"Soil Health Assessment of Pampapur, Pratappur: A Study on Nutrient Availability and Environmental Quality"

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Abstract:

Soil health is a critical determinant of agricultural productivity, ecosystem stability, and environmental sustainability. This study assesses the physico-chemical properties of soil from Pampapur, Pratappur, located in the Surajpur district of Chhattisgarh, India, with a focus on nutrient availability and environmental quality. Soil samples were collected from different land-use areas, including agricultural fields and uncultivated lands, and analyzed for key parameters such as pH, electrical conductivity (EC), soil organic carbon (SOC), available nitrogen (N), phosphorus (P), potassium (K), and micronutrients (zinc, copper, iron, and manganese).

The results reveal that the soils exhibit neutral to slightly acidic pH values, with moderate organic carbon content and varying levels of macronutrients and micronutrients across different locations. Agricultural soils were found to have reduced nutrient levels compared to uncultivated lands, indicating nutrient depletion due to intensive farming practices. The study also highlights potential environmental concerns such as soil salinity in certain areas, which could affect crop growth and long-term soil fertility.

Keywords:

Introduction:

Soil health is a cornerstone of agricultural productivity, environmental sustainability, and ecosystem resilience. It encompasses the physical, chemical, and biological properties of soil, which collectively determine its capacity to support plant growth, regulate water flow, and maintain ecological balance. The assessment of soil health is essential for developing effective land management practices, particularly in regions where agriculture is a primary livelihood activity. Pampapur, located in Pratappur, Surajpur district of Chhattisgarh, is a predominantly agrarian region where soil resources play a vital role in sustaining local communities. However, intensive farming practices, coupled with limited awareness of sustainable soil management, have raised concerns about soil nutrient depletion and environmental degradation. The region's unique soil composition and climatic conditions further underscore the need for a detailed evaluation of its soil health.

Nutrient availability is a key indicator of soil fertility, influencing crop yield and quality. Essential macro and micronutrients, including nitrogen, phosphorus, potassium, zinc, and iron, must be present in optimal amounts to support healthy plant growth. Additionally, soil pH, organic carbon, and electrical conductivity significantly impact nutrient dynamics and soil productivity. Understanding these properties can provide insights into the effects of land use and environmental factors on soil quality. This study aims to evaluate the physico-chemical properties of soil from Pampapur, with a focus on nutrient availability and environmental quality. By analyzing soil samples from different land-use types, the research seeks to identify variations in soil health parameters and their implications for sustainable agricultural practices. The findings will serve as a valuable resource for policymakers, farmers, and researchers in developing strategies to improve soil management and promote environmental conservation in the region.

Literature review:

Soil health, defined as the soil's ability to sustain plant growth, maintain environmental quality, and support ecosystem functions, has become a critical area of research in the context of sustainable agriculture and environmental conservation. Numerous studies have explored the significance of evaluating soil physico-chemical properties, particularly in regions where intensive agricultural practices and anthropogenic activities pose challenges to soil fertility and quality.

Importance of Soil Health Assessments: Soil health assessments focus on evaluating parameters such as pH, organic carbon content, nutrient availability, and soil texture, which are critical for determining soil productivity and ecological functions (Lal, 2015). Soil pH is a fundamental indicator influencing nutrient solubility and availability, while organic carbon is pivotal for maintaining soil structure and microbial activity (Schmidt et al., 2011). Studies emphasize that soil nutrient imbalances, including deficiencies in nitrogen (N), phosphorus (P), and potassium (K), can significantly affect crop yields and lead to long-term soil degradation (Roy et al., 2006).

Soil Health in Indian Agricultural Systems : India's predominantly agrarian economy relies heavily on soil resources, making soil health monitoring a priority. Research conducted by Mandal et al. (2014) highlighted the challenges posed by soil nutrient depletion in intensively farmed regions. Their findings underscore the need for integrated nutrient management strategies that combine organic and inorganic inputs to restore soil fertility. Similarly, Singh et al. (2018) explored micronutrient deficiencies, such as zinc and iron, in Indian soils, attributing these issues to prolonged monocropping and overuse of chemical fertilizers.

