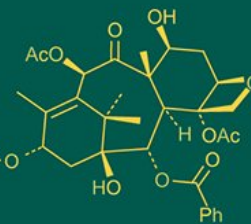
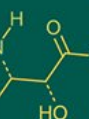
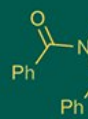


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**Shridhar**  
Department of Soil Science,  
College of Agriculture,  
KSNUAHS, Shivamogga,  
Karnataka, India

**Vishwanath J**  
Department of Soil Science,  
College of Agriculture,  
Gangavathi, Karnataka, India

## Primary and secondary nutrient status of salt affected soils of Hospet Taluk in TBP irrigation command area, Karnataka

**Shridhar and Vishwanath J**

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### Abstract

A study was conducted to assess the status of primary nutrients (available N,  $P_2O_5$ , and  $K_2O$ ) and secondary nutrients (exchangeable Ca, exchangeable Mg, and available S) and their relationship with soil properties in Hospet Taluk of Bellary district, Karnataka. Soil samples were collected during summer 2017 using GPS and topographic sheets at a scale of 1:50,000. A total of 82 soil samples were collected from 41 sampling points representing 15 grids on a  $5' \times 5'$  grid basis at two soil depths, namely 0-15 and 15-30 cm, and analyzed for primary and secondary nutrient status.

Among the primary nutrients, the majority of soil samples had low available nitrogen (95.12-97.60%) ( $<280 \text{ kg ha}^{-1}$ ), high available phosphorus (90.20-100%) ( $>56.3 \text{ kg ha}^{-1}$ ), and high available potassium (48.90-68.30%) ( $>336 \text{ kg ha}^{-1}$ ) at the surface and subsurface depths, respectively. Among the secondary nutrients, the majority of samples had low exchangeable magnesium (63.41-78.05%) ( $<10.3 \text{ meq } 100 \text{ g}^{-1}$ ) at both depths. For exchangeable calcium, the highest proportion of surface soil samples (51.20%) was in the medium category (12.5-25  $\text{meq } 100 \text{ g}^{-1}$ ), whereas the highest proportion of subsurface samples (48.80%) was in the low category ( $<12.5 \text{ meq } 100 \text{ g}^{-1}$ ). Regarding available sulphur, the highest proportion of surface soil samples (65.85%) was in the high category ( $>50 \text{ ppm}$ ), while the majority of subsurface samples (70.73%) were in the medium category (10-50 ppm).

**Keywords:** Primary nutrients, secondary nutrients, nutrient distribution, distribution mapping, salt-affected soils

### 1. Introduction

Soil is one of the most valuable natural resources upon which agricultural productivity largely depends. Salt-affected soils constitute an important category of degraded soils in which productivity is reduced because of excessive soluble salts, sodicity, or a combination of both. Salinity is generally associated with an electrical conductivity of the soil saturation extract (ECe) greater than  $4 \text{ dS m}^{-1}$ , whereas sodicity is commonly characterized by an exchangeable sodium percentage (ESP) greater than 15. Although all soils contain varying amounts of soluble salts, excessive accumulation of salts in the active root zone can adversely affect plant growth, crop yield, and produce quality. Salt-affected soils are generally distinguished from normal soils by higher concentrations of soluble electrolytes and/or exchangeable sodium (Szabolcs, 1989) [33].

The accumulation of salts in soil can induce several degradation processes, including soil dispersion, surface crust formation, deterioration of soil structure, reduced aggregate stability, and compaction. High concentrations of soluble salts may also interfere with nutrient availability and uptake, resulting in nutrient imbalances and, in severe cases, the accumulation of potentially toxic ions in plants (Priyadarshini, 2011) [17]. Based on the dominant constraint, salt-affected soils are broadly classified as saline, sodic, and saline-sodic soils. In India, these soils are generally categorized as saline and sodic (alkali) soils. According to the reconciled estimates of CSSRI, Karnal, NRSA, and NBSS&LUP (2006) [13], approximately 6.73 million hectares of land were affected by salinity and sodicity, comprising about 3.77 million hectares of sodic soils and 2.96 million hectares of saline soils. Earlier projections estimated that approximately 11.7 million hectares could be affected by salinity and alkalinity by 2025.

