Study of Physio-chemical Properties of Soil in Various Land Use Systems of Krishna District, Andhra Pradesh, India

Abstract

A study was carried out to evaluate the impact of various land use systems on the physiochemical characteristics of the soil of Krishna District, Andhra Pradesh. The samples were collected from various land use systems (normally cultivated land, plantation, forest, fruit and vegetable) at two different depths (0-15 cm and 15-30 cm) and analysed at the Soil Science - Soil and Water Conservation Laboratory at the Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Uttar Pradesh. Geographically, the experimental site is located under the tropical zone at the coordinates of 16.4° N and 81.0° E. Study showed, the maximum bulk density (1.58 Mg/m^3), particle density (2.7 Mg/m^3) at lower depth of 15-30 cm, water holding capacity (49.70 %) and highest porosity (48.68 %) in upper soil layer (0-15 cm) in normally cultivation land. Forest land had showed the highest organic carbon content of 0.77 % and 0.71 % soil in two different study depths of 0-15 cm and 15-30 cm, respectively. Also, the maximum availability of nitrogen (280.17 kg/ha), phosphorus (18.63 kg/ha), potassium (212.65 kg/ha) and sulphur (8.64 mg/kg of soil) were reported in forest, Vegetable, fruit and cultivated land respectively, in upper soFil layer (0-15 cm), also all were found to depleting with increasing soil depths. The results of this study showed that land use patterns had considerable impact on many soil physiochemical properties. This study have a great importance for improving the standard of the produce, raising crop yields by a greater percentage through nutrient management, appropriate soil conservation practices and also, for better prevention of the environment.

1. Introduction

For every living being, soil is a highly important and valuable resource. Climatic condition, topography, flora, time, and several other life-forms are all factors to consider important components in determining the soil's qualities. A soil horizon is a soil layer that runs parallel to its crust as well as unique physiochemical properties than the layers above and below it. Major soil constituents like granules, compost, moisture and atmosphere are all influenced by the environment. Soils constitute a significant carbon sink and a huge carbon reservoir. Carton sequestration is a method of reducing carbon dioxide enrichment in the atmosphere. Soil organic carbon (SOC) storage has long been thought of as a means of combat global climatic change is caused by storing carbon in the soil. Carbon sequestration in the soils can be accomplished in a number a variety of land-use and management strategies.

Organic matter in the soil is crucial for preserving the stability of the soil's structure, facilitating air and water infiltration, enhancing water retention, and preventing erosion. Soil carbon loss due to cultivation is typically associated with the deterioration of the soil's physical characteristics. According to **[1],** soil erodibility and soil organic matter are closely related. In addition to aggregate stability and size distribution, soil organic matter, soil particle density, and soil porosity all play a role in soil bulk density and porosity. A decrease in organic matter would result in an increase in bulk density and a decrease in porosity, which would decrease soil infiltration and the capacity to store both water and air **[2]**.

A lack of an essential nutrient makes it impossible for a plant to complete the vegetative and reproductive stages of its life cycle because the plant needs those nutrients to complete its life cycle. In order to add the proper amount of nutrients and identify the nutrients that are lacking, it will be necessary to analyse the soils. In comparison to micronutrients, macronutrient requirements are relatively higher in plants **[3]**. The ability of soil to work as a vital living system within the constraints of ecosystems and land uses, to support plant and animal productivity, maintain or improve water and air quality, and to promote plant and animal health **[4].**

Chlorophyll, nucleic acids, enzymes, amino acids, and proteins all include nitrogen, which is crucial for root development and the induction of vegetative growth. Phosphorus serves as a plant's energy reserve and promotes the growth of seeds and roots. Potassium works as an enzyme activator, aids in stomata function, aids in disease and drought tolerance in plants, and aids in the synthesis and transport of sugar and carbohydrates. The secondary nutrients Ca, Mg, and S are crucial for plant growth and development because they encourage the production of nodules in the roots of leguminous plants **[5].**

The Krishna district is located near the Krishna River in peninsular India, which causes significant dirt removal by natural forces such as wind and water in such a way that the soil-forming process cannot restore it. Top soil contains a high proportion of the nutrients required for plant growth. The soil's fertility declines with depth. By washing away the fertile top layer, erosion reduces the fertility of the soil. Soil erosion occurs at a considerably higher rate than soil formation, resulting in a steady deterioration of soil quality. Most of the area of this district is under agricultural which consider 69.76%, forest (7.18%), plantation (3.80%) and scrubs / shrubs land (1.45%) of the whole district area.

