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# "A REVIEW ON METHODS AND TECHNIQUES FOR DETERMINING SOIL PHYSICO-CHEMICAL PROPERTIES"

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## ABSTRACT

Soil is a vital natural resource that supports terrestrial ecosystems and regulates environmental processes such as nutrient cycling, water movement, and pollutant retention (Brady & Weil, 2016). The physico-chemical properties of soil determine its structure, fertility, and environmental quality (Hillel, 2004). Accurate evaluation of soil properties requires systematic sampling and reliable analytical techniques in both field and laboratory conditions (Sparks, 1996). Various methods are used to determine physical properties such as soil texture, bulk density, particle density, porosity, and water holding capacity, as well as chemical parameters including pH, electrical conductivity, organic carbon, and nutrient availability (Piper, 2002). Standard analytical procedures such as hydrometer analysis, pycnometer method, pH meter measurement, and Walkley–Black oxidation are widely used for soil evaluation . This review paper discusses the major techniques used for determining soil physico-chemical properties and highlights their importance in environmental monitoring and soil quality assessment.

**KEYWORDS:** Soil characterization, Soil physico-chemical properties, Soil sampling techniques, Electrical conductivity (EC), Soil nutrient analysis, Environmental soil quality.

## 1. INTRODUCTION

Soil is a complex natural system composed of mineral particles, organic matter, water, air, and living organisms that interact to regulate environmental processes (Brady & Weil, 2016). The physico-chemical characteristics of soil play an essential role in determining soil productivity, nutrient availability, and ecological stability (Hillel, 2004). Soil properties such as texture, density, porosity, and chemical composition influence water retention, microbial activity, and plant growth (Sparks, 1996). Understanding soil physico-chemical properties is essential for environmental studies, land management, and ecosystem conservation (Piper, 2002). Scientists use a variety of analytical methods to determine these properties in order to evaluate soil quality and environmental conditions (Jackson, 1973). These methods include laboratory experiments, field measurements, and instrumental techniques designed to measure both physical and chemical characteristics of soil (Sparks, 1996).

Standard procedures for soil analysis have been developed to ensure accuracy, reliability, and comparability of results obtained from different laboratories and research studies (Piper, 2002). Proper soil sampling, sample preparation, and laboratory analysis are essential steps for obtaining accurate results in soil research (Jackson, 1973).

## 2. Soil Sampling and Sample Preparation

Soil sampling is the first and most important step in the analysis of soil properties because accurate laboratory results depend on the representativeness of the collected samples (Jackson, 1973). Soil samples are usually collected from different depths and locations within a study area using tools such as augers, corers, or spades (Piper, 2002). Sampling techniques such as random sampling, systematic sampling, and grid sampling are commonly used to obtain representative soil samples for analysis (Sparks, 1996). After collection, soil samples are air-dried, crushed gently, and passed through a sieve to remove stones, roots, and plant debris before laboratory testing (Piper, 2002). Proper preparation of soil samples ensures uniformity and improves the accuracy of physico-chemical analysis by eliminating external contaminants and large particles that may influence the results (Jackson, 1973). Standard soil testing laboratories follow strict protocols for drying, grinding, and storing soil samples to maintain consistency in analytical procedures (Sparks, 1996).

## 3. Methods for Determining Physical Properties of Soil

### 3.1 Soil Texture Analysis

Soil texture refers to the relative proportion of sand, silt, and clay particles present in soil (Hillel, 2004). Soil texture influences water retention, permeability, aeration, and nutrient availability within the soil system (Brady & Weil, 2016). One of the most widely used techniques for determining soil texture is the hydrometer method, which measures the rate at which soil particles settle in a suspension according to their size and density . The method is based on the principle that larger particles settle faster than smaller particles in water due to gravitational forces. Another technique used for particle size analysis is the international pipette method, which measures the concentration of suspended particles at specific depths and times during sedimentation . Sieve analysis is also used for separating coarse soil particles into different size fractions for texture determination.

