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# Geospatial analyses of the quality and management of the soil resource in the chambal division, with special reference to the Sheopur District

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**Abstract**
The natural resource on Earth's surface that can sustain plant development is called soil. Their distinctiveness comes from their regular shape in layers or horizons that define a certain profile, along with a mixture of organic and mineral components. In the research region, the soil's quality has declined. The soil in Sheopur district has phosphorus, nitrogen and magnesium content below the ideal requirement for crop growth, while pH and potassium content are high. Analyzing the chemical composition of the soil in the research region is the project's main goal. Making maps of the chemical composition of soil is the study's secondary goal. The third objective of the study is to investigate the impact of agricultural practices on soil quality degradation. The study's ultimate goal is to provide recommendations for the management of soil resources. For this inquiry, both primary and secondary data were utilized. Discussion with farmers about the consumption of fertilizers in crops were conducted during field surveys. Secondary data of chemical composition of soil sample was collected from Soil Testing Laboratory, Farmers Welfare and Agricultural Development Department of Sheopur district, which is the result of soil samples brought by local farmers. ArcGIS technology has been used to analyze and mapping geospatial variation in soil chemical composition. The main factors that increase soil pH are excessive wood ash addition to the soil and excessive irrigation. Due to excessive irrigation, leaching process starts due to which important nutrients of the soil like nitrogen, zinc, boron, magnesium, copper etc. get washed away with water and the soil becomes less fertile. The reason potassium levels are high in a soil test is due to potassium being used in manure or fertilizer at a rate much higher than what the crop needs for a long period of time. This research article attempts to understand and provide solutions to the issue of declining soil resource quality in Sheopur district.

**Keywords:** Soil degradation, geospatial, chemical composition, resource management

## 1. Introduction
Important ecological services that soil offer include the production of food, the retention of water, and the sequestration of soil organic carbon (SOC). The productivity of agriculture and the ability of soils to stabilise SOC have decreased globally as a result of intensive land usage and subpar agricultural management techniques. Numerous interactions in the soil—physical, chemical, and biological-lead to the formation of soil structure. The concentrations of certain chemicals, such as phosphorus, nitrogen, carbon, magnesium, iron, copper, potassium, sulphur, trace metals and elements, etc., as well as pH and electrical conductivity, are among the chemical features of soil. These characteristics have an impact on biological activity, soil formation, pollutant destiny, nutrient cycling, and erosion. Consequently, a mechanistic comprehension of the chemically significant elements governing the formation of soil aggregates from loose mineral particles is required. The purpose of this research is to conduct geospatial analysis of soil chemical properties and provide management strategies.

## 2. Study Area
Sheopur district is situated on the northern part of the state. The district is bordered to the west by Sawai Madhopur in Rajasthan, to the south-west by Kota and to the south by Bara; to the east and north, respectively, are Shivpuri and Morena. Its latitude ranges are $25^0$ 15' to $25^0$ 45' north and its longitude ranges are $76^0$ 22' to $77^0$ 22' east. Its geographical area, as recorded by the Surveyor General of India, is 6606 km², according to the 2011 census.

Its size, which makes up 2.14% of Madhya Pradesh's total territory, ranks it as the 19th biggest district in the state. The district's northern and north-western belts run along the Chambal River, while the southern and southeast areas are located on the vast Vindhyan plateau.

