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Assessment and mapping of soil nutrient status of Sakoli tehsil of Bhandara district of Maharashtra using GIS techniques

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Abstract
Composite soil samples were collected from 92 villages of Sakoli Tehsil of Bhandara district in Maharashtra state of India, located in north deccan Maharashtra lower plateau in '*Wainganga'* sub-basin of '*Godawari'* basin, during the pre-monsoon season of 2015-2018 and were analyzed for physico-chemical properties, available macronutrient and micro-nutrient status using standard methodology. The results showed that, pH, EC, OC, N, K, P, S, Zn, Fe, Cu, Mn and B were ranging from 6.13 to 7.31, 0.16-1.27 dSm^{-1}, 0.27-0.87 %, 115.22-596.37 kg ha^{-1}, 8.95-109.27 kg ha^{-1}, 170.20-847.28 kg ha^{-1}, 0.09-42.11 kg ha^{-1}, 0.12-4.26 mg kg^{-1}, 0.24-14.90 mg kg^{-1}, 0.74-3.86 mg kg^{-1}, 1.37-23.34 mg kg^{-1} and 0.11-2.36 mg kg^{-1} respectively. Overall 44.7% of total soil samples were in low category, 27.9 % samples were moderate or medium range and only 27.4 % soil samples were in high category of soil fertility. The nutrient index of N, P, K and S was 1.54, 2.37, 2.91 and 1.63 respectively. However, nutrient index of analyzed micronutrients viz., Zn, Fe, Cu, Mn and B was 1.14, 1.49, 2.97, 2.80 and 1.00 respectively.

Keywords: Soil fertility status, Sakoli tehsil, Bhandara, spatial mapping, GIS

Introduction
Land is the resource for food production, fuel, fiber and essential things required to human as well as all living organisms. In agriculture, soil has utmost importance as it is the cradle for all plants and crops. The 1-inch layer of soil is formed in 250-1200 years [1] and it takes another 3000 to 12000 years to make it agriculturally productive [2]. In current scenario, the soil fertility is being depilated by excessive and inefficient use of chemical fertilizers for more and more production in order to meet the requirements [3] and this excessive use of chemical is inducing the rate soil loss and deterioration in major parts of India. The application macronutrients only have created a micronutrients deficient zone in soils. The macro and micronutrients determine the soil fertility as it is the inherent ability of soil to supply nutrients to plants [4]. The GIS based soil fertility mapping can be most appropriate techniques to counter the land degradation. The integrated techniques like remote sensing and geographic information system are rapid, reliable as well as cost effective to provide quick spatial information about the ground surface for future studies [5]. The integrated use of GPS and GIS makes the results to be used for the recommendation of soil test-based fertilizer recommendation which can effectively reduce the total cost of cultivation for farmers community [5].

Material and Methods
The experiment was conducted at Sakoli tehsil of Bhandara district in Maharashtra, India which is located in north deccan Maharashtra lower plateau in '*Wainganga'* sub-basin of '*Godawari'* basin, and lies between 21.0736° N, 79.8297° E (Figure 1). The study area falls under hot moist sub humid region with moderate winter and severe summer as well distributed rainfall is received from southwest monsoon during June to September. The normal annual rainfall ranges from 1250 to 1500 mm. The surface soil samples (0-15 cm) were collected from 92 villages of Sakoli tehsil for macro and micro nutrient analysis. The georeferencing of the sampling location was done by Garmin GPSMAP 78S Marine GPS Navigator for the preparation of thematic maps of soil fertility. All the thematic maps were generated using ArcGIS 10.4.1 by kriging interpolation technique in ArcGIS toolbox. The estimation of pH by glass electrode pH meter [6], electrical conductivity by electrical conductivity meter [6], organic carbon by wet oxidation method [7], nitrogen by alkaline $KMnO_4$ method [8], phosphorus by Bray's method [9] and Olsen's method [10], potassium by Ammonium Acetate method [11] and sulphur by calcium chloride method [12]. The micronutrients like zinc, iron, copper and

manganese was estimated using DTPA solution [13]. The boron was estimated using Azomethine-H method [14].