### 3.2 Bulk Density Determination

Bulk density is defined as the mass of dry soil per unit volume, including the pore spaces present in the soil structure (Brady & Weil, 2016). Bulk density is an important parameter for evaluating soil compaction, root penetration, and water movement within soil profiles (Sparks, 1996).

The core sampler method is the most widely used technique for determining soil bulk density because it allows direct measurement of soil volume and dry mass . In this method, a cylindrical metal core is inserted into the soil, and the collected sample is dried in an oven and weighed.

Other methods for determining bulk density include the clod method and excavation method, which are used when soil samples cannot be collected using core samplers .

### 3.3 Particle Density Measurement

Particle density refers to the density of soil solids excluding pore spaces and is mainly determined by the mineral composition of soil (Piper, 2002). Particle density is usually measured using the pycnometer method, which determines the volume of soil particles displaced by water .

The particle density of most mineral soils ranges between 2.6 and 2.7 g/cm$^3$ due to the presence of quartz and silicate minerals (Brady & Weil, 2016). Determination of particle density is essential for calculating soil porosity and evaluating soil structure.

### 3.4 Soil Porosity

Soil porosity represents the percentage of pore space within soil and influences aeration, water infiltration, and root growth (Hillel, 2004). Porosity is usually calculated using bulk density and particle density values obtained from laboratory measurements. Higher porosity improves soil aeration and water movement, while low porosity indicates compacted soil conditions that may restrict plant growth and microbial activity (Brady & Weil, 2016).

### 3.5 Water Holding Capacity

Water holding capacity is the ability of soil to retain water against gravitational forces and supply moisture to plants (Hillel, 2004). This property depends on soil texture, organic matter content, and pore structure (Brady & Weil, 2016). The Keen-Raczkowski brass cup method is commonly used to determine the maximum water holding capacity of soil samples . In this method, soil is saturated with water and allowed to drain under controlled conditions to determine the amount of water retained in the soil.

## 4. Methods for Determining Chemical Properties of Soil

### 4.1 Soil pH Measurement

Soil pH indicates the acidity or alkalinity of soil and affects nutrient availability, microbial activity, and chemical reactions in soil systems (Sparks, 1996). The potentiometric method using a glass electrode pH meter is widely used for soil pH measurement in soil-water suspensions such as 1:1 or 1:2.5 ratios . Soil pH plays a significant role in determining the solubility and availability of nutrients in soil environments.

### 4.2 Electrical Conductivity (EC)

Electrical conductivity measures the concentration of soluble salts present in soil solution and is an indicator of soil salinity (Sparks, 1996). The conductometric method using an EC meter is used to determine soil electrical conductivity in soil-water extracts . High EC values indicate saline conditions that may affect plant growth and soil health.

### 4.3 Soil Organic Carbon

Soil organic carbon is an important parameter for evaluating soil fertility and biological activity (Brady & Weil, 2016). The Walkley–Black wet oxidation method is widely used for determining organic carbon content in soil samples through chemical oxidation of organic matter . Organic carbon improves soil structure, increases water retention capacity, and supports microbial activity.

### 4.4 Nitrogen Determination

Nitrogen is a major nutrient required for plant growth and soil fertility (Sparks, 1996). The Kjeldahl digestion method is commonly used to determine total nitrogen in soil samples by converting organic nitrogen into ammonium through acid digestion . This method is widely used in soil chemistry and environmental research.

### 4.5 Phosphorus and Potassium Determination

Phosphorus and potassium are essential nutrients that influence plant growth and soil productivity (Brady & Weil, 2016). The Olsen extraction method is commonly used for determining available phosphorus in soil, while potassium is measured using flame photometry after ammonium acetate extraction . These methods provide reliable information about soil nutrient status.

### 4.6 Cation Exchange Capacity (CEC)

Cation exchange capacity represents the ability of soil to retain and exchange positively charged ions such as calcium, magnesium, potassium, and ammonium (Hillel, 2004). CEC is commonly determined using ammonium acetate extraction methods followed by chemical analysis of exchanged cations . High CEC values indicate greater nutrient retention capacity and improved soil fertility.

