



E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(5): 1015-1021
Received: 21-07-2019
Accepted: 25-08-2019

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Micronutrient status of salt affected soils of Hospet taluk in TBP irrigation command area

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Abstract

A study was conducted to assess available micro-nutrient (Fe, Mn, Cu and Zn) status and their relationship with soil properties of Hospet taluk in Bellary district by the aid of GPS and toposheet (1:50000 scale). A total of 82 soil samples (0-15 and 15-30 cm) collected during summer 2017 on a grid basis (5' x 5') from 15 grids (41 sampling points) were analysed for micro-nutrient status and mapped by geographic information system (GIS) technique. Majority of samples had DTPA-Zn (60.97 to 90.24%) in low category (< 1 ppm) and Fe (60.97 to 51.22%) in medium category (2.5 to 10 ppm) and Mn (97.56 to 63.41%) in medium category (5 to 25 ppm) at surface and subsurface soils respectively. The maximum per cent of surface samples had DTPA-Cu (51.22%) in high category (>2.5 ppm) and maximum per cent of sub-surface sample (78.05%) in medium category (0.5-2.5). In general, DTPA extractable Zn, Fe, Mn and Cu had negative correlation with soil pH and positive correlation with organic carbon.

Keywords: DTPA-extractable micro-nutrient, Distribution map, Salt affected soils

Introduction

Salt affected areas are one of the most important degraded areas where soil productivity is reduced due to either salinization ($EC > 4 \text{ dS m}^{-1}$) or sodicity ($ESP > 15$) or both. All soils contain some soluble salts, which is indeed essential for the healthy growth of plants. Many of these act as a source of essential nutrients. However, when quantity of salts in active root zone exceeds threshold limit the growth, yield and quality of most crops are adversely affected. Soil that contains excess salts which impair its productivity is called salt-affected soil. Salt affected soils usually occur in association with their normal counterparts, but distinguish themselves in having higher concentration of electrolytes and/or higher content of exchangeable sodium Szaboles (1989) [20].

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. Nearly 96,215 ha accounting about 26.5 per cent (3.63 lakh ha) of the total area in the command is reported to be salt affected Anonymous (2012) [1] and about 1000 ha area is being added every year IDNP (2002) [3]. As reported by Rashid *et al.* (2004) [12] 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 Naidu and Rengaswamy (1993) [8] 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 Ilyas *et al.* (2007) [4]. 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 Page *et al.* (1990) [9]. It is reported that presence of major nutrients affect crop uptake of micronutrient due to either negative or positive interactions Kumar and Babel (2011) [5].

Information on the characterization of salt affected soils through ground truth in the command is meagre or lacking and particularly no such information on micronutrient status and their distribution maps are available for soils of Hospet taluk, Bellary district, Karnataka. Hence, in view of the above the present study was undertaken.

Material and Methods**Study area**

The Tungabhadra irrigation command area in Karnataka meets irrigation requirements of crops in Bellary, Koppal and parts of Raichur districts. The study area *i.e.*, Hospet taluk in Bellary district is located at $15^{\circ}16'0''\text{N } 76^{\circ}24'0''\text{E}$ at an elevation 479 m (1,572 ft.) and has the geographical area of 934 km² respectively (Fig. 1). The major soils occurring in these are

medium deep, red gravelly clay soils, deep black clayey soils and to some extent deep black calcareous clayey soils and deep alluvial clayey soils. The average annual rainfall of Hospet taluk is 658.3 mm. The major crops grown in these taluks include paddy, jowar, maize, cotton, sugarcane etc. Soil saturation paste method of analysis revealed that about 26.83

and 48.78 and 14.63 and 9.76 per cent of surface and sub-surface samples in Hospet taluk were reported to have pHe in the range of 7.5-8.5 and E_{Ce} >4 dS m⁻¹ respectively. And about 92.68 and 29.30 per cent of surface and sub-surface samples reported to contain organic carbon >0.75 per cent Shridhar (2018) [17].