In Krishna district, the soil problem is the consequence of a multiples of factors working together, including both natural and human activities. Kuderu is a Krishna district settlement where farmed soils degrade into waste soils. Due to human activity or climate change, desert-like conditions are spreading over arid and semi-arid areas. Wind causes the most erosion in desert soil. Wind-borne sand is deposited on fertile soils or lands adjacent to waste land or desert lands. The rate of soil fertility in these soils decreases due to an imbalance in soil nutrient availability, resulting in crop harm.

2. MATERIALS AND METHODS

2.1 Location

Geographically the experimental site located under the tropical zone with latitude of 16.441025'N and longitude of 80.992630'E. The samples were collected from various land use systems of Krishna district, Andhra Pradesh, India. The samples were analysed at the Soil Science - Soil and Water Conservation laboratory at the Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Uttar Pradesh.

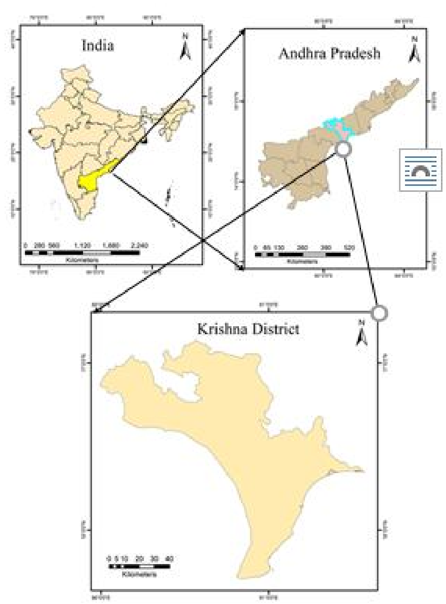

Figure 1: Study Area Location

2.1.1 Climate and Weather

Theexperimental area comes under the hot- humid condition of Krishna district. According to Koppen - Geiger climate classification is Aw. The average annual temperature is 28.1C with the annual rainfall is 966 mm. Maximum temperature of 33.3°C was record in the month of May and minimum temperature of 24.1°C is recorded in the month of December.

2.1.2 Land Use and Soil of the Study Area

The sampling sites were selected on the basis of different Land Use Systems such as Forest Land, Turmeric(Curcuma longa), Plantation Cultivation [Coconut(Cocos nucifera)], Fruits Cultivation [Guava (Psidium guajava), Lemon(Citrus limon), Banana(Musa acumnata)], Cultivation crops [Cotton (Gossypium spp), Jowar(Sorghum bicolor)], Vegetable Cultivation [Okra(Abelmoschus esculentus)]. In the KRISHNA district mostly black cotton soils arefound with low soil fertility, and poor organic matter.

2.2 Soil Analysis:

2.2.1 Water Holding Capacity

Water holding capacity of the soil samples done with the help of Piper's Method (1966) [6], by using following equation-

$$\text{Water Holding Capacity (\%)} = \frac{\text{Wet wt.} - \text{Dry wt.}}{\text{Dry wt.}} \; X \; 100$$

2.2.2 Soil Bulk Density and Particle Density

The particle density and bulk density of collected soil samples of were determined by the help of Pycnometer, as suggested by Black *et al*, 1965 [7]

$$\text{Particle density} = \frac{Ws}{(W2+Ws)-W3}$$

$$\text{Bulk density} = \frac{Mass\ of\ the\ soil}{Volume\ of\ the\ soil}$$

where, Ws = Mass of soil

W_2 = Mass of pycnometer + water

W_3 = Mass of pycnometer + water + soil

2.2.3 Soil pH

Soil pH was determined by preparation of 1 : 2.5 soil-water suspension (10 g of dirt with 25 ml of distilled water) and the pH measurement with a pH metre.

2.2.4 Soil Electrical Conductivity

The electrical conductivity of a soil sample was determined using a soil water suspension prepared for the study of soil pH. The electrical conductivity of the soil is determined using an EC metre and expressed as dS/m **[8].**

2.2.5 Soil Porosity

The formula was used to calculate porosity using bulk density and particle density measurements.

$$\text{Per cent Porosity} = \frac{1-BP}{PD} \text{ x } 100$$

where, B D = Bulk Density

P D = Particle Density

2.2.6 Available Nitrogen

The alkaline Potassium permanganate method proposed by Subbiah and Asija was used to determine the available Nitrogen content in soil using a Kjeldhal semi-auto Nitrogen analyser**.**

$$\text{Mineralization N (Kg/ha)} = \text{(S-V) x } 125.44$$

where, S = Sample titration reading

V = Blank titration reading

2.2.7 Soil Available Phosphorus

Available Phosphorus content in soil samples was determined by Olsen's method using Olsen's reagent (0.5 M NaHCO3, pH 8.5)

$$\text{Available P (kg/ha)} = \frac{\text{Absorbency X dilution factor X 2.24}}{\text{Slope of the standard curve}}$$