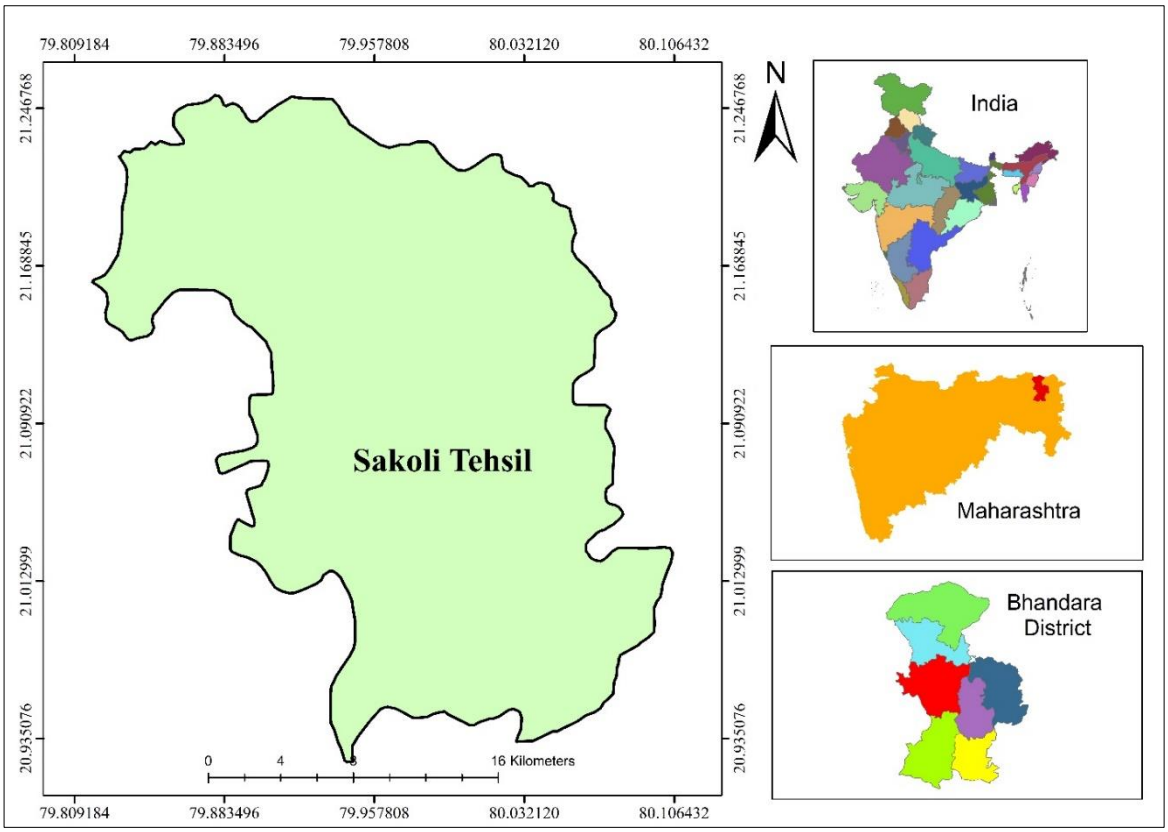

Fig 1: Location map of Sakoli tehsil of Bhandara district, Maharashtra

Results and Discussion

Physico-chemical properties in soils of Sakoli tehsil

Soil pH

The soil pH of the Sakoli tehsil was ranging from 6.13 to 7.31, with a mean of 6.77. Village Kinhi mokhe recorded the highest soil pH of 7.31 and village Borgaon recorded the lowest pH of 6.13. The soils of 16 villages (17.4 %) was acidic in nature, 76 villages (82.6 %) was neutral (Table 1).

Electrical conductivity

The electrical conductivity (EC) was ranging from 0.16 to 1.27 dSm^{-1}, with a mean of 0.32 dSm^{-1}. Soil of Mokhe village was recorded with lowest EC, which was in normal range of 0.16 dSm^{-1} but soil of Umarzari village was saline (1.27 dSm^{-1}) (Table 1). 98.9% of soil samples were in normal range, whereas only 1.1% samples were in slightly saline range.

Organic carbon

Organic carbon was ranging from 0.27 % to 0.86 %, with a mean of 0.42%. Least content of organic matter was recorded in Jamnapur village (0.27%) and highest content was recorded in Sawargaon village (0.86) (Table 1). 84.8% of soil samples were in low range, 8.7 % samples were in moderate range and 6.5 % of sample were high in organic carbon content. The thematic maps of soil fertility are presented in Fig.2 to Fig.4.