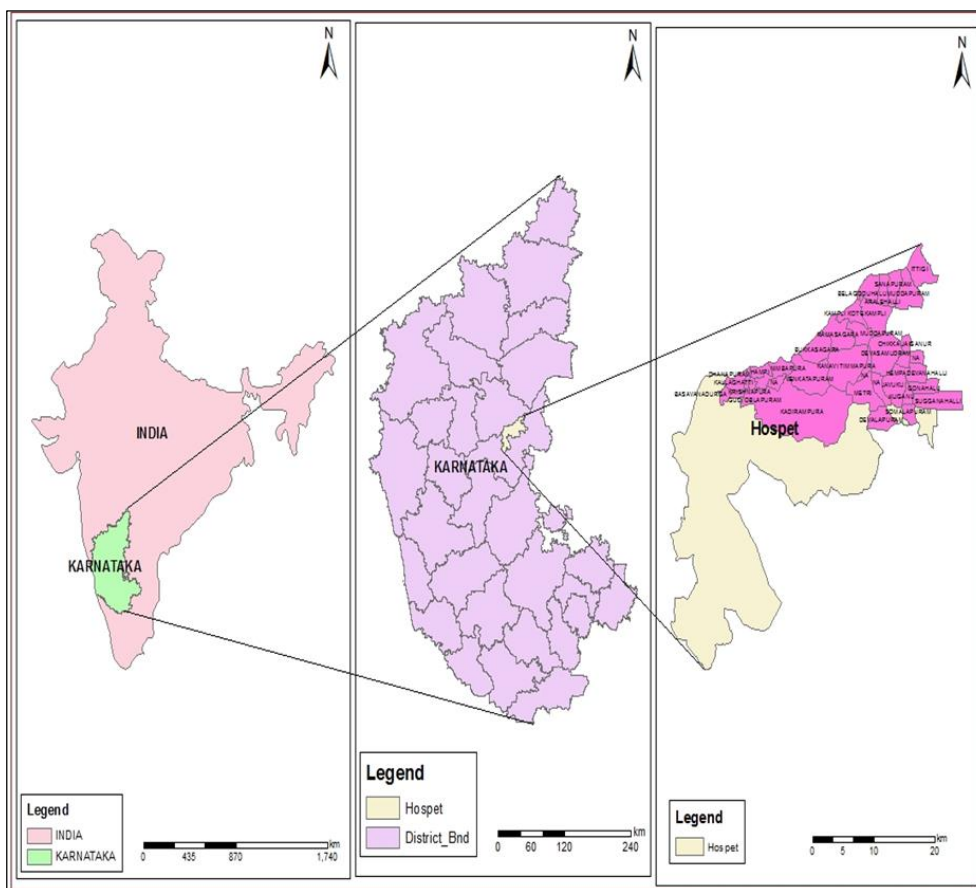
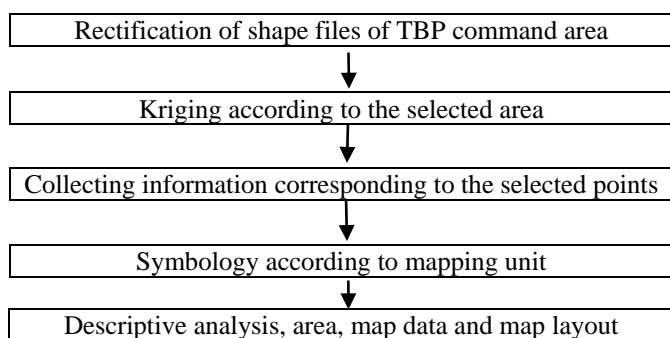


Fig. 1: Location map of Hospet taluk

Collection of soil samples and mapping of salt affected soils

A total of 81 soil samples (0-15 and 15-30 cm) collected during May 2017 on a grid basis (5' x 5') from 15 grids (41 sampling points) were analysed for micro-nutrient status and mapped by geographic information system (GIS) technique. The collected soil samples were air dried under shade, powdered with a pestle and mortar, sieved through 2 mm sieve and stored in polythene bags until further analysis. The DTPA-extractable Fe, Mn, Cu and Zn content of these samples were determined by Atomic Absorption Spectrophotometer (AAS).

The analyzed soil samples were then interpolated for mapping of DTPA-extractable micronutrients by using Arc GIS Ver., 10.4 as per procedure detailed below:



During the interpolation of the data in Arc. GIS, the values having marginal differences among the classes are either considered in the previous and/or next classes based on the lower frequency of occurrence.