2.2.8 Available Potassium

The Flame Photometer (1 N ammonium acetate extract) method is used to estimate the available potassium content of soil **(Hanway and Heidel , 1952) [9],**

$$\text{Available K (kg/ha)} = \text{C x dilution factor x 2.24}$$

where, C= Concentration of K in the sample from standard curve against the reading

2.2.9 Available Sulphur

Estimation of Sulphur in the soil by Turbidity method **(Chesnin and Yien, 1950) [10],**

$$\text{Available Sulphur (mg Kg}^{-1}\text{)} = R\ X\ \frac{50}{10}\ X\ \frac{1}{10}$$

where, R stands for S content in μg as read on X-axis

2.2.10 Organic carbon

Organic carbon of soil sample was estimated by **Walkey and Black (1934) [11]** method of wet oxidation, using the formula-

$$\text{\% Organic carbon} = Organic\ Carbon \frac{(B-C)}{Weight\ of\ the\ soil} \text{ X 0.0003 X 100}$$

where, A = Volume of 0.5N ferrous ammonium sulphate required to neutralize 10 ml of 1N of $K_2Cr_2O_7$ i.e. blank titration (blank reading).

B = Volume of 0.5N ferrous ammonium sulphate needed for titration of soil sample (reading with soil).

Table 1: Rating of the soils test values for different Nutrients.

Nutrients	**Testing Values**		
	LOW	**MEDIUM**	**HIGH**
Organic Carbon (%)	< 0.5	0.5 - 0.75	> 0.75
Available Nitrogen (kg/ha)	< 280	280 - 560	> 560

Available Phosphorus (kg/ha)	< 10	10 – 25	> 25
Available Potassium (kg/ha)	< 118	118 - 280	> 280
Available Sulphur (mg/kg)	< 10	10 – 20	> 20

3. RESULTS AND DISSCUSION

The purpose of this chapter is to identify the degree of variation seen in the various depth levels of distinct land use systems. The physiochemical characteristics of soil and the pools of soil organic carbon were determined.

3.1 Soil Physical Parameter under different land use systems:

3.1.1 Particle Density

Soil ranged from 1.4 to 2.7 Mg/m^3 depending on different depth and land use system. The maximum particle density of 2.7 Mg/m^3 was found in cultivated land at depths of 15-30 cm whereas, the minimum particle density of 1.4 Mg/m^3 was found at 0-15 cm depth in forest terrain. Rigorous examination of the analysis data showed that the particle density of soil varied significantly with different land use system and depth. The leaf litter becomes a part of soil and reduce the particle density of soil in land use regimes, which are richer sources of organic matter. As **Li *et al*., 2007 [12]** showed soil particle density was significantly affected by land use at all depths. Cultivation had substantially decreased total organic C concentration in soil at depths ranging from 0–30 cm, as consistent with other reports by **Wu and Tiessen, (2002) [13].**

3.1.2 Bulk Density

The bulk density of soil found to be varied significantly with the different land use systems and depth. The bulk density ranged from 1.30 to 1.58 Mg/m^3. The maximum bulk density of 1.58 Mg/m^3 was found in crop cultivated land at depths of 15-30 cm whereas, the minimum bulk density of 1.30 Mg/m^3 was found between 0 and 15 cm in forest land. Bulk density and porosity were significantly affected by land use only when averaged across all depths. Bulk density is largely controlled by soil organic matter content **[14].** Soil bulk density is a function of soil organic matter, aggregate stability and size distribution, and soil particle density **[15].**

3.1.3 Water Holding capacity

The water holding capacity for different depth of the soil ranged from 42.18 to 49.70 per cent (Table 2). The maximum water holding capacity of 49.70 per cent was found in cultivated land followed at 0-15 cm depth and the minimum water holding capacity of 42.18% was found at 15-30 cm in fruit cultivated land A close examination of the data revealed that the water holding capacity of soil changed considerably with soil depth. It is widely accepted that both soil water holding capacity is directly accepted with the soil organic matter content **[16].**

3.1.4 Porosity

The soil porosity varied from 41.43 to 48.68 per cent depending on the depth of the soil (Table 2). The highest porosity of 48.68 per cent was found in cultivated land between 0-15 cm depth and the minimum porosity of 41.43 per cent was found in a plantation crop between 15-30 cm depth. A close examination of the data revealed that the porosity of soil changed considerably with soil depth. Changes in porosity were highly sensitive to soil water content. A decrease in organic matter would cause a decrease in porosity, thereby reducing soil infiltration, and water and air storage capacities **[17]**.

