

Table 3: Major soil series and family level classification.

| Soil Series        | Alfisols Family level classification |
|--------------------|--------------------------------------|
| Balliganur (BNR)   | Clayey- skeletal, mixed, isohyperthermic, Typic Haplustalfs |
| Nagadevanahalli (NDH) | Loamy-skeletal , mixed, isohyperthermic, Typic Haplustalfs |
| Thimmappura (TIM)  | Fine, mixed, isohyperthermic, Typic Haplustalfs |
| Koranahalli (KOR)  | Fine, mixed, isohyperthermic, Vertic Haplustalfs |
| Tadaga (TAD)       | Clayey-skeletal, mixed, isohyperthermic, Kanhaplic Haplustalfs |
| Hanumapura (HNM)   | Clayey-skeletal, mixed, isohyperthermic, Kandic Paleustalfs |
| Aldahalli (ALD)    | Fine, mixed, isohyperthermic, Typic Kanhapustalfs |
Soil Classification: Based on morphology and soil properties, the soils were classified according to Keys to Soil Taxonomy (Soil Survey Staff, 2003) into the order Alfisols. The seven soil series showed the presence of argillic (Bt) sub-surface diagnostic horizon as evidenced by the fact that the illuvial horizon contains 1.2 times more clay than the eluvial horizon and also had base saturation more than 35 per cent throughout the profile. However, these pedons were classified as Ustalfs at sub-order level due to the presence of ustic soil moisture regime (Table 3).

CONCLUSION

The study of morphological, physical and physico-chemical analysis of soil samples revealed that the red soils of Sollapura sub-watershed were slightly acidic to moderately alkaline in soil reaction, non-saline and low to high in organic carbon content. Further CEC was also low to medium and exchange complex was dominated by Ca²⁺. The soils of sub-watershed were classified up to sub-group level. Based on the soil properties suitable land use plan has to be suggested for sustaining crop production in watershed.

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