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Soil Quality Evaluation: A Study of Physico-Chemical Parameters in Gaura Village, Pratappur, Chhattisgarh

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Abstract:

This study investigates the physico-chemical properties of soil from Gaura Village, located in Pratappur, Surajpur District, Chhattisgarh, India. Soil quality plays a critical role in agricultural productivity and environmental health, necessitating an in-depth analysis of its fundamental characteristics. Samples were collected systematically across the region, and a comprehensive analysis was conducted to evaluate parameters such as pH, electrical conductivity, bulk density, particle density, porosity, water-holding capacity, organic carbon content, and macro- and micro-nutrient concentrations, including nitrogen, phosphorus, potassium, zinc, copper, and iron. The findings revealed a moderately acidic to neutral pH range, optimal electrical conductivity, and sufficient levels of organic carbon, indicating fertile conditions for crop cultivation. However, variations in micro-nutrient levels and water retention properties suggest localized differences that could affect agricultural practices. The study underscores the importance of regular soil assessments to maintain soil health and sustain agricultural outputs in Gaura Village. Furthermore, the results provide a valuable baseline for implementing soil management strategies tailored to the region's unique agro-climatic conditions.

Keywords: Physical properties, chemical properties, Soil texture, Soil Structure, Conductivity.

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Introduction:

Soil quality is a cornerstone of sustainable agriculture and environmental management, serving as the foundation for plant growth, water filtration, and nutrient cycling. The physico-chemical properties of soil significantly influence its fertility, productivity, and capacity to support diverse ecosystems. Assessing these properties is essential for understanding soil health and guiding effective land-use and management practices.

Gaura Village, located in Pratappur, Surajpur District, Chhattisgarh, is primarily an agrarian community, where soil quality directly impacts the livelihoods of local farmers. The region's agricultural output is influenced by a range of factors, including soil composition, nutrient availability, and water retention capacity. However, the lack of detailed studies on the region's soil properties poses challenges to optimizing land use and addressing potential degradation.

This study aims to evaluate the physico-chemical properties of soil in Gaura Village to establish a baseline for its quality and fertility. Key parameters analyzed include pH, electrical conductivity, organic carbon content, bulk and particle densities, porosity, water-holding capacity, and concentrations of essential nutrients such as nitrogen, phosphorus, potassium, and micronutrients. By identifying variations in soil properties across the study area, this research seeks to provide actionable insights for sustainable agricultural practices and improved soil management.

The findings of this study are expected to benefit farmers, agronomists, and policymakers by offering a scientific basis for enhancing crop productivity while preserving the ecological integrity of the region. Furthermore, this work contributes to the growing body of knowledge on soil quality in semi-arid regions like Chhattisgarh, where the interplay of climatic and anthropogenic factors significantly affects soil health.

Literature review:
Soil quality evaluation has been a critical area of research due to its direct implications for agriculture, environmental sustainability, and land management. Numerous studies have demonstrated that the physico-chemical properties of soil, such as pH, electrical conductivity, organic carbon content, and nutrient levels, play pivotal roles in determining soil fertility and overall productivity.

Soil Physico-Chemical Properties and Their Importance
Soil pH is a key determinant of nutrient availability and microbial activity. Studies have shown that soil pH affects the solubility of essential nutrients like phosphorus and micronutrients such as iron and zinc (Brady & Weil, 2016). Electrical conductivity, on the other hand, serves as an indicator of soil salinity, which can impact crop yields, particularly in arid and semi-arid regions (Rhoades et al., 1992). Organic carbon content is another vital parameter influencing soil health. It enhances soil structure, water retention, and cation exchange capacity (Lal, 2004). The presence of adequate organic carbon is often associated with higher microbial activity and improved nutrient cycling, making it essential for sustainable agriculture (Six et al., 2002).

Nutrient Availability and Soil Fertility:

The availability of macro-nutrients such as nitrogen, phosphorus, and potassium is critical for plant growth. Nitrogen supports vegetative growth, phosphorus is essential for energy transfer, and potassium aids in water regulation and enzyme activation (Tisdale et al., 1985). Micronutrients like zinc, copper, and manganese, though required in smaller quantities, are equally important for enzyme functions and plant development (Alloway, 2008). Studies on Indian soils highlight significant spatial variability in nutrient concentrations due to differences in climatic conditions, soil management practices, and parent material (Bhattacharyya et al., 2013). Such variability necessitates localized studies to develop tailored soil management strategies.

Regional Studies on Soil Quality: Several studies in the Chhattisgarh region have examined the impact of physico-chemical properties on agricultural productivity. For instance, Kumar et al. (2018) assessed soil quality in Surguja district and reported variations in organic carbon and nutrient levels, which were linked to differing land-use patterns. Similarly, Das et al. (2020) highlighted the role of soil texture in influencing water retention and nutrient availability in semi-arid regions. However, specific studies focusing on soil quality in Gaura Village are limited, creating a gap in the understanding of its unique soil characteristics. This study seeks to address this gap by providing a comprehensive evaluation of the physico-chemical properties of soil in Gaura Village and their implications for agricultural practices.

Materials and Methods
Sampling Methodology :Soil samples were collected using a systematic random sampling method to ensure representative coverage of the study area (Carter and Gregorich, 2008). Soil samples were collected at a depth of 15-30 cm from the research areas. Samples were collected using stainless steel augers to avoid contamination, placed in labeled polyethylene bags, and transported to the laboratory. Samples were air-dried, sieved through 2 mm mesh, and stored for subsequent analysis.

Analytical Methods

The physico-chemical properties of the soil samples were analyzed using standard procedures.