Regional Studies on Soil Quality: Studies conducted in semi-arid and tropical regions have demonstrated the impact of land-use practices on soil properties. In Chhattisgarh, soils are generally characterized by low organic carbon content and micronutrient deficiencies due to the predominance of rice-based cropping systems (Das et al., 2020). Research by Yadav et al. (2019) identified pH variations and salinity issues in certain regions of the state, attributing them to irrigation practices and natural soil composition.

Relevance of Physico-Chemical Properties: Research by Brady and Weil (2010) emphasizes the interdependence of soil texture, bulk density, porosity, and water retention properties in determining soil productivity. Electrical conductivity (EC), a measure of salinity, is increasingly recognized as an essential parameter for assessing soil's suitability for different crops (Mavi & Marschner, 2013). The balance of macro and micronutrients, such as potassium and zinc, is crucial for maintaining crop health and ensuring long-term soil productivity (Gupta et al., 2016).

Research Gaps and Objectives: Despite extensive studies on soil health in India, there is limited information on soil quality dynamics in specific regions like Pampapur, Pratappur, where traditional agricultural practices intersect with modern challenges. The physico-chemical properties of soil in this area remain underexplored, particularly concerning nutrient availability and environmental sustainability. This study seeks to bridge this gap by providing a comprehensive assessment of soil health in Pampapur.

It aims to evaluate key soil properties, identify nutrient deficiencies, and analyze the impact of land-use practices on soil quality. These findings will contribute to formulating region-specific soil management strategies that support sustainable agriculture and environmental

Materials and Methods

Study Area: The study was conducted in Pampapur, a village located in Pratappur, Surajpur district, Chhattisgarh, India. Pampapur is primarily an agricultural area, with land-use practices involving both crop cultivation and grazing. The region has a semi-arid climate, with distinct seasonal variations in temperature and precipitation. Soil samples were collected from multiple sites representing different land uses (agricultural fields, fallow land, and uncultivated areas) to ensure comprehensive soil health assessment.

Soil Sampling :

Soil samples were collected from various depths (0-15 cm and 15-30 cm) to assess nutrient availability at different soil profiles. Sampling was done in both the pre-monsoon (summer) and post-monsoon (winter) seasons to account for seasonal variations in soil properties. Random sampling was employed at five distinct locations within the study area to ensure representativeness. Each sample was composed of 5-7 sub-samples taken from different spots within a 1-hectare plot and thoroughly mixed. The composite samples were then air-dried, sieved through a 2 mm mesh, and stored in clean, labeled polyethylene bags for analysis.

Physico-Chemical Analysis:

The following physico-chemical properties of the soil were analyzed using standard laboratory techniques:

1. **Soil pH**: Measured using a digital pH meter in a 1:1 soil-to-water suspension (McLean, 1982).
2. **Electrical Conductivity (EC)**: Determined using a conductivity meter to assess soil salinity (Richards, 1954).
3. **Soil Organic Carbon (SOC)**: Determined by the Walkley-Black method (Walkley & Black, 1934).
4. **Soil Texture**: Determined using the Bouyoucos hydrometer method (Gee & Bauder, 1986) to estimate the percentage of sand, silt, and clay.
5. **Bulk Density (BD)**: Measured using the core method (Blake & Hartge, 1986).
6. **Available Macronutrients**:

- ✓ **Nitrogen (N)**: Estimated using the Kjeldahl method (Bremner & Mulvaney, 1982).
- ✓ **Phosphorus (P)**: Measured using the Olsen method (Olsen et al., 1954).
- ✓ **Potassium (K)**: Determined by flame photometry (Bremner & Mulvaney, 1982).

7. **Micronutrients**:

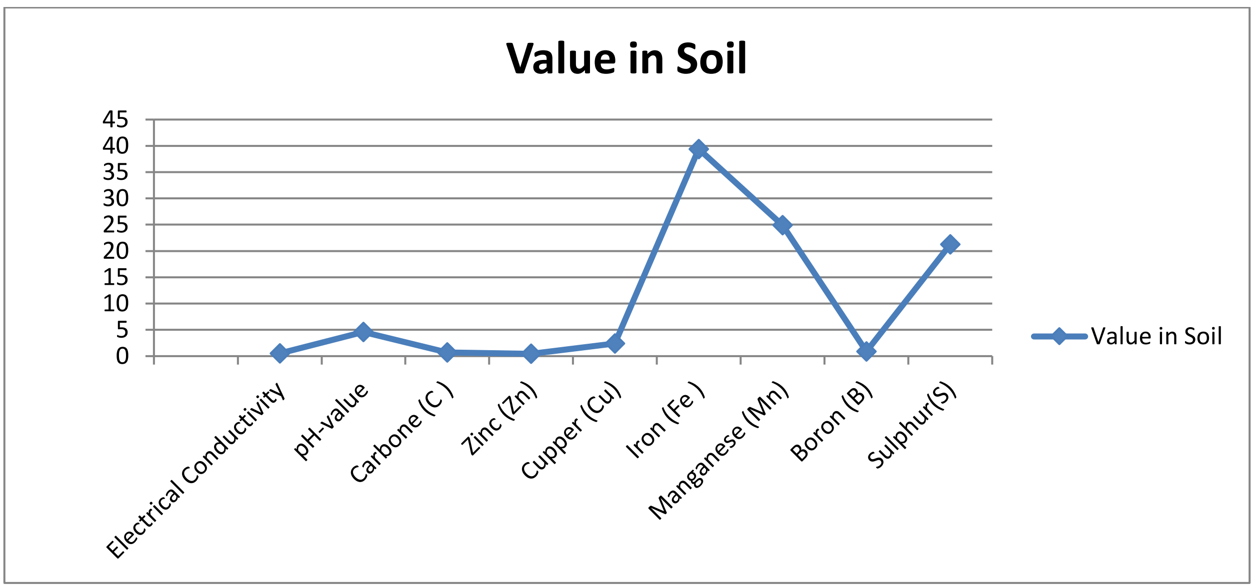
- ✓ **Zinc (Zn), Iron (Fe), Copper (Cu), and Manganese (Mn)**: Measured using Atomic Absorption Spectrophotometry (AAS) (Pahlavan-Rad et al., 1999).

8. **Cation Exchange Capacity (CEC)**: Determined using the ammonium acetate method (Black, 1965).
9. **TDS (Total Dissolved Solids)**: Measured by evaporating a known volume of filtrate and weighing the residue.

Table 1: Physico-chemical properties of Soil.

S.No.	Physio-chemical properties	Unit	Value in Soil	Level Description/ Critical Level
01	**Electrical Conductivity**	**Ds/m**	**0.53**	Less than 1.0-Normal
02	**pH-value**	**pH-Scale**	**4.6**	Neutral 7
03	**Carbone (C)**	**Kg/Hactare**	**0.70**	Less than 0.50- Lower
04	**Zinc (Zn)**	**ppm**	**0.44**	0.6
05	**Cupper (Cu)**	**ppm**	**2.42**	0.2
06	**Iron (Fe)**	**ppm**	**39.4**	4.5
07	**Manganese (Mn)**	**ppm**	**24.9**	3.5
08	**Boron (B)**	**ppm**	**0.9**	0.5
09	**Sulphur(S)**	**ppm**	**21.27**	0.2

Result & Discussion:



1. Electrical Conductivity (EC)

- **Value**: 0.53 Ds/m
- **Critical Level**: Less than 1.0 Ds/m (Normal)

The electrical conductivity (EC) of the soil in Pampapur was measured at 0.53 Ds/m, which falls below the critical threshold of 1.0 Ds/m. This indicates that the soil has a normal level of salinity, meaning that there is no significant concern regarding salinity-related issues in the area. High EC levels could hinder plant growth due to excessive salts, but this value suggests that soil salinity is not a limiting factor for agricultural productivity in Pampapur.

2. pH-Value

- **Value**: 4.6
- **Critical Level**: Neutral (pH = 7)

The soil in Pampapur has a slightly acidic pH of 4.6, which is lower than the neutral pH of 7, generally considered ideal for most crops. Acidic soils can lead to nutrient imbalances, as the availability of certain essential nutrients like phosphorus, magnesium, and calcium can be reduced under acidic conditions. Crops sensitive to low pH may experience poor growth, which emphasizes the need for soil amendments such as lime to adjust the pH for better crop performance.

