Physico-chemical characterization of soils in the selected distributaries of TLBC command area, Raichur

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Abstract

An attempt has been made to analyze soils physically by determining the soil texture, bulk density, infiltration rate, hydraulic conductivity and chemically by determining the soil pH, EC and the soil micro and macronutrients using standard laboratory procedure for the selected three distributaries (D-17, D-65 and D-95) of TLBC command area, Raichur, Karnataka. The results reveled that, the soils of the selected distributaries of the command area were classified as clayey soils with more than 35 per cent of clay fraction in the soil. The mean soil bulk density of 1.52, 1.68 and 2.1g cc^{-1}, the average basic infiltration rate of 2.30, 3.53 and 2.10 cm hr^{-1}, the average hydraulic conductivity of 0.185, 0.203 and 0.136 m day^{-1} was observed in head (D-17), middle (D-65) and tail (D-95) reaches of the TLBC command area respectively. The soil pH varied from 8.21 to 8.53, 8.11 to 8.18 and 7.46 to 8.23, the electrical conductivity ranged from 0.911 to 1.13 dS m^{-1}, 0.85 to 1.28 dS m^{-1} and 0.76 to 0.9 dS m^{-1} respectively for distributary D-17, D-65 and D-95. The average organic carbon content in the selected distributaries of TLBC command area *viz.,* D-17, D-65 and D-95 were estimated as 0.58, 0.6 and 0.61 per cent respectively. The available macro and micro nutrient status of the soils in the selected distributaries were analyzed According to the soil test rating of primary, secondary and cationic micronutrients, the Available Nitrogen was medium in the D-17 and low in the D-65 and D-95), the Available Phosphorous and Available Potassium were in medium range. The soils of all the selected distributaries were found to be low in Available Sulphur content, and high in exchangeable Magnesium, Copper, Iron and Zinc content.

Keywords: Soil physical and chemical properties, micro and macro nutrients, distributaries, TLBC command area.

1. Introduction

Land and water are finite natural resources, which are diminishing due to indiscriminate and unscrupulous exploitation. Due to increasing population pressure, situation becomes more serious and calls for efficient and productive utilization of resources. Increasing population leads to overexploitation of productive lands which creates serious problem of lowering the fertility status of soil and it leads to deterioration of soil. The deficiency of nutrients directly affects on the growth of crops and crop response become poor. Hence it is necessary to assess the fertility status of soil with the consideration of available micro and macro nutrients in soils and to recommend the specific nutrients for the proper management of soil. Information on soil fertility status in crop field is very important and useful for fertilizer requirement and also to the specific management of the crop and soil (Bai *et al.,* 2017). Soil salinity and water logging are the twin problems of Tungabhadra Project (TBP) command due to unscientific land and water management and violation of cropping pattern over the decades. As reported by Rashid *et al.,* (2004) even though micronutrients are required in relatively smaller quantities for plant growth, they are as important as macronutrient in rice production to obtain optimum yield and balanced nutrition. Most micronutrients are usually poorly available in salt affected soils, a fact which is generally attributed to the high soil pH and salt stress. Generally, the solubility of cationic trace elements decreases as pH increases, while the solubility of the anionic trace elements increases as the pH increases. Therefore, micronutrients such as copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) exhibit low levels of solubility in sodic soils, which may result in micronutrient deficiencies. It is reported that presence of major nutrients affects crop uptake of micronutrient due to either negative or positive interactions (Shridhar *et al.,* 2019). Information on the characterization of salt affected soils through ground truth in the command area at distributary scale is meagre or lacking and particularly no such information on micronutrient status is available for soils of three selected distributaries D-17, D-65 and D-95 of TLBC command area. Hence, in view of the above the present study was undertaken.

1.1 Study Area

The river Tungabhadra is a sacred river in southern India which flows through the state of Karnataka and Andhra Pradesh. The river Tungabhadra derives its name from the Tunga, and the Bhadra, formed by the confluence of two rivers, the Tunga and the Bhadra, which flow down the eastern slope of the Western Ghats in the state of Karnataka at an altitude of about 1,196 m. Major tributaries are the Bhadra, Haridra, Vedavati, Tunga, Varda and Kumdavathi (Brochure 2019, River Basin Profile Tungabhadra Sub-Basin Karnataka).Tungabhadra irrigation project is an inter-state multipurpose project which is constructed across the Tungabhadra River at Mallapur village about 5 kms from Hospet town, Vijayanagar district, Karnataka (Fig. 1). The Tungabhadra project was built to provide water to the area of 5.23 lakh hectares. In that 3.63 lakh hectares is given to Karnataka state and 1.6 lakh hectares is for Andhra Pradesh.

