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Characterization and mapping of salt affected soils of hospet taluk in tungabhadra project irrigation command area, Karnataka

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Abstract

A systematic assessment of the spatial distribution of soil salinity and sodicity was carried out in Hospet Taluk, Bellary District, Karnataka, using a grid-based soil sampling approach. With the aid of GPS and topographic sheets, 121 soil samples were collected from 15 grid points at four depths: 0-15, 15-30, 30-60, and >60 cm. At the surface depth (0-15 cm), pH (1:2.5), pHe, EC (1:2.5), and ECe ranged from 5.72-8.74, 5.88-8.26, 0.15-3.40 dS m⁻¹, and 0.39-43.0 dS m⁻¹, respectively, with corresponding mean values of 7.51, 7.25, 0.91 dS m⁻¹, and 2.96 dS m⁻¹. Sodium (Na⁺) was the predominant cation, exceeding the combined concentration of Ca²⁺ + Mg²⁺, followed by K⁺, while the major anions occurred in the order Cl⁻ > HCO₃⁻ > SO₄²⁻.

Approximately 15% of the surface soil samples had ECe > 4.0 dS m⁻¹, indicating saline conditions, while 19.5% had SAR > 13, indicating a sodicity hazard. At 15-30 cm depth, pH (1:2.5), pHe, EC (1:2.5), and ECe ranged from 6.20-8.60, 6.49-8.14, 0.20-12.40 dS m⁻¹, and 0.23-17.80 dS m⁻¹, respectively, with mean values of 7.60, 7.45, 1.10 dS m⁻¹, and 1.57 dS m⁻¹. Less than 10% of the samples at this depth had ECe > 4.0 dS m⁻¹, whereas 7.3% had SAR > 13. At 30-60 and >60 cm depths, mean ECe values remained below 4.0 dS m⁻¹; however, 12.5% and 20.0% of samples, respectively, had ECe > 4.0 dS m⁻¹, while 25% and 60% had SAR > 13.

The results demonstrate considerable spatial and vertical variability in soil salinity and sodicity. Although average ECe values were generally below the salinity threshold, localized saline conditions occurred throughout the soil profile, while sodicity was particularly pronounced at greater depths. The findings emphasize the need for depth-specific soil monitoring, improved drainage and leaching management, and site-specific amelioration practices to minimize salinity and sodicity constraints and support sustainable agricultural production in the study area.

Keywords: GPS, pHe, ECe, SAR, Anions, Cations, Derived Parameters and Salt affected soil

Introduction

Soil is one of the most important natural resources supporting agricultural production and food security. Among the major forms of land degradation, soil salinity and sodicity are particularly important because they adversely affect soil quality, crop growth, and agricultural productivity. Salt-affected soils are generally characterized by excessive concentrations of soluble salts, exchangeable sodium, or both. Salinity is commonly associated with an electrical conductivity of the saturated soil extract (ECe) greater than 4.0 dS m⁻¹, whereas sodicity is generally indicated by an exchangeable sodium percentage (ESP) >15. Although soluble salts are naturally present in all soils and several ions contribute essential nutrients required for plant growth, their excessive accumulation within the active root zone can adversely affect crop establishment, growth, yield, and produce quality. Salt-affected soils therefore represent a major constraint to sustainable agricultural production. These soils commonly occur in association with unaffected soils but are distinguished by higher concentrations of soluble electrolytes and/or exchangeable sodium (Szaboles, 1989).

Excessive salt accumulation can induce several forms of soil degradation, including soil aggregate dispersion, surface crusting, deterioration of soil structure, reduced infiltration, and increased compaction. High salinity may also disturb the availability and uptake of essential

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nutrients, resulting in nutritional imbalances and, under certain conditions, increased accumulation of potentially toxic ions in plant tissues (Priyadarshini, 2011) ^[11]. Based on the dominant chemical characteristics, salt-affected soils are generally categorized as saline, sodic, and saline-sodic soils. In India, however, salt-affected soils are broadly grouped into saline and sodic (alkali) soils. According to the reconciled estimates of CSSRI, Karnal; NRSA; and NBSS&LUP (2006), approximately 6.73 million ha of land was affected by salinity and sodicity, comprising 3.77 million ha of sodic soils and 2.96 million ha of saline soils. It was further projected that approximately 11.7 million ha could be affected by salinity and alkalinity in India by 2025. Estimates of salt-affected areas may vary among studies because remote-sensing-based assessments can be influenced by soil moisture, parent material, vegetation cover, and other surface characteristics (Mandal and Sharma, 2001). Since saline and sodic soils differ considerably in their physical, chemical, and biological properties, their accurate characterization at the local scale is essential for developing appropriate management, reclamation, and productivity-enhancement strategies.

The Tungabhadra Project (TBP) command area is affected by the interacting problems of soil salinity and waterlogging, which have developed over several decades owing to inappropriate land and water management practices and deviations from recommended cropping patterns. Approximately 96,215 ha, accounting for about 26.5% of the total 3.63 lakh ha command area, was reported to be salt affected (Anonymous, 2012) ^[1]. Furthermore, an estimated 1,000 ha of land is added annually to the salt-affected area (IDNP, 2002). The continuing expansion of salinity highlights the need for systematic monitoring and periodic assessment of soil properties to identify areas undergoing degradation and to facilitate timely corrective measures. Such monitoring can provide a scientific basis for modifying land and water management practices and for implementing appropriate reclamation and rehabilitation measures.

Despite the extent and agricultural importance of the problem, ground-truthed information on the spatial distribution and characterization of salt-affected soils within the command area remains limited, and comprehensive salinity base maps are lacking. Ground-based characterization of soil salinity and

sodicity is therefore essential for validating the extent and severity of salt-affected areas and for identifying their vertical distribution within the soil profile. Systematic sampling and characterization can also provide reliable information for developing spatial maps and identifying areas requiring priority intervention.

Accordingly, delineation and characterization of salt-affected soils through systematic ground-truthing are imperative for obtaining a reliable estimate of the affected area. Detailed assessment and mapping of soil salinity and sodicity in the TBP command can help researchers, planners, and policymakers understand the spatial and vertical distribution of soil degradation, identify areas at risk of further deterioration, and develop site-specific management strategies. Such information is essential for arresting the expansion of salt-affected areas and for improving the productivity and sustainable utilization of degraded soils within the command area.

Study Area

The Tungabhadra irrigation command area serves the irrigation requirements of agricultural crops in Bellary, Koppal, and parts of Raichur districts of Karnataka. The present study was conducted in Hospet Taluk of Bellary District, located in the eastern part of Karnataka. The district extends approximately between 15°30' and 15°50' N latitude and 75°40' and 77°11' E longitude, covering a geographical area of approximately 8,447 km². Hospet Taluk is situated at approximately 15°16' N latitude and 76°24' E longitude, at an elevation of about 479 m above mean sea level, and covers an area of approximately 934 km² (Fig. 1).

The study area is characterized by diverse soil types, including 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 principal crops cultivated in the region include paddy, sorghum (jowar), maize, cotton, and sugarcane. The predominance of irrigated agriculture, together with the climatic and soil conditions of the region, makes the area particularly important for assessing the development and spatial distribution of soil salinity and sodicity within the Tungabhadra irrigation command.