Statistical analysis

Correlation coefficients (r) of DTPA-Zn, Fe, Mn and Cu with basic soil properties were worked out by following procedure as outlined by Snedecor and Cochran (1980) [18].

Karl Pearson correlation coefficient (product moment correlation coefficient)

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

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 $t_{\text{table}} < t_{\text{calculated}}$ value then 'r' is significant and if $t_{\text{table}} > t_{\text{calculated}}$ then it is non-significant.

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

Results and Discussion

DTPA-extractable Fe, Mn, Zn and Cu contents, per cent distribution and their correlation with basic soil properties.

DTPA- Fe

The DTPA extractable Fe content in surface soil (0-15 cm) varied from 0.92 to 31.29 ppm with a mean value of 9.62 ppm. At sub-surface (15-30 cm), it varied from 0.62 to 24.81 ppm with a mean value of 5.55 ppm. The mean DTPA extractable Fe content was higher in surface samples compared to sub-surface samples. Higher content of DTPA-Fe in surface soil might be due to accumulation of humic material in the surface soils besides prevalence of reduced condition in subsurface soils (Table 1). The maximum per cent of surface (60.97) and sub-surface (51.22) soil samples had DTPA-Fe in medium (2.5-10 ppm) content, as per soil test fertility ratings Tandon (2017) [21] (Table 2) and the distribution of DTPA-Fe concentration in surface and sub-surface soils of Hospet taluk is depicted in Fig. 2a and 3a. In salt affected soils of Nellore and Gudur divisions of Nellore district Andhra Pradesh, Priyadarshini (2011) [10] reported that the DTPA extractable iron content of surface soil samples varied from 0.6 to 140.7 ppm with a mean value of 31.0 ppm whereas in sub-surface samples it ranged from 0.8 to 149.2

ppm with a mean value of 24.4 ppm. About 100 per cent of surface and sub-surface samples were found to be above the critical limit (4.5 ppm) as per the ratings of Lindsay and Norvell (1978) [6]. Similarly, higher DTPA-Fe content in surface compared to subsurface soils was reported by Suribabu *et al.* (2002) [19] and Sharma *et al.* (2003) [16]. DTPA-Fe had significant and negative correlation with pHe ($r = -0.794^{**}$ and -0.641^{**}) at surface and sub-surface sample but significant and positive correlation with organic carbon ($r = 0.426^*$) at 0-15 cm (Table 3). Higher pH is responsible for iron oxidation. The most readily available form of iron i.e., Fe^{2+} ions convert into less soluble form (Fe^{3+} ions) after oxidation and precipitate as insoluble $Fe(OH)_3$ which reduces its availability. Since, organic carbon acts as a store house of nutrients and chelating agent could increase the solubility and availability of iron.

Sair Sarwar *et al.* (2007) [15] and Vijay Kumar (2009) [22] and Priyadarshini (2011) [10] studied correlation of micro nutrients with physicochemical properties of soil of district Paladin, Azad Kashmir, salt affected soils of Ongole division, Prakasam district and Nellore and Gudur divisions of Nellore district in Andhra Pradesh respectively. In general they revealed that the pH was negatively correlated with all micronutrient (Cu, Fe, Mn, Zn) while organic matter was positively correlated with Zn, Fe and Mn. Similar results were also observed by Yeresheemi *et al.* (1997) [25] for salt affected Vertisols of Upper Krishna Command, Karnataka

Table 1: Available micronutrient status in salt affected soils of Hospet Taluk, Bellary district, Karnataka.