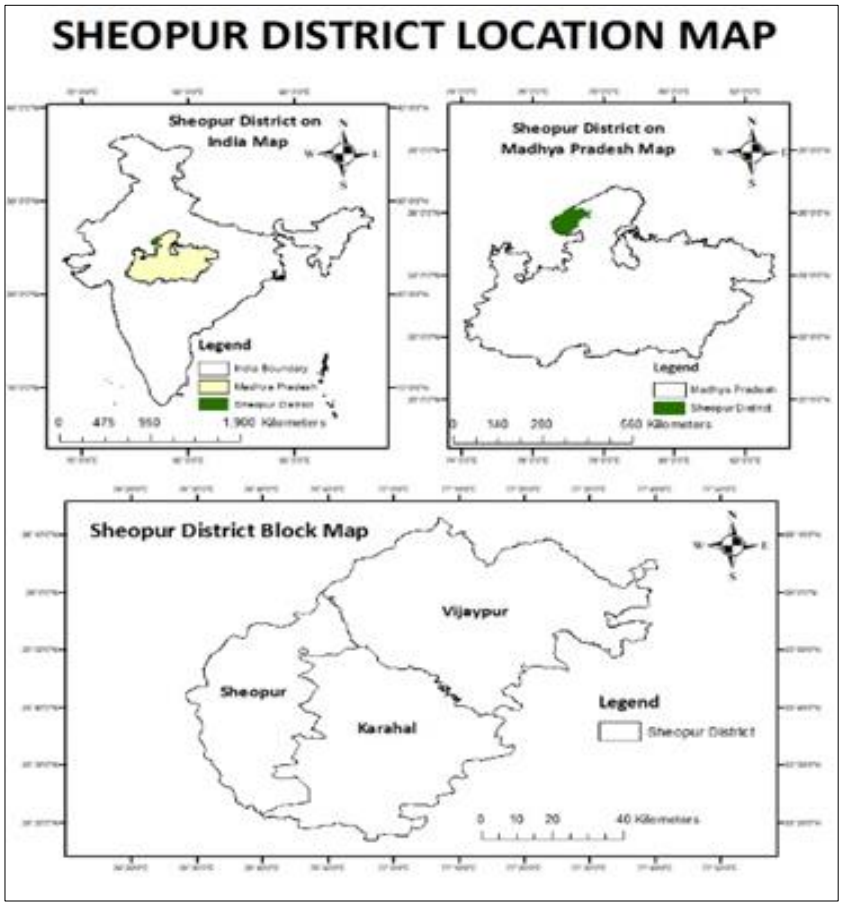


**Fig 2.1:** Study Area Map

The district is located in a Ganges drainage basin. The district's principal river, the Chambal, enters the Yamuna. Numerous rivers and tributaries, including the Parbati, Sip, Kuno, Kunwari, and Asan rivers, drain the Sheopur area as well. The area generally slopes in the direction of the northeast. On the other hand, the slopes of northern Sheopur and Vijaypur are towards the north, while the slopes of southern Sheopur tahsil are towards the west.

The district's economy greatly depends on the forest. Forests are crucial for preserving the natural order, preventing soil erosion, and supporting forest-based enterprises. The district's total area is 6606 sq. km, of which 3949.55 sq. km (or 59.79%) are covered by forests. There are 3006.11 square kilometres of reserved forest and 943.44 square kilometres of protected forest in the district.

Traditionally, the district has farmed Jowar, Bajra, Soybean, and Tur as its main kharif crops. There is also some rice cultivation. The primary Rabi crops, which have all gained significant importance, are wheat, barley, gramme, mustard, and groundnut. The district's soil is excellent for growing commercial crops.

## 3. Objectives

- To analysis the chemical composition levels found in soil.
- To create maps of the chemical composition of soil.
- To investigate the impact of agricultural practices on soil quality degradation.
- To give suggestions for management in soil quality.

## 4. Research techniques

For this inquiry, both primary and secondary data were utilized. Discussion with farmers about the consumption of fertilizers in crops were conducted during field surveys. Secondary data of chemical composition of soil sample was collected from Soil Testing Laboratory, Farmers Welfare and Agricultural Development Department of Sheopur district, which is the result of soil samples brought by local farmers. Tabulation method in MS Excel, and some statistical formulas such as Mean, Maxima, Minima, etc. ArcGIS technology has been used to analyze and mapping geospatial variation in soil chemical composition.

**Table 4.1:** Sample Area

| Block | Sample Villages |
|---|---|
| Sheopur | Baroda, Bhilwara, Dadoni, Daulatpura, Jaini, Kanapur, Kanwarpura, Kashipur, Kathodi, Khedli, Kishorpura, Kotra, Kudaytha, Madwaa, Manpur, Nanawad, Raped, Rigni, Sirsod, Utanwad |
| Karahal | Ajnoy, Daveli, Gadhla, Girdharpur, Goras, Hirapur, Kalarna, Karrai, Kissanpura, Madanpura |
| Vijaypur | Lahosghani, Sarangpur, Bangrod |

## 5. Soil chemical properties

The chemical properties of soil include phosphorus, nitrogen, major cations, trace metals, electrical conductivity, potassium, iron, organic matter and pH etc. which are block wise discussed below:

**Table 5.1:** Range of Chemical properties of soil in Vijaypur block

| Chemical Content | Minimum | Maximum | Average | Average Level |
|---|---|---|---|---|
| pH | 6.66 | 8.46 | 7.53 | Low Alkaline |
| Ec | 0.14 | 0.98 | 0.53 | Ideal |
| oC | 0.14 | 0.84 | 0.5 | Low |
| N | 114 | 286 | 201.65 | Low |
| P | 7.56 | 35.66 | 14.73 | Low |
| K | 128 | 426 | 241.56 | Very High |
| S | 7 | 28 | 12.2 | Ideal |
| Zn | 0.07 | 0.93 | 0.5 | Low |
| B | o.28 | 0.99 | 0.65 | Ideal |
| Fe | 4.66 | 12.89 | 8.25 | Ideal |
| Mn | 3.64 | 12.66 | 7.92 | Low |
| Cu | 0.19 | 0.98 | 0.58 | Ideal |

**Source:** Soil Testing Lab, Sheopur

According to Table 5.1, the soil in Vijaypur block has organic carbon, phosphorus, nitrogen, zinc and magnesium content below the ideal requirement for crop growth, while pH and potassium content are high. Electoral conductivity, sulfur, boron, iron and copper contents are in ideal state.

**Table 5.2:** Range of Chemical properties of soil in Karahal block

| Chemical Content | Minimum | Maximum | Average | Average Level |
|---|---|---|---|---|
| pH | 6.4 | 9.22 | 7.26 | Low Alkaline |
| Ec | 0.08 | 0.98 | 0.53 | Ideal |
| oC | 0.31 | 0.8 | 0.54 | Ideal |
| N | 114.6 | 294.6 | 213.1 | Low |
| P | 6.16 | 32.67 | 13.67 | Low |
| K | 110 | 361 | 230.88 | Very High |
| S | 2 | 25 | 12.59 | Ideal |
| Zn | 0.25 | 0.94 | 0.54 | Ideal |
| B | 0.23 | 0.98 | 0.6 | Ideal |
| Fe | 0.58 | 10.67 | 7.28 | Ideal |
| Mn | 3.1 | 10.88 | 7.67 | Low |
| Cu | 0.19 | 0.98 | 0.54 | Ideal |

**Source:** Soil Testing Lab, Sheopur

According to Table 5.2, the soil in Karahal block has nitrogen, phosphorus and magnesium content below the ideal requirement for crop growth, while pH and potassium content are high. Electoral conductivity, organic carbon, sulfur, zinc, boron, iron and copper contents are in ideal state.

**Table 5.3:** Range of Chemical properties of soil in Sheopur block

| Chemical Content | Minimum | Maximum | Average | Average Level |
|---|---|---|---|---|
| pH | 6.33 | 8.81 | 7.22 | Low Alkaline |
| Ec | 0.11 | 0.95 | 0.53 | Ideal |
| oC | 0.28 | 0.88 | 0.5 | Low |
| N | 119 | 343.3 | 204.38 | Low |
| P | 7.16 | 41.56 | 14.39 | Low |
| K | 146 | 441 | 255.21 | Very High |
| S | 0 | 25 | 11.9 | Ideal |
| Zn | 0.12 | 0.98 | 0.51 | Ideal |
| B | 0.31 | 0.99 | 0.64 | Ideal |
| Fe | 4.37 | 16.66 | 8.21 | Ideal |
| Mn | 4.66 | 13.66 | 8 | Low |
| Cu | 0.13 | 0.98 | 0.56 | Ideal |

**Source:** Soil Testing Lab, Sheopur

According to Table 5.3, the soil in Sheopur block has organic carbon, nitrogen, phosphorus and magnesium content below the ideal requirement for crop growth, while pH and potassium content are high. Electoral conductivity, sulfur, zinc, boron, iron and copper contents are in ideal state.