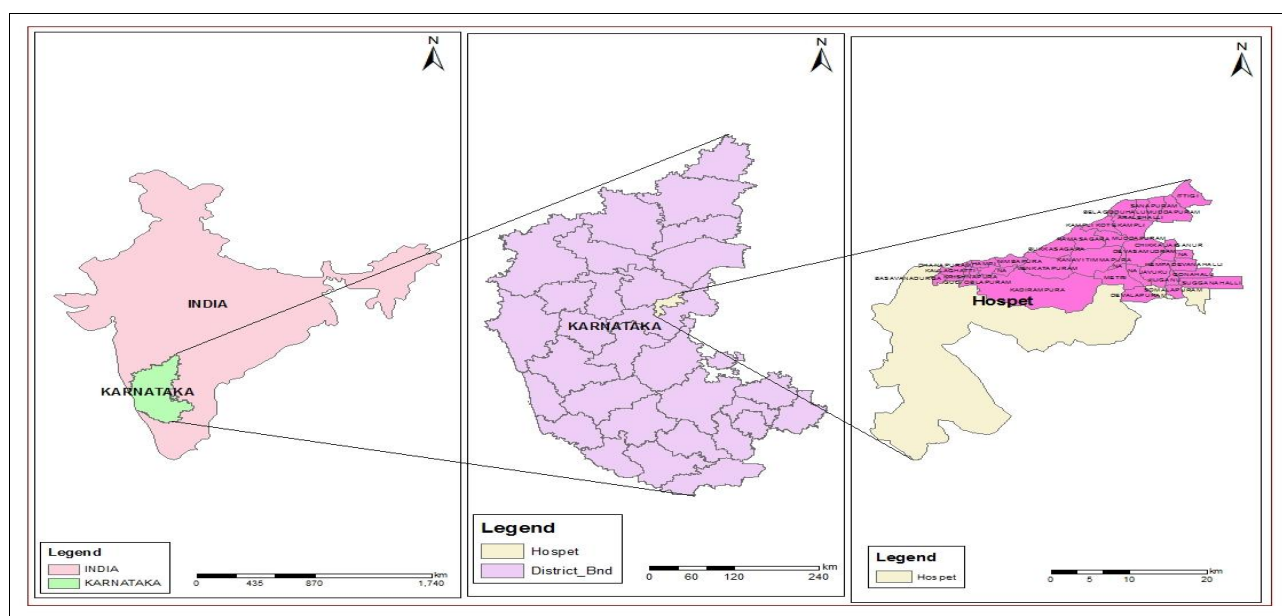
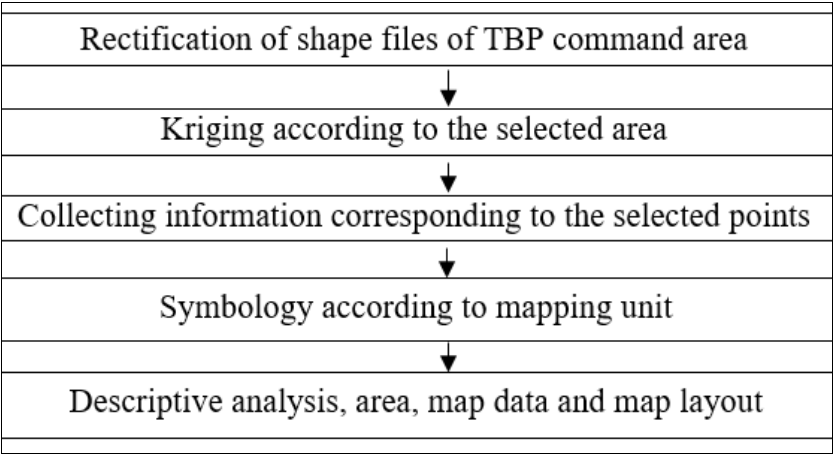


Fig 1: Location map of Hospet taluk

Collection of Soil Samples and Mapping of Salt-Affected Soils
With the aid of GPS and topographic sheets (1:50,000 scale), soil samples were collected on a systematic grid basis (5' × 5') from 15 grids of Hospet Taluk, Bellary District, during April-May 2017. Soil samples were collected from the irrigated command area receiving water from the Left Bank Canal of the Tungabhadra Project (TBP). Samples were collected to a depth of >60 cm at four depth intervals, namely 0-15, 15-30, 30-60, and >60 cm, using a soil auger. The collected soil samples were air-dried under shade, gently crushed using a pestle and mortar, passed through a 2-mm sieve, and stored in clean polythene bags until analysis. The samples

were analyzed for pH (1:2.5), electrical conductivity [EC (1:2.5)], pHe, electrical conductivity of the saturation extract (ECe), sodium adsorption ratio (SAR), and the cationic and anionic composition of the saturation paste extract using standard analytical procedures. The general distribution of salt-affected soils and the soil-sampling locations within the TBP command area are presented in Plates 1a and 1b. The analytical data obtained from the soil samples were used to prepare spatial distribution maps of soil salinity and other selected soil properties. The spatial interpolation and mapping were performed using ArcGIS version 10.4, following the procedure described below.



Statistical analysis

Various soil properties were tested for their correlation (r) with other properties as per the procedure by Snedecor and Cochran (1980)^[15].
Karl Pearson correlation coefficient (product moment

correlation coefficient).

$$r = \frac{\sum xy - n\bar{x}\bar{y}}{\sqrt{(\sum x^2 - n\bar{x}^2)(\sum y^2 - n\bar{y}^2)}}$$



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



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

Where,

r = correlation coefficient

x and y are variables

n = no. of observations in x and y

The ' r ' value indicates degree of association between two variables. If ' r ' value is positive, two variables are positively correlated and it is negative, then two variables are negatively correlated.

The significant of correlation coefficient was tested by t test. If $t_{table} < t_{calculated}$ value then ' r ' is significant and if $t_{table} > t_{calculated}$ then it is non-significant.

$$t_{calculated} (|t|) = \frac{r}{\sqrt{(1-r^2)/(n-2)}}$$

Results and discussion

Characterization of soil samples of the study area

Soil $pH_{(1:2.5)}$ and pH_e

Ionic Composition and Soil Reaction

The ionic composition of soluble salts and selected physicochemical characteristics of the salt-affected soils are presented in Table 1. In Hospet Taluk of Bellary District, the mean soil pH showed a slight increasing trend with increasing soil depth. Overall, the mean soil pH across the different depths ranged from 7.51 to 8.07, corresponding predominantly to the mildly alkaline category (7.5-8.0), although some values slightly exceeded the upper limit of this range. The corresponding mean pH_e values indicated slightly alkaline soil conditions.

The mildly alkaline reaction of these soils may be associated with the semi-arid climatic conditions, nature of the parent material (e.g., gneissic complex), restricted drainage, presence of calcium carbonate, and relatively high concentrations of exchangeable base cations (Ravi Kumar *et al.*, 2007). These factors can promote the accumulation of basic cations and carbonate species and consequently influence soil reaction.

