*Agropedology 2021, 31 (01), 76-82*
doi.org/10.47114/j.agroped.2021.jun8

# GIS and GPS Based Soil Fertility Mapping of Micro and Secondary Nutrients of Coastal Soils of Baleswar District of Odisha, India

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**Abstract:** The basic principle of precise fertilization is to adjust the fertilizer input according to the specific circumstances or properties of soils in each location to minimize the loss and maximize the profit. To know the secondary and micro-nutrient in surface soil of Baleswar district, 360 geo-referenced surface soil samples were collected at 2 × 2 km grid interval in different land uses like rice, maize, pulses *etc.* Data indicated that deficiency of boron (B) were highest followed by zinc (Zn) and sulphur (S). Soils were sufficient in DTPA-Fe whereas deficiency showed by Mn and Cu were recorded in same patches. Three nutrient deficiencies (B+Zn+S) were observed in 15% of soils in the district.

**Key words:** *Micro and secondary nutrients, spatial distribution, single and multi-nutrients deficiency*

## Introduction

The deficiency or the excess presence of the micronutrients such as iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) in soil may have synergistic and antagonistic effects in plants. To ensure optimum agricultural production, it is imperative to know nutrients status of soils and their management to achieve sustainable production.

The GIS techniques have great demand in agriculture for future site-specific management of nutrients in different locations/villages (Vivekananda *et al.* 2017). Developing accurate application maps for site-specific fertilization is critical in implementing precision farming technology (Reza *et al.* 2010). The spatial variability of soil properties can be mapped using an interpolation technique (Cambardella and Carlen 1999). Many spatial interpolation methods have been developed of which Kriging is a geostatic interpolation technique that has proven sufficiently robust for estimating values at non-sampled locations based on sampled data. Farmers hardly have any knowledge of micronutrients and its importance for crop production. AICRP (All India Coordinated Research Project) is mainly involved in assessment of secondary and micro nutrients in soils, identifying the micro-secondary deficiency in important cropping systems and their management in different districts and agro-climatic zones of different states of the country. The present paper focuses on such assessment of soil secondary and micro nutrient content and their extent of deficiency in a coastal laterite alluvial soil of Odisha.

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## Materials and Methods

*Study area*

Baleswar, a coastal district (20.48 to 21.59 N; 86.16 to 87.29 E) with annual rainfall of the 1568.4 mm. The district is divided into 3 physiographic units' namely coastal belt, inner alluvium and north-western hills (Fig. 1). This region is mostly flooded with brackish water of estuarine rivers which is unsuitable for cultivation. Presently this area is utilized for coconut and betel cultivation. The second region is deltaic alluvial plain which is highly fertile and irrigated land. The north-western hill region is mostly hilly terrain and vegetated with tropical semi-evergreen forests.

**Fig 1. Location map of Baleswar**

*Soil sampling and analysis*

To know the status of secondary and micro nutrients, 360 soil samples were collected from surface soil upto a depth of 15 cm from 12 blocks (30 soil samples per block) at GPS 2 km grid intervals. Soil samples were air dried, grounded, sieved and analysed for secondary and micro nutrients. The soil pH and EC were measured in 1:2.5 soil: water ratio (w/v) suspension using pH meter and EC meter (Jackson 1973). Soil Organic Carbon content was estimated by Walkley and Black (1934) rapid titration method and exchangeable Ca and Mg by Versanate titration method (Page *et al*. 1982).

Available sulphur was extracted in 0.15% $CaCl_2$ and its content was determined spectrophotometrically using $BaCl_2$ as outlined by Chesnin and Yien (1951). The soils were extracted with 0.005 *M* Diethylene Triamine Penta Acetic acid (pH 7.3) extracting solution for estimation of cationic micronutrients Fe, Mn, Zn and Cu by Atomic absorption Spectrophotometers (Lindsay and Norvell 1978). Hot water soluble boron was determined as per the procedure outlined by Berger and Trough (1939) followed by colorimetric estimation using Azomethin H indicator method of John *et al*. (1975).

The descriptive statistics like minimum, maximum, mean, standard deviation (SD) for soil properties were computed using the SAS 9.2 software pack (SAS 2011). Relationship among the soil properties were established using Pearson's correlation coefficient analysis. The digital soil fertility map for available S, Cu, Zn, Mn, Fe and B have been generated.