Table 1: Status of physico-chemical properties of Sakoli tehsil of Bhandara district

Particulars/Soil properties	Range	Mean	SD	CV
pH	6.13-7.31	6.77	0.26	0.04
EC	0.16-1.27	0.32	0.13	0.40
OC	0.27-0.86	0.42	0.13	0.32

Macro-nutrient status in soils of Sakoli tehsil

Available nitrogen status

The average available nitrogen content was 318 N kg ha^{-1} and ranging between 115.22 to 596.37 kg ha^{-1}. Jambhali village was recorded with lowest available nitrogen (115.22 N kg ha^{-1}) content and Sawargaon village was highest in nitrogen (596.37 N kg ha^{-1}) availability as well as SD and CV were ± 110.53 and 1.54% respectively. The NIV for the 92 soil samples of sakoli tehsil was 1.54 (Table 2 and Fig 5). Similar result was observed by Dongarwar *et al*., 2018 [5]; Kashiwar *et al*., 2018 [15]; Mali & Raut, 2001 [17].

Available phosphorous status

The average available phosphorous content was 28.28 P kg ha^{-1} and ranging between 8.95 to 109.27 kg ha^{-1}. Sukali village was recorded with lowest available phosphorous (8.95 P kg ha^{-1}) content and Wadad village was highest in phosphorous (109.28 P kg ha^{-1}) availability as well as SD and CV were ± 13.46 and 0.48% respectively. The NIV for the 92 soil samples of sakoli tehsil was 2.37 (Table 3 and Fig 6). Similar result was observed by Dongarwar *et al*., 2018 [5]; Kashiwar *et al*., 2018 [15]; Mali & Raut, 2001 [17]. In phosphorus content 1.1% of soil samples were low, 60.9% were medium and 38.0 were high (Table 2 and Fig 6).

Available potassium status

The average available potassium content was 459.11 K kg ha^{-1} and ranging between 170.20 to 847.28 kg ha^{-1}. Sakara village was recorded with lowest available potassium (170.20 K kg ha^{-1}) content and Papala Bk. village was highest in potassium (847.28 K kg ha^{-1}) availability as well as SD and CV were ± 159.45 and 0.35% respectively. The NIV for the 92 soil samples of sakoli tehsil was 2.91 (Table 2 and Fig 7). The analogous result of soil was observed by Dongarwar *et*

al., 2015 [3]; Dongarwar *et al*., 2018 [5]; Kashiwar *et al*., 2018 [15].

Table 2: Status of available macro-nutrient in Soils of Sakoli tehsil of Bhandara district

Particulars/ Soil properties	Range	Mean	SD	CV	NIV
Available N	115.22-596.37	318.08	110.53	0.35	1.54
Available P	8.95-109.27	28.28	13.46	0.48	2.37
Available K	170.20-847.28	459.11	159.45	0.35	2.91
Available S	0.09-42.11	10.38	7.65	0.74	1.63

Available Sulphur status

The average available sulphur content was 10.38 S kg ha^{-1} and ranging between 0.09 to 42.11 kg ha^{-1}. Khandala village was recorded with lowest sulphur (0.09 S kg ha^{-1}) content and Amgaon Kh. village was highest in sulphur (42.11 S kg ha^{-1}) availability as well as SD and CV were ± 7.65 and 0.74% respectively. The NIV for the 92 soil samples of sakoli tehsil was 2.91 (Table 2 and Fig. 8). Similar result was observed by Dongarwar *et al*., 2015 [3]; Dongarwar *et al*., 2018 [5]; Kashiwar *et al*., 2018 [15].

Micro-nutrient status in soils of Sakoli tehsil

Available zinc status

The average zinc content was 0.42 Zn mg kg^{-1} and ranging between 0.12 to 4.26 mg kg^{-1}. Sarati village was recorded with lowest zinc (0.12 Zn mg kg^{-1}) content and Satalwada village was highest in zinc (4.26 Zn mg kg^{-1}) availability as well as SD and CV were ± 0.45 and 1.07% respectively. The NIV for the 92 soil samples of sakoli tehsil was 1.14 (Table 3 and Fig 9). Similar result was observed by Dongarwar *et al*., 2018 [5]; Kashiwar *et al*., 2018 [15]; Mali & Raut, 2001 [17]. In zinc content 87% of soil samples were low, 12% were medium and 1.1% were high.