The percentage distribution of soil samples according to pH and pH_e further indicated that a substantial proportion of the soils were moderately to mildly alkaline at different depths. Approximately 56.10% to 70.83% of the samples across the 15-30 and 30-60 cm depths, respectively, were within the moderately to mildly alkaline categories based on pH. Similarly, the proportion of samples showing moderately to mildly alkaline reaction based on pH_e ranged from 40.00% at >60 cm depth to 73.20% at 0-15 cm depth (Table 2).

The predominance of mildly to moderately alkaline soil reaction across the profile indicates that alkalinity is a characteristic feature of the salt-affected soils of the study area. Similar observations were reported by Priyadarshini (2011) ^[11], who found that approximately 45%, 11%, and 12% of surface soil samples from the salt-affected soils of Nellore and Gudur divisions of Nellore District, Andhra Pradesh, were mildly alkaline, moderately alkaline, and strongly alkaline ($pH > 8.5$), respectively. The comparatively lower occurrence of strongly alkaline soils in the present study suggests that, although alkaline conditions are widespread, extreme alkalinity is relatively localized within the sampled area.

Table 1: Characterization of soil samples collected from Hospet taluk, Bellary district, Karnataka for soil salinity appraisal

Properties	Depth (cm)											
	0-15 cm			15-30 cm			30-60 cm			60+ cm		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
pH (1:2.5)	5.72	8.74	7.51	4.76	8.56	7.55	6.72	8.69	7.87	7.06	8.76	7.93
EC (1:2.5)	0.15	19.0	1.28	0.16	12.40	1.03	0.20	8.80	1.17	0.19	6.50	1.26
pHe	5.88	8.26	7.25	6.49	8.14	7.45	6.53	8.29	7.45	6.48	8.10	7.57
ECe (dS/m)	0.39	43.0	2.96	0.23	17.80	1.57	0.30	12.3	1.77	0.36	8.80	2.02
Cation (me l⁻¹)												
Ca+Mg	4.20	46.60	11.93	2.40	64.80	8.74	3.20	31.2	8.80	3.7	22.20	8.11
Na ⁺	1.59	153.2	21.4	1.2	62.5	10.5	2.0	168	25.1	2.72	141.7	28.8
K ⁺	0.08	1.24	0.37	0.23	0.58	0.33	0.03	0.35	0.12	0.05	1.05	0.19
Anion (me l⁻¹)												
HCO ₃ ⁻	6.50	35.0	10.67	5.00	18.0	8.26	5.0	22.0	8.79	6.00	15.0	8.10
Cl ⁻	5.50	346.0	21.24	4.50	87.5	11.41	6.50	44.5	11.9	5.00	26.0	10.7
SO ₄ ²⁻	Tr	2.71	0.50	0.01	2.30	0.28	0.01	2.21	0.48	0.04	2.22	0.66
SAR	0.94	42.1	7.90	0.07	33.6	4.98	1.29	45.4	10.4	1.22	54.2	13.1
(CO ₃ +HCO ₃)/ (Cl+SO ₄)	0.04	3.21	0.92	0.10	2.33	0.94	0.12	1.28	0.82	0.30	1.59	0.81
Na/(Cl+SO ₄)	0.23	3.41	1.10	0.14	4.61	0.86	0.26	6.30	1.64	0.14	11.1	2.40

Table 2: Per cent distribution of soil properties of samples collected from Hospet taluk, Bellary district, Karnataka for soil salinity appraisal.

Soil Depth (Cm)	pH			pHe			EC (dS/m)			ECe (dS/m)			(CO ₃ +HCO ₃)/ (Cl+SO ₄)		Na/(Cl+SO ₄)		SAR	
	<7.5	7.5-8.5	>8.5	<7.5	7.5-8.5	>8.5	<2.0	2-4	>4	<2.0	2-4	>4	<1	>1	<1	>1	<13	>13
0-15	36.60 (15)	58.50 (24)	4.90 (2)	73.2 (30)	26.8 (11)	0	85.40 (35)	12.20 (5)	2.40 (1)	70.7 (29)	14.6 (6)	14.6 (6)	58.5 (24)	41.5 (17)	61.0 (25)	39.0 (16)	80.5 (33)	19.5 (8)
15-30	41.50 (17)	56.10 (23)	2.40 (1)	51.2 (21)	48.8 (20)	0	87.80 (36)	4.90 (2)	7.32 (3)	85.4 (35)	4.80 (2)	9.80 (4)	68.3 (28)	31.7 (13)	80.5 (33)	19.5 (8)	92.7 (38)	7.3 (3)
30-60	25.00 (6)	70.83 (17)	4.16 (1)	54.2 (13)	45.8 (11)		87.50 (21)	4.16 (1)	8.33 (2)	79.2 (19)	8.30 (2)	12.5 (3)	75.0 (18)	25.0 (6)	37.5 (9)	62.5 (15)	75 (18)	25 (6)
60+	20.00 (3)	60.00 (9)	20.00 (3)	40.0 (6)	60.0 (9)	0	80.00 (12)	13.33 (2)	6.66 (1)	66.7 (10)	13.3 (2)	20.0 (3)	80.0 (12)	20.0 (3)	80 (12)	20 (3)	40 (6)	60 (9)

The soil reaction (pHe) maps of surface and sub-surface soils of Hospet taluk is depicted in Fig.2a and 2b. The distribution of area under different categories of soil pHe as depicted in Fig.2a, revealed that out of the total sampled area in Hospet taluk (41,307.4 ha) about 2.90 (0.007%), 13,768.9 (33.33%) and 27,535.7 ha (66.66%) area had pHe in the range of 5.5 to 6.5, 6.5 to 7.5 and 7.5-8.5 respectively. At 15-30 cm, about 22,006.0 (53.27%) and 19,300.5 ha (46.72%) had pHe in the range of 6.49 to 7.5 and 7.5 to 8.14 respectively (Fig. 2b).

Soil EC_(1:2.5) and ECe

Unlike soil pH, no consistent trend with depth was observed with respect to the mean EC_(1:2.5) and ECe of Hospet taluk soil samples, the mean EC and ECe ranging from 0.91 to 1.16 and 1.57 to 2.96 dS/m respectively (Table 1), though the surface samples generally had slightly higher values. Further, mean ECe at all depths were greater than respective EC_(1:2.5) values in Hospet taluks. Overall, the mean EC and ECe values were <4.0

dS m⁻¹ at all the depths in Hospet taluks reflecting that the soils are non-saline. However, looking at per cent distribution of ECe values (Table 2) varied from 20.0 (60+ cm) to 9.80% (15-30 cm) in Hospet taluk were >4 dS m⁻¹ reflecting that they are saline at the time of sampling.

The distribution of area under different categories of soil ECe as depicted in Fig.3a, revealed that out of the total sampled area in Hospet taluk about 49.99, 35.81, 13.98, 0.09, 0.06 and 0.05% of total area had ECe in the range of <2, 2.0 to 4.0, 4.0 to 8.0, 8.0 to 12.0, 12.0 to 16.0 and 16.0 to 43.0 dS m⁻¹ respectively. At 15-30 cm, about 73.73, 25.96, 0.19, 0.06 and 0.05% of area had ECe in the range of 0.23 to 2, 2.0 to 4.0, 4.0 to 8.0, 8.0 to 12 and 12 to 17.8 dS m⁻¹ respectively (Fig. 3b).