Sl. No	Coordinates	DTPA extractable micronutrient (ppm)							
		Fe		Mn		Cu		Zn	
		Depth (cm)							
		0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
1	N 15°25'37.7" E 76°36'44.4"	11.20	7.87	5.82	11.63	3.51	2.20	1.84	0.68
2	N 15°25'40.3" E 76°37'28.5"	13.65	4.74	15.29	14.58	3.43	1.66	3.20	0.31
3	N 15°25'42.6" E 76°38'12.9"	12.39	10.36	13.37	11.35	4.45	1.41	3.89	0.83
4	N 15°26'08.4" E 76°39'08.8"	9.29	6.47	19.77	20.55	2.94	2.69	3.21	1.35
5	N 15°27'27.4" E 76°41'04.1"	5.22	13.51	24.23	20.61	2.48	2.82	0.66	0.83
6	N 15°28'17.3" E 76°42'17.5"	6.43	2.00	15.48	5.56	2.49	0.97	0.65	0.15
7	N 15°22'10.1" E 76°36'46.2"	2.75	1.13	9.25	4.66	1.98	1.79	0.69	0.51
8	N 15°21'12.2" E 76°38'24.3"	2.61	0.75	6.19	5.65	3.77	2.07	0.32	0.21
9	N 15°20'21.6" E 76°39'23.2"	5.71	1.20	8.75	7.64	2.58	2.48	4.93	1.18
10	N 15°19'39.1" E 77°39'55.1"	4.59	1.68	10.79	7.53	4.69	1.38	5.13	0.77
11	N 15°18'21.9" E 76°41'05.5"	9.47	2.14	13.94	7.82	3.17	2.06	0.98	0.24
12	N 15°17'32.3" E 76°40'20.1"	3.25	0.62	12.61	4.49	1.83	1.82	0.80	0.27
13	N 15°17'01.6" E 76°38'15.3"	5.52	5.05	6.07	4.36	1.18	1.41	0.62	0.41
14	N 15°18'04.4" E 76°28'16.9"	8.21	3.14	7.32	5.71	2.17	0.48	2.27	0.49
15	N 15°17'54.5" E 76°23'21.4"	3.74	1.67	8.07	5.94	1.32	1.81	0.56	0.26
16	N 15°18'13.2" E 76°24'15.0"	29.09	21.87	6.49	10.62	1.31	2.29	1.40	1.45
17	N 15°19'14.4" E 76°24'56.2"	18.23	9.27	10.50	9.89	2.99	1.85	0.80	0.57
18	N 15°19'03.5" E 76°26'22.3"	28.61	14.28	26.33	19.91	2.28	2.71	0.81	0.47
19	N 15°19'28.8" E 76°29'36.7"	11.41	5.96	22.47	9.53	1.26	2.21	3.76	1.79
20	N 15°20'04.5" E 76°31'04.4"	5.13	2.64	8.00	5.71	1.42	1.54	0.55	0.14
21	N 15°21'57.5" E 76°32'22.3"	8.06	4.96	6.45	2.89	1.42	1.00	0.90	0.35
22	N 15°22'49.6" E 76°35'28.4"	26.63	12.17	21.17	8.71	3.70	0.62	1.69	0.37
23	N 15°25'36.4" E 76°36'21.7"	15.94	10.20	18.66	3.86	4.50	1.37	2.48	0.46
24	N 15°25'52.6" E 76°36'38.5"	11.24	5.92	12.15	11.10	5.11	2.73	1.00	0.43
25	N 15°26'13.5" E 76°36'59.2"	15.85	5.13	17.33	5.62	5.46	2.16	1.41	0.39
26	N 15°26'26.3" E 76°36'04.1"	8.20	3.95	14.66	3.59	3.52	1.18	1.54	0.41
27	N 15°25'18.3" E 76°37'18.4"	31.29	24.81	19.29	16.30	3.82	1.99	1.80	0.97
28	N 15°24'58.3" E 76°37'13.2"	6.48	3.21	11.56	3.51	3.70	1.25	0.59	0.19
29	N 15°24'01.8" E 76°37'21.8"	3.31	2.26	8.75	2.41	2.44	1.51	0.30	0.20
30	N 15°23'33.8" E 76°37'48.4"	2.56	2.81	10.58	7.95	2.95	1.47	0.63	0.78
31	N 15°22'42.0" E 76°38'18.3"	3.68	1.01	17.81	3.76	2.49	0.29	1.31	0.10
32	N 15°23'04.4" E 76°37'15.4"	0.92	0.94	11.84	4.25	2.85	0.31	0.41	0.06
33	N 15°21'56.0" E 76°36'30.0"	6.27	3.92	14.20	3.30	2.05	0.88	1.20	0.16