Available iron status

The average iron content was 5.13 Fe mg kg^{-1} and ranging between 0.24 to 14.90 mg kg^{-1}. Sonpuri village was recorded with lowest iron (0.24 Fe mg kg^{-1}) content and Tudmapuri village was highest in iron (14.90 Fe mg kg^{-1}) availability as well as SD and CV were ± 3.65 and 0.71% respectively. Similar result was observed by Dongarwar *et al*., 2018 [5]; Kashiwar *et al*., 2018 [15]; Mali & Raut, 2001 [17]. In iron content 51.1% of soil samples were low, 48.9% were medium and 0.0% were high. The NIV for the 92 soil samples of sakoli tehsil was 1.49 (Table 3 and Fig 10).

Available copper status

The average copper content was 1.35 Cu mg kg^{-1} and ranging between 0.74 to 3.86 mg kg^{-1}. Sarati village was recorded with lowest copper (0.74 Cu mg kg^{-1}) content and Tudmapuri village was highest in copper (3.86 Cu mg kg^{-1}) availability as well as SD and CV were ± 0.50 and 0.37% respectively. Similar result was observed by Dongarwar *et al*., 2018 [5]; Kashiwar *et al*., 2018 [15]; Mali & Raut, 2001 [17]. In copper content 51.1% of soil samples were low, 48.9% were medium and 0.0% were high. The NIV for the 92 soil samples of sakoli tehsil was 2.97 (Table 3 and Fig 11).

Table 3: Status of available Micro-nutrient in Soils of Sakoli tehsil of Bhandara district

Particulars/Soil properties	Range	Mean	SD	CV	NIV
Available Zn	0.12-4.26	0.42	0.45	1.07	1.14
Available Fe	0.24-14.90	5.13	3.65	0.71	1.49
Available Cu	0.74-3.86	1.35	0.50	0.37	2.97
Available Mn	1.37-23.34	9.90	6.00	0.61	2.80
Available B	0.11-2.36	0.80	0.76	0.94	1.00

Available manganese status

The average manganese content was 9.90 Mn mg kg^{-1} and ranging between 1.37 to 23.34 mg kg^{-1}. Salai Kh. village was recorded with lowest manganese (1.37 Mn mg kg^{-1}) content and Sonegaon village was highest in manganese (23.34 Mn mg kg^{-1}) availability as well as SD and CV were ± 6.0 and 0.61% respectively. Similar result was observed by Dongarwar *et al*., 2018 [5]; Kashiwar *et al*., 2018 [15]; Mali & Raut, 2001 [17]. In manganese content 2.2% of soil samples were low, 15.2% were medium and 82.6% were high. The NIV for the 92 soil samples of sakoli tehsil was 2.80 (Table 3 and Fig 12).

Available boron status

The average boron content was 0.80 B mg kg^{-1} and ranging between 0.11 to 2.36 mg kg^{-1}. Amgaon Bk. village was recorded with lowest boron (0.11 B mg kg^{-1}) content and Chichgaon village was highest in boron (2.36 B mg kg^{-1}) availability as well as SD and CV were ± 0.76 and 0.94% respectively. Similar result was observed by Dongarwar *et al*., 2018 [5]; Kashiwar *et al*., 2018 [15]; Mali & Raut, 2001 [17]. In boron content, 100% of soil samples were low and the NIV for the 92 soil samples of sakoli tehsil was 1.00 (Table 3 and Fig 12).

Conclusion

The soils of Sakoli tehsil are moderate in nitrogen content whereas, sufficient to excessive in phosphorus and potassium content. The availability micronutrient Zinc, Iron and Boron were deficient whereas, copper and manganese were sufficiently available. The application of macronutrients only in Rice-Wheat cropping system area might be the reason for low fertility status. The lower fertility status can be countered by conjoint application of complex fertilizers, organic manures like farm yard manure, compost etc. and biofertilizers to intensify the microbial population in soil.