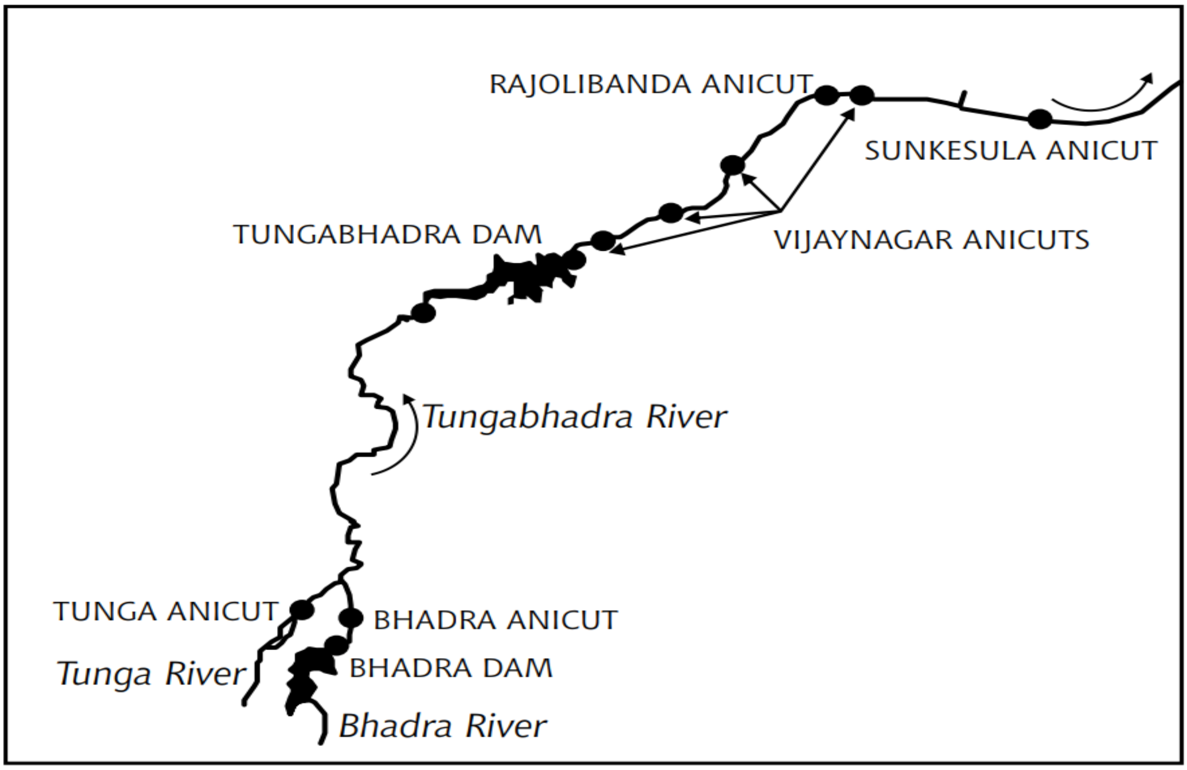

Fig. 1. Formation of Tungabhadra River with dams and anicuts

The present research study was focus on Tungabhadra Left Bank Canal (TLBC) command area which lies from 15° 15.50' 46" N, 76° 19' 43" E and 16° 10.27' 26" N, 77° 19' 50" E at an elevation of 402-516 m above the mean sea level. The irrigation water is supplied from the Tungabhadra dam through 227 km long main canal to 106 distributaries having the total command area of 244,000 ha.

The selection of the sample (distributary) was based on stratified sampling, the strata being distributary, outlet, village and farm households' size of the distributary in terms of designed discharge of water, area irrigated, crops grown and extent of area affected by waterlogging, salinity and alkalinity and the presence of a WUA were the main criteria for selection the outlet. Based on these criteria, three outlets under the distributary number 17, 65, and 95 from Tungabhadra Left Bank Canal (TLBC) at the upper, middle and lower reaches of the main canal were selected.

The three distributaries namely, D-17 (distributary-17) near Gangawathi, D-65 (distributary-65) near Halapur and D-95 (distributary-95) near Atnur village of TLBC command area were selected for the detailed study of water productivity and are presented in Fig. 2 and the geographical locations arial extent of selected distributaries of TLBC command area are presented in Table 1.