34	N 15°21'5.4" E 76°37'5.8"	5.57	3.04	7.81	3.71	3.59	1.29	0.61	0.26
35	N 15°20'33.4" E 76°37'27.1"	3.79	3.76	11.19	5.75	1.86	1.01	0.48	0.12
36	N 15°18'45.6" E 76°37'30.7"	1.88	0.96	9.90	2.15	2.02	0.84	0.60	0.25
37	N 15°23'50.0" E 76°35'47.9"	12.03	7.93	9.87	10.81	3.77	4.07	0.48	0.71
38	N 15°22'41.4" E 76°34'52.2"	8.34	3.41	5.80	6.61	1.85	1.74	0.14	0.42
39	N 15°22'18.0" E 76°32'39.7"	11.12	2.51	14.89	2.35	0.85	0.80	0.50	0.17
40	N 15°23'0.0" E 76°35'46.8"	6.12	2.12	7.52	7.52	2.18	2.18	0.32	0.19
41	N 15°24'20.2" E 76°35'40.5"	8.55	6.33	18.82	18.82	4.86	4.86	0.88	0.61
Maximum		0.92	0.62	5.80	2.15	0.85	0.29	0.14	0.06
Minimum		31.29	24.81	26.33	20.61	5.46	4.20	5.13	1.79
Average		9.62	5.55	12.71	7.86	2.84	1.70	1.37	0.50

Table 2: Percent distribution of soil samples with respect to soil available micronutrient status.

Soil Depth (cm)	DTPA extractable micronutrient (ppm)											
	Fe			Mn			Cu			Zn		
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
0-15	4.89 (2)	60.97 (25)	34.15 (14)	0	97.56 (40)	2.44 (1)	0	48.78 (20)	51.22 (21)	60.97 (25)	24.39 (10)	14.63 (6)
15-30	31.71 (13)	51.22 (21)	17.07 (7)	36.58 (15)	63.41 (26)	0	7.32 (3)	78.05 (32)	14.63 (6)	90.24 (37)	9.76 (4)	0

Note: Values in parenthesis indicate number of samples.

Table 3: Correlation coefficient (r) between micronutrient and soil properties in salt affected soils of Hospet Taluk, Bellary District, Karnataka.

Soil properties	Soil Depth (cm)													
	0-15							15-30						
	pHe	ECe	OC	Fe	Mn	Cu	Zn	pHe	ECe	OC	Fe	Mn	Cu	Zn
pHe	1	0.410**	-0.298	-0.794**	-0.335*	-0.109	-0.067	1	0.332*	-0.193	-0.641**	-0.347*	-0.289	-0.065
ECe		1	-0.078	-0.243	0.006	-0.013	-0.78		1	-0.106	-0.224	-0.138	-0.290	-0.221
OC			1	0.426*	0.113	0.198	0.435*			1	0.265	0.275	0.245	0.166
Fe				1	0.419**	0.195	0.168				1	0.620**	0.323*	0.505**
Mn					1	0.236	0.217					1	0.660**	0.556**
Cu						1	0.283						1	0.483**
Zn							1							1

** Correlation is significant at 0.01 level (1%)

* Correlation is significant at 0.05 level (5%)

DTPA- Mn

The DTPA extractable Mn content in surface soil (0-15 cm) varied from 5.80 to 26.33 ppm with a mean value of 12.71 ppm. At sub-surface (15-30 cm) soil it varied from 2.15 to 20.61 ppm with a mean of 7.86 ppm. The mean DTPA extractable Mn content was higher in surface samples compared to sub-surface samples (Table 1) in Hospet taluk. The maximum per cent of surface (97.56) and sub-surface (63.41) samples had DTPA-Mn content in medium (5-25 ppm) content (Table 2) and the distribution of DTPA-Mn concentration in surface and sub-surface soils of Hospet taluk is depicted in Fig. 2b and 3b. Under irrigated cropping system, heavy nature of these soils Sharma *et al.* (2003) [16] and granite gneiss parent material Rajkumar (1994) [11] might have contributed for the accumulation of reducible and soluble forms of manganese in the surface layers. Vijay Kumar (2009) [22] reported that the average available manganese content of surface of soil was slightly higher (11.94 ppm) compared to sub-surface soil (10.99 ppm) respectively with a range of 1.46 to 48.25 ppm and 2.04 to 37.25 ppm respectively.