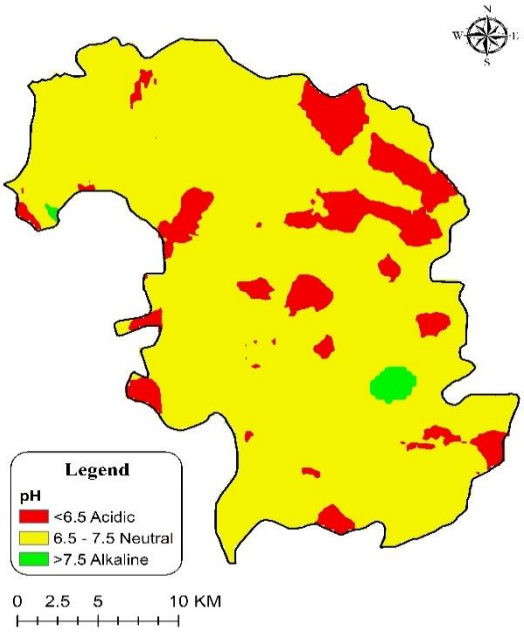

Fig 2: Thematic soil map of soil pH

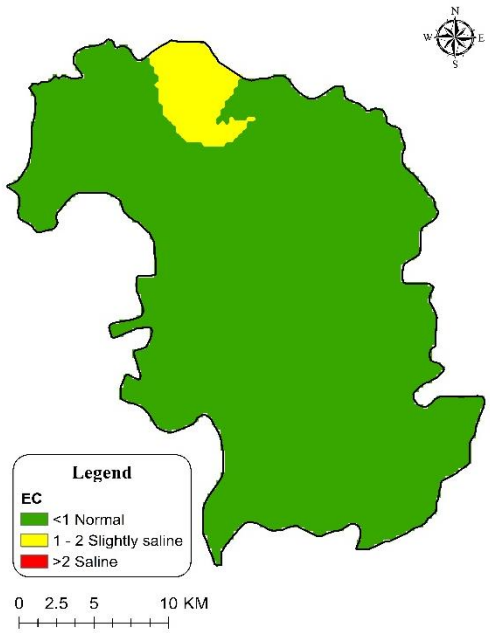

Fig 3: Thematic soil map of soil EC

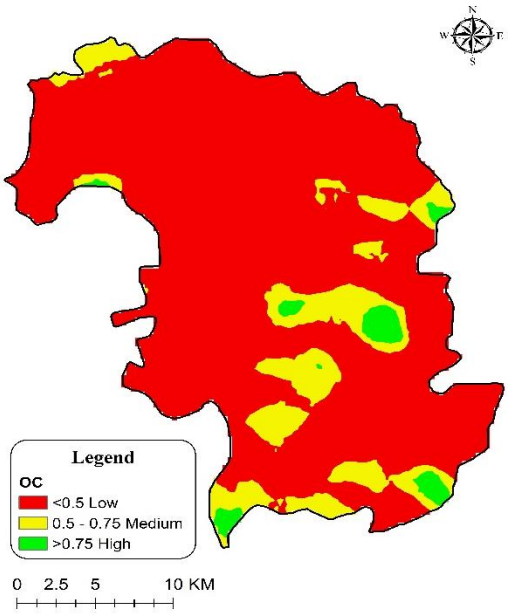

Fig 4: Thematic soil map of soil OC

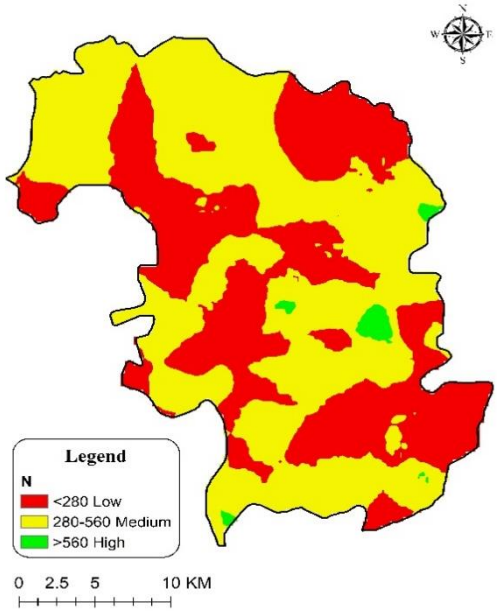

Fig 5: Thematic soil map of available N

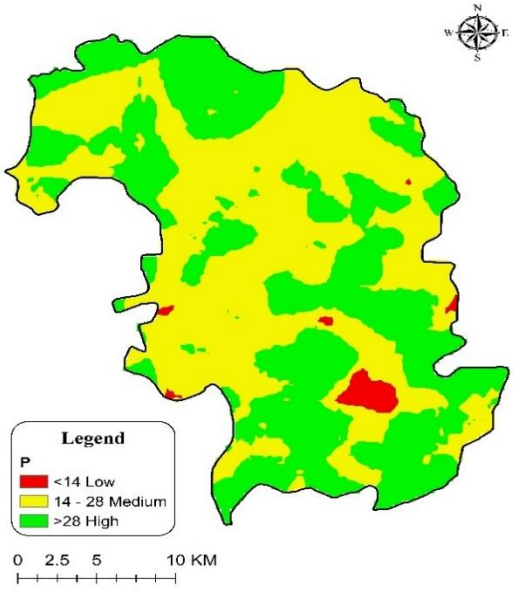