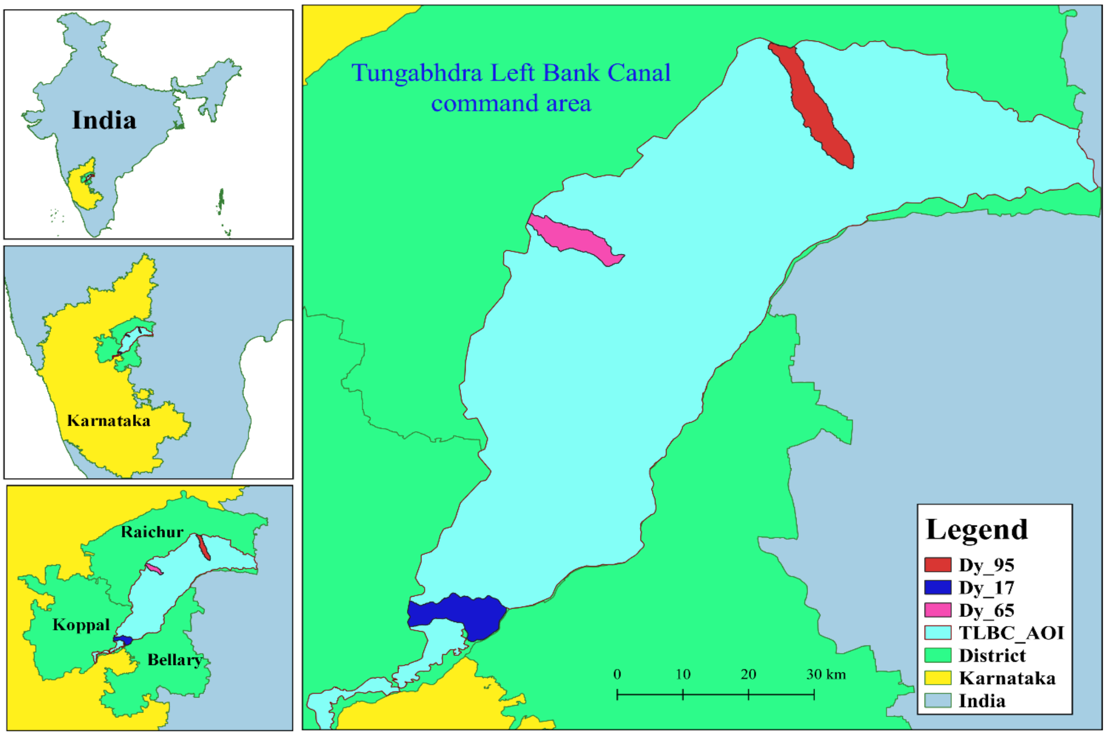

Fig. 2. Location map of selected distributaries of TLBC command area

Table 1. Details of geographical location of selected distributaries of TLBC command area

Particular	TLBC	D-17	D-65	D-95
Elevation (m)	516-358	466-419	453-403	433-392
Latitude (N)	15°15' 50''	15° 26' 36.40"	16° 0' 56.22"	16°13' 23.93"
Longitude (E)	76° 20' 60"	76° 28' 4.53"	76° 42' 29.50"	77° 5' 57.91"
Area (ha)	244103	3955.08	3180.53	3026.75
Length (km)	227	15.97	14.46	11.36
Designed discharge (cumecs)	87.761	2.77	0.99	0.96
Actual discharge (cumecs)*	116.12	2.63	1.59	0.82

*Actual discharge data provided by the Tungabhadra board, Annual report, 2020-21.

The climate of the command area is characterized by oppressive hot weather in the summer season extending from the middle of February to middle of June. The average annual rainfall of the area is 650-700 mm. However, the actual rainfall is considerably lesser than this. The number of rainy days is very less with hardly 29 days on an average. The period from July to September is having surplus water while remaining month of the year are under water deficit. The major part of the command area is dominated by black cotton soils. The other soils include like reddish sandy soil, light grey loamy soil and the reddish-brown soil. In Irrigated areas, paddy is grown in the entire command area, where as in *Rabi* the head and middle reach farmers go for the paddy (second crop) and in tail reaches of the farmers grow the cotton, maize and other crops. The rainfed crops during *Rabi* includes cereals, pulses and oilseeds.

2. Methodology

The characterization of soil and water was done to know the different soil properties which are responsible for the plant growth and development and water characteristics to increase the crop yield, crop productivity and water productivity. The characterization of soil and water includes the analysis of soil physically and chemically by using standard procedure. The soil sampling was carried out in the study area based on Global Positioning System (GPS) reading. A total of nine soil samples at each side of the distributary were collected at different depth of 30, 60, 90 and 120 cm. The soil samples were air dried in the shade, ground in wooden pestle and mortar and passed through 2 mm sieve. The soil samples were analyzed physically and chemically by using following the standard methods.