## Results and Discussion

The pH of surface soils of district ranged from 4.44-7.43. About 96% soils were acidic and others were neutral in reaction. The losses of basic cation and other nutrients through erosion and leaching leaves the hydrogen and aluminum ions that can cause soil acidity (Brady and Well 2007). Electrical conductivity of the soils ranged from 0.022-1.66 $dSm^{-1}$ (mean 0.19 $dSm^{-1}$). Organic carbon content of soils ranged from 0.04-1.72% (mean 0.60%). Forty one percent soils were low, 32% high and others were medium in organic carbon status (Table 1).

Exchangeable calcium content of surface soils ranged from 1.6-18.8 meq100 $g^{-1}$ (mean 8.98 meq 100 $g^{-1}$) and were sufficient in exchangeable calcium content (Table 1). Exchangeable Mg content of surface soils ranged from 0.4-19.6 meq100 $g^{-1}$ with (mean 4.5 meq 100 $g^{-1}$) and its deficiency occurred 16.7-57.1% in soil samples. Highest magnesium deficiency and no deficiency were observed in Basta block and Nilgiri block respectively.

**Table 1.** Exchangeable calcium and magnesium content of soils of different blocks of Baleswar district

| Block | | Exch. Ca (meq 100 $g^{-1}$ ) | Exch. Mg (meq 100 $g^{-1}$ ) |
|---|---|---|---|
| **Khaira** | Range | 1.6-15.2 | 0.4-6.8 |
| | Mean | 8.36 | 2.76 |
| | PSD | - | 30 |
| **Simulia** | Range | 1.6-16.0 | 0.4-6.0 |
| | Mean | 6.32 | 1.68 |
| | PSD | | 50 |
| **Jaleswar** | Range | 7.6-18.8 | 0.4-14.4 |
| | Mean | 13.2 | 5.2 |
| | PSD | | 50 |
| **Bhograi** | Range | 8.4-13.6 | 0.8-16.8 |
| | Mean | 12.08 | 9.28 |
| | PSD | | 20 |
| **Basta** | Range | 8.4-16.0 | 0.4-10.8 |
| | Mean | 10.97 | 3.31 |
| | PSD | | 57.1 |
| **Baleswar** | Range | 2.8-10.0 | 0.4-19.6 |
| | Mean | 5.73 | 8.67 |
| | PSD | | 33.3 |
| **Baliapal** | Range | 3.6-16.4 | 0.4-7.6 |
| | Mean | 8.4 | 3.67 |
| | PSD | | 50 |
| **Remuna** | Range | 6.8-12 | 0.8-8.4 |
| | Mean | 8.73 | 4.13 |
| | PSD | | 16.7 |
| **Nilgiri** | Range | 6-12 | 5.6-10.4 |
| | Mean | 8.4 | 7.3 |
| | PSD | | nil |
| **Overall** | Range | **1.6-18.8** | 0.4-19.6 |
| | Mean | **8.98** | 4.5 |
| | PSD | | |

PSD : percent sample deficient

After precise analysis of no of surface soils the mean, range and deficiency per cent of available S, DTPA extractable micro nutrients cations and hot water soluble boron content of Baleswar district presented in table 2 and fertility maps of these nutrients have been depicted in figure 3. $CaCl_2$ extractable sulphur status of surface soils of Baleswar district ranged from 0.30-282.3 mg $kg^{-1}$ (mean 22.2 kg $ha^{-1}$). Sulphur deficiency was observed in 36.7% of the soils. About 70% soils were deficient in Khairia block and lowest deficiency of 3% was observed in Bhograi block. Deficiency was low in coastal area than interior ones. Similar findings were observed by Mishra *et al.* (2015) for coastal soils. DTPA extractable Zn in surface soils ranged from 0.01 -10.24 mg $kg^{-1}$ (mean 0.69 mg $kg^{-1}$). The zinc deficiency of 55.84 per cent was reported in soils. Blocks with more than 50% of soils showing Zn deficiency in Simulia, Bhograi, Oupada, Bahanaga and Soro blocks. DTPA extractable Fe in surface soils ranged from 5.36 -398.0 mg $kg^{-1}$ (mean 102 mg $kg^{-1}$). DTPA extractable Mn surface soils ranged from 0.36 – 125.6 mg $kg^{-1}$ (mean 27.5 mg $kg^{-1}$). Manganese deficiency was observed in 16% of soils of Baleswar district. DTPA extractable copper varied from 0.006 -7.58 mg $kg^{-1}$ (mean 2.43 mg

