Soil fertility appraisal of Bhandara block of Maharashtra using geospatial techniques

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Abstract

The geospatial techniques are playing a vital role in spatial assessment of soil nutrient variabilities. Study was undertaken to assess the available macronutrient and micro-nutrient status of Bhandara tehsil of Maharashtra with the help of GPS based one hundred forty-seven soil samples during the period of 2015-2018. The results recorded that pH of 70% samples were neutral in nature, non-saline and 72% samples were deficient in terms of oxidizable organic carbon. The mean values of 291.70 kg ha\(^{-1}\), 37.07 kg ha\(^{-1}\), 531.33 kg ha\(^{-1}\), 11.94 kg ha\(^{-1}\), 0.35 mg kg\(^{-1}\), 4.44 mg kg\(^{-1}\), 1.26 mg kg\(^{-1}\), 7.66 mg kg\(^{-1}\) and 1.52 mg kg\(^{-1}\) for N, K, P, S, Zn, Fe, Cu, Mn and B respectively was recorded. The nutrient index values of nitrogen, phosphorus, potassium and sulphur were 1.5, 2.6, 3.0 and 1.6 respectively. In case of micronutrients, nutrient index values of zinc, iron, copper, manganese and boron were 1.0, 1.4, 2.8, 2.9 and 1.00 respectively.

Keywords: Nutrient status, spatial mapping, GPS, GIS, bhandara, maharashtra

Introduction

The soil plays the prime role in agriculture and supports all the living organisms on earth by supplying various food, fuel, fiber and essential things required (Kashiwar et al., 2019a; 2019b)\(^{[10,11]}\). In the current 21\(^{st}\) century the excessive growth in the population has pushed the farmers community toward the intensive cultivation of high yielding varieties for increasing the food production but it has tremendously declined the soil fertility status in the Indian soils (Kashiwar et al., 2019a; Arunkumar et al., 2016)\(^{[10,1]}\). This is directly affecting the use fertilizer and production and productivity of many crops (Jena et al., 2016)\(^{[9]}\). The geospatial technologies are being widely adopted in agriculture due to its usefulness and effectiveness over conventional method. In current scenario there is a need of systematic mapping of the available soil nutrients for site specific nutrient management using soil fertility maps. The modern spatial techniques are cost and time efficient over conventional methods. These techniques widely help in future policy making decisions (Kashiwar et al., 2019a; Kashiwar et al., 2016)\(^{[10,12]}\). The Geospatial techniques of soil fertility mapping provide key support in making the future policy and provide support for decision as well as it effectively reduced the excessive use of chemical fertilizer and cost of cultivation (Kashiwar et al., 2019a)\(^{[10]}\). With this background, a study was undertaken to assess the available macro- and micro-nutrient status of Bhandara tehsil of Maharashtra using geospatial techniques.

Material and methods

The Bhandara block is located between 21.265455 N and 20.966684 N latitude; between 79.486451 E and 79.835310 E longitude (Figure 1) in the state of Maharashtra, India. The georeferenced surface soil samples (0-15 cm) from 147 villages of Bhandara block were collected for macro and micro nutrient analysis. The Garmin GPSMAP 78S Marine GPS Navigator was used for the collection of georeferenced soil sample. The spatial thematic maps were generated using ArcGIS 10.4.1 by kriging as well as IDW interpolation technique in ArcGIS toolbox. The estimation of pH by glass electrode pH meter (Jackson, 1973)\(^{[8]}\), electrical conductivity by electrical conductivity meter(Jackson, 1973)\(^{[8]}\), organic carbon by wet oxidation method (Walkey and Black, 1934)\(^{[17]}\), nitrogen by alkaline KMnO\(_4\) method (Subbiah and Asija, 1956)\(^{[16]}\), phosphorus by Bray’s method (Bray and Kurtz, 1946)\(^{[2]}\) and...
Olsen’s method (Olsen, 1954) \(^{15}\), potassium by Ammonium Acetate method (Hanway and Heidel, 1952) \(^{7}\) and sulphur by turbidimetric method using calcium chloride extractant (Chesnin and Yien, 1951) \(^{3}\). The micronutrients like zinc, iron, copper and manganese was estimated using DTPA extractant (Lindsay and Norvell, 1978) \(^{13}\). The boron was estimated using Azomethine- H method by spectrophotometer (Wolf, 1974) \(^{19}\).

### Result and Discussion

**Physico-chemical properties of soils of Bhandara block**

The average soil pH of Bhandara tehsil was 7.2 and ranging between 6.2 to 7.8. A village named ‘Dighori’ is recorded with 7.8 soil pH as highest and ‘Mujbi’ village soil was recorded with 6.2 as lowest. Around 2.7% of samples were acidic, 70.7% were neutral and 26.5% were alkaline in nature (Table 1). The electrical conductivity of entire tehsil was found in non-saline range (<1 dSm\(^{-1}\)) which was ranging from 0.19 to 0.70 dSm\(^{-1}\) (Table 1). The average organic carbon was 0.45% of which, lowest was recorded in ‘Sonkund’ village with 0.28% and ‘Belgaon’ was highest with 0.80% of organic carbon (Table 1). Around 72.8% samples were low, 25.9% were moderate and only 1.4% samples were found high in organic carbon content. The thematic maps of pH, electrical conductivity and organic carbon are presented in Fig.2, Fig.3 and Fig.4.