2.1 Analysis of physical properties

The samples are analyzed for physical such as soil texture, bulk density, hydraulic conductivity, infiltration rate, and chemical properties such as soil pH, electrical conductivity (EC), organic carbon (OC), mineral nitrogen (N), Available Phosphorous and Potassium. Micronutrient analysis for the other micro and beneficial elements are analyzed in the pesticide residue and food quality analysis laboratory.

A. Soil texture

Textural classification of soil was carried out by the international pipette method using sodium hexa-metaphosphate as a dispersing agent described by Piper (1966). The results were reported as clay, silt and sand on moisture free basis and textural class was determined by USDA textural classification.

B. Bulk density

Bulk density (BD) is a simple measure of soil structure, with measurements made over the course of many routine soil surveys to determine soil compaction and porosity. BD is defined as the ratio of the mass of an oven-dried soil sample to its bulk volume. Bulk density is classically evaluated with the core method, which consists of sampling the soil by pressing or driving a steel cylinder to a desired depth, then carefully removing the cylinder to obtain an exact volumetric sample.0

C. Infiltration rate and hydraulic conductivity

The infiltration rates are measured at selected locations of each distributary by using double ring infiltrometer. Infiltrometer and inverse auger hole methods based on similar hypothesis and are employed for measuring in-situ saturated hydraulic conductivity of soil. Infiltrometer method is suitable for measurement of vertical saturated hydraulic conductivity of surface soil while inverse auger hole method is suitable for determination of horizontal saturated conductivity of subsoil.

Hydraulic conductivity is measured by digging the hole into the soil to a certain depth below the water table. When equilibrium is reached with the surrounding groundwater, a part of the water in the hole is removed. The water seeps into the hole again, and the rate at which the water fall in the hole is measured and then converted by a suitable formula to the hydraulic conductivity (K) for the soil.

$$K = 1.15r \times \frac{\log(h_o + (\frac{1}{2})r) - \log(h_t + (\frac{1}{2})r)}{t - t_o} \quad \text{--- (1)}$$

where,

K = Hydraulic conductivity, m day^{-1}

t = Time since the starting of measurements, s

h_t = Height of water column in the hole at time ‘t’, cm

h_o = Height of water column at time ‘to’, cm

r = Radius of the hole, cm

Soil organic carbon was determined by Walkley and Black's wet oxidation method using potassium dichromate and sulphuric acid. (Jackson, 1973).

2.2 Analysis of chemical properties

The soil samples are collected in selected distributaries areas based on the Global Positioning System (GPS) readings. The soil samples are air dried in the shade, ground in wooden pestle and mortar and passed through 2 mm sieve. The soil samples are analyzed for electrical conductivity (EC), soil reaction (pH), N, P and K by following the standard methods.

A. Soil reaction (pH) measurement

The pH meter was calibrated using pH 7 buffer solution. The pH of buffer solutions of 4.0 and 9.2 was adjusted. Then 20 g of soil was weighed and transferred into 100 ml beaker. 50 ml distilled water was added and stirred well with a glass rod. This is allowed to stand for half an hour with intermittent stirring. To the soil water suspension in the beaker, the electrode was immersed and pH value was determined from the automatic display of the pH meter. The soil samples were analyzed for pH in 1:2.5 soil water suspension using digital pH meter and the readings were noted.

B. Soil salinity (ECe)

The soil samples collected at different distributaries during the study period were analyzed for soil salinity by weighing the 20 g air-dried, grounded soil samples. Then adding the distilled water to each 20 g soil sample in the ratio of 1:2.5 soil to water. The soil water mixture was shaken vigorously for five minutes and was left to stand for 24 h in containers. The EC of the extract was measured using the EC meter and the readings were noted.

C. Available Nitrogen

The Available Nitrogen was determined by alkaline potassium permanganate method (Hesse, 1971). A known weight of soil was treated with excess of 0.32 per cent potassium permanganate with 25 per cent NaOH solution. The liberated ammonia was trapped in boric acid mixed indicator solution and determined by titration against standard H_2SO_4. The Available Nitrogen content of the soil was calculated using equation.

$$N\ (kg\ ha^{-1}) = \frac{T.V \times N\ of\ H_2SO_4 \times 0.014 \times 10^6}{Wt.\ of\ soil\ sample} \times 2.24 \qquad \text{--- (2)}$$