**Table 5.4:** Range of Chemical properties of soil in Sheopur Study area

| Chemical Content | Minimum | Maximum | Average | Average Level |
|---|---|---|---|---|
| pH | 6.33 | 9.22 | 7.32 | Low alkaline |
| Ec | 0.08 | 0.98 | 0.53 | Ideal |
| oC | 0.14 | 0.88 | 0.51 | Ideal |
| N | 114 | 343.3 | 206.52 | Low |
| P | 6.16 | 41.56 | 14.24 | Low |
| K | 110 | 441 | 243.42 | Very High |
| S | 0 | 28 | 12.21 | Ideal |
| Zn | 0.07 | 0.98 | 0.52 | Ideal |
| B | 0.23 | 0.99 | 0.63 | Ideal |
| Fe | 0.58 | 16.66 | 7.91 | Ideal |
| Mn | 3.1 | 13.66 | 7.88 | Low |
| Cu | 0.13 | 0.98 | 0.56 | Ideal |

**Source:** Soil Testing Lab, Sheopur

According to Table 5.4, the soil in Study area has nitrogen, phosphorus and magnesium content below the ideal requirement for crop growth, while pH and potassium content are high. Electoral conductivity, organic carbon, sulfur, zinc, boron, iron and copper contents are in ideal state.

**Table 5.5:** Percentage of Soil's samples Chemical compositions in Vijaypur Block

| Quantity | Very Low | Low | Ideal | High | Very High | Total |
|---|---|---|---|---|---|---|
| pH | 0 | 0 | 13.51 | 59.46 | 27.03 | 100 |
| Ec | 0 | 9 | 80.18 | 10.81 | 0 | 100 |
| oC | 0 | 51.35 | 39.64 | 9 | 0 | 100 |
| N | 13.51 | 84.68 | 1.8 | 0 | 0 | 100 |
| P | 0 | 92.79 | 7.2 | 0 | 0 | 100 |
| K | 0 | 0 | 0 | 1.8 | 98.2 | 100 |
| S | 0 | 0.9 | 78.38 | 20.72 | 0 | 100 |
| Zn | 0 | 47.75 | 48.65 | 3.6 | 0 | 100 |
| B | 0 | 23.42 | 50.45 | 26.13 | 0 | 100 |
| Fe | 0 | 0 | 81.98 | 18 | 0 | 100 |
| Mn | 8.1 | 80.18 | 11.71 | 0 | 0 | 100 |
| Cu | 0 | 33.33 | 54.95 | 11.71 | 0 | 100 |

**Source:** Soil Testing Lab, Sheopur

According to Table 5.5, the soil in Vijaypur block has 59.46 percent samples have high pH in soil and 27.03 percent samples have very high pH; 10.81 percent samples have high electoral conductivity in soil; 51.35 percent samples have low organic carbon in soil and 9 percent samples have high organic carbon in soil; 84.68 percent samples have low nitrogen in soil and 13.51 percent samples have very low nitrogen level in soil; 92.79 percent samples have low phosphorous in soil; 1.8 percent samples have high potassium in soil and 98.2 percent samples have very high potassium in soil; 20.72 percent samples have high sulfur and 0.9 percent samples have low sulfur level in soil; 47.75 percent samples have low zinc in soil and 3.6 percent samples have high zinc level in soil; 23.42 percent samples have low boron content in soil and 26.13 percent samples have high boron content in soil; 18 percent samples have high iron content in soil; 8.1 percent samples have very low magnesium content in soil and 80.18 percent samples have low magnesium content in soil; 33.33 percent samples have

low copper content in soil and 11.71 percent samples have high copper content in soil.

**Table 5.6:** Percentage of Soil's samples Chemical compositions in Karahal Block

| Quantity | Very Low | Low | Ideal | High | Very High | Total |
|---|---|---|---|---|---|---|
| pH | 0 | 0 | 34.33 | 52.24 | 13.43 | 100 |
| Ec | 0 | 3.73 | 90.3 | 5.97 | 0 | 100 |
| oC | 0 | 47.76 | 47.76 | 4.48 | 0 | 100 |
| N | 0.75 | 97.01 | 2.24 | 0 | 0 | 100 |
| P | 0 | 98.51 | 1.49 | 0 | 0 | 100 |
| K | 0 | 0 | 0.75 | 3.73 | 95.52 | 100 |
| S | 0 | 0.75 | 76.12 | 23.13 | 0 | 100 |
| Zn | 0 | 42.54 | 51.49 | 5.97 | 0 | 100 |
| B | 0 | 32.84 | 52.24 | 14.92 | 0 | 100 |
| Fe | 0 | 1.49 | 91.79 | 6.72 | 0 | 100 |
| Mn | 5.97 | 88.06 | 5.97 | 0 | 0 | 100 |
| Cu | 0 | 44.03 | 49.25 | 6.72 | 0 | 100 |

