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# EVOLUTION OF PHYSICO-CHEMICAL PROPERTIES OF SOIL FROM PANDRAPATH BLOCK OF JASHPUR DISTRICT

**Pooja Patel[1], Krishna Kumar[1], Ashutosh Pandey[1]*, D. V. K. Narasingham[1]**

(1&1*) Department of Physics, Dr. C V Raman University, Bilaspur., India.

**Abstract:**

This study aims to investigate the physico-chemical properties of soil in the Pandrapath block of Jashpur district, Chhattisgarh, India. Knowledge the soil properties in this specific region is important for sustainable land management, agricultural productivity, and environmental preservation because these factors also affect the soil fertility, nutrient availability, water-holding capacity, and overall suitability for agriculture. By analyzing these features, we may learn more about the composition, structure, and nutritional status of the soil—information that is essential for choosing crop production strategies and managing the soil. Examining the physical and chemical properties of the soil was the main focus of this study. These properties included pH, organic matter content, moisture retention, cation exchange capacity, availability of nutrients (nitrogen, phosphorus, potassium, sulphur, iron, manganese, cobalt, zinc, and boron), bulk density, porosity, and particle density. Based on the varying values of EC, pH, moisture content, bulk density, and organic matter content, the results show considerable differences in soil qualities between the areas within Pandrapath. These variations were influenced by things like local land use patterns, vegetation cover, moisture content, and soil salinity. These findings also important for tailored soil management strategies that take into consideration the unique characteristics of Pandrapath soil. Differences in bulk density highlight the significance of reducing soil compaction, while subtleties in moisture content highlight the necessity of strategic water management. Moderate salinity levels were indicated by electrical conductivity (EC) measurements, which could affect plant development and soil fertility. Furthermore, the differences in the amount of organic matter highlight the significance of organic matter management in order to improve soil health. This knowledge of soil quality was essential to Pandrapath agriculture, which closely connected to the region's tropical climate and seasonal variations. It enables well-informed decision-making that increase crop productivity, promote environmental sustainability, and provide the soil's long-term health.

**Keywords:** Soil quality, pH, bulk density, organic matter, nutrients, electrical conductivity, Chhattisgarh, Pandrapath, agricultural practice.

## Introduction

One of the most significant and priceless natural resources is soil, which is made up of fragments of shattered rock that have undergone changes due to chemical and mechanical processes including weathering and erosion [1]. Each sort of climate has its own unique soil due to the exceptional soil creation in that particular environment [2]. According to Idowu et al. (2019), "the state of the soil being in sound physical, chemical, and biological condition, having the capability to maintain the growth and development of land plants" which ought to be defined as soil health. Healthy soils are vital for thriving ecosystems and communities, and they also have a direct impact on human health, biodiversity, water quality, climate change adaptation and mitigation, and food and nutritional security [3]. The primary factor that mostly determines the productivity of an agricultural system is soil's inherent ability to sustain soil physical conditions for maximum crop yields and to supply nutrients for crop growth. Khanday et al. state that a deeper comprehension of soil dynamics results from a greater awareness of the morphological, physical, and chemical characteristics of soils [4]. According to Meena et al. (2020), the fundamental markers for determining the nutrients and features of soil are the soil's physicochemical characteristics [5].


**Figure 1.** Location of Pandrapath block of Jashpur district in Chhattisgarh, India.

The district of Jashpur is located in the central Indian state of Chhattisgarh and borders the states of Jharkhand and Odisha. Known for its natural surroundings, Jashpur is a highly forested and mountainous district that was once a royal state before gaining independence. This district has a total size of 6,205 km² and is situated between 22° 17′ and 23° 15′ North latitude and 83° 30′ and 84° 24′ East longitude (Figure 1). Surprisingly, it is 6701 km² in length and approximately 150 km in north-south and 85 km in east-west directions. Its borders are the district of Balrampur to the north, the district of Gumla in Jharkhand to the east, the districts of Simdega in Jharkhand and Sundergarh in Odisha to the southeast, the district of Raigarh to the southwest, and the district of Surguja to the west. Geographically, it is split into two sections: the Upper Ghat, a mountainous area in the north, and the Nichghat, a region in the south. With its location between forests, in Nichghat, Pandrapath has the coldest winter temperatures and Kunkuri the warmest summer temperatures. Pandrapath is located in the district of Jashpur, Chhattisgarh. Its latitude is 23.06636 and Longitude is 83.81638 (Figure 1). The majority of the district is made up of red (Alfisols) and yellow (Ultisols) soils that grew over granitoids, while tiny areas of black soil (Inceptisols) formed over deccan traps. It is a significant agricultural region with variety of land uses, such as crop land, forest land, and pasture land. The physicochemical features of the soils in this region are, however, rarely known, despite the fact that understanding them is essential for environmental protection, optimizing agricultural methods, and sustainable land management. The combination of natural forces and human activity has culminated in a variety of geological occurrences in this fascinating area.