D. Available Phosphorous

Available phosphorus in soil was extracted by Olsen's extractant and phosphorus is determined by stannous chloride molybdophosphoric blue colour method (Hesse, 1971). Available Phosphorus in soil was extracted by using 0.5 M $NaHCO_3$. The blue colour was developed by chloromolybdic acid and intensity of blue colour was determined at 660 nm. The Available Phosphorus content of the soil was calculated using equation.

$$P\ (kg\ ha^{-1}) = \frac{Gr\ ppm}{10^6} \times \frac{vol\ of\ extract}{wt.\ of\ soil} \times \frac{vol\ made}{vol\ of\ aliquate} \times 2.24 \times 10^6 \qquad \text{--- (3)}$$

E. Available Potassium

Available potassium was extracted with neutral normal ammonium acetate solution and was determined using flame photometer as described by Jackson (1973). The Available Potassium content of the soil was calculated using equation.

$$K\ (kg\ ha^{-1}) = \frac{Gr.\ ppm}{10^6} \times \frac{Vol.\ of\ exracant}{Wt.\ of\ Soil} \times 2.24 \times 10^6 \qquad \text{--- (4)}$$

2.3 Micronutrient and pesticide residue analysis

The Available micronutrients present in soils was estimated by the method developed by Lindsay and Novell using DTPA (Diethyl Triamine Penta Acetic Acid) which was found useful for separating soils into deficient and non-deficient categories for micronutrients by using atomic absorption spectrophotometer (Nigam *et al.,* 2014). The step by procedure involved in the estimation of soil nutrients in soil. The results obtained from the analysis are compared with international agricultural standards (Table 2) and permissible limits for soil micro and macro nutrients and discussed.

3. Results and discussion

3.1 Analysis of Soil physical properties

The soil samples from the three (D-17, D-65 and D-95) selected distributaries of the study area were analysed for different soil physical properties such as soil texture, bulk density, hydraulic conductivity, infiltration rate chemical properties *viz*., soil reaction, soil salinity, micro and macro nutrients of the soil were determined based on standard procedures. The Table 3 shows the Percentage of sand, silt and clay and the results of Physico-chemical properties of the soils in the selected distributaries of the study area is presented in Table 4.

Table 2 International agricultural soil standards

Sl. No.	Parameter	Units	Permissible limits
1	Phosphorus (P)	mg kg^{-1}	> 7
2	Potassium(K)	mg kg^{-1}	> 80
3	Organic matter	%	> 0.86
4	Soil salinity (pH)	Unitless	4 - 8.5
5	Soil reaction (EC_e)	mS cm^{-1}	4
6	Copper (C)	mg kg^{-1}	100
7	Mercury (Hg)	mg kg^{-1}	1.0
8	Cadmium (Cd)	mg kg^{-1}	1.0
9	Chromium (Cr)	mg kg^{-1}	100
10	Arsenic (As)	mg kg^{-1}	30
11	Lead (Pb)	mg kg^{-1}	500
12	Iron (Fe)	mg kg^{-1}	NGVS
13	Manganese (Mn)	mg kg^{-1}	500
14	Nickel (Ni)	mg kg^{-1}	20
15	Zinc (Zn)	mg kg^{-1}	250

Source: Alloway (1990)17 NGVS: No. guideline value set

A. Soil textural classification

The average percentage of sand, silt and clay in the D-17 was 36.9, 19.6 and 43.5 0-30 cm depth, 32.6, 20.5 and 46.9 at 30 – 60 cm depth, 30.4, 17.2 and 52.4 per cent at 60-90 cm depth and 31.7, 19.8 and 48.5 per cent at 90-120 cm depth respectively.

The average per centage of sand, silt and clay in the D-65 was 35.5, 17.6 and 46.6 per cent at 0-30 cm depth, 33.6, 18.2 and 48.2 per cent at 30 – 60 cm depth, 34.3, 14.5 and 51.2 per cent at 60-90 cm depth and 35.5, 15.6 and 48.9 per cent at 90-120 cm depth respectively. The average percentage of sand, silt and clay in the distributary D-95 was 35.5, 16.1 and 48.4 per cent at 0-30 cm depth, 34.3, 15.9 and 49.8 per cent at 30-60 cm depth, 33.1, 15.2 and 51.7 per cent at 60-90 cm depth and 34.4, 16.7 and 48.5 per cent at 90 to 120 cm depth respectively.