**Corresponding Author:**  
**Shridhar**  
Department of Soil Science,  
College of Agriculture,  
KSNUAHS, Shivamogga,  
Karnataka, India

However, estimates of salt-affected areas may vary considerably because of differences in assessment methods, including the use of satellite imagery, which can be influenced by soil moisture, parent material, topography, and other surface characteristics (Mandal and Sharma, 2001) [11].

Salt-affected soils exhibit considerable variation in their physical, chemical, and biological properties, which can influence soil fertility and crop productivity. Therefore, characterization of their nutrient status is essential for developing appropriate soil and crop management strategies. In particular, the availability of primary nutrients, namely nitrogen (N), phosphorus (P), and potassium (K), and secondary nutrients, namely calcium (Ca), magnesium (Mg), and sulphur (S), is important for evaluating the fertility status and productive potential of salt-affected soils. Excessive concentrations of soluble salts and sodium can influence nutrient transformations, availability, and plant uptake, while deficiencies or imbalances of essential nutrients may further restrict crop growth. Assessment of the distribution of these nutrients at different soil depths can therefore provide valuable information for nutrient management in salt-affected agricultural soils.

The Tungabhadra Project (TBP) command area is an important irrigated agricultural region where soil salinity and waterlogging have emerged as major constraints, particularly because of inappropriate land and water management practices and deviations from recommended cropping patterns over several decades. Approximately 96,215 ha, accounting for about 26.5% of the total command area, has been reported to be salt affected (Anonymous, 2012) [1], with an additional 1,000 ha reportedly becoming salt affected annually (IDNP, 2002) [7]. The continued expansion of salt-affected areas highlights the need for systematic assessment and monitoring of soil fertility and nutrient availability to support appropriate management and reclamation practices.

In this context, the present study was undertaken to assess the status and distribution of primary and secondary nutrients in the salt-affected soils of Hospet Taluk in the TBP irrigation command area. The study evaluated available nitrogen, phosphorus, and potassium, along with exchangeable calcium, exchangeable magnesium, and available sulphur at surface and subsurface soil depths. The findings provide information on the spatial and depth-wise distribution of essential nutrients and can serve as a basis for developing appropriate nutrient management strategies for improving soil fertility and sustaining agricultural productivity in the salt-affected soils of the TBP command area.

In salt-affected soils, the availability and uptake of essential plant nutrients are strongly influenced by the concentration and composition of soluble salts. Excessive salinity can modify soil chemical conditions, alter nutrient solubility and mobility, and interfere with nutrient uptake by plants, thereby resulting in nutrient deficiencies or imbalances. High concentrations of sodium, for instance, can interfere with potassium uptake because of competition between  $\text{Na}^+$  and  $\text{K}^+$  at the root surface, potentially leading to potassium deficiency (Shahin *et al.*, 2009) [26]. Excessive sodium may also contribute to the deterioration of soil structure through clay dispersion, reducing aggregate stability, water infiltration, and soil permeability and thereby aggravating salinity-related constraints (Munns and Tester, 2008) [12].

Nitrogen availability in saline soils may be affected by changes in microbial activity and the processes involved in nitrogen cycling (Yusuf *et al.*, 2008) [41]. High salt concentrations can also suppress biological nitrogen fixation by rhizobia, particularly in soils supporting leguminous crops. Phosphorus availability may likewise be altered under saline and sodic conditions because its solubility and retention are influenced by soil pH and interactions with calcium, magnesium, iron, and aluminium. Under certain soil conditions, these interactions can reduce the concentration of readily available phosphorus in the soil solution (Zhao *et al.*, 2009) [43]. Potassium, which plays an essential role in osmotic regulation, enzyme activation, and plant tolerance to abiotic stress, is particularly vulnerable to ionic competition from  $\text{Na}^+$ , which can restrict  $\text{K}^+$  uptake by plant roots (Shahin *et al.*, 2009) [26].

The availability of the secondary nutrients calcium and magnesium can also be influenced by salinity and sodicity. Excessive  $\text{Na}^+$  in the soil exchange complex can alter the relative proportions of exchangeable  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  and may contribute to their displacement under sodic conditions. Calcium is particularly important for maintaining soil aggregation and structural stability, while both calcium and magnesium are essential for plant growth and physiological processes. Consequently, an imbalance in these nutrients may further limit crop productivity in salt-affected soils.