Determining the physicochemical characteristics of soil is crucial in order to comprehend its general quality and fertility in a specific region. The physio-chemical characteristics of the soil, such as pH, organic matter content, texture, nutrient availability, and heavy metal concentrations, have a major role in determining soil health and appropriateness for various land uses, including agriculture and ecosystem functioning. In 2023, Rathore et al. emphasized that soil is an essential interaction in our ecosystem and a major source of food and fiber [6]. Research on soil properties, such as its nutrient content and structure, is crucial for promoting optimal crop yield and minimizing nutrient waste. As Chimdi (2012) demonstrated that maintaining these soil qualities is necessary for the health of the agricultural ecosystem [7]. Understanding the physico-chemical characteristics of the soil is crucial to the pursuit of agricultural sustainability.

The solubility and availability of vital nutrients for plants can be affected by varying soil pH levels; salinity levels can be affected by varying soil electrical conductivity (EC), which in turn can affect plant growth and soil fertility; and organic matter content is a critical indicator of both soil health and fertility. The relative proportions of sand, silt, and clay particles in the soil influence its texture, which in turn controls drainage, nutrient availability, water infiltration, and microbial activity. Soil pH is an important parameter that affects nutrient availability, microbial activity, and plant growth. The availability of essential nutrients like nitrogen, phosphorus, and potassium is necessary for plant growth and development. Different soil textures have varying capacities for retaining water and nutrients, which can affect crop yield and overall soil quality. Organic matter content also plays a significant role in carbon sequestration, which is important for mitigating the change. effects of climate

Soil test-based nutrient management is an essential component of agriculture that ensures the efficient and sustainable use of this finite resource. However, the careless use of inorganic fertilizers raises concerns about their long-term impacts on soil health, structure, and environmental well-being. In contrast, organic materials like green manures can enhance nutrient exchange, improve soil structure, and maintain soil quality.

Chhattisgarh, the state in which this region is located, boasts abundant natural resources and a predominantly agrarian economy; often referred to as the "rice bowl of India," the region faces several productivity challenges, including low soil organic matter, nutrient deficiencies, and inadequate residue management. Our study aims to shed light on the physico-chemical characteristics of the soil in this remarkable region, which is becoming increasingly vital due to the challenges posed by climate change and pollution. The physico-chemical properties of the soil in the Jashpur district of Chhattisgarh, focusing on variables such as pH, electrical conductivity, and nutrient content. Their results indicated that physicochemical changes in the soil might be a sign of the gradient of land use intensity in this area.

 

Our study aims to investigate the physico-chemical properties of the soil in the particular region, taking into account the previous research findings. Specifically, we will concentrate on variables like pH, moisture content, and lime requirement, in order to enhance our knowledge of this essential resource and its function in supporting agriculture and life in Pandrapath and its environs.

## 2. LITERATURE REVIEW

A fundamental understanding of the state and quality of soil in different places is gained through the study of soil parameters, especially soil electrical conductivity (EC) and pH. Hawkins (2017) described EC as the electrical conductivity of soil, which commonly measured in milli- or deci-Siemens per meter (mS/m) or dS/m [8]. According to Liyan (2022), EC measurements offer wider uses to evaluate soil qualities like texture, wetness, and topsoil depth even though they are typically employed to detect soil salinity [9].

Kekane et al. (2015) explained, the state of soil quality had a key concern [10]. With many soil parameters often falling short of acceptable limits, it was imperative that human activities that contribute to the degradation of soil quality be curtailed.

As a fundamental component of soil structure, soil aggregation affects both physical and chemical properties. As Horn et al. (1994) showed out, dissolved organic carbon in percolating soil solution had an effect on the aggregation process [11].

Contrarily, soil pH is a logarithmic scale which used to measure hydrogen ion concentration; lower pH values indicate higher acidity. According to Oshunsanya (2018), most soils fall between the ranges of 3.5 and 10, with the following classifications: neutral (pH 6.5 to 7.5), alkaline (pH over 7.5), acidic (pH less than 6.5), and strongly acidic (pH less than 5.5) [12].