<table>
<thead>
<tr>
<th>Particular/Soil properties</th>
<th>Range</th>
<th>Mean</th>
<th>SD</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.2-7.8</td>
<td>7.20</td>
<td>0.30</td>
<td>0.05</td>
</tr>
<tr>
<td>EC</td>
<td>0.20-0.70</td>
<td>0.30</td>
<td>0.10</td>
<td>0.20</td>
</tr>
<tr>
<td>OC</td>
<td>0.28-0.80</td>
<td>0.45</td>
<td>0.10</td>
<td>0.30</td>
</tr>
</tbody>
</table>

**Table 1: Status of Physico-chemical properties of Bhandara block of Maharashtra**

**Macro-nutrient status in soils of Bhandara block**

**Available nitrogen status**

The soil samples were recorded with mean available nitrogen content of 291.70 N kg ha\(^{-1}\) from which, village ‘Wadipar’ was recorded with lowest available nitrogen (121.17 N kg ha\(^{-1}\)) and soil of ‘Khokurala’ village was highest in nitrogen (537.35 N kg ha\(^{-1}\)) content. Around 51.7% samples were low, 48.3% were medium and none of the samples were recorded high nitrogen content in Bhandara tehsil. The nutrient index value (NIV) for nitrogen for 147 samples was 1.5 (Table 2 and Fig 5). Similar results were also observed by Kashiwar et al., 2019b \(^{11}\), 2019a \(^{10}\), 2018 \(^{12}\); Dongarwar et al., 2018b \(^{5}\), 2018a \(^{6}\); Mali & Raut, 2001 \(^{14}\).

**Available phosphorous status**

The mean available phosphorous (P) content of 147 soil samples was 37.07 kg ha\(^{-1}\) from which, ‘Salebadi’ village was lowest (9.83 kg ha\(^{-1}\)) and ‘Kothurna’ village was recorded with the highest in phosphorius (124.93 kg ha\(^{-1}\)) availability. The available phosphorus content of 3.4% samples was low, 36.1% were medium and 60.5% were high in phosphorus content. (Table 2 and Fig 6). The NIV for available phosphorus of 147 soil samples of Bhandara block was 2.6 (Table 3 and Fig 6). Similar results were also observed by Kashiwar et al., 2019b \(^{11}\), 2019a \(^{10}\), 2018 \(^{12}\); Dongarwar et al., 2018b \(^{5}\), 2018a \(^{6}\); Mali & Raut, 2001 \(^{14}\).

**Available potassium status**
The average available potassium (K) content throughout the samples was 531.33 kg ha⁻¹ from which soil of village ‘Palgaon’ was recorded with lowest value of 258.05 kg ha⁻¹ and ‘Chikhaldobi’ village was recorded with highest availability of potassium (941.37 kg ha⁻¹). The NIV for available K of 147 soil samples of Bhandara block was 3.0. (Table 2 and Fig 7). The similar results were observed by Kashiwar et al., 2019b [11]; 2019a [10]; 2018 [12]; Dongarwar et al., 2015 [4]; 2018b [5]; 2018a [6]; Mali & Raut, 2001 [14].

<table>
<thead>
<tr>
<th>Particular/Soil properties</th>
<th>Range</th>
<th>Mean</th>
<th>SD</th>
<th>CV</th>
<th>NIV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available N</td>
<td>121.2-537.4</td>
<td>291.7</td>
<td>125.4</td>
<td>0.4</td>
<td>1.5</td>
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<td>Available P</td>
<td>9.8-124.9</td>
<td>37.1</td>
<td>18.9</td>
<td>0.5</td>
<td>2.6</td>
</tr>
<tr>
<td>Available K</td>
<td>258.0-941.4</td>
<td>531.3</td>
<td>149.3</td>
<td>0.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Available S</td>
<td>3.7-41.6</td>
<td>11.9</td>
<td>6.5</td>
<td>0.5</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Available sulphur status
The available Sulphur (S) content of around 42.2% soil samples was low, 51.0% were medium and only 6.8% were recorded with higher content. The mean value of 11.94 kg ha⁻¹ was recorded from 147 soil samples from which, village ‘Gopiwada’ was the lowest (3.74 kg ha⁻¹) and ‘Bela’ village was recorded with highest (41.63 kg ha⁻¹) availability of sulphur. In terms of nutrient index, it was recorded with 1.6 (Table 2 and Fig 8). Similar results were reported by Kashiwar et al., 2019b [11]; 2019a [10]; 2018 [12]; Dongarwar et al., 2015 [4]; 2018b [5]; 2018a [6]; Mali & Raut, 2001 [14].