Table 2: Particle Density, Bulk Density, Porosity and Water Holding capacity under different land use systems in Krishna District, Andhra Pradesh.

Land Use System	Bulk Density (Mg/m^3)		Particle Density (Mg/m^3)		Porosity %		WHC %	
Soil Depth (cm)	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Cultivated	1.44	1.58	2.4	2.7	48.68	47.22	49.70	47.60
Plantation	1.33	1.36	1.5	1.9	42.54	41.43	43.18	42.30
Forest	1.30	1.32	1.4	1.8	43.76	42.54	42.49	40.83
Fruit	1.47	1.48	2.1	2.3	45.84	43.16	43.92	42.18
Vegetable	1.37	1.40	1.8	2.0	45.94	43.68	48.12	45.20
SE	0.06	0.05	0.15	0.09	2.0	1.87	1.56	1.42
CD	N/A	0.16	0.45	0.28	N/A	N/A	4.74	4.29

3.2 Analysis of Soil Chemical Parameter under Different Land Use Systems:-

3.2.1 Soil pH

Soil pH values ranged from 6.2 to 7.7 at different depths and land use system as shown in Table 3. The highest pH of 7.7 was found in vegetable cultivated land at the depth of 15-30 cm whereas, the minimum pH was observed at the depth of 0-15 cm in the fruit cultivated land. The pH of the soil is among the most helpful and widely determined soil chemical characteristics and it has a direct impact on plant growth. It is a significant determinant of plant element availability.

3.2.2 Electrical Conductivity

The electrical conductivity of the soils varied from 0.11 to 0.44 dS/m. Vegetable crops soils had the highest electrical conductivity value 0. 44 dS/m between 0-15 cm depths. The minimum electrical conductivity of 0.11 dS/m was observed in a fruit cultivated land at a depth of 15-30 cm. Further analysis of the data showed that the EC of soil varied non-significantly with different land use regimes.The chemical property of soil electrical conductivity has a direct impact on crop productivity. As cations or anions, the plant receives all of the major and minor nutrients it needs to grow. Soil Electrical Conductivity is linked to certain soil factors which impact crops output, such as the depth of the topsoil, the pH, the levels of salt, and the ability to store water **[18].**

Table 3: Soil pH and Electrical Conductivity under different Land Use Systems in Krishna District, Andhra Pradesh.

Land Use System	**pH**		**EC (dS/m)**	
Soil Depth (cm)	**0-15**	**15-30**	**0-15**	**15-30**
Cultivated	7.1	7.3	0.34	0.12
Plantation	6.4	6.6	0.39	0.17
Forest	6.3	6.5	0.35	0.28
Fruit	6.2	6.5	0.27	0.11
Vegetable	6.8	7.7	0.44	0.23
SE	0.19	0.36	N/A	N/A
CD	0.59	N /A	0.04	0.05

3.3 Analysis of Organic Carbon and Soil Available Nutrients under Different Land Use Systems:-

3.3.1 Soil Organic Carbon

At different depths, the soil organic carbon levels varied from 0.22 to 0.77 per cent as shown in Table 4. The highest level of organic carbon 0.77 per cent was found in forest land between top 0-15 cm soil profile. The lowest level (0.22 per cent) of the soil organic carbon content was found at 15-30 cm depth in the vegetable cultivated land. As per the findings fruit and cultivated crops had a medium content at 0-15 cm depth, whereas cultivated and fruit crops had low organic carbon content. Analysis revealed that the soil organic carbon content varied significantly with different Land Use systems and as the depth of soil increased, the soil organic carbon content reduced. The high organic load of plant litter in forest and plantations could explain the rise in organic carbon content and soil with a high organic matter concentration has better physical and chemical qualities **[19], [20].**

Table 4: Soil Organic Carbon,Available Nitrogen, Phosphorous, Potassium and Sulphur content