**Source:** Soil Testing Lab, Sheopur

According to Table 5.6, the soil in Karahal block has 52.24 percent samples have high pH in soil and 13.43 percent samples have very high pH in soil; 3.73 percent samples have low electoral conductivity in soil and 5.97 percent samples have high electoral conductivity in soil; 47.76 percent samples have low organic carbon in soil and 4.48 percent samples have high organic carbon in soil; 97.01 percent samples have low nitrogen in soil and 0.75 percent samples have very low nitrogen level in soil; 98.51 percent samples have low phosphorous in soil; 3.73 percent samples have high potassium in soil and 95.52 percent samples have very high potassium in soil; 23.13 percent samples have high sulfur and 0.75 percent samples have low sulfur level in soil; 42.54 percent samples have low zinc in soil and 5.97 percent samples have high zinc level in soil; 32.84 percent samples have low boron content in soil and 14.92 percent samples have high boron content in soil; 1.49 percent samples have low iron content in soil and 6.72 percent samples have high iron content in soil; 5.97 percent samples have very low magnesium content in soil and 88.06 percent samples have low magnesium content in soil; 44.03 percent samples have low copper content in soil and 6.72 percent samples have high copper content in soil.

According to Table 5.7, the soil in Sheopur block has 56.87 percent samples have high pH in soil and 9.37 percent samples have very high pH; 4.37 percent samples have low electoral conductivity in soil and 10 percent samples have high electoral conductivity in soil; 58.12 percent samples have low organic carbon in soil and 3.75 percent samples have high organic carbon in soil; 97.5 percent samples have low nitrogen in soil and 1.25 percent samples have very low nitrogen level in soil; 92.5 percent samples have low phosphorous in soil and 0.62 percent samples have high phosphorous in soil; 1.25 percent samples have high potassium in soil and 98.75 percent samples have very high potassium in soil; 18.75 percent samples have high sulfur and 2.5 percent samples have low sulfur level in soil; 50 percent samples have low zinc in soil and 5 percent samples have high zinc level in soil; 27.5 percent samples have low boron content in soil and 26.25 percent samples have high boron content in soil; 15.62 percent samples have high iron content in soil; 1.25 percent samples have very low magnesium content in soil and 90 percent samples have low magnesium content in soil; 37.5 percent samples have low copper content in soil and 8.75 percent samples have high copper content in soil.

**Table 5.7:** Percentage of Soil's samples Chemical compositions in Sheopur Block

| Quantity | Very Low | Low | Ideal | High | Very High | Total |
|---|---|---|---|---|---|---|
| pH | 0 | 0 | 33.75 | 56.87 | 9.37 | 100 |
| Ec | 0 | 4.375 | 85.62 | 10 | 0 | 100 |
| oC | 0 | 58.12 | 38.12 | 3.75 | 0 | 100 |
| N | 1.25 | 97.5 | 1.25 | 0 | 0 | 100 |
| P | 0 | 92.5 | 6.87 | 0.62 | 0 | 100 |
| K | 0 | 0 | 0 | 1.25 | 98.75 | 100 |
| S | 0 | 2.5 | 78.75 | 18.75 | 0 | 100 |
| Zn | 0 | 50 | 45 | 5 | 0 | 100 |
| B | 0 | 27.5 | 46.25 | 26.25 | 0 | 100 |
| Fe | 0 | 0 | 84.37 | 15.62 | 0 | 100 |
| Mn | 1.25 | 90 | 8.75 | 0 | 0 | 100 |
| Cu | 0 | 37.5 | 53.75 | 8.75 | 0 | 100 |

**Source:** Soil Testing Lab, Sheopur

## 6. Spatial distribution of chemical contents in soil

The spatial distribution of chemical contents in soil includes pH, electrical conductivity, organic matter, nitrogen, phosphorus, major captions, trace metals, potassium, iron, and etc. which discussed below