**Table 2.** Available S and micro nutrient cations in different blocks of Baleswar district

| Block | | S | Fe | Mn | Cu | Zn | B |
|---|---|---|---|---|---|---|---|
| | | mg kg$^{-1}$ | | | | | |
| **Khairia** | Range | 1.5-36.3 | 38.5-398 | 1.0-116 | 0.55-5.41 | 0.10-1.86 | 0.02-2.34 |
| | Mean | 8.44 | 136.8 | 37.5 | 2.64 | 0.71 | 0.46 |
| | PSD | 70 | | | | 46.7 | 76.7 |
| **Simulia** | Range | 1.2-40.8 | 28.5-260.8 | 0.60-125.6 | 0.01-2.65 | 0.01-1.74 | 0.17-0.91 |
| | Mean | 10.2 | 97.4 | 14.5 | 0.93 | 0.63 | 0.42 |
| | PSD | 66.7 | | | 3.3 | 63.3 | 80 |
| **Jaleswar** | Range | 3.9-91.0 | 37.6-190.7 | 3.4-122.7 | 1.75-7.58 | 0.15-1.86 | 0.10-0.77 |
| | Mean | 23.7 | 116.1 | 35.2 | 4.12 | 0.71 | 0.37 |
| | PSD | 30 | | | | 43.3 | 76.67 |
| **Bhograi** | Range | 6.5-282.3 | 5.4-207.2 | 0.8-76.1 | 0.19-7.29 | 0.01-0.97 | 0.10-4.02 |
| | Mean | 70.8 | 79.5 | 21.6 | 2.54 | 0.38 | 0.91 |
| | PSD | 3.33 | | | 6.7 | 86.7 | 23.3 |
| **Basta** | Range | 0.30-72.9 | 31.7-279.2 | 2.4-112.6 | 0.57-5.22 | 0.16-1.56 | 0.05-0.82 |
| | Mean | 12.7 | 120.4 | 52.05 | 2.92 | 0.65 | 0.37 |
| | PSD | 63.3 | | | | 46.7 | 73.3 |
| **Baleswar** | Range | 2.7-78.5 | 16.9-184.5 | 0.60-24.4 | 0.18-3.37 | 0.12-1.92 | 0.05-0.99 |
| | Mean | 21.3 | 97.5 | 5.22 | 1.38 | 0.66 | 0.23 |
| | PSD | 43.3 | | | | 50 | 86.67 |
| **Baliapal** | Range | 3.0-205.2 | 34.7-307.6 | 0.5-83.9 | 0.34-170.5 | 0.18-10.24 | 0.12-0.70 |
| | Mean | 30.09 | 103.6 | 33.4 | 8.9 | 1.12 | 0.26 |
| | PSD | 6.67 | | | 3.3 | 36.7 | 93.33 |
| **Remuna** | Range | 1.5-63.9 | 29.6-249.5 | 0.4-118.3 | 0.50-117.2 | 0.33-5.28 | 0.05-2.36 |
| | Mean | 22.12 | 104 | 44.7 | 7.14 | 0.97 | 0.28 |
| | PSD | 20 | | | | 40 | 90 |
| **Nilgiri** | Range | 2.97-71.4 | 16.8-162.9 | 1.4-107.2 | 0.35-6.22 | 0.12-1.86 | 0.02-0.51 |
| | Mean | 14.36 | 89.8 | 36.5 | 2.4 | 0.9 | 0.23 |
| | PSD | 50 | | | | 30 | 96.67 |
| **Oupada** | Range | 2.97-77.9 | 19.8-166.2 | 1.60-59.0 | 0.30-3.29 | 0.14-1.54 | 0.12-2.91 |
| | Mean | 20.2 | 92.6 | 17.12 | 1.85 | 0.54 | 1.54 |
| | PSD | 40 | | | 3.3 | 66.7 | 6.67 |
| **Bahanaga** | Range | 3.6-43.7 | 17.8-180.7 | 1.0-44.7 | 0.49-2.92 | 0.09-2.50 | 0.05-0.79 |
| | Mean | 15.08 | 89.8 | 10.32 | 1.3 | 0.61 | 0.26 |
| | PSD | 20 | | | | 76.7 | 93.3 |
| **Soro)** | Range | 2.7-30.6 | 10.5-260.1 | 4.3-60.9 | 0.74-3.95 | 0.07-1.20 | 0.02-0.65 |
| | Mean | 13.3 | 96.87 | 21.3 | 2.17 | 0.42 | 0.27 |
| | PSD | 26.7 | | | | 83.3 | 86.67 |
| **Overall** | **Range** | **0.30-282.3** | **5.36-398.0** | **0.36-125.6** | **0.006-7.58** | **0.01-10.24** | **0.02-4.02** |
| | **Mean** | **22.2** | **102** | **27.5** | **2.43** | **0.69** | **0.46** |
| | **PSD** | **36.7** | **nil** | **16.11** | **4.43** | **55.84** | **73.61** |