A relatively higher ECe values in surface layer as compared to sub-surface soils may be ascribed to the upward movement of soluble salts due to capillary raise and deposition at the soil surface particularly during summer. Similar observations were made by Mohammad *et al.* (2017) [8] and Priyadarshini (2011) [11].

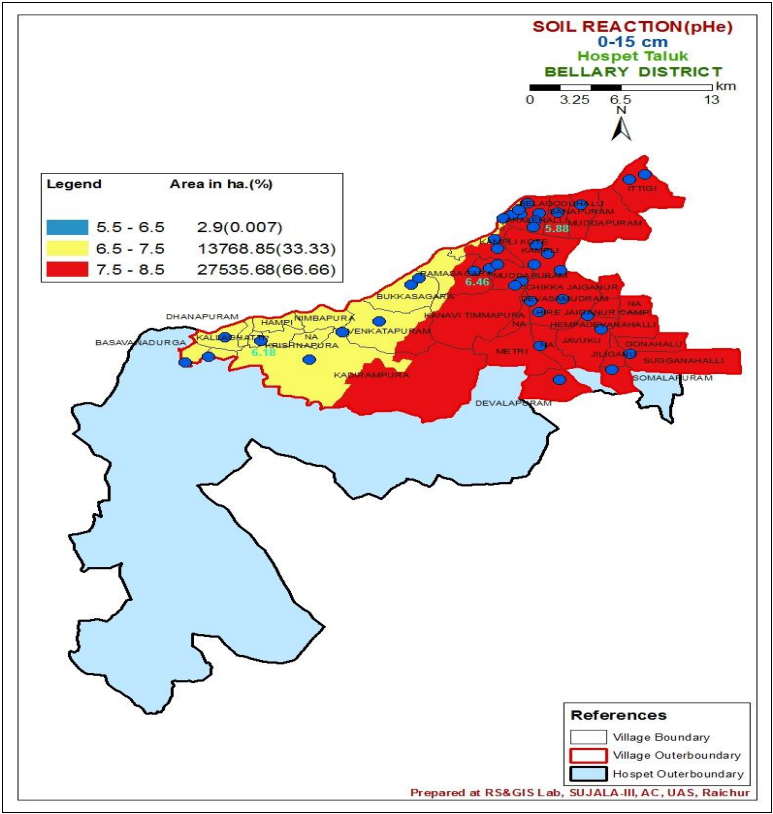


Fig 2a: pHe distribution map of surface soil (0-15 cm) in Hospet taluk

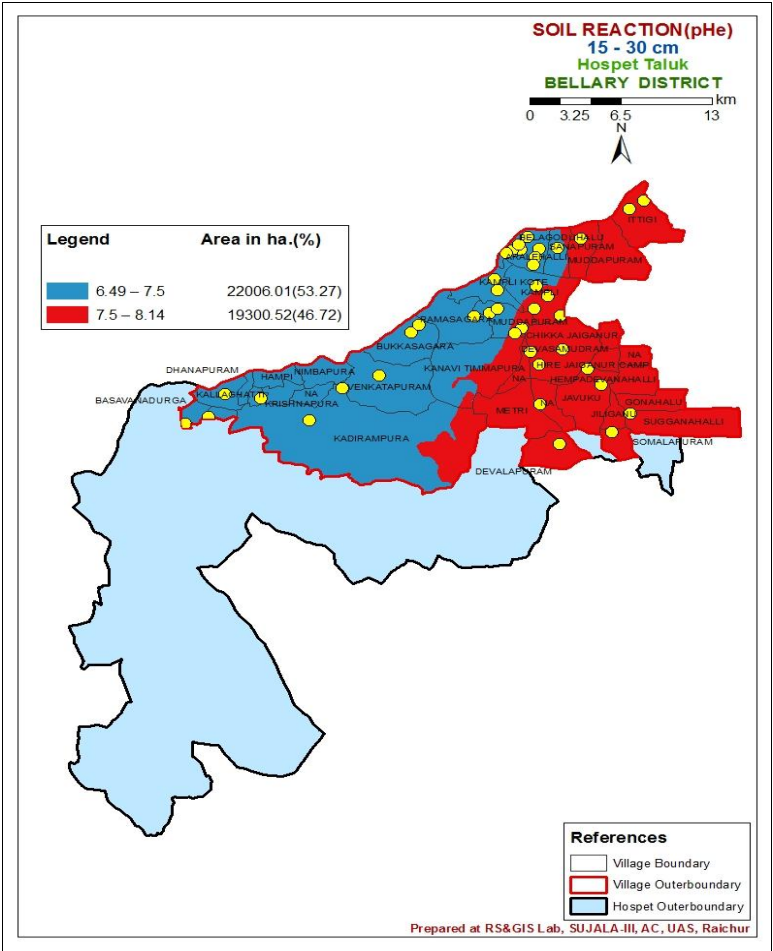


Fig 2b: pHe distribution map of sub-surface soil (15-30 cm) in Hospet taluk

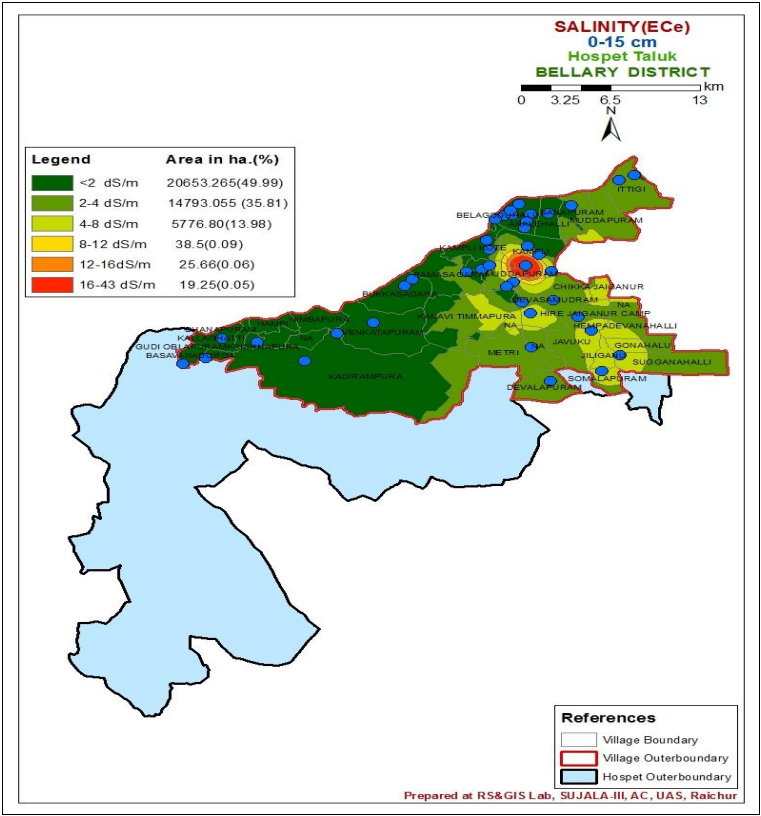


Fig 3a: E_c distribution map of surface soil (0-15 cm) in Hospet taluk

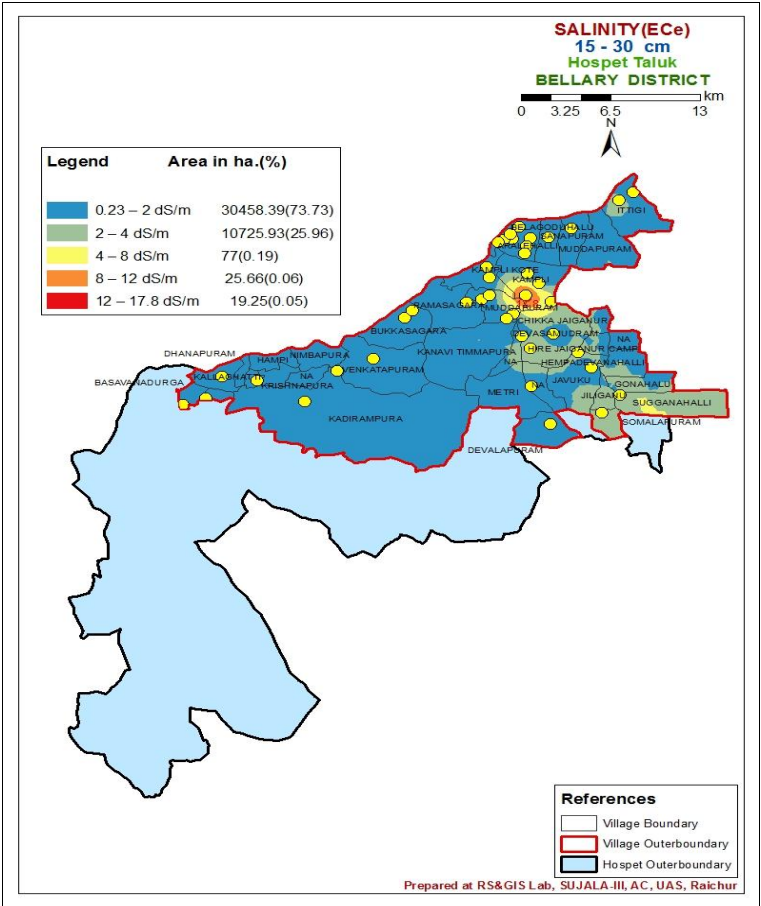


Fig 3b: E_c distribution map of sub-surface soil (15-30 cm) in Hospet taluk

Cation and Anion Composition

The mean concentrations of the major soluble cations, namely Ca²⁺ + Mg²⁺, Na⁺, and K⁺, in the soil saturation extracts of Hospet Taluk were 11.93, 21.40, and 0.37 meq L⁻¹ at 0-15 cm; 8.74, 10.50, and 0.33 meq L⁻¹ at 15-30 cm; 8.80, 25.10, and 0.12 meq L⁻¹ at 30-60 cm; and 8.11, 28.80, and 0.19 meq L⁻¹ at >60

cm depth, respectively. The corresponding mean concentrations of the major anions, namely HCO_3^- , Cl^- , and SO_4^{2-} , were 10.67, 21.24, and 0.50 meq L^{-1} at 0-15 cm; 8.26, 11.41, and 0.28 meq L^{-1} at 15-30 cm; 8.79, 11.90, and 0.48 meq L^{-1} at 30-60 cm; and 8.10, 10.70, and 0.66 meq L^{-1} at >60 cm depth, respectively (Table 1).

Irrespective of soil depth, Na^+ was the predominant soluble cation, followed by $\text{Ca}^{2+} + \text{Mg}^{2+}$ and K^+ , while Cl^- was the predominant anion, followed by HCO_3^- and SO_4^{2-} . The relatively higher concentration of Na^+ may be attributed to its comparatively high solubility and mobility relative to several other cationic salts (Sunitha *et al.*, 2010) [16]. The predominance of Na^+ and Cl^- indicates the importance of soluble sodium and chloride salts in determining the salinity and sodicity characteristics of the soils. Similar predominance of Na^+ among soluble cations has been reported by Panwar (2015), Sharma and Bhargava (1993), and Challa *et al.* (2000).