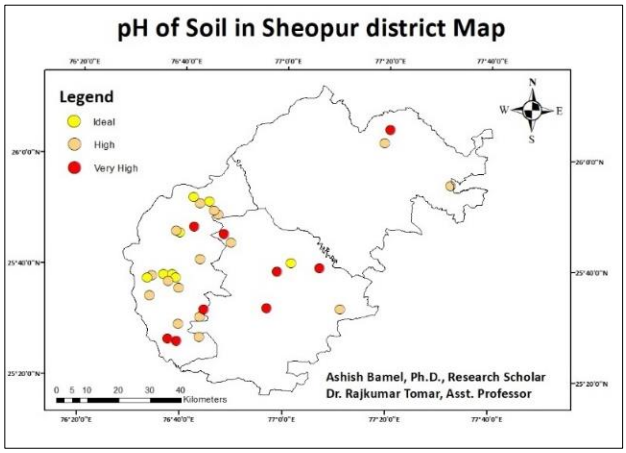


**Fig 6.1:** Show pH of soil Sheopur district map

| Quantity | pH (% sample) |
|---|---|
| Very Low | 0 |
| Low | 0 |
| Ideal | 28.39 |
| High | 56.05 |
| Very High | 15.56 |
| Total | 100 |

**Source:** Soil Testing Lab, Sheopur

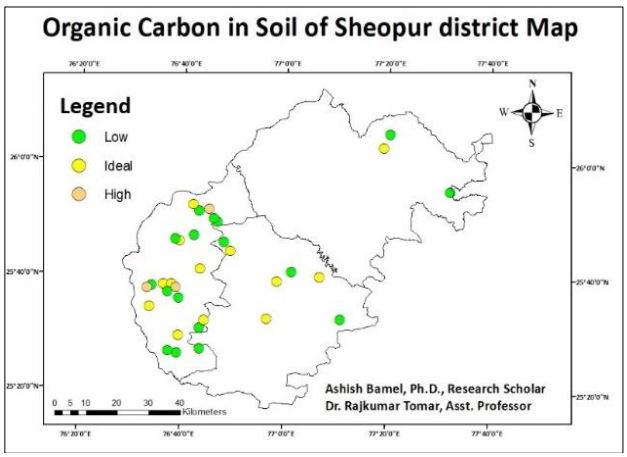


**Fig 6.2:** Show Organic Carbon in soil Sheopur district map

| Quantity | °C (% sample) |
|---|---|
| Very Low | 0 |
| Low | 52.84 |
| Ideal | 41.73 |
| High | 5.43 |
| Very High | 0 |
| Total | 100 |

**Source:** Soil Testing Lab, Sheopur

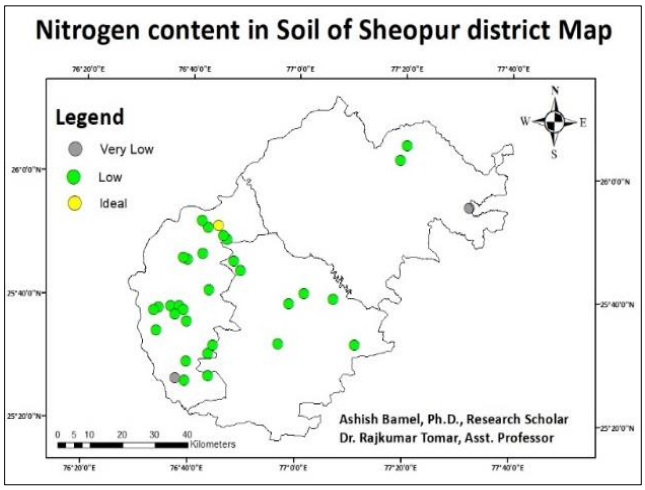


**Fig 6.3:** Show Nitrogen content in soil of Sheopur district map

| Quantity | N (% sample) |
|---|---|
| Very Low | 4.44 |
| Low | 93.83 |
| Ideal | 1.73 |
| High | 0 |
| Very High | 0 |
| Total | 100 |