kg$^{-1}$) and copper deficiency were observed in 4.4% soils of district. Hot water soluble boron content of soils ranged from 0.02 – 4.02 mg kg$^{-1}$ (mean 0.46 mg kg$^{-1}$) and 73.61% soils were deficient in Boron. Highest deficiency was observed for boron followed by zinc and sulphur in coastal soils of Baleswar. Highest boron deficiency may be attributed to light texture sandy soil with low organic matter content as well as non application of boron. Deficiency of micronutrients followed in the order B>Zn>S for coastal soils of Baleswar which was mostly due to light texture acidic sandy loam soil with low organic matter. Digitised soil fertility maps were prepared using kirging interpolation method by using arc GIS software and presented in figure 3.

Multi-nutrient deficiency such as S+B was highest in 26.4% of soils followed by Zn + S in 20.8% soils. Combined deficiency of S+B+Zn was noticed in 15.3% of samples (Fig. 2).

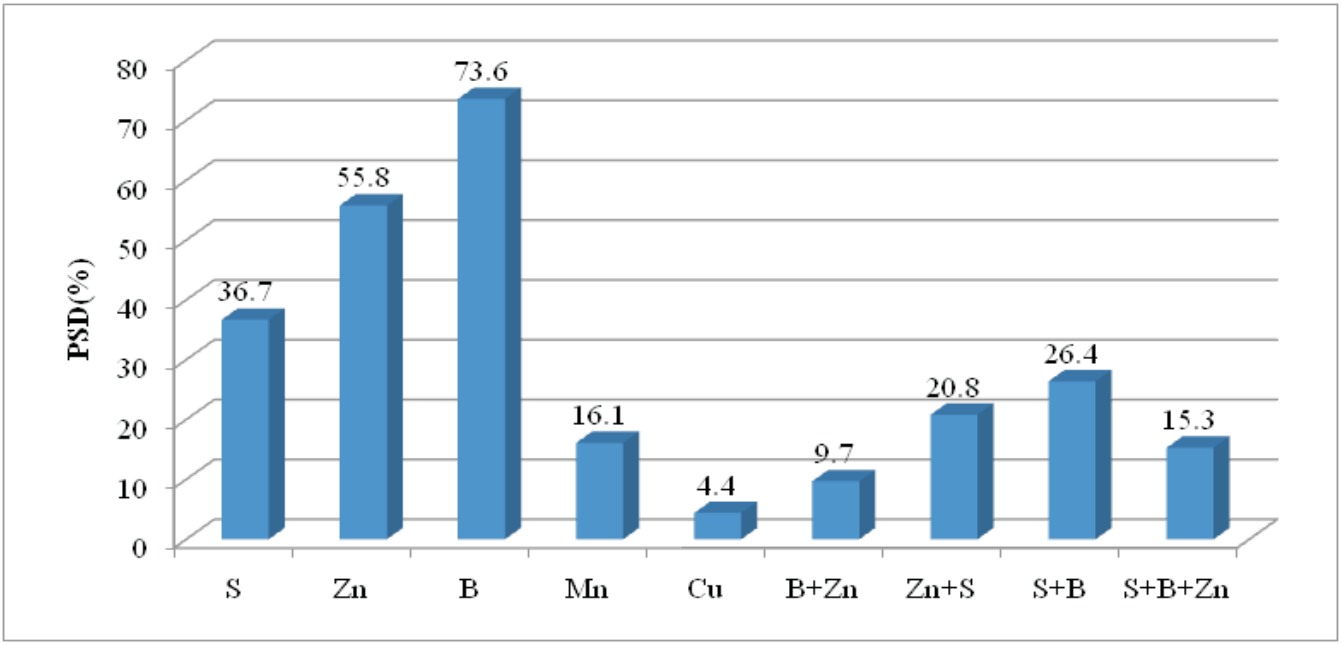



**Fig. 2.** Single and multi-nutrient deficiency of in soils of Baleswar district

*Correlation coefficient of different soil parameters with nutrients*

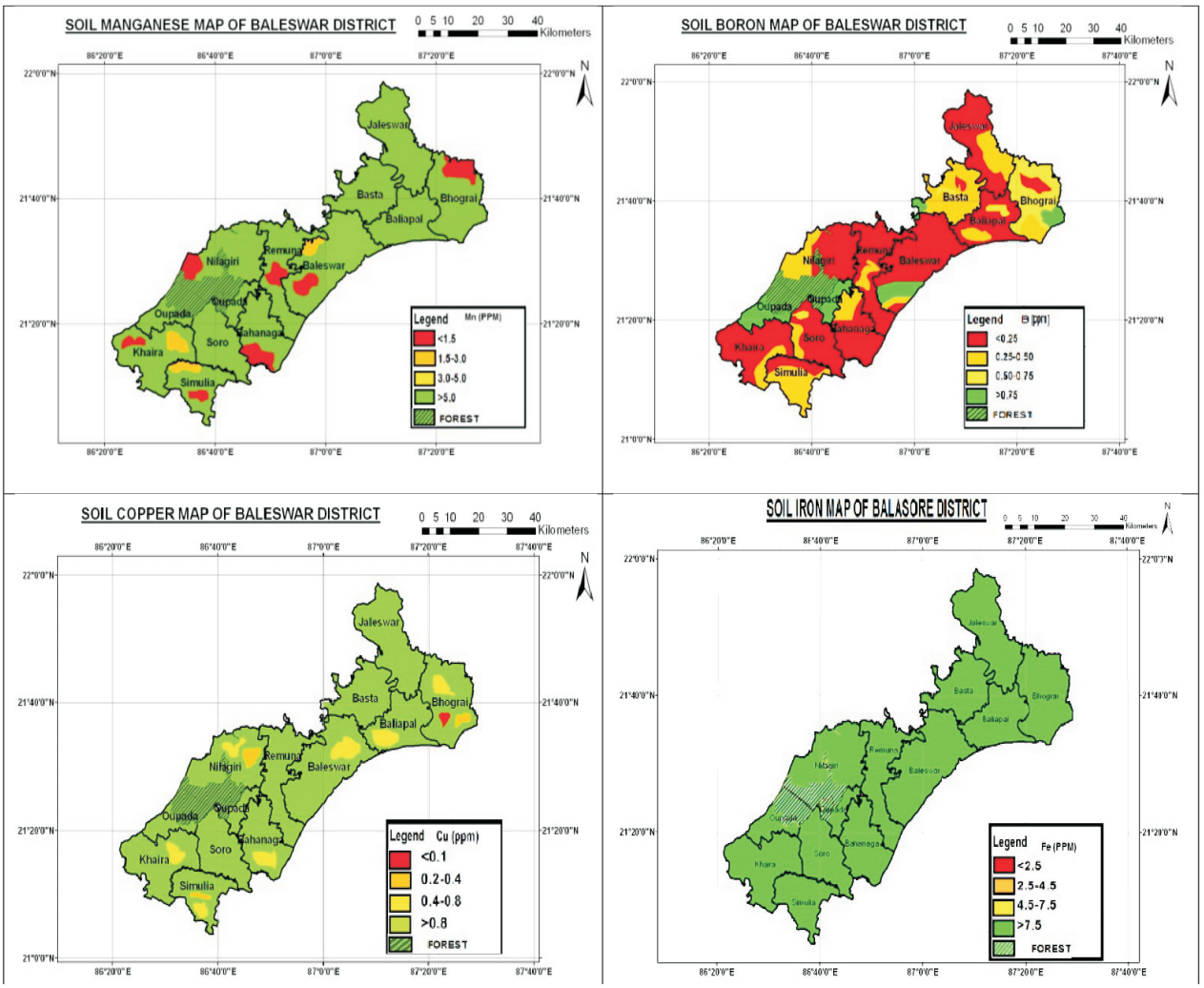
Simple linear Correlation coefficient of nutrients with basic soil properties were computed and presented in table 3. It was found that non-significant negative correlation was observed between pH and cationic micronutrients. Bansal and Takkar (1985) reported similar findings for Zn. Non significant positive correlation of pH was observed with available boron and sulphur. Positive correlation was observed between organic carbon and nutrients (r = 0.540 for Cu and r = 0.370 for Mn) except boron.