Land Use System	Organic Carbon (%)		Nitrogen (kg/ha)		Phosphorous (kg/ha)		Potassium (kg/ha)		Sulphur (mg/kg of soil)	
Soil Depth (cm)	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Cultivated	0.49	0.38	260.32	236.91	15.67	13.83	202.34	169.93	8.64	8.05
Plantation	0.62	0.53	250.41	237.85	13.72	13.67	152.43	139.82	6.56	6.38
Forest	0.77	0.71	280.17	251.47	14.63	14.07	162.37	157.74	6.91	6.61
Fruit	0.56	0.38	222.99	218.62	14.37	11.61	213.65	207.28	7.54	7.17
Vegetable	0.31	0.22	243.59	236.27	18.63	16.96	203.84	183.68	7.96	7.81
SE	0.12	0.09	12.66	9.21	3.13	3.18	11.82	20.78	0.47	0.53
CD	N/A	0.28	N/A	N/A	1.03	1.05	35.74	N/A	1.42	N/A

3.3.2 Available Nitrogen

The amount of available nitrogen at two different depths in the soil ranged from 280 to 218 kg/ha (Table 4). Forest soils have the highest available nitrogen content of 280 kg/ha in top soil (0-15 cm) whereas, lowest available nitrogen content of 218 kg/ha found between the depth of 15-30 cm in the Fruits cultivated land. Further examination of the data showed that the topsoil available nitrogen concentration varied non-significantly with different Land Use systems and the nitrogen content decreases with depth **[21].**

3.3.3 Available Phosphorus

The available phosphorus content of soil changed significantly for different land use system and soil depth. The available phosphorus varied from 18.63 to 11.61 kg/ha (Table 4). Vegetable land showed the highest available phosphorus content of 18.63 kg/ha at 0-15 cm depth. Deep down, at 15-30 cm the Fruit cultivated land soils had the least available phosphorus content of 11.61

kg/ha. The accessible phosphorus concentration in soils of all plantings was in the medium range and gradually decreases with increasing soil depth. Organic P was highest on the surface soil of the virgin land followed by the farmer's field. The largest depletion organic phosphorus occurred due to long term cultivation compared with the soils under natural forest vegetation **[22]**.

3.3.4 Exchangeable Potassium

At varying depths and land use system of soil, exchangeable potassium ranged from 213.65 to 139.82 kg/ha (Table 4). Fruit cropped land soils showed the highest level of exchangeable potassium 213.65 kg/ha at 0-15 cm. At a depth of 15-30 cm, the least exchangeable potassium concentration of 139.82 kg/ha was found under plantation soils. The exchangeable potassium concentration in all land use system was in the medium to high range and with increasing soil depth, it gradually decreased. The exchangeable potassium content of soil varied greatly with different land use systems and soil depth. Available phosphorus content in surface layer soil in all land use types was higher than that of the sub-surface horizons **[23]**.

3.3.5 Available Sulphur

The available sulphur content at various soil depths and alnd use system varied from 6.38 to 8.64 mg/kg. The maximum available sulphur 8.64 mg/kg was recorded in the soils of cultivated crops at 0-15 cm soil layer followed by vegetable soils (7.96 mg/kg). The minimum available sulphur content of 6.38 mg/kg was recorded under plantation land use, at 15-30 cm depth. The available Sulphur content in different land use system were under low category and it progressively decreased as soil depth increased. The available sulphur content of soil varied non-significantly with various land use system. **Jiang *et al*., 2007 [24]** also reported non-significantly distribution of total sulphur under different land uses.

CONCLUSION

Experimental results, reveled the physiochemical properties of Krishna district of Andhra Pradesh under different five different land use system at two different depths of 0-15 cm and 15-30 cm. Maximum bulk density, particle density and water holding capacity was recorded in normally cultivation land at lower depth of 15-30 cm and highest porosity was reported in cultivation land use system at upper soil layer (0-15 cm). It had been observed that soil bulk density and particle density increased with depth, and water holding capacity decreased with depth. Forest land had showed the maximum organic carbon content in upper soil (0-15 cm) as well as lower soil (15-30 cm) due high organic load of plant litter in forest whereas least carbon content was found in cultivated land soil. More availability of nitrogen, phosphorus, potassium and sulphur were reported in upper soil layer (0-15 cm) in all land use system considered in this study and also, found to depleting with depth. Due to varying levels of soil Organic Carbon and aggregation dynamics, different land uses have varying carbon sequestration potentials. Thorough understanding of the spatial variability of soil nutrients in relation to site properties such as climate, land use, topography, and other variables required for understanding the functioning of the ecosystem and determining the effects of further land use change on soil properties. The results of this study indicate that land use has an impact on many soil physiochemical properties. This study have a great importance for improving the standard of the produce, raising crop yields by a greater percentage through soil conservation and better preservation of the environment.

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