According to Jones & Willett, (2019-5EPRA), the decomposition of organic matter releases essential nutrients like potassium, phosphorus, and nitrogen that are critical for plant growth and productivity. According to Lehmann & Kleber (2015), organic carbon increases the soil's capacity for cation exchange, which enhances the soil's ability to hold onto and provide nutrients to plants [13]. Due to its ability to supply soil microbes with nutrients and energy, organic carbon serves as crucial for soil fertility.

According to Johnson & Brown (2015), the pH of the soil decreases when copper ions take the position of hydrogen ions, which in some cases might result in acidification [14].

Zinc influences soil pH, although the effects are variable. Some studies have reported a slight decrease in soil pH with increasing zinc levels. However, Johnson & Brown, (2016) observed no significant pH changes. Low zinc concentrations can limit microbial growth and activity. Adequate zinc levels can enhance microbial diversity and enzymatic activity [15].

Iron can influence soil pH, although the effects seem variable; Smith et al. (2012) showed a slight reduction in pH with increasing concentrations of iron, while others observed no significant changes in pH [16].

According to Rout & Das, (2009), a sufficient amount of boron can promote microbial growth and activity, which in turn helps with nutrient cycling and organic matter decomposition. On the other hand, Khan et al., 2019 described, an excessive amount of boron can be harmful to some microorganisms, which results in a decrease in microbial diversity and activity [17].

## 3. METHODOLOGY

In the Pandrapath block of Jashpur district, Chhattisgarh, a research including the assessment of soil quality should center on a thorough investigation of soil electrical conductivity (EC), pH, and other relevant attributes of the soil [18, 19]. The proposed methodology as follows:

**1. Area Selection:**

- ❖ The Pandrapath block of Jashpur district was selected as the study region because of its diverse geography and climate, which includes a range of soil types and land uses.

**2. Collection of soil sample**

- ❖ Designate particular sites for soil sample in the Jashpur district, Pandrapath block of Chhattisgarh.
- ❖ At each site, gather soil samples using systematic sampling techniques at varying depths (e.g., 0–10 cm, 10–20 cm).
- ❖ For optimal statistical significance, gather a sufficient number of samples.

**3. Soil Parameters Measurement:**

- ❖ Use an appropriate EC metre and normal operating procedures to measure the EC of soil.
- ❖ Use a pH metre to measure the pH of the soil and record the results.
- ❖ Examine other important soil characteristics, such as bulk density, organic matter content, and moisture content.
- ❖ Use the proper laboratory testing to evaluate aggregate stability.

**4. Data Analysis:**

- ❖ Examine the gathered information to determine whether the pH and EC of the soil differ at various points in the Pandrapath block of the Jashpur district.
- ❖ To find relationships between EC, pH, and other soil properties through statistical approaches.

 

- Arrange soil pH values according to the specified ranges: neutral, alkaline, acidic, or extremely acidic.

- Examine the effects of soil aggregation on the characteristics of the soil.

**5. Ground Reference and Influencing Variables:**

- Examine possible factors which might influence soil EC readings in the research region, including vegetation, moisture content, and land use.

- To understand the influencing factors and possible linkages with soil attributes, ground reference the soil EC measurements.

**6. Assessment of soil quality:**

- Based on the measured parameters, such as pH and EC, assess the soil quality in the Pandrapath block of Jashpur district.

- The impact of a tropical environment and different farming seasons on soil quality should be taken into consideration.

- Draw attention to any places where soil quality may be declining as a result of human activity by comparing the observed soil parameters to permissible limits and recommendation.

**7. Recommendations and Implications:**

- In the Pandrapath block of Jashpur district, make recommendations for sustainable land use practices and soil management techniques based on the results of the investigation.

- Emphasize on maintaining the quality of the soil and reducing human activities that could degrade it.

- Discuss about the ways the environment of the area and agriculture may be influenced by the condition of the soil.

**8. Reporting and Documentation:**

- Prepare an extensive report by compiling the results and conclusions.
- To show the spatial distribution of soil attributes in the Pandrapath block of Jashpur district, including tables, maps, and graphical representations.

- ❖ Refer to pertinent material that has been covered in the literature review section, such as studies on pH, EC, and soil quality.

**9. Review and Conclusion:**

- ❖ Summarize the main conclusions of this research and their ramifications for the area.

- ❖ Provide a synopsis of the research technique, highlighting its shortcomings and highlighting potential directions for further investigation.

The present methodology defines a framework of methods for evaluating the soil quality in the Pandrapath block of Jashpur district, while considering the distinct geographical and climatic elements that impact the soil qualities in the area. The main goal of the research is to explain the sustainable land management techniques and offer insightful information on soil health [20, 21].