**Conclusion**

It was found that highest deficiency of boron was observed in Baleswar soils followed by Zn. Deficiency of secondary and micro nutrients followed the order as B>S>Zn>Mn>Cu. S+B+Zn deficiency was observed in 15 % of samples of Baleswar district. The soils of Khairia and Simulia blocks need sulphur management for oilseeds and pulses. Bhograi and Soro blocks with > 80% Zn deficiency need Zn management for cereals. Copper and Mn deficiency was observed at few locations. Since rice is the dominant crop of Baleswar, deficiency of Zn and B may hamper grain filling and quality foodgrain production. Soil management practices with respect to the deficient nutrients needs to be planned for crops and cropping systems of the district for higher crop production.

**Table 3.** Correlation matrix of secondary and micro nutrients with soil properties

| | pH | EC | OC | B | Zn | Cu | Fe | Mn | S |
|---|---|---|---|---|---|---|---|---|---|
| **pH** | 1.000 | | | | | | | | |
| **EC** | -0.112 | 1.000 | | | | | | | |
| **OC** | -0.074 | 0.282 | 1.000 | | | | | | |
| **B** | 0.036 | -0.053 | -0.015 | 1.000 | | | | | |
| **Zn** | -0.141 | 0.027 | 0.146 | -0.092 | 1.000 | | | | |
| **Cu** | -0.086 | 0.394* | 0.504* | -0.013 | 0.196 | 1.000 | | | |
| **Fe** | -0.293 | -0.076 | 0.110 | -0.019 | 0.331* | 0.203 | 1.000 | | |
| **Mn** | -0.050 | 0.334* | 0.370* | -0.034 | 0.139 | 0.603* | 0.010 | 1.000 | |
| **S** | 0.059 | 0.145 | 0.220 | 0.113 | 0.038 | 0.109 | -0.134 | -0.030 | 1.000 |



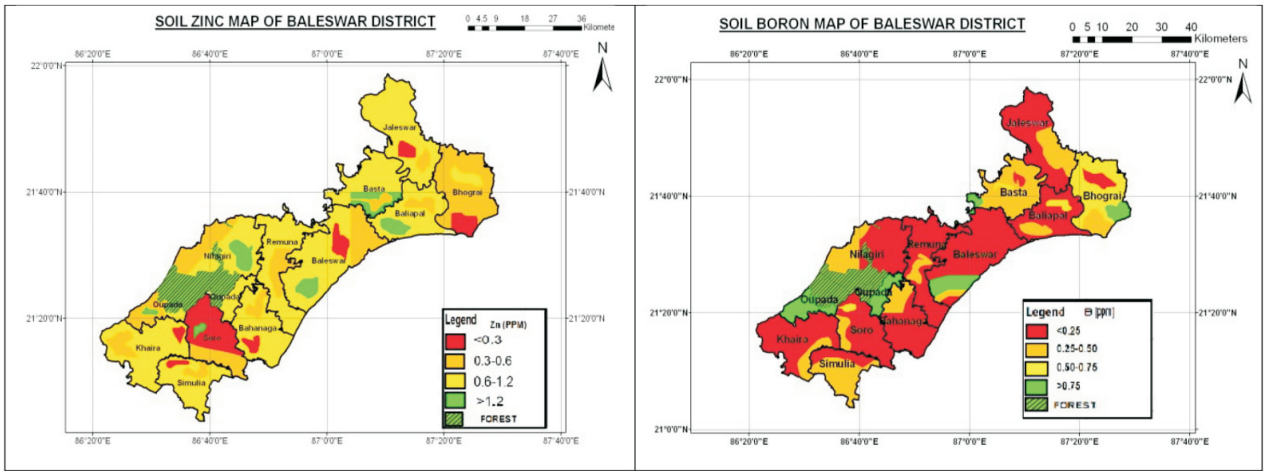



**Fig. 3.** Digitized soil fertility map of S, B, Zn, Fe, Mn, Cu for surface soils of Balasore district

**Acknowledgment**

Authors express sincere thanks to the Project Coordinator, AICRP on Micronutrient Project as well as Indian Council of Agricultural Research for funding this work.

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*Received: February, 2021* *Accepted: May, 2021*