The concentrations of most soluble cations and anions generally showed a decreasing trend with increasing soil depth, although some deviations were observed, particularly for Na^+ . The relatively higher concentration of soluble salts in the surface layer may be associated with upward capillary movement of soil water followed by evaporation during the dry summer period. Under irrigated conditions in semi-arid and arid environments, high evapotranspiration can promote the upward movement and concentration of soluble salts in the near-surface soil layers. Mohammad *et al.* (2017) [8] and Scott and Smith (1987) similarly reported that alkali cations can accumulate near the soil surface through capillary movement and evaporation under irrigated conditions.

$(\text{CO}_3^{2-} + \text{HCO}_3^-)/(\text{Cl}^- + \text{SO}_4^{2-})$ and $\text{Na}^+/(\text{Cl}^- + \text{SO}_4^{2-})$ Ratios

The mean value of the $(\text{CO}_3^{2-} + \text{HCO}_3^-)/(\text{Cl}^- + \text{SO}_4^{2-})$ ratio was <1 at all soil depths in Hospet Taluk (Table 1). The proportion of samples having a ratio >1 ranged from 20.0% at >60 cm depth to 41.5% at 0-15 cm depth (Table 2). This indicates that although chloride and sulphate generally dominated the anionic composition, a considerable proportion of samples exhibited relatively greater contributions from carbonate and bicarbonate ions.

In contrast, the mean $\text{Na}^+/(\text{Cl}^- + \text{SO}_4^{2-})$ ratio was generally >1, ranging from 1.10 to 2.40, with the exception of the 15-30 cm depth (Table 1). The proportion of samples with a $\text{Na}^+/(\text{Cl}^- + \text{SO}_4^{2-})$ ratio >1 ranged from 19.5% at 15-30 cm to 62.5% at 30-60 cm depth (Table 2). The relatively high $\text{Na}^+/(\text{Cl}^- + \text{SO}_4^{2-})$ ratios at several depths indicate a potential tendency towards sodium accumulation and sodicity development.

Unlike ECe, which primarily reflects the overall concentration of soluble salts, ionic ratios provide additional information about the relative composition and possible sodicity tendency of the soil solution. According to the criteria proposed by Chhabra

(2003), soils in which either $(\text{CO}_3^{2-} + \text{HCO}_3^-)/(\text{Cl}^- + \text{SO}_4^{2-})$ and/or $\text{Na}^+/(\text{Cl}^- + \text{SO}_4^{2-}) > 1$ may be considered to have an alkaline or sodicity tendency. Conversely, when both ratios are <1, the soils may be considered saline irrespective of their pH and SAR. These ratios should, however, be interpreted together with ECe, pH, SAR, and other relevant soil chemical properties for reliable classification.