Similar to Fe, DTPA-Mn had significant and negative correlation with pHe ($r = -0.335^*$ and -0.347^*) similar results were also observed by kumar and bable (2011) [5], but significant and positive correlation with DTPA-Fe ($r = 0.419^{**}$ and 0.620^{**}) similar results were also observed by Haribhushan *et al.* (2011) [2] at surface (0-15 cm) subsurface (15-30 cm) soil, (Table 3). Similar to Fe, increase in pH, convert divalent form of Mn i.e., Mn^{2+} into tri or tetra valiant forms (Mn^{3+} and Mn^{4+}), which are water insoluble and hence not readily available to plants.

DTPA-Cu

The DTPA extractable Cu content in surface soil (0-15 cm) varied from 0.85 to 5.46 ppm with a mean value of 2.84 ppm. At sub-surface (15-30 cm) varied from 0.29 to 4.20 ppm with a mean value of 1.70 ppm. The mean DTPA extractable Cu contents were higher in surface samples compared to sub-surface samples (Table 1). The maximum per cent of surface (51.22) and sub-surface (78.05) samples had DTPA-Cu content in high (>2.5) and medium category (0.5-2.5) respectively, as per soil test fertility ratings (Tandon, 2017) [21] (Table 2) and the distribution of DTPA-Cu concentration in surface and sub-surface soils of Hospet taluk is depicted in Fig. 2c and 3c. Higher organic carbon content and consistent use of Cu based fungicide in control of paddy diseases could have resulted in sufficient or more than sufficient Cu content particularly in surface soils.

Vijay Kumar (2009) [22] reported that the average DTPA-Cu content of surface of soil was slightly higher (1.87 ppm) compared to sub-surface soil (1.78 ppm) respectively with a range of 0.22 to 8.10 and 0.24 to 6.54 ppm respectively.

DTPA-Cu had significant and positive correlation with DTPA-Fe, Mn and Zn ($r = 0.323^*$, 0.660^{**}) in sub-surface soil only (Table 3). The results are in agreement with the findings of Vijay Kumar (2009) [22] who also reported significant positive correlation of DTPA-Cu with Mn ($r = 0.3947^{**}$), Fe ($r = 0.3542^{**}$) and Zn ($r = 0.2293^*$).

DTPA-Zn

The DTPA extractable Zn content in surface soil (0-15 cm) varied from 0.14 to 5.13 ppm with a mean value of 1.37 ppm. At sub-surface (15-30 cm) varied from 0.06 to 1.79 ppm with a mean value of 0.50 ppm. The mean DTPA extractable Zn

content was higher in surface samples compared to sub-surface samples (Table 1). Priyadarshini (2011) [10] reported that the DTPA-Zn content of surface soil had slightly higher (0.81 ppm) content compared to sub-surface soil (0.80 ppm). Maximum per cent of surface (60.97) and sub-surface (90.24) samples had DTPA-Zn in low (<1 ppm) category as per soil test fertility ratings (Tandon, 2017) [21] in Hospet taluk (Table 2) and the distribution of DTPA-Zn concentration in surface and sub-surface soils of Hospet taluk is depicted in Fig. 2d and 3d. The lower availability of DTPA-Zn in such soils could be due alkaline soil reaction and presence of CaCO₃ which could cause precipitation of Zn as hydroxides and carbonates under alkaline pH range and/or fixation of zinc in the octahedral layers Revathi *et al.* (2005) [14]. Similar observations were made by Vijayashekar *et al.* (2000) [23] and Ravi Kumar *et al.* (2007) [13]. Vijay Kumar (2009) [22] also reported lower available zinc

content of surface soil samples ranged in salt affected soils of Ongole division, Prakasam district, Andhra Pradesh wherein it ranged from 0.17 to 3.64 ppm with a mean value of 0.70 ppm in surface soil and from 0.25 to 2.71 ppm with a mean value of 0.62 ppm in sub-surface soils respectively.

DTPA-Zn significant and positive correlation with organic carbon (0.435*). Similar observations were made by Mathur *et al.* (2006) [7] and yadav (2008) [24], DTPA-Fe ($r= 0.505^{**}$), DTPA-Mn ($r= 0.556^{**}$) and DTPA-Cu ($r= 0.483^{**}$) at 15-30 cm (Table 3).