Effective management of nutrient status in salt-affected agricultural soils requires integrated approaches that consider both nutrient availability and the underlying salinity or sodicity constraints. Regular soil testing, balanced fertilization, appropriate irrigation and drainage management, and the use of suitable organic amendments can help improve nutrient availability and soil condition. Where appropriate, the use of salt-tolerant crop varieties can further enhance crop establishment and productivity under saline conditions. Thus, assessment of the status and distribution of primary and secondary nutrients is essential for developing site-specific nutrient management strategies and improving the productive potential of salt-affected soils in irrigation command areas.

## 2. Material and methods

### 2.1 Study Area

The Tungabhadra irrigation command area in Karnataka provides irrigation facilities for agricultural crops in Bellary, Koppal, and parts of Raichur districts. The present study was conducted in Hospet Taluk of Bellary district, which is situated in the eastern part of Karnataka and extends broadly from southwest to northeast. Bellary district lies between  $15^{\circ}30'$  and  $15^{\circ}50'$  N latitude and  $75^{\circ}40'$  and  $77^{\circ}11'$  E longitude, covering a geographical area of approximately 8,447 km<sup>2</sup>.

Hospet Taluk is located at approximately  $15^{\circ}16'00''$  N latitude and  $76^{\circ}24'00''$  E longitude, with an average elevation of 479 m (1,572 ft) and a geographical area of 934 km<sup>2</sup> (Fig. 1). The major soil types occurring in the study area include medium-deep red gravelly clay soils, deep black clayey soils, deep black calcareous clayey soils, and deep alluvial clayey soils. The average annual rainfall of Hospet Taluk is approximately 658.3 mm. The major crops cultivated in the taluk include paddy, sorghum (jowar), maize, cotton, and sugarcane.

### Collection of Soil Samples and Mapping of Primary and Secondary Nutrients

Soil samples were collected during April-May 2017 using a Global Positioning System (GPS) and topographic sheets at a scale of 1:50,000. Sampling was conducted on a 5' × 5' grid basis, covering 15 grids in Hospet Taluk. The sampling sites were selected from agricultural areas within the TBP command area receiving irrigation water from the Left Bank Canal.

Soil samples were collected using an auger from four depth intervals, namely 0-15, 15-30, 30-60, and >60 cm (60+ cm). The collected samples were air-dried under shade, gently powdered using a pestle and mortar, passed through a 2 mm sieve, and stored in clean polythene bags until analysis. The samples were analyzed for primary nutrients (available nitrogen, phosphorus, and potassium) and secondary nutrients (exchangeable calcium, exchangeable magnesium, and available sulphur) using standard analytical procedures. The spatial distribution of primary and secondary nutrients was assessed using the nutrient status data, and distribution maps were prepared to delineate the variability of nutrient availability within the study area. An overview of the salt-affected soils and soil-sampling locations in the TBP command area is presented in Plates 1a and 1b.

### 3. Results and discussion

#### Characterization of soil samples of the study area

The soil pH, EC ( $\text{dS m}^{-1}$ ), organic carbon content, and per cent distribution of soil samples are presented in Tables 1 and 2.

#### Soil pH<sub>(1:2.5)</sub>

The data on soil pH<sub>(1:2.5)</sub> at 0-15, 15-30, 30-60 and 60+ cm varied from 5.72 to 8.74, 6.20 to 8.60, 6.72 to 8.69 and 7.06 to 9.15 with a mean value of 7.51, 7.60, 7.89 and 8.07 respectively. The mean soil pH increased slightly with soil depth. Generally, the mean soil pH (Table 1) at all the depths of Hospet taluk was in the category of mildly alkaline (7.5 to 8.0) (Brady and Well, 2007). However, Slight alkalinity of these soils could be attributed to semiarid climate, presence of basic parent material (*viz.*, Gneissic complex), restricted drainage, high calcium carbonate and exchangeable bases (Ravi Kumar *et al.*, 2007) [25]. As far as per cent distribution of pH is considered, in general about 56.10 (15-30 cm) to 70.83 (30-60 cm) in Hospet taluk were moderately to mildly alkaline in reaction (Table 2). Priyadarshini (2011) [17] reported that about 45, 11 and 12 per cent of surface soil samples were mildly alkaline, moderately alkaline and strongly alkaline (> 8.5) respectively in soil reaction of salt affected soils of Nellore and Gudur divisions of Nellore district, Andhra Pradesh).