Spatial Distribution of Ionic Ratios

The spatial distribution maps of the mean $(\text{CO}_3^{2-} + \text{HCO}_3^-)/(\text{Cl}^- + \text{SO}_4^{2-})$ ratio for surface and subsurface soils of Hospet Taluk are presented in Fig. 4a and 4b. At the surface depth, approximately 48.82% of the total mapped area (41,307.43 ha) had a ratio <1, whereas 48.78% had a ratio >1. At the 15-30 cm depth, approximately 50.46% of the area had a ratio <1 and 49.53% had a ratio >1 (Fig. 4b). The nearly equal spatial distribution of the two categories indicates substantial heterogeneity in the relative dominance of carbonate-bicarbonate versus chloride-sulphate ions across the study area.

The spatial distribution of the mean $\text{Na}^+/(\text{Cl}^- + \text{SO}_4^{2-})$ ratio at surface and subsurface depths is presented in Fig. 5a and 5b. At the surface, approximately 32.04% of the area had a ratio <1, whereas 67.95% had a ratio >1. At the 15-30 cm depth, approximately 28,856.74 ha (69.86%) had a ratio <1, while 12,449.86 ha (30.12%) had a ratio >1 (Fig. 5b). The larger proportion of surface area with $\text{Na}^+/(\text{Cl}^- + \text{SO}_4^{2-}) > 1$ suggests a greater tendency for sodium dominance in the surface soil solution. In contrast, the predominance of areas with ratios <1 at 15-30 cm indicates considerable vertical variation in soluble-ion composition.

Overall, the ionic composition and ratio analysis indicate that Na^+ and Cl^- are the major contributors to the soluble salt pool in the salt-affected soils of Hospet Taluk. The occurrence of elevated $\text{Na}^+/(\text{Cl}^- + \text{SO}_4^{2-})$ ratios in a substantial proportion of the area, particularly at the surface, suggests a potential sodicity tendency. Therefore, assessment of both soluble salt concentration and ionic composition is important for identifying areas requiring appropriate drainage, leaching, and sodicity-management interventions.

Sodium Adsorption Ratio (SAR)

The mean SAR content of Hospet taluk was 7.90, 4.98, 10.4 and 13.1 at 0-15, 15-30, 30-60 and 60+ cm depths (Table-1). As far as per cent distribution of samples with SAR (Table 2) is considered, 7.3 (15-30 cm) to 60% (60+ cm) of samples had $\text{SAR} > 13$ in Hospet taluk reflecting that generally the lower layers have higher SAR values compared to surface layer in Hospet taluk. The tendency of SAR to increase with depth indicates the beginning of sodification process in subsoil layer since higher values of SAR may lead to sodification following salt leaching. Similar results have been reported by Sharma (2002); Balpande *et al.* (1996) [2] and Challa *et al.* (2000).

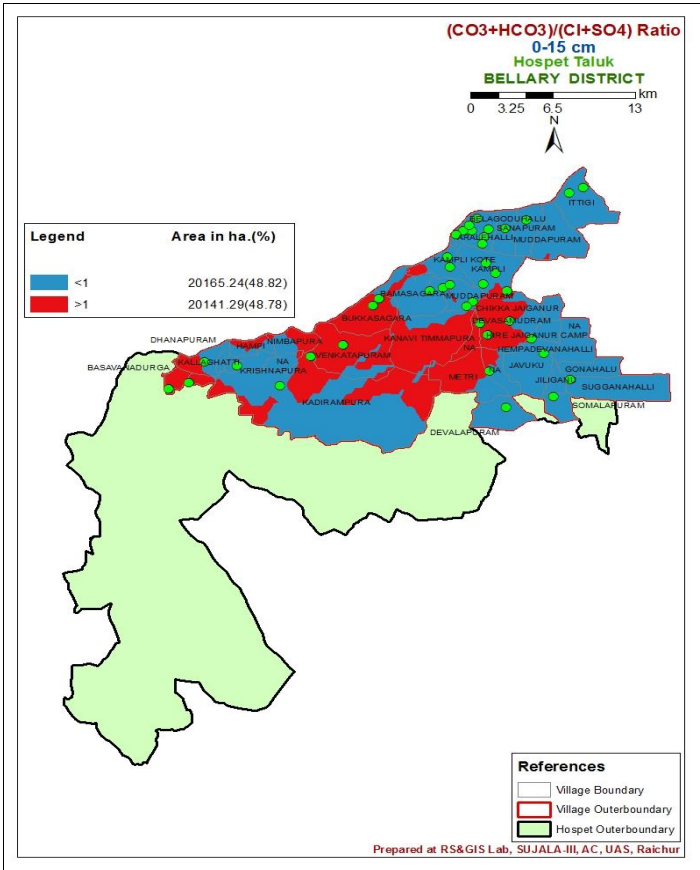


Fig 4a: $(\text{CO}_3+\text{HCO}_3)/(\text{Cl}+\text{SO}_4)$ ionic ratio distribution map of surface soil (0-15 cm) in Hospet taluk

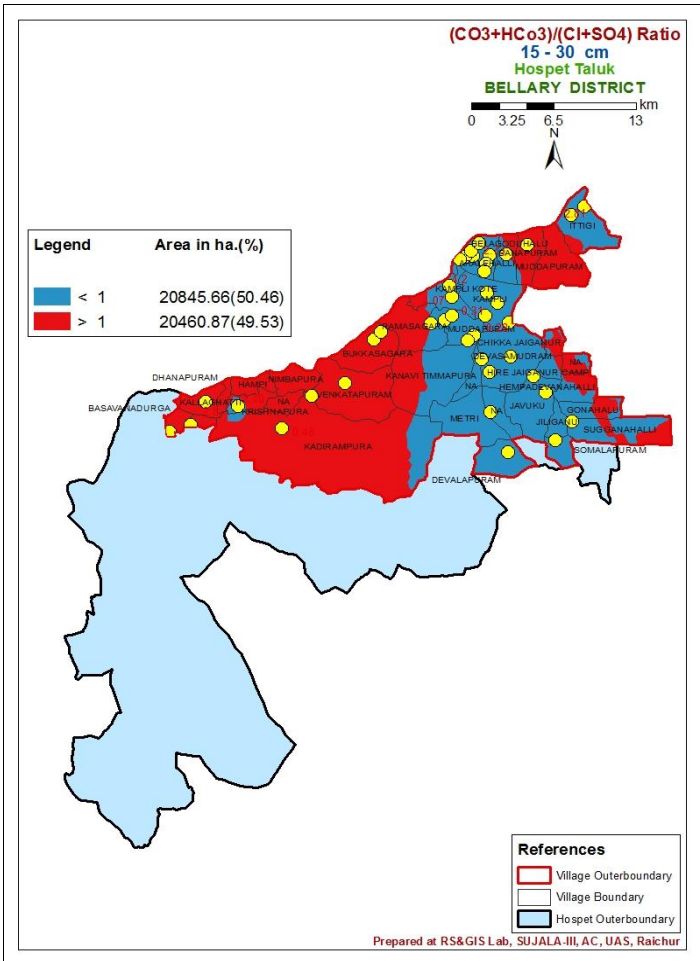


Fig 4b: $(\text{CO}_3+\text{HCO}_3)/(\text{Cl}+\text{SO}_4)$ ionic ratio distribution map of sub-surface soil (15-30 cm) in Hospet taluk