From the study, it is clear that DTPA-Zn content in surface and sub-surface soils was in low category which needs to be supplied through organics and/or inorganic fertilizers for sustainable crop production in these soils. Further, correlation studies indicate that soil pH and organic carbon are the main soil characteristics which control the micronutrient availability in the study area.

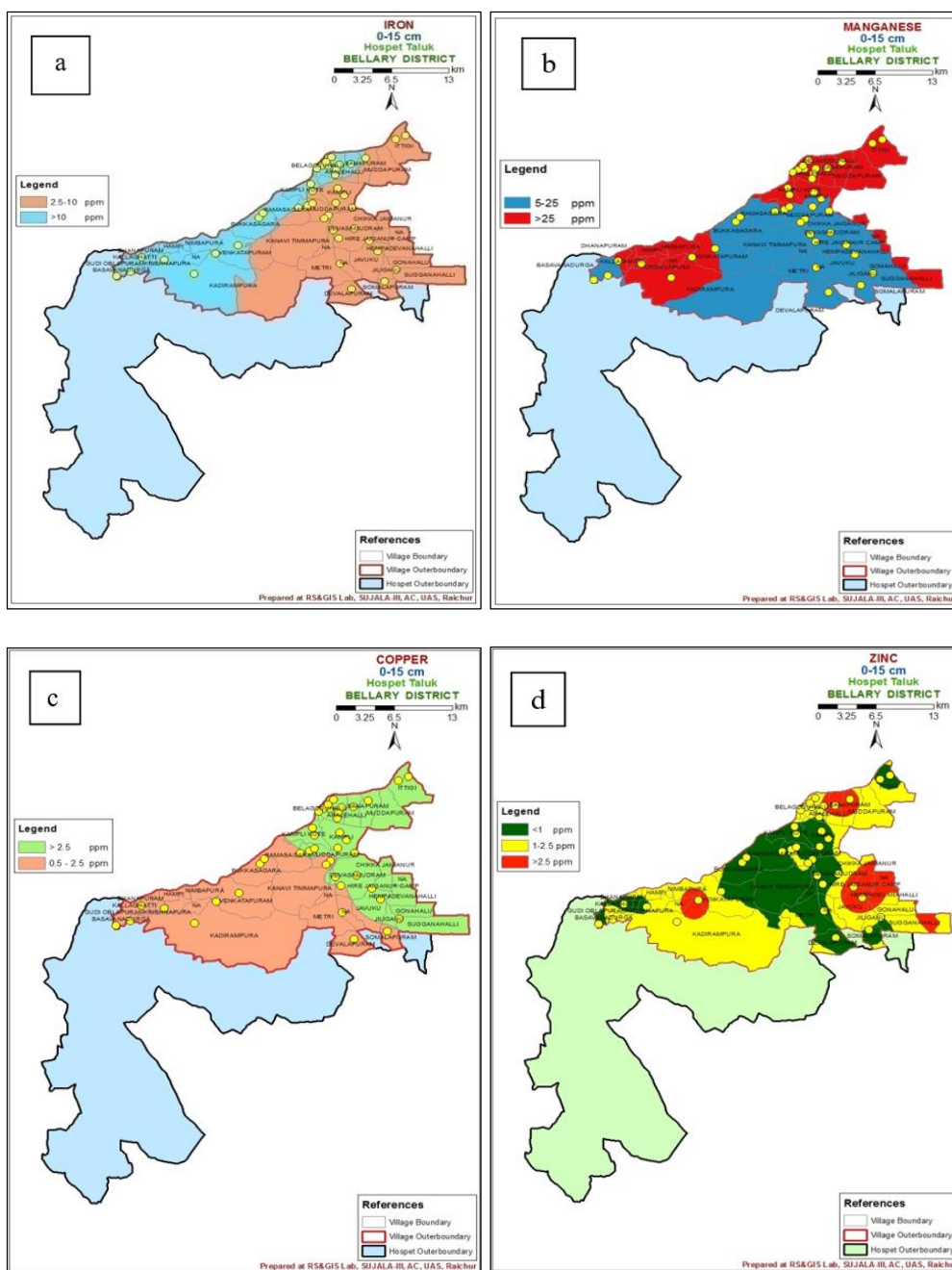


Fig 2: Distribution map of DTPA extractable (a) Fe, (b) Mn, (c) Cu and (d) Zn in surface (0-15 cm) soils of Hospet taluk.