**Source:** Soil Testing Lab, Sheopur

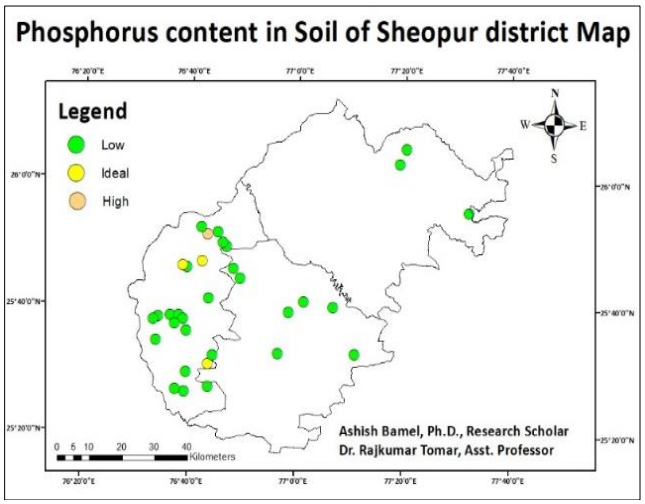


**Fig 6.4:** Show Phosphorus content in soil of Sheopur district map

| Quantity | P (% sample) |
|---|---|
| Very Low | 0 |
| Low | 94.57 |
| Ideal | 5.18 |
| High | 0.25 |
| Very High | 0 |
| Total | 100 |

**Source:** Soil Testing Lab, Sheopur

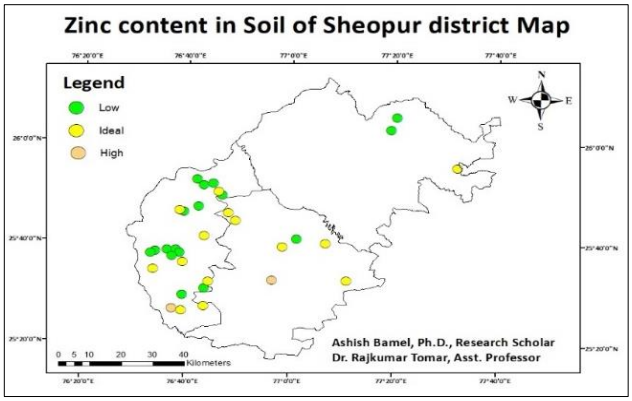


**Fig 6.5:** Show Zinc content in soil of Sheopur district map

| Quantity | Zn (% sample) |
|---|---|
| Very Low | 0 |
| Low | 46.91 |
| Ideal | 48.15 |
| High | 4.94 |
| Very High | 0 |
| Total | 100 |

**Source:** Soil Testing Lab, Sheopur

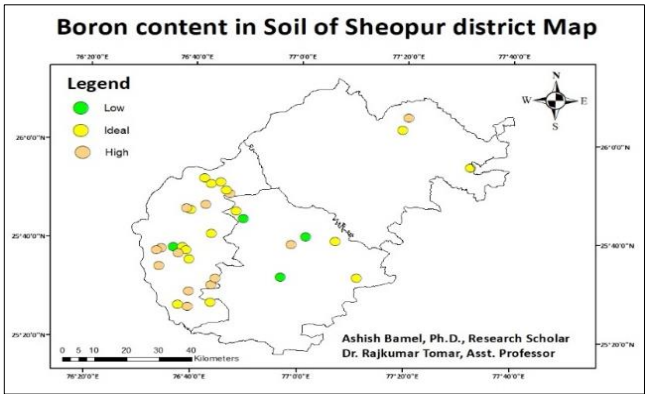


**Fig 6.6:** Show Boron content in soil of Sheopur district map

| Quantity | B (% sample) |
|---|---|
| Very Low | 0 |
| Low | 28.15 |
| Ideal | 49.38 |
| High | 22.47 |
| Very High | 0 |
| Total | 100 |

**Source:** Soil Testing Lab, Sheopur

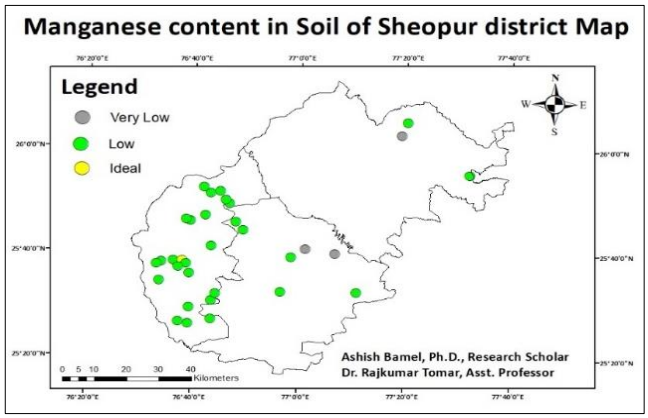


**Fig 6.7:** Show manganese content in soil of Sheopur district map

| Quantity | Mn (% sample) |
|---|---|
| Very Low | 4.69 |
| Low | 86.67 |
| Ideal | 8.64 |
| High | 0 |
| Very High | 0 |
| Total | 100 |