Fig 6: Thematic soil map of available P

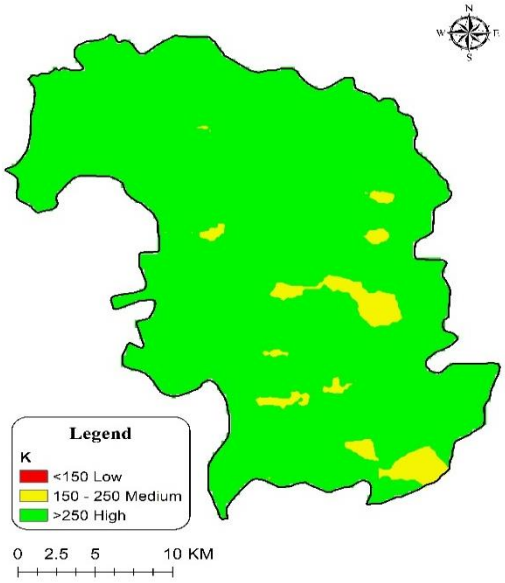

Fig 7: Thematic soil map of available K

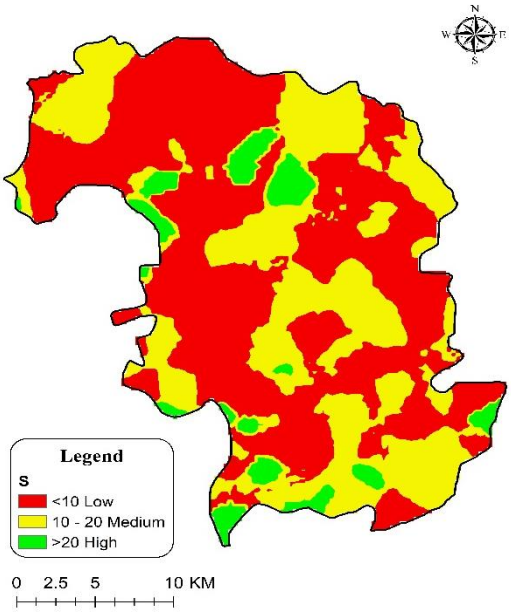

Fig 8: Thematic soil map of available S

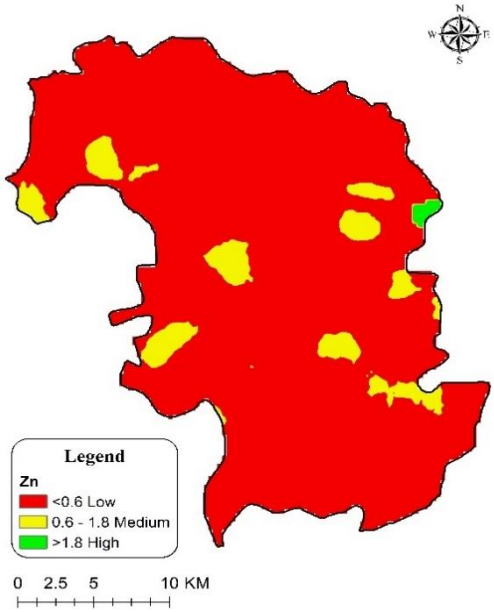

Fig 9: Thematic soil map of available Zn

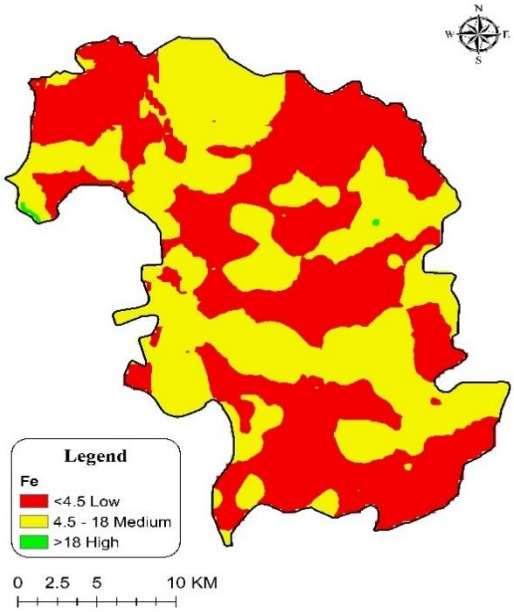