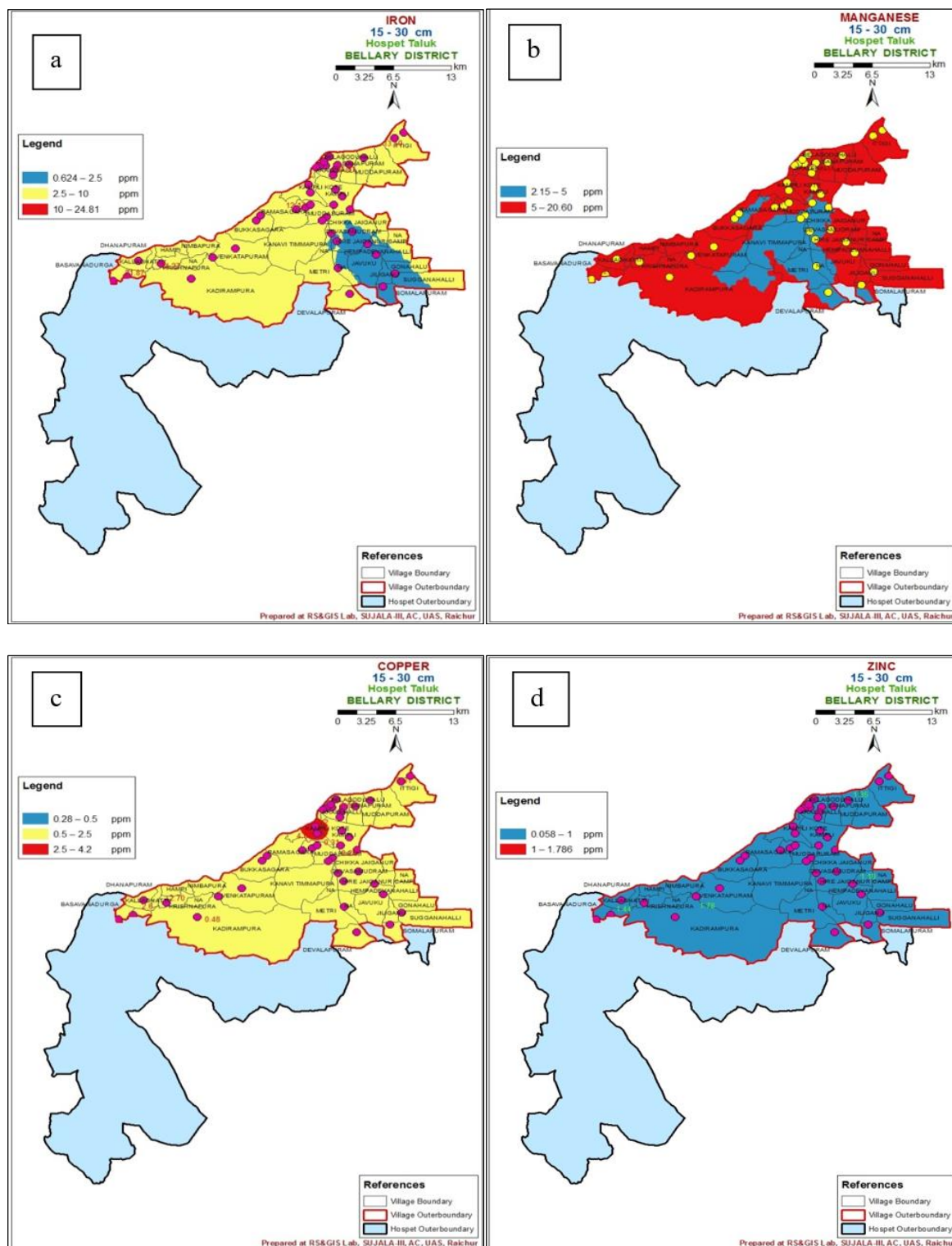


Fig 3: Distribution map of DTPA extractable (a) Fe, (b) Mn, (c) Cu and (d) Zn in subsurface soils (15-30 cm) of Hospet taluk.

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