Table 3. Percentage of sand, silt and clay in selected distributaries of study area

Distributary	Soil depth, cm	Sand (%)	Silt (%)	Clay (%)	Textural class
D-17	0-30	36.9	19.6	43.5	Clay
	30-60	32.6	20.5	46.9	Clay
	60-90	30.4	17.2	52.4	Clay
	90-120	31.7	19.8	48.5	Clay
D-65	0-30	35.8	17.6	46.6	Clay
	30-60	33.6	18.2	48.2	Clay
	60-90	34.3	14.5	51.2	Clay
	90-120	35.5	15.6	48.9	Clay
D-95	0-30	35.5	16.1	48.4	Clay
	30-60	34.3	15.9	49.8	Clay
	60-90	33.1	15.2	51.7	Clay
	90-120	34.4	16.7	48.9	Clay

As per the textural triangle diagram according to ISSS system of classification of soil particles, the soil contains more than 35 per cent of clay fraction the soils can be classified as clayey soils, Phogat *et al.,* (2016). The results show that, the soils of the study area are classified as clayey soil of fine textured soil. Similar results were reported by Rajkumar *et al.,* (2019) at 0-30, 30-60 and 60-90 cm depth in the soils of D-17 of Tungabhadra canal command area.

B. Bulk density

It is an indirect measure of pore space within a soil. The higher the bulk density, more compact is the soil and smaller is the pore space. The bulk density of the selected distributaries D-17, D-65 and D-95 was 1.27 to 1.74 g cc^{-1}, 1.26 to 1.76 g cc^{-1} and 1.28 to 1.71 g cc^{-1} respectively. Similar results were reported Rajkumar *et al.,* (2018 and 2019) over TBP command area.

C. Infiltration rate and hydraulic conductivity

The infiltration rate of the soils of the selected distributaries varied from 0.32 to 4.29 cm hr^{-1} for the distributary D-17, while it varied from 2.02 to 5.04 cm hr^{-1} for D-65 and 0.29 to 3.92 cm hr^{-1} for D-95 respectively. According to the guidelines for basic infiltration rate for various soil types, the soils of the study area could be classified as very slow to slow infiltration rate soil, Srinivasan and Poongothai (2013). Rajkumar *et al.,* (2018) also reported the similar results for infiltration rate in the soils of TBP command area.

Table 4. Physico-chemical properties of the selected distributaries of the study area

Parameter	Unit	D-17	D-65	D-95
Bulk density	g/cc	1.27 - 1.74	1.26 - 1.76	1.28 - 1.71
Infiltration rate	mm/h	0.32 - 4.29	2.02 - 5.04	0.29 - 3.92
Hydraulic conductivity	m/day	0.11 - 0.25	0.12 -0.28	0.04 -0.23
soil reaction (pH)	Unitless	8.21 - 8.53	8.11 - 8.18	7.63 - 8.23
soil salinity (EC_e)	dS/m	0.91 -1.13	0.85 - 1.28	0.76 - 0.9
Organic carbon	%	0.58	0.60	0.62

The hydraulic conductivity is a measure of the water transmitting capacity of soils. The Hydraulic conductivity ranged from 0.112 to 0.259 m day^{-1} in the soils of D-17, 0.121 to 0.286 m day^{-1} in the soils of D-65 and 0.042 to 0.231 m day^{-1} in the soils of D-95 respectively. Similar results were reported by Manjunatha *et al.,* (2004) for the TBP command area.

D. Soil reaction

The reaction of a soil refers to its acidity or alkalinity. It is an important indicator of soil health. It can be easily measured and is usually expressed by the pH value. The average soil pH of the selected distributaries of the TLBC command varied from 8.21 to 8.53 for D-17, 8.11 to 8.18 for D-65 and 7.63 to 8.23 for D-95 indicating that the soils are slightly to moderately alkaline. Yeledalli *et al.,* (2008) and Rajkumar *et al.,* (2019) reported the similar average pH value 8.2 for Tungabhadra canal command area. The variation in soil pH was related to the parent material, and topography. Relatively higher pH value in black soils was due to the accumulation of the high amounts of exchangeable bases in sodium as they are poorly drained (Dasog and Patil, 2011).

E. Electrical conductivity (EC_e)

The electrical conductivity values for the study area varied from 0.911 to 1.13 in the soils of D-17, 0.85 to 1.28 in the soils of D-65 and 0.76 to 0.9 dS m^{-1} in the soils of D-17. The electrical conductivity ranged from 0.76 to 1.28 dS m^{-1} with mean value of 1.02 dS m^{-1}. All of the soil samples are under 1 dS m^{-1}. It indicates that the soils are saline in nature as suggested by Muhr *et al.,* (1963). The prolonged waterlogging condition, high application of fertilizers and pesticides, taking up of same crop continuously without any mixed cropping methods and higher evaporation leads to accumulation of salt on the surface of the soil influences the increase in electrical conductivity in the study area.