Release of several organic acids during decomposition of organic matter could lower the soil pH values in surface soil samples compared to sub-soils (Bhadrapur and Seshagiri Rao, 1977) [5]. Further, the increase in pH with depth could be attributed to leaching and accumulation of exchangeable sodium and calcium carbonate salts at lower depths with the formation of sodium carbonate under low CO<sub>2</sub> conditions leading to high soil pH (Shivakumar *et al.* 2017 and Sharma *et al.* 2008) [31, 27]. Similar results were observed by Yeresheemi *et al.* (1997) [39] in salt affected soils of Upper Krishna project of Karnataka, Balpande *et al.* (1996) [2] in degraded Vertisols of Purna valley in Maharashtra and

Mahendra (2007) [10] in soils at Main Agriculture Research Station, Dharwad, Karnataka.

#### Soil EC<sub>(1:2.5)</sub>

#### Soil Electrical Conductivity

The soil electrical conductivity (EC, 1:2.5) at 0-15, 15-30, 30-60, and >60 cm depths ranged from 0.15 to 3.40, 0.20 to 12.40, 0.20 to 8.80, and 0.19 to 6.50  $\text{dS m}^{-1}$ , respectively, with corresponding mean values of 0.91, 1.10, 1.16, and 1.11  $\text{dS m}^{-1}$ . Unlike soil pH, the mean EC did not show a consistent trend with depth, although slightly higher values were generally observed in the subsurface layers. The mean EC values were below 4.0  $\text{dS m}^{-1}$  at all depths, indicating that the soils were, on average, within the non-saline range at the time of sampling. However, the distribution of individual EC values (Table 2) showed that 2.40 to 8.33% of the samples, depending on soil depth, had EC values exceeding 4.0  $\text{dS m}^{-1}$ , indicating the presence of saline conditions in these samples at the time of sampling.

#### Soil Organic Carbon

The mean soil organic carbon (OC) content was considerably higher in the surface soil (1.13%) than in the subsurface soil (0.60%) of Hospet Taluk (Table 1). According to the soil-test fertility rating proposed by Tandon (2017) [35], approximately 92.7% of surface soil samples and 29.3% of subsurface soil samples had OC contents in the high category (>0.75%) (Table 2). The higher OC content in surface soil may be attributed to the accumulation of root biomass, decomposition of crop residues, and the regular application of farmyard manure (FYM) and other organic amendments over the years. These organic inputs are predominantly incorporated into the surface layer, resulting in greater organic carbon accumulation compared with deeper soil layers.

The present findings are consistent with observations reported for the soils of Gangavathi Taluk, where medium to high OC contents were recorded and attributed to the incorporation of paddy stubbles and the addition of organic manures (Ravi Kumar *et al.*, 2007; Wijebandara *et al.*, 2011) [25, 37]. The marked decline in OC with depth observed in the present study is also consistent with the greater biological activity and continuous addition of organic residues in the surface soil.

#### Available Nitrogen, Phosphorus and Potassium

The contents of available N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O, along with their percentage distribution in surface and subsurface soil samples of Hospet Taluk, are presented in Tables 3 and 4, respectively.

#### Available Nitrogen

Similar to soil organic carbon, the mean available nitrogen (N) content was higher in the surface soil (218.4  $\text{kg ha}^{-1}$ ) than in the subsurface soil (165.4  $\text{kg ha}^{-1}$ ) of Hospet Taluk (Table 3). However, the mean available N content at both depths fell within the low category (<280  $\text{kg ha}^{-1}$ ) according to the soil-test fertility ratings of Tandon (2017) [35]. Approximately 95.12% of the surface soil samples were classified as low in available N (Table 4). Despite the generally high organic carbon status of these soils, the low available N content may be attributed to the susceptibility of nitrogen to various loss processes, including leaching, volatilization, and denitrification (Rao and Batra, 1983) [19].

In addition, the relatively lower microbial activity and organic carbon content in subsurface layers may contribute to reduced nitrogen availability at greater depths. The present findings are consistent with those of Patel *et al.* (2017) <sup>[15]</sup>, who reported low available N contents in salt-affected soils of Dholka Taluka in the Bhal region of Gujarat.