## 5. Modern and Advanced Techniques in Soil Analysis

Recent advances in soil science have introduced modern analytical techniques such as spectroscopy, remote sensing, and machine learning for rapid soil analysis (Sparks, 1996). Spectroscopic methods such as X-ray fluorescence and visible-near infrared spectroscopy are increasingly used for rapid determination of soil chemical properties including organic matter, nutrients, and mineral composition (Santana et al., 2020).

Machine learning techniques are also being used to predict soil properties using large datasets and spectral information, allowing rapid and cost-effective soil analysis (Kumar et al., 2025). Field-based geotechnical methods such as the cone penetration test are used to determine soil stratigraphy and geotechnical characteristics by pushing an instrumented cone into the ground at a controlled rate . These modern methods improve the efficiency and accuracy of soil property evaluation.

## 6. CONCLUSION

Determination of soil physico-chemical properties is essential for understanding soil quality, environmental sustainability, and ecosystem functioning. Various traditional and modern analytical methods are used to measure soil parameters such as texture, density, porosity, pH, electrical conductivity, organic carbon, and nutrient content. Standard laboratory techniques such as hydrometer analysis, pycnometer method, Walkley–Black oxidation, and Kjeldahl digestion remain widely used in soil science research. Modern techniques including spectroscopy, remote sensing, and machine learning are improving the efficiency and accuracy of soil analysis. Continuous development of analytical techniques will enhance soil monitoring, environmental management, and sustainable land use practices.

## REFERENCES (APA Style)

1. Brady, N. C., & Weil, R. R. (2016). *The nature and properties of soils*. Pearson Education.
2. Hillel, D. (2004). *Introduction to environmental soil physics*. Academic Press.
3. Jackson, M. L. (1973). *Soil chemical analysis*. Prentice Hall.
4. Piper, C. S. (2002). *Soil and plant analysis*. Scientific Publishers.
5. Sparks, D. L. (1996). *Methods of soil analysis: Chemical methods*. Soil Science Society of America.
6. Subbiah, B. V., & Asija, G. L. (1956). A rapid procedure for estimation of available nitrogen in soils. *Current Science*, 25, 259-260.
7. Nelson, D. W., & Sommers, L. E. (1982). Total carbon, organic carbon and organic matter. In *Methods of soil analysis*. American Society of Agronomy.
8. Rhoades, J. D. (1982). Soluble salts. In *Methods of soil analysis*. American Society of Agronomy.
9. Dewangan, S. K., Jaiswal, A., Shukla, N., Pandey, U., Kumar, A., & Kumari, N. (2022). Characterization of agriculture Soil of Gangapur area located in Latori, Surguja division of Chhattisgarh. International Journal of Science, Engineering And Technology, 11(1). Web-link. Researchget
10. Dewangan, S. K., Kumari, J., Tiwari, V., Kumari, L. (2022). Study the Physico-Chemical Properties of Red Soil of Duldula Area Located in Jashpur District, Surguja Division of

Chhattisgarh, India. International Journal of Scientific Research in Engineering and Management (IJSREM), 06(11), 1-5. Web-link , Researchget

11. Dewangan, S. K., Kumari, L., Minj, P., Kumari, J., & Sahu, R. (2023). The Effects of Soil pH on Soil Health and Environmental Sustainability: A Review. International Journal of Emerging Technologies and Innovative Research, 10(6), Web-link. Researchget
12. Dewangan, S. K., Kumari, L., Tiwari, V., Kumari, J. (2022). Study the Physio-Chemical Properties of Red Soil of Kandora Village of Jashpur District, Surguja Division of Chhattisgarh, India. International Journal of Innovative Research in Engineering (IJIRE), 3(6), 172-175. Web-link , Researchget
13. Dewangan, S. K., Minj, A. K., & Yadav, S. (2022). Study the Physico-Chemical Properties of Soil of Bouncing Land Jaljali Mainpat, Surguja Division of Chhattisgarh, India. International Journal of Creative Research Thoughts, 10(10), 312-315. Web-link , Researchget
14. Dewangan, S. K., Minj, P., Singh, P., Singh, P