F. Organic carbon:

Soil organic carbon is a measurable component of soil organic matter. Organic matter makes up just 2 to 10 per cent of most soils mass and has an important role in the physical, chemical and biological function of agricultural soils. Soil organic carbon tends to be concentrated in the topsoil. Topsoil ranged from 0.5 per cent to 3.0 per cent organic carbon for most upland soils. The average organic carbon content in the selected distributaries of TLBC *viz*., D-17, D-65 and D-95 were 0.58 per cent, 0.6 per cent and 0.61 per cent respectively. Similar OC of 0.5 to 0.6 per cent were obtained by Yeladalli *et al.,* (2008), Rajkumar *et al.,* (2018) over TBP command area. Manjunath *et al.,* (2004) also reported the presence of 0.5 per cent organic carbon content over TBP in the LBMC command on D-36/1 distributary canal.

3.2 Available Macro and micro nutrient status in the study area

Macronutrients (N, P and K) and Micronutrients (Fe, Mn, Zn, and Cu) are important soil elements that controls soil fertility. Top soil confine humus, an important food resource for plants, which increase biological activity, soil fertility and control the air and water content of soil. Table 5 shows the nutrient content in the soils of the selected distributaries of the TLBC command area.

Table 5 Nutrient status in the selected distributaries of the study

Nutrient	Unit	D-17	D-65	D-95
Available Nitrogen	kg ha^{-1}	288.51	270.95	270.32
Available Phosphorous	kg ha^{-1}	37.41	34.27	29.79
Available Potassium	kg ha^{-1}	164.42	148.85	147.84
Available Sulphur	mg/kg	10.31	9.94	9.42
Exchangeable Calcium	mg/kg	83.14	2596.69	2338.63
Exchangeable magnesium	mg/kg	436.6	3148.43	3062.98
DTPA-extractable Iron	mg/kg	4083.45	7116.59	6931.21

DTPA-extractable Copper	mg/kg	2.14	7.74	7.36
DTPA-extractable Manganese	mg/kg	73.13	218.79	283.73
DTPA-extractable Zinc	mg/kg	17.02	16.35	19.22

A. Available Nitrogen

Nitrogen is an important factor to increase the soil fertility. The Available Nitrogen content in the soil of the selected distributaries of the command area was 288.51, 270.95 and 270.32 kg ha^{-1} for D-17, D-65 and D-95 respectively. According to the soil test rating of primary, secondary and cationic micronutrients, the Nitrogen available for plant growth in the D-17 was medium and low in the D-65 and D-95. The deficiency of Nitrogen shows uniform yellowing of older leaves including veins, leaves that will eventually turn brown and die. The low Nitrogen content was reported by Yeledhalli *et al.,* (2008) over TBP canal command area. Prasad *et al.,* (2020), Srinivasan and Poongothai (2013), and Binitha *et al.,* (2009) reported low to medium Nitrogen content in their respective study area and quoted the that, more volatilization occurs due to high temperature in semi-arid climate results in low Nitrogen content in the soils.

B. Available Phosphorus

Phosphorus is the second most critical plant nutrient which is essential for the growth of plants during flowering stage. It is estimated that 0.1 per cent of the total weight of the soil is from phosphorus. But only one per cent of it is available to plants. The available part is 50 per cent made up from organic matter. The Available Phosphorus status in the selected distributaries of the study area was 37.4, 34.27 and 29.79 kg ha^{-1} for D-17, D-65 and D-95 respectively. The Phosphorus content is medium range in the study area. Yeledhalli, *et al.,* (2008) reported low to medium rate of phosphorus content and decreased considerably with depth. The Phosphorous content can be increased by cultivation and phosphorus fertilization, Binitha *et al.,* (2009).

C. Available Potassium

Potassium is involved in water control and the transport of reserve chemicals in plants. It improves photosynthesis, strengthens cell tissue, and promotes nitrate absorption. The available Potassium content in selected distributaries of the study area was 164.42 148.85 and 147.63 kg ha^{-1} for D-17, D-65 and D-95 respectively. The Available Potassium status in the study area was medium. Yedalli *et al.,* (2009) reported the medium to high potassium content in the TLBC command area. Since the soils of the TLBC command area are derived from granite-gneisses parent rock containing Potassium bearing minerals like mica and feldspars. Binitha *et al.,* (2009) and Prasad *et al.,* (2020) reported medium to high Potassium content in the soils of their study area and confirmed that, the adequate amount of Potassium in the soils attributed to the prevalence of Potassium-rich minerals like Illite and Feldspars in the Inceptisols, Alfisols and Vertisols.