**Source:** Soil Testing Lab, Sheopur

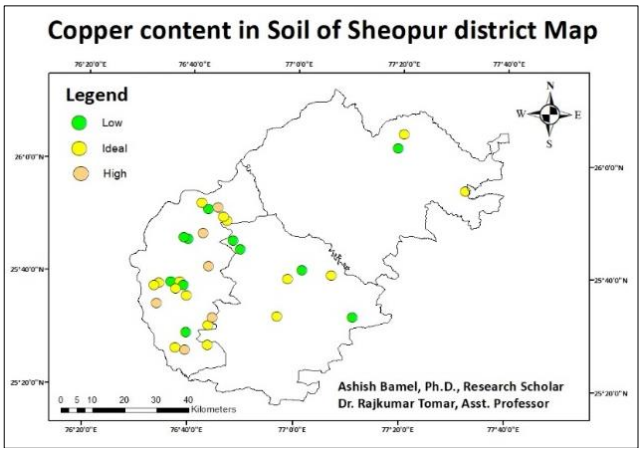


**Fig 6.8:** Show copper content in soil of Sheopur district map

| Quantity | Cu (% sample) |
|---|---|
| Very Low | 0 |
| Low | 38.52 |
| Ideal | 52.59 |
| High | 8.89 |
| Very High | 0 |
| Total | 100 |

**Source:** Soil Testing Lab, Sheopur

**Table 6:** Show soil in study content in soil of Sheopur district map

| Quantity | Ec (% sample) | K (% sample) | Fe (% sample) | S (% sample) |
|---|---|---|---|---|
| Very Low | 0 | 0 | 0 | 0 |
| Low | 5.43 | 0 | 0.49 | 1.48 |
| Ideal | 85.68 | 0.25 | 86.17 | 77.78 |
| High | 8.89 | 2.22 | 13.33 | 20.74 |
| Very High | 0 | 97.53 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 |

The soil in study area has 56.05 percent samples have high pH in soil and 15.56 percent samples have very high pH; 5.43 percent samples have low electoral conductivity in soil and 8.89 percent samples have high electoral conductivity in soil, 52.84 percent samples have low organic carbon in soil and 5.43 percent samples have high organic carbon in soil; 93.83 percent samples have low nitrogen in soil and 4.44 percent samples have very low nitrogen level in soil; 94.57 percent samples have low phosphorous in soil and 0.25 percent samples have high phosphorous in soil, 2.22 percent samples have high potassium in soil and 97.53 percent samples have very high potassium in soil, 20.74 percent samples have high sulfur and 1.48 percent samples have low sulfur level in soil; 46.91 percent samples have low zinc in soil and 4.94 percent samples have high zinc level in soil; 28.15 percent samples have low boron content in soil and 22.47 percent samples have high boron content in soil; 13.33 percent samples have high iron content in soil and 0.49 percent samples have low iron content in soil; 4.69 percent samples have very low magnesium content in soil and 86.67 percent samples have low magnesium content in soil, 38.52 percent samples have low copper content in soil and 8.89 percent samples have high copper content in soil.

## 7. Impact of agricultural practices on soil quality degradation

The main factors that increase soil pH are excessive wood ash addition to the soil and excessive irrigation. Due to excessive irrigation, leaching process starts due to which important nutrients of the soil like organic carbon, nitrogen, zinc, boron, magnesium, copper etc. get washed away with water and the soil becomes less fertile. The reason potassium levels are high in a soil test is due to potassium being used in manure or fertilizer at a rate much higher than what the crop needs for a long period of time. Contaminated materials such as compost, mulch, soil, dung or fertilizer are used around sensitive plants that cause herbicide damage which is also cause of Phosphorus deficiency.

## 8. Suggestions for management in soil quality

- The amount of wood ash addition in the soil should be controlled or used after 2-3 years cycle of agriculture.
- Irrigation as required.
- Check soil quality before using chemical fertilizers.
- Loosen the soil with a fork or shovel, then water deeply to dissolve and flush out the surplus in potassium-rich soil. Allow the soil to dry completely, then repeat two or three more times.

## 9. Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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