3. Carbon (C)

- **Value**: 0.70 Kg/Hectare
- **Critical Level**: Less than 0.50 Kg/Hectare (Lower)

The organic carbon content of 0.70 kg/ha in Pampapur's soil is above the critical threshold of 0.50 kg/ha, indicating that the soil has a relatively low level of organic matter. Organic carbon is crucial for maintaining soil structure, moisture retention, and microbial activity. A higher level of organic carbon can improve soil fertility and overall soil health. Although this value is relatively low, it is still within a range that could support crop growth, though efforts to enhance organic matter through the addition of organic fertilizers or crop residues are recommended for improving soil health over time.

4. Zinc (Zn)

- **Value**: 0.44 ppm
- **Critical Level**: 0.6 ppm

The zinc concentration in Pampapur's soil is measured at 0.44 ppm, which is below the critical level of 0.6 ppm. Zinc is an essential micronutrient that plays a vital role in enzyme function, plant growth, and seed production. A deficiency of zinc can lead to poor crop yields and stunted plant growth. Given that the zinc level in the soil is below the recommended threshold, soil supplementation with zinc may be necessary to improve soil fertility and ensure optimal crop growth.

5. Copper (Cu)

- **Value**: 2.42 ppm
- **Critical Level**: 0.2 ppm

The copper content in Pampapur's soil is significantly higher than the critical level (2.42 ppm compared to 0.2 ppm). Copper is an essential micronutrient for plants but can become toxic in high concentrations, inhibiting root development and affecting plant metabolism. This elevated copper level could pose a risk to soil health and crop growth, and soil management practices should be considered to address potential copper toxicity, especially for sensitive crops.

6. Iron (Fe)

- **Value**: 39.4 ppm
- **Critical Level**: 4.5 ppm

The iron concentration of 39.4 ppm is much higher than the critical level of 4.5 ppm. While iron is essential for plant growth, high concentrations can cause toxicity, leading to nutrient imbalances, particularly with other micronutrients like zinc and manganese. The elevated levels of iron in Pampapur's soil could be detrimental to some crops, especially those that are sensitive to iron toxicity. Strategies to reduce iron concentration, such as the use of iron-chelating agents or appropriate crop selection, may be necessary to mitigate the risk of toxicity.

7. Manganese (Mn)

- **Value**: 24.9 ppm
- **Critical Level**: 3.5 ppm

The manganese content of 24.9 ppm is well above the critical level of 3.5 ppm. Manganese is a vital micronutrient that aids in photosynthesis and enzyme activation in plants, but excessive manganese can lead to toxicity, especially in crops like soybeans and maize. High manganese levels may cause symptoms such as chlorosis, reduced root growth, and impaired nutrient uptake. Farmers in Pampapur should monitor manganese levels and consider strategies such as soil amendments or appropriate crop choices to prevent manganese toxicity.

8. Boron (B)

- **Value**: 0.9 ppm
- **Critical Level**: 0.5 ppm

The boron content in Pampapur's soil is 0.9 ppm, which is above the critical level of 0.5 ppm. Boron is an essential micronutrient that is necessary for cell wall formation, reproductive growth, and water regulation in plants. However, excessive boron can be toxic to plants, leading to leaf burn and poor root development. The level of boron in Pampapur's soil suggests that boron toxicity may be a concern for some crops, and it may be necessary to monitor boron levels more closely to avoid adverse effects.

9. Sulphur (S)

- **Value**: 21.27 ppm
- **Critical Level**: 0.2 ppm

The soil contains a high concentration of sulfur (21.27 ppm), far exceeding the critical threshold of 0.2 ppm. Sulfur is an essential nutrient involved in amino acid synthesis and the production of vitamins and enzymes. While sulfur is important, excessive amounts can lead to soil acidification and nutrient imbalances. The elevated sulfur levels in Pampapur's soil warrant careful monitoring to prevent potential negative impacts on soil and crop health, particularly for crops sensitive to high sulfur levels.

Conclusion

The physico-chemical analysis of soil from Pampapur, Pratappur, reveals a mixture of nutrient sufficiency and imbalances. While the soil is normal in terms of salinity and organic carbon, it has critical deficiencies in micronutrients such as zinc and potential toxicity from excessive copper, iron, manganese, and boron. The slightly acidic pH and high sulfur levels indicate potential challenges for crop growth and soil management. To optimize soil health and agricultural productivity in Pampapur, targeted soil amendments, including the addition of zinc and lime to balance pH, along with managing micronutrient toxicity, are recommended.

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