D. Sulphur

It helps in the formation of Chlorophyll, required for photosynthesis and tissue development. The concentration of Sulphur in the selected distributaries of the study area was 228.3 mg kg^{-1}, 215.1 mg kg^{-1} and 213.5 kg ha^{-1} for D-17, D-65 and D-95 respectively. The Sulphur content was low in the study area.

E. Calcium

It is essential for cell development and growth. Calcium helps in the mineral retention in the soil as well as their transfer and also helps in seed development. The Calcium content in the soil samples for D-17, D-65 and D-95 was 83.14, 2596.69 and 2338.63 mg kg^{-1} respectively. The low Calcium content was observed in the D-17 and high Calcium content was observed in the D-65 and D-95. Ananthanarayana, 1978 reported higher exchangeable Ca and Mg content can be obtained in black soils as the soils are calcareous soils than red and laterite soils.

F. Magnesium

Magnesium plays an active role in plant growth and metabolism. It regulates the ATP enzymes, carbon dioxide fixation, cellular pH control, chlorophyll content, chloroplast pigmentation and many other functions of crop development (Imran *et al.,* 2010). The Magnesium content in the selected distributaries D-17, D-65 and D-95 were 436.6 mg kg^{-1}, 3148.43 mg kg^{-1} and 3062.98 mg kg^{-1} respectively. The Magnesium content was high (more than 120 mg kg^{-1}) the study area. Similar result was reported by Binitha *et al.,* (2009).

G. Manganese

It activates enzymes involved in respiration, photosynthesis Nitrogen metabolism. It splits the water molecule to liberate the oxygen during photosynthesis. The average concentration of Manganese in the D-17, D-65 and D-95 was found to be 73.13, 218.79 and 283.73 mg kg^{-1}. According to International agricultural soil standards, the soil samples of the D-17 were found within the permissible maximum limits of 100 mg kg^{-1} whereas the D-65 and D-95 showed higher concentration. Srikanth *et al.,* (2008) reported that higher Available Manganese content in soils originated from granite genesis parent material with semiarid climate. High concentration of Manganese in soils can cause swellings of cell wall, weathering of leaves and brown spots on leaves.

H. Zinc

Plants obtain Zinc in the form of Zn^{2+} ions. It activates enzymes in the process of carboxylases. The concentration of Zinc was found to be in 17.02 mg kg^{-1}, 16.35 mg kg^{-1} and 19.22 mg kg^{-1} for D-17, D-65 and D-95 respectively. On the basis of Soil test rating of primary, secondary and cationic micronutrients, the Available Zinc concentration was high (greater than 1.2 mg kg^{-1}) in all the distributaries of the command area. Similar results were obtained by Imran *et al.,* (2010). The soil having greater surface area are capable of absorbing a greater number of ions and ion exchange thus it can contribute to greater DTPA-extractable forms of metal ions Prasad *et al.,* (2020).

I. Copper

Copper does not break down in the environment and can be accumulated in plants and animals when it is found in soil. It is absorbed as cupric ions (Cu^{2+}). It is essential for the overall metabolism in plants. The value of Copper in the soil samples was found to be 2.14, 7.74 and 7.36 mg kg^{-1} for the D-17, D-65 and D-95 respectively. Similar analysis for the estimation of Copper done by Arokiyaraj *et al.,* (2017) over Tamilnadu, Meena *et al.,* (2017) and reported that the increase in Available Copper content in the soil increase with increase in clay content, which might be due to the improvement in soil structure and aeration conditions of soils with increase in finer fractions in soil mass. Thus, the soils of the study area have higher amount of Copper content.

J. Iron

It is required for the formation of chlorophyll in plant cells and serves as an activator for biochemical processes such as respiration, photosynthesis and symbiotic Nitrogen fixation. The Available Iron content in in the selected distributaries D-17, D-65 and D-95 was 4083.45, 7116.59 and 6931.21 mg kg^{-1} respectively. On the basis of critical limits, the soils of the study area are high in Iron content.

4. Conclusion

The soils of the command area were classified as clayey soils, non-saline to saline with pH and EC_e ranging from 7.63 to 8.53 and 0.85 to 1.13 dS m^{-1} with very slow to slow infiltration capacity. The soils have medium to high concentration of micro and macro nutrients in the study area. All these said nutrients decreased with depth. Therefore, using the soils according to their potential and suitability and by applying the required management would optimize agricultural production in a sustainable manner. Special emphasis should also be given to soil organic matter management as it plays a major role in soil physical, chemical, and biological quality. Additionally, integrated soil fertility management should be implemented in the area to optimize and sustain crop production.

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