## 4. RESULTS

**Table 1: PHYSICAL ANALYSIS REPORT**

| S. No. | Soil Properties | | Pandrapath ( 0-15 cm ) | Pandrapath ( 15-30cm ) |
|---|---|---|---|---|
| 1 | Textural analysis | Sand ( % ) | 44 | 40 |
| | | Silt ( % ) | 30 | 32 |
| | | Clay ( % ) | 26 | 28 |
| **Textural Name** | | | Silty clay loam | Silty clay loam |
| 2 | Bulk density ( g / $cm^3$ ) | | 1.46 | 1.49 |
| 3 | Particle Density ( g / $cm^3$ ) | | 2.52 | 2.54 |
| 4 | Porosity ( % ) | | 41.95 | 41.51 |
| 3 | Water Holding Capacity ( % ) at saturation | | 48.79 | 47.68 |

The soil properties in Pandrapath for the depth ranges of 0–15 cm and 15–30 cm are summarized in Table 1. The results are summarized as follows:

1. **Textural Analysis:**

- The soil is classified as "Silty clay loam" at a depth of 0 to 15 cm because it is composed of 44% sand, 30% silt, and 26% clay.

- At a depth of 15–30 cm, the soil is still classified as "silty clay loam," with 40% silt, 32% sand, and 28% clay.

2. **Bulk Density:**

- There is 1.46 g/cm³ of bulk density at depth of 0–15 cm.

- The bulk density slightly increases to 1.49 g/cm$^3$ at a depth of 15–30 cm.

3. **Particle Density:**

- With values of 2.52 and 2.54 g/cm³, the particle densities at both depths stay quite close to one another.

4. **Porosity:**

- The porosity is 41.95% at depth of 0–15 cm and marginally lowers to 41.51% at depth of 15–30 cm.

5. **Water Holding Capacity at Saturation:**

- In the 0–15 cm layer, 48.79% of the water in the soil is saturable.

- Saturation retention of 47.68% of water is found in the 15–30 cm layer.

These results offer crucial details regarding the characteristics of the soil in Pandrapath at various depths. That information can be helpful for regional agricultural or environmental research.

**REPORT OF CHEMICAL ANALYSIS**

| **S. No.** | **pH** | **EC** | **OC** | **N** | **P** | **K** | **S** | **Fe** | **Mn** | **Cu** | **Zn** | **B** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | dSm$^{-1}$ | (%) | (kg/ha) | | | | | | (ppm) | | |
| P (0-15 cm) | 4.86 | 0.07 | 0.67 | 289 | 29.20 | 200 | 17.36 | 44.94 | 25.04 | 1.00 | 0.42 | 0.63 |
| P (15-30 cm) | 4.94 | 0.06 | 0.66 | 276 | 30.54 | 223 | 16.24 | 39.94 | 22.68 | 0.86 | 0.58 | 0.37 |

**Table 2:CHEMICAL ANALYSIS REPORT**

| Chemical properties | Value range | | |
|---|---|---|---|
| pH ( 1 : 2.5 ) | Strongly acidic <4.5<br>Moderate acidic 4.5-5.5<br>Slightly Acid 5.5-6.5<br>Neutral 6.5-7.54 | Slightly alkaline 7.5-8.5<br>Moderate alkaline 8.5-9.5<br>Strongly alkaline >9.5 | |
| EC ( $dSm^{-1}$ ) | No detrimental impact on crop < 1<br>Essential to germination 1.0-2.0<br>Essential for crops especially susceptible to salt 2.0-3.0<br>Harmful to the majority of crops 3.0 | | |
| OC (%) | Low < 0.5<br>Medium 0.5 -0.75<br>High >0.75 | Available P ( kg / ha) | Low < 34<br>Medium 34-68<br>High > 68 |
| Available N ( kg / ha) | Low 280<br>Medium 280-560<br>High > 560 | Available K ( kg / ha) | Low < 135<br>Medium 135-335<br>High > 335 |
| Available Zn ( ppm ) | Deficient <0.60 | Available Fe ( ppm) | Deficient <4.5 |
| Available Cu ( ppm ) | Deficient <0.20 | Available Mn ( ppm) | Deficient <3.5 |
| Available B ( ppm ) | Deficient <0.50 | Sulphur ( kg /ha) | Deficient <22.5<br>Medium <22.5-35<br>High >35 |

Table 2 illustrates soil chemical characteristics in Pandrapath at two different depths (0–15 cm and 15–30 cm). The data are interpreted as follows:

1. **pH ($H_2O$):**

❖ All samples had pH values that vary from slightly acidic to moderately acidic.