Micro-nutrient status in soils of Bhandara block

**DTTPA extractable zinc**
The DTPA extractable zinc (Zn) content of 97.3% soil samples was low and only 2.7% samples were recorded with medium values. The mean value recorded was 0.35 mg kg⁻¹. The village ‘Gardi Jangli’ was recorded with lowest zinc (0.22 mg kg⁻¹) and soil of ‘Pimpalgaon’ was found with higher (1.53 mg kg⁻¹) content of DTPA extractable zinc. The nutrient index of DTPA extractable zinc was 1.0 (Table 3 and Fig 9). Similar results were observed by Kashiwar et al., 2019b [11]; 2019a [10]; 2018 [12]; Dongarwar et al., 2015 [4]; 2018b [5]; 2018a [6]; Mali & Raut, 2001 [14].

<table>
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<th>SD</th>
<th>CV</th>
<th>NIV</th>
</tr>
</thead>
<tbody>
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<td>0.4</td>
<td>0.1</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Available Fe</td>
<td>0.6-14.3</td>
<td>4.4</td>
<td>2.7</td>
<td>0.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Available Cu</td>
<td>0.3-2.8</td>
<td>1.3</td>
<td>0.6</td>
<td>0.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Available Mn</td>
<td>1.5-16.4</td>
<td>7.7</td>
<td>2.7</td>
<td>0.4</td>
<td>2.9</td>
</tr>
<tr>
<td>Available B</td>
<td>0.2-4.3</td>
<td>1.5</td>
<td>0.5</td>
<td>0.3</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**DTTPA extractable manganese**
The DTPA extractable manganese (Mn) content of 2.0% soil samples was low, 8.8% were medium and 89.1% were recorded with high values. The mean value recorded was 7.7 mg kg⁻¹. The village ‘Surewada’ was recorded with lowest manganese (1.5 mg kg⁻¹) and soil of ‘Pindkepar’ was found with higher (16.4 mg kg⁻¹) content of DTTPA extractable manganese. The nutrient index of DTTPA extractable manganese was 2.9 (Table 3 and Fig 12). Similar result was observed by Kashiwar et al., 2019b [11]; 2019a [10]; 2018 [12]; Dongarwar et al., 2015 [4]; 2018b [5]; 2018a [6]; Mali & Raut, 2001 [14].

**DTTPA extractable iron**
The DTPA extractable iron (Fe) content of 57.8% soil samples was low and 42.2% samples were recorded with medium values. Its mean value recorded was 4.44 mg kg⁻¹. The village ‘Chikhal Pahela’ was recorded with lowest iron (0.64 mg kg⁻¹) and soil of ‘Dawadipar’ was found with higher (14.27 mg kg⁻¹) content of DTTPA extractable iron. The nutrient index of DTTPA extractable iron was 1.4 (Table 3 and Fig 10). Similar results were observed by Kashiwar et al., 2019b [11]; 2019a [10]; 2018 [12]; Dongarwar et al., 2015 [4]; 2018b [5]; 2018a [6]; Mali & Raut, 2001 [14].

Hot water-soluble boron
The average hot water-soluble boron content was 1.52 mg kg⁻¹ and ranging between 0.17 to 4.28 mg kg⁻¹. The ‘Singori’ village was recorded with lowest boron (0.17 mg kg⁻¹) content and ‘Ajimabad’ village was highest in boron (4.28 mg kg⁻¹) availability. Similar result was observed by Kashiwar et al., 2019b [11]; 2019a [10]; 2018 [12]; Dongarwar et al., 2015 [4]; 2018b [5]; 2018a [6]; Mali & Raut, 2001 [14]. In boron content, 100% of soil samples were low and the NIV for the 147 soil samples of Bhandara block was 1.00 (Table 3 and Fig 13).

Conclusion
The study revealed that the soils of 104 and 39 villages of Bhandara block are neutral and alkaline in nature respectively. The nitrogen content was found deficient in major part of the study area. Whereas, the availability of phosphorus and potassium was found excessive in most of the parts. The availability of micronutrients like copper and manganese was excessively but zinc, iron and boron were deficient in most of the parts of study area. The rice-wheat and sugarcane growing farmers of the study area neglects towards the application of micronutrients which has resulted in poor fertility status of the area. The use of biofertilizers like Trichoderma, Azotobacter, Rhizobium, Pseudomonas etc. along with organic manures like farm yard manure, compost can boost up the soil nutrient status.
Fig 2: Thematic map of soil pH

Fig 3: Thematic map of soil EC

Fig 4: Thematic map of soil OC

Fig 5: Thematic map of soil nitrogen
Fig. 6: Thematic map of soil phosphorus

Fig 7: Thematic map of soil potassium

Fig 8: Thematic map of soil Sulphur

Fig 9: Thematic map of soil zinc
Fig 10: Thematic map of soil iron

Fig 11: Thematic map of soil copper

Fig. 12: Thematic map of soil manganese

Fig. 13: Thematic map of soil boron

References