1. **pH and Electrical Conductivity (EC):** Soil pH was measured using a 1:2.5 soil-to-water suspension with a digital pH meter, as described by Jackson (1973). Electrical conductivity was determined using a conductivity meter to assess soil salinity.
2. **Organic Carbon:** The organic carbon content was estimated using the Walkley-Black method, a widely accepted procedure for soil organic matter analysis (Walkley & Black, 1934).

3. **Bulk Density, Particle Density, and Porosity:** Bulk density and particle density were measured using the core method. Porosity was calculated using the formula:

$$\text{Porosity} = \left(1 - \frac{\text{Bulk Density}}{\text{Particle Density}}\right) \times 100$$

□ **Water-Holding Capacity (WHC):** WHC was determined using the gravimetric method, wherein saturated soil samples were drained and weighed (Klute, 1986).

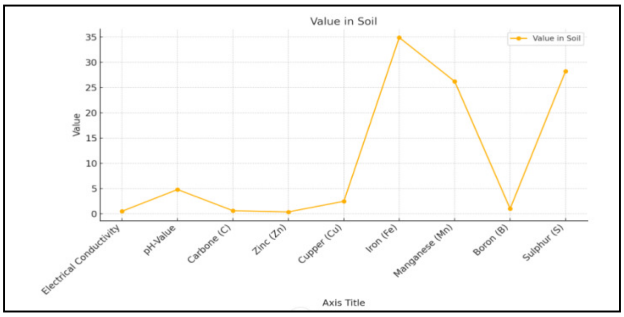
Nutrient Analysis:

- **Nitrogen:** Available nitrogen was determined using the alkaline permanganate method (Subbiah & Asija, 1956).
- **Phosphorus:** Available phosphorus was measured using the Olsen method (Olsen et al., 1954).
- **Potassium:** Exchangeable potassium was extracted using ammonium acetate and measured using a flame photometer (Toth & Prince, 1949).
- **Micronutrients:** DTPA (Diethylene triamine pentaacetic acid) extraction was used to estimate available zinc, copper, iron, and manganese (Lindsay & Norvell, 1978).

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**	**0.51**	Less than 1.0-Normal
02	**pH-value**	**pH-Scale**	**4.8**	Neutral 7
03	**Carbone (C)**	**Kg/Hactare**	**0.61**	Less than 0.50- Lower
04	**Zinc (Zn)**	**ppm**	**0.37**	0.6
05	**Cupper (Cu)**	**ppm**	**2.47**	0.2
06	**Iron (Fe)**	**ppm**	**34.9**	4.5
07	**Manganese (Mn)**	**ppm**	**26.2**	3.5
08	**Boron (B)**	**ppm**	**1.0**	0.5
09	**Sulphur(S)**	**ppm**	**28.24**	0.2

Result & Discussion:



1. Electrical Conductivity (EC)

The electrical conductivity of the soil was measured at 0.51 Ds/m, indicating normal salinity levels. This value suggests that the soil is non-saline, which is favorable for crop growth and does not pose risks to plant health (Rhoades et al., 1992).

2. pH Value

The soil pH was 4.8, classifying it as strongly acidic. Acidic soils can limit nutrient availability, particularly phosphorus, and may require lime application to increase pH to a neutral range for optimal agricultural productivity (Brady & Weil, 2016).

3. Organic Carbon

The organic carbon content was found to be 0.61 kg/ha, which is slightly above the lower threshold of 0.50 kg/ha. This indicates moderate organic matter content, which is crucial for maintaining soil structure, water retention, and nutrient availability. Increasing organic matter through the addition of compost or green manure can further enhance soil quality (Lal, 2004).

4. Micronutrient Analysis

- **Zinc (Zn):** The zinc concentration was 0.37 ppm, below the critical level of 0.6 ppm, indicating a potential deficiency. Zinc deficiency can impair plant metabolic functions, necessitating zinc supplementation through fertilizers.

- **Copper (Cu):** Copper was measured at 2.47 ppm, significantly above the critical level of 0.2 ppm, indicating adequate availability. High copper levels support enzyme activity in plants.
- **Iron (Fe):** Iron concentration was 34.9 ppm, far exceeding the critical level of 4.5 ppm. This indicates sufficient iron availability, which supports photosynthesis and chlorophyll synthesis in plants.
- **Manganese (Mn):** Manganese levels were recorded at 26.2 ppm, well above the critical level of 3.5 ppm. Adequate manganese promotes enzymatic activity and resistance to diseases in plants.
- **Boron (B):** The boron concentration was 1.0 ppm, surpassing the critical threshold of 0.5 ppm, indicating sufficient levels to support cell wall development and reproductive growth in plants.

5. Sulphur (S)

The sulphur content in the soil was 28.24 ppm, far above the critical level of 0.2 ppm. Sulphur is essential for protein synthesis and enzymatic reactions, and its adequate presence supports healthy crop growth.

Discussion

The results indicate that the soil in Gaura Village exhibits normal salinity and adequate levels of most micronutrients, including copper, iron, manganese, boron, and sulphur. However, the soil is strongly acidic (pH 4.8), which may restrict the availability of certain nutrients, particularly phosphorus. The low zinc levels further highlight the need for targeted supplementation to address micronutrient deficiencies.

Conclusion:

The physico-chemical analysis of soil from Gaura Village, Pratappur, Chhattisgarh, indicates that the soil is strongly acidic (pH 4.8) with normal salinity levels (EC 0.51 Ds/m). While organic carbon content (0.61 kg/ha) is slightly above the lower threshold, it suggests moderate fertility. Micronutrient analysis revealed adequate levels of copper, iron, manganese, boron, and sulphur, but a deficiency in zinc (0.37 ppm) below the critical level of 0.6 ppm. Overall, the soil is suitable for agriculture but requires measures such as liming to neutralize acidity and zinc supplementation to address deficiencies. Enhancing organic matter through compost or green manure could further improve soil quality and productivity.

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