#### Available Phosphorus

Unlike available N, there was little difference in the mean available  $P_2O_5$  content between the surface ( $266.2 \text{ kg ha}^{-1}$ ) and subsurface ( $270.5 \text{ kg ha}^{-1}$ ) soils of Hospet Taluk (Table 3). Although organic matter and crop residues in the surface layer may promote the mineralization and solubilization of relatively unavailable phosphorus compounds, thereby increasing phosphorus availability (Chaudhary and Ghosh, 2006) <sup>[6]</sup>, the observed difference between the two depths was small.

The distribution of samples showed that 100% of the surface and 90.2% of the subsurface samples had available  $P_2O_5$  contents in the high category ( $>56.3 \text{ kg ha}^{-1}$ ) (Table 4), according to the soil-test fertility ratings of Tandon (2017) <sup>[35]</sup>. This indicates that the soils were generally well supplied with available phosphorus. The long-term application of di-ammonium phosphate (DAP) and poultry manure under the prevailing paddy-paddy cropping system may have contributed to the accumulation and maintenance of relatively high available phosphorus levels in these soils.

#### Available Potassium

Similar to available N, the mean available  $K_2O$  content was higher in the surface soil ( $454.1 \text{ kg ha}^{-1}$ ) than in the subsurface soil ( $353.0 \text{ kg ha}^{-1}$ ) of Hospet Taluk (Table 3). According to the soil-test fertility ratings of Tandon (2017) <sup>[35]</sup>, the highest proportion of samples in both surface (68.3%) and subsurface (48.9%) soils had available  $K_2O$  contents in the high category ( $>336 \text{ kg ha}^{-1}$ ) (Table 4).

The relatively high available  $K_2O$  status of these soils may be associated with the occurrence of K-bearing micaceous minerals, which are common in soils of arid and semi-arid regions (Kapoor *et al.*, 1981; Ravi Kumar *et al.*, 2007) <sup>[9, 25]</sup>. The release of potassium through the weathering or dissolution of K-bearing minerals such as muscovite under sodic conditions may also contribute to the available K pool (Pal, 1985) <sup>[14]</sup>. The higher  $K_2O$  content in surface soil may additionally be associated with the regular return of crop residues and organic inputs to the surface layer.

In general, the lower contents of available N and  $K_2O$  in subsurface soils compared with surface soils may be associated with the lower organic carbon content, reduced biological activity, and limited accumulation of organic residues at greater depths. However, the small difference in mean available  $P_2O_5$  between the two depths indicates that phosphorus distribution was comparatively less variable within the soil profile.

The contents of exchangeable calcium (Ca), exchangeable magnesium (Mg), and available sulphur (S) and their

percentage distribution in surface and subsurface soil samples of Hospet Taluk are presented in Tables 3 and 4, respectively.

#### Exchangeable Calcium

Similar to available N, the mean exchangeable calcium (Ca) content was higher in the surface soil ( $19.02 \text{ meq } 100 \text{ g}^{-1}$ ) than in the subsurface soil ( $16.10 \text{ meq } 100 \text{ g}^{-1}$ ) of Hospet Taluk (Table 3). The distribution of soil samples showed that the maximum proportion of surface (51.20%) and subsurface (48.80%) samples fell within the medium ( $12.5\text{--}25 \text{ meq } 100 \text{ g}^{-1}$ ) and low ( $<12.5 \text{ meq } 100 \text{ g}^{-1}$ ) categories, respectively (Table 4), according to the soil-test fertility ratings of Tandon (2017) <sup>[35]</sup>.

Calcium generally dominates the exchange complex in soils of semi-arid regions (Sharma *et al.*, 1996) <sup>[30]</sup>. Similar observations were reported by Surekha *et al.* (1997) <sup>[32]</sup> in the semi-arid region of Andhra Pradesh, Sharma *et al.* (2004) <sup>[28]</sup> in salt-affected soils of southern Rajasthan, and Ram *et al.* (2010) <sup>[18]</sup> in flood-prone soils of eastern Rajasthan. The relatively higher exchangeable Ca content in the surface soil may be associated with the accumulation of organic residues and exchangeable bases in the upper soil layer. In irrigated soils, the distribution of soluble and exchangeable calcium may also be influenced by dissolution, movement, and redistribution within the soil profile (Pathak and Patel, 1980) <sup>[16]</sup>.

#### Exchangeable Magnesium

The mean exchangeable magnesium (Mg) content was  $8.63 \text{ meq } 100 \text{ g}^{-1}$  in the surface soil and  $9.30 \text{ meq } 100 \text{ g}^{-1}$  in the subsurface soil of Hospet Taluk (Table 3), indicating a slight increase with depth. According to the soil-test fertility ratings of Tandon (2017) <sup>[35]</sup>, the majority of surface (78.05%) and subsurface (63.41%) soil samples had exchangeable Mg contents below  $10.3 \text{ meq } 100 \text{ g}^{-1}$  and were therefore classified in the low category (Table 4). The relatively higher mean Mg content in the subsurface soil may be associated with the downward movement and redistribution of soluble and exchangeable magnesium within the soil profile.

#### Available Sulphur

The mean available sulphur (S) content was higher in the surface soil ( $198.0 \text{ ppm}$ ) than in the subsurface soil ( $145.3 \text{ ppm}$ ) of Hospet Taluk (Table 3). Based on the soil-test fertility ratings of Tandon (2017) <sup>[35]</sup>, the highest proportion of surface (65.85%) and subsurface (70.73%) soil samples fell within the high ( $>50 \text{ ppm}$ ) to medium ( $10\text{--}50 \text{ ppm}$ ) categories (Table 4). The relatively high available S content in these soils may be associated with the presence of soluble sulphate salts and the addition of sulphur through fertilizers and other agricultural inputs. Similar observations were reported by Shivakumar *et al.* (2017) <sup>[31]</sup> in salt-affected soils of the Vani Vilas Command area of Hiriya Taluk, Chitradurga district.

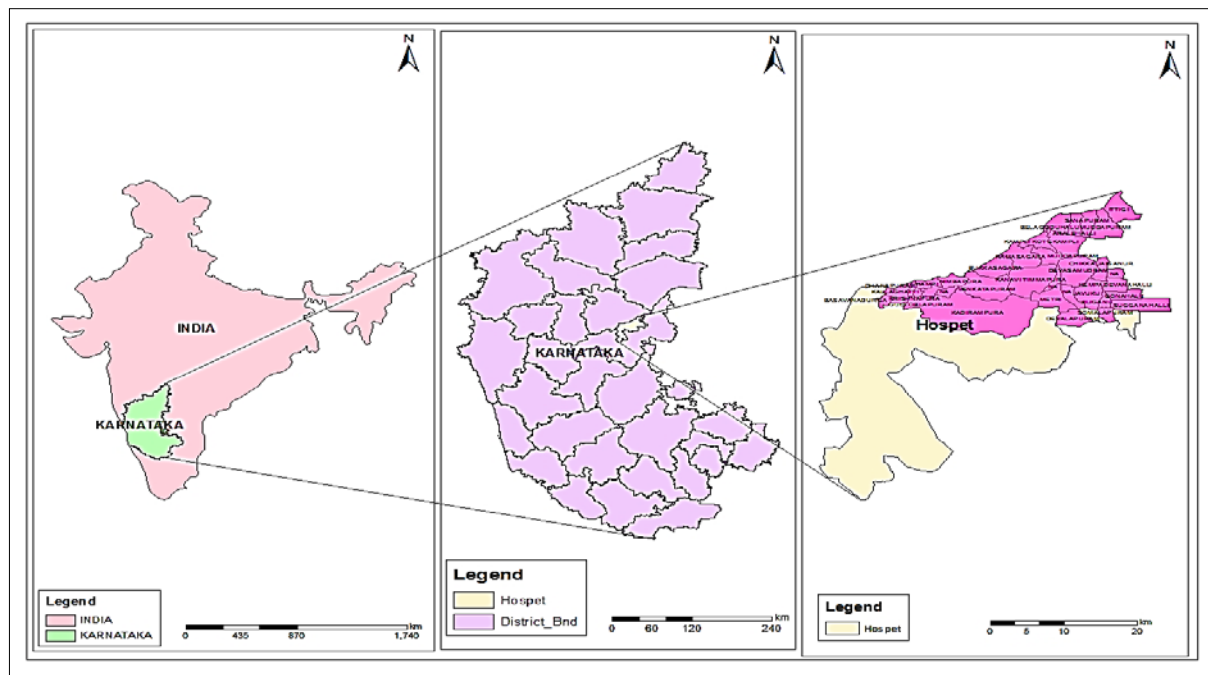


**Fig 1:** Location map of Hospet taluk



**Plate 1a:** View of salt affected soils in TBP command area



**Plate 1b:** View of soil sampling in salt affected soils in TBP command

**Table 1:** pH<sub>(1:2.5)</sub>, EC (dS m<sup>-1</sup>) and organic carbon status in salt affected soils of Hospet taluk, Bellary district, Karnataka.

| Soil properties          | Soil depth (cm) |      |      |       |       |      |       |      |      |       |      |      |
|--------------------------|-----------------|------|------|-------|-------|------|-------|------|------|-------|------|------|
|                          | 0-15            |      |      | 15-30 |       |      | 30-60 |      |      | 60-90 |      |      |
|                          | Min.            | Max. | Avg. | Min.  | Max.  | Avg. | Min.  | Max. | Avg. | Min.  | Max. | Avg. |
| pH                       | 5.72            | 8.74 | 7.51 | 6.20  | 8.60  | 7.60 | 6.72  | 8.69 | 7.89 | 7.06  | 9.15 | 8.07 |
| EC (dS m <sup>-1</sup> ) | 0.15            | 3.40 | 0.91 | 0.20  | 12.40 | 1.10 | 0.20  | 8.80 | 1.16 | 0.19  | 6.50 | 1.11 |
| OC (%)                   | 0.50            | 1.73 | 1.13 | 0.10  | 1.30  | 0.60 | nd*   |      |      |       |      |      |

Note: nd\*= Not determined.

**Table 2:** Per cent distribution of soil samples with respect to different ratings of soil pH, EC and organic carbon content of Hospet taluk.

| Soil Depth (cm) | pH         |            |           | EC (dS m <sup>-1</sup> ) |           |          | OC (%)     |           |            |
|-----------------|------------|------------|-----------|--------------------------|-----------|----------|------------|-----------|------------|
|                 | <7.5       | 7.5-8.5    | >8.5      | <2                       | 2-4       | >4       | <0.5       | 0.5-0.75  | >0.75      |
| 0-15            | 36.60 (15) | 58.50 (24) | 4.90 (2)  | 85.40 (35)               | 12.20 (5) | 2.40 (1) | 2.44 (1)   | 4.88 (2)  | 92.68 (38) |
| 15-30           | 41.50 (17) | 56.10 (23) | 2.40 (1)  | 87.80 (36)               | 4.90 (2)  | 7.32 (3) | 48.90 (20) | 21.90 (9) | 29.30 (12) |
| 30-60           | 25.00 (6)  | 70.83 (17) | 4.16 (1)  | 87.50 (21)               | 4.16 (1)  | 8.33 (2) | nd*        |           |            |
| 60+             | 20.00 (3)  | 60.00 (9)  | 20.00 (3) | 80.00 (12)               | 13.33 (2) | 6.66 (1) |            |           |            |

Note: Values in parenthesis indicate number of samples nd\*= Not determined

**Table 3:** Primary and secondary nutrient status in salt affected soils of Hospet taluk, Bellary district, Karnataka.

| Soil properties                                             | Soil depth (cm) |         |        |        |         |        |
|-------------------------------------------------------------|-----------------|---------|--------|--------|---------|--------|
|                                                             | 0-15            |         |        | 15-30  |         |        |
|                                                             | Min.            | Max.    | Avg.   | Min.   | Max.    | Avg.   |
| Avail. N (kg ha <sup>-1</sup> )                             | 125.44          | 323.01  | 218.37 | 59.60  | 414.0   | 165.40 |
| Avail. P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> ) | 64.72           | 562.54  | 266.24 | 14.50  | 640.40  | 270.50 |
| Avail. K <sub>2</sub> O (kg ha <sup>-1</sup> )              | 126.52          | 1124.93 | 454.07 | 104.80 | 841.30  | 353.0  |
| Exch. Ca (meq 100g <sup>-1</sup> )                          | 5.40            | 37.60   | 19.02  | 5.60   | 40.40   | 16.10  |
| Exch. Mg (meq 100g <sup>-1</sup> )                          | 1.90            | 31.80   | 8.63   | 1.20   | 34.0    | 9.30   |
| Avail. S (ppm)                                              | 24.70           | 1325.0  | 198.0  | 25.0   | 1246.60 | 145.30 |

**Table 4:** Per cent distribution of soil samples with respect to different rating of primary and secondary nutrients in salt affected soils of Hospet taluk, Bellary district, Karnataka.

| Soil properties                                             | Soil depth (cm) |            |            |            |            |            |
|-------------------------------------------------------------|-----------------|------------|------------|------------|------------|------------|
|                                                             | 0-15            |            |            | 15-30      |            |            |
|                                                             | Low             | Medium     | High       | Low        | Medium     | High       |
| Avail. N (kg ha <sup>-1</sup> )                             | 95.12 (39)      | 4.88 (2)   | 0          | 97.60(40)  | 2.40 (1)   | 0          |
| Avail. P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> ) | 0               | 0          | 100 (41)   | 4.90 (2)   | 4.90 (2)   | 90.20 (37) |
| Avail. K <sub>2</sub> O (kg ha <sup>-1</sup> )              | 2.44 (1)        | 29.30 (12) | 68.30 (28) | 7.30 (3)   | 43.90 (18) | 48.90 (20) |
| Exch. Ca (meq 100g <sup>-1</sup> )                          | 29.30 (12)      | 51.20 (21) | 19.50 (8)  | 48.80 (20) | 34.14 (14) | 17.10 (7)  |
| Exch. Mg (meq 100g <sup>-1</sup> )                          | 78.05(32)       | 19.51(8)   | 2.44 (1)   | 63.41 (26) | 31.70 (13) | 4.90 (2)   |
| Avail. S (ppm)                                              | 0               | 34.15 (14) | 65.85 (27) | 0          | 70.73 (29) | 29.27 (12) |

Note: Values in parenthesis indicate number of samples.

|        | N                      | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O       | Ca                        | Mg                        | S     | Zn    | Fe     | Mn    | Cu      |
|--------|------------------------|-------------------------------|------------------------|---------------------------|---------------------------|-------|-------|--------|-------|---------|
|        | (kg ha <sup>-1</sup> ) | (kg ha <sup>-1</sup> )        | (kg ha <sup>-1</sup> ) | (meq 100g <sup>-1</sup> ) | (meq 100g <sup>-1</sup> ) | (ppm) | (ppm) | (ppm)  | (ppm) | (ppm)   |
| Low    | <280                   | <22.9                         | <129.6                 | <12.5                     | <10.3                     | <10   | <1    | <2.5   | <5    | <0.5    |
| Medium | 280-560                | 22.9-56.3                     | 129.6-336              | 12.5-25                   | 10.3-20.6                 | 10-50 | 1-2.5 | 2.5-10 | 5-25  | 0.5-2.5 |
| High   | >560                   | >56.3                         | >336                   | >25                       | >20.6                     | >50   | >2.5  | >10    | >25   | >2.5    |

## Conclusion

The study revealed that the soils of Hospet Taluk were predominantly mildly alkaline, with mean soil pH values ranging from 7.51 to 8.07 across the investigated depths. The mean EC values were below 4.0 dS m<sup>-1</sup> at all depths, indicating that the soils were generally non-saline at the time of sampling. However, a proportion of individual samples had EC values exceeding 4.0 dS m<sup>-1</sup>, indicating localized saline conditions. Specifically, 2.40% of surface (0-15 cm) samples and 7.32% of subsurface (15-30 cm) samples had EC values >4.0 dS m<sup>-1</sup>. The soils generally had medium to high organic carbon contents.

With respect to primary nutrients, the mean available N content was in the low category (<280 kg ha<sup>-1</sup>), whereas available P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were in the high categories (>56.3 and >336 kg ha<sup>-1</sup>, respectively). Among the secondary nutrients, the mean exchangeable Mg content was in the low category (<10.3 meq 100 g<sup>-1</sup>), while exchangeable Ca was in the medium category (12.5-25 meq 100 g<sup>-1</sup>) and available

S was in the high category (>50 ppm). Overall, the results indicate that nitrogen and magnesium were the major nutrient constraints, whereas phosphorus, potassium, calcium, and sulphur were generally present at adequate to high levels. These findings highlight the need for balanced and site-specific nutrient management, particularly through appropriate nitrogen and magnesium supplementation, to sustain crop productivity in the TBP irrigation command area.

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