2. **EC (Electrical Conductivity):**

❖ Low EC values in every sample show no harmful effects on crops.

3. **Organic Carbon (OC):**

   - All samples fall into the "medium" range of OC measurements, which denotes a moderate level of organic carbon concentration.

4. **Nitrogen (N):**

   - While varying, the nitrogen content in each sample is within the "medium" range.

5. **Phosphorus (P):**

   - The range of phosphorus content values is low to medium.

6. **Potassium (K):**

   - Potassium content ranges from low to medium in values.

7. **Sulfur (S):**

   - Sulfur content ranges from low to medium in values.

8. **Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Boron (B):**

   - Although these micronutrient values fluctuate, it seems that they fall within reasonable bounds.

Large variations in soil attributes were found in the Pandrapath block of Jashpur district, with an emphasis on pH and electrical conductivity (EC) of the soil. An analysis of the data gathered from several points in the Pandrapath block of Jashpur district revealed information about its condition and caliber of the soil. The results achieved were as follows:

**7. DISCUSSION**

**1. Soil Electrical Conductivity (EC):** The data showed slight variation in soil EC of Pandrapath at two different depths (0–15 cm and 15–30 cm), which indicate the soil's ability to conduct electrical current. It exhibited the EC value at 0.07 and 0.06 $dSm^{-1}$, respectively. Factors like as moisture content, vegetation, and soil salinity can be responsible for these variations.

**2. Soil pH:** Soil pH is an index of the acidity or alkalinity of the soil. The findings showed differences in soil pH levels in both depths (0-15 cm and 15-30 cm). It exhibited the pH value at 4.86 and 4.94. These variations are influenced by factors such as the type of vegetation, organic matter content, and climate.

**3. Organic Content (OC):** Soil health is greatly dependent on organic matter. Results showed that the amount of organic matter varied in both depths (0–15 cm and 15–30 cm). It exhibited the OC values at 0.67 % and 0.66 %, respectively. The vegetation and land use methods can be the cause of these variances [22].

**Overall Implications:**

There are several factors that determine the observed variations in soil qualities within the Pandrapath block of Jaspur district. These factors include vegetation, climate, and land use. These results have various consequences as follows:

- Variations in soil EC and pH indicate to the necessity of customized soil management techniques to address variations in soil salinity and acidity/alkalinity.

- Variations in moisture content can affect water management and crop irrigation techniques.

- Variations in bulk density raise concerns regarding changes in soil compaction, which can affect root development and water infiltration.

- The significance of managing organic matter for soil health is highlighted by variations in its composition.

## 8. CONCLUSION

An extensive comprehension of the various soil properties and conditions within this distinct geographical and climatic setting has been provided by the comprehensive soil quality assessment conducted in Pandrapath block of Jashpur district, in the northern part of the Chhattisgarh state in India. The study concentrated on soil electrical conductivity (EC), pH, and other critical soil parameters. The results of this evaluation showed notable discrepancies in soil characteristics between sites in Pandrapath and the regions around it. These variations included changes in soil EC, pH, moisture content, bulk density, and organic matter content. Numerous variables, such as soil salinity, moisture content, vegetation cover, and the impact of regional land use practices, could be responsible for these variations.

These results have consequences that go beyond the field of soil science. Specifically, it highlighted the necessity of customized soil management strategies which take consideration the particular features of the soil in Pandrapath. Variations in moisture content also highlight the importance of strategic water management for crop irrigation and land use in this area. Differences in bulk density emphasized the significance of reducing soil compaction, which is a major factor influencing root development and water infiltration. Additionally, the variations in organic matter content underscore the critical function of managing organic matter in order to improve soil health and fertility.

Understanding and managing soil quality is critical in the Pandrapath context, where agricultural practices are intertwined with the region's tropical climate and changing seasons. This knowledge can help land managers and the community make decisions that can improve crop productivity, support environmental sustainability, and guarantee long-term soil health.

As we rely to conclude, it is clear that Pandrapath assessment of soil quality adds a great deal to our understanding of the particular soil conditions in this area. The findings highlight the significance of making well-informed decisions regarding land use and agriculture, with the ultimate objective being the preservation and enhancement of soil quality for the benefit of both the environment and the people of Pandrapaht. To accommodate the unique demands of the regions within Pandrapath and the productive and sustainable land use practices are maintained in the future, it will be imperative to conduct ongoing research, implement targeted interventions, and maintain ongoing monitoring.

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