Fig 10: Thematic soil map of available Fe

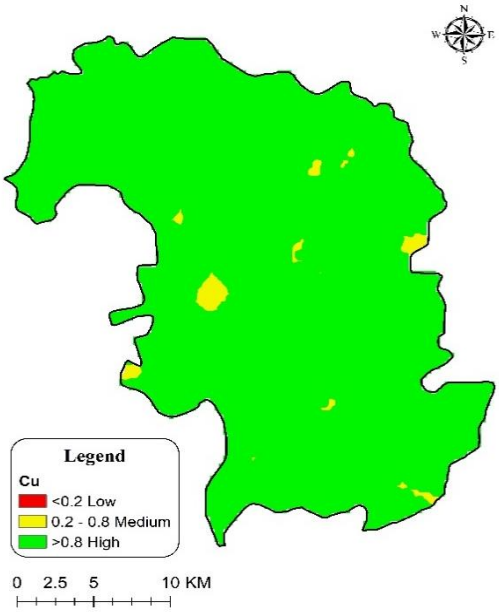

Fig 11: Thematic soil map of available Cu

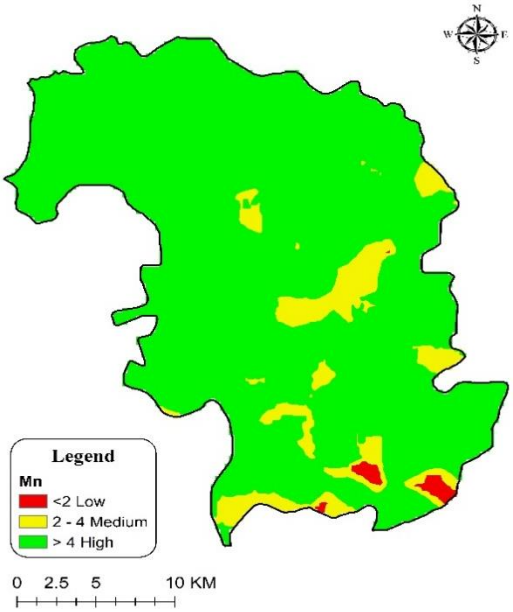

Fig 12: Thematic soil map of available Mn

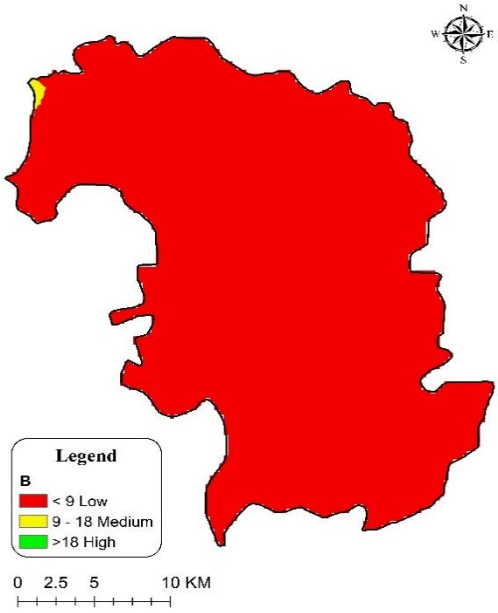

Fig 13: Thematic soil map of available B

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