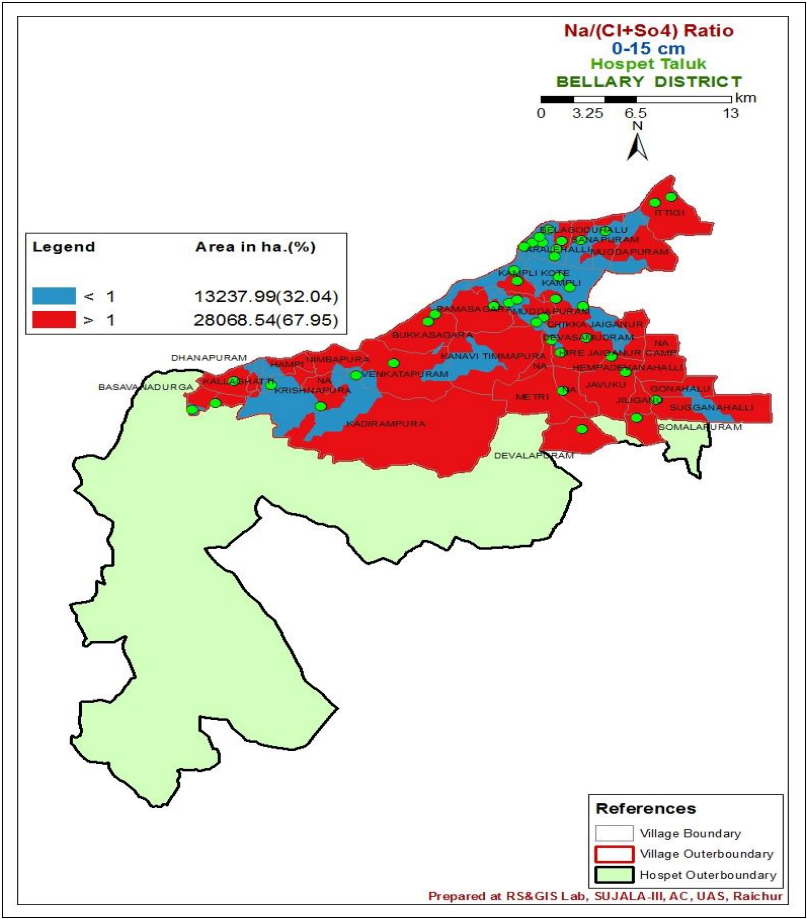


Fig 5a: Na/(Cl+SO₄) ionic ratio distribution map of surface soil (0-15 cm) in Hospet taluk

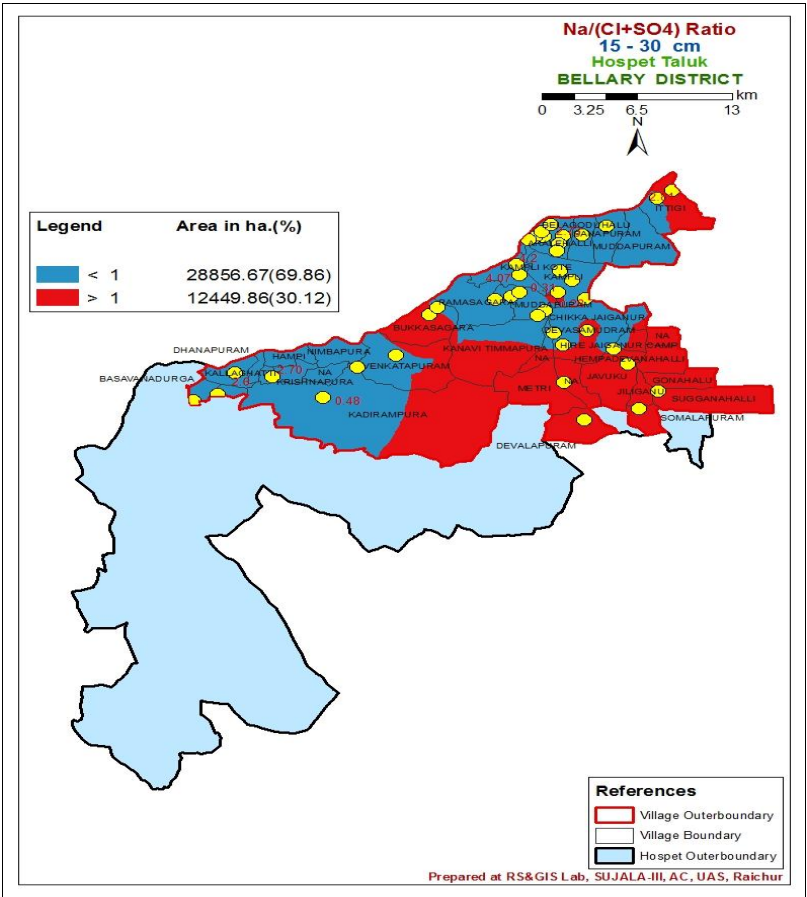


Fig 5b: Na/(Cl+SO₄) ionic ratio distribution map of sub-surface soil (15-30 cm) in Hospet taluk

The sodium absorption ratio (SAR) maps of surface and sub-surface soils of Hospet taluk is depicted in Fig.6a and 6b. The distribution of area under different categories of soil SAR as depicted in Fig.6a, revealed that out of the total sampled area in Hospet taluk (41,307.43ha), about 75.35, 19.32, 4.83 and 0.48% of area had SAR in the range of 0.97 to 13, 13.0 to 20.0, 20.0 to 30.0 and 30.0 to 42.09 respectively. At 15-30 cm, about 98.35, 1.64 and 0.04% of area had SAR in the range of 0.68 to 13.0, 13.0 to 20.0 and 20.0 to 33.69 respectively (Fig. 6b).

Conclusion

The study revealed that approximately 14.6% of the surface soil samples (0-15 cm) collected from different grids in Hospet Taluk had $EC_e > 4.0 \text{ dS m}^{-1}$, indicating that these soils were saline at the time of sampling. Among the subsurface soils, approximately 10-20% of the samples also recorded EC_e values

$> 4.0 \text{ dS m}^{-1}$, indicating the occurrence of salinity at different depths.

A considerable proportion of the samples exhibited $(\text{CO}_3^{2-} + \text{HCO}_3^-)/(\text{Cl}^- + \text{SO}_4^{2-})$ and $\text{Na}^+(\text{Cl}^- + \text{SO}_4^{2-})$ ratios > 1 , suggesting a potential tendency towards sodicity. These observations indicate that, in the absence of appropriate reclamation and soil-water management practices, some of the affected soils may progressively develop sodicity. The SAR values further supported this tendency, with approximately 20% of the surface soil samples recording SAR > 13 . Overall, the findings highlight the need for regular monitoring, appropriate drainage and leaching practices, and site-specific reclamation measures to prevent the further development and spread of salinity and sodicity in the Tungabhadra irrigation command area.

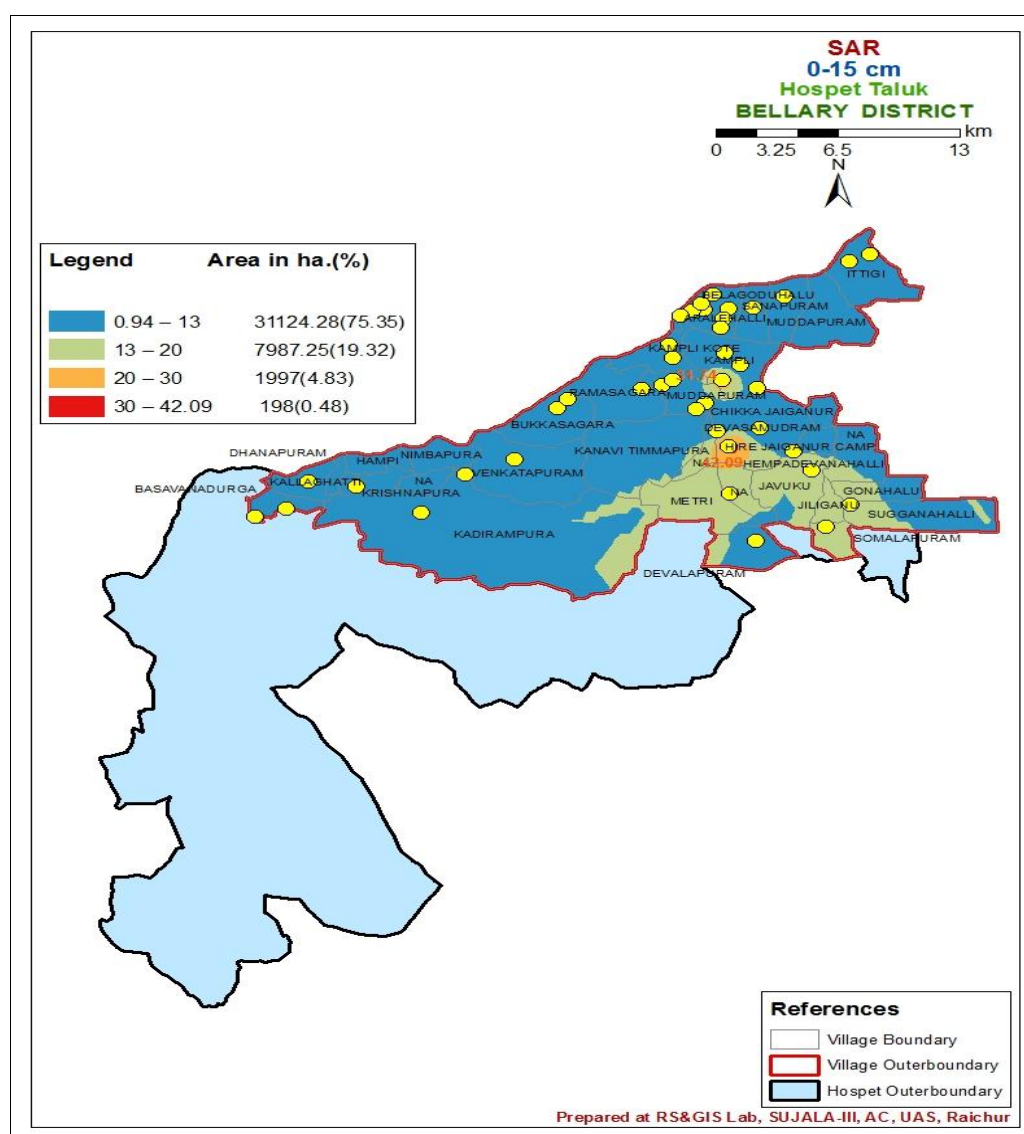


Fig 6a: SAR distribution map of surface soil (0-15 cm) in Hospet taluk

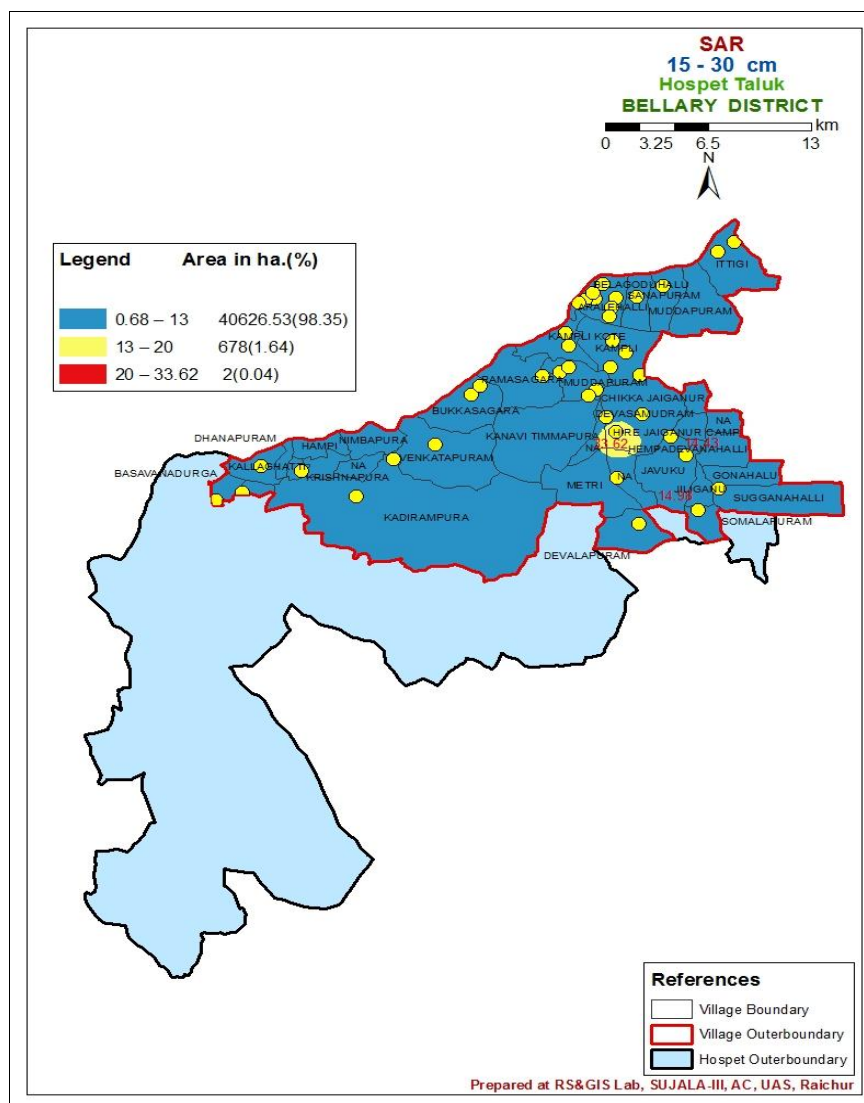


Fig 6b: SAR distribution map of sub-surface soil (15-30 cm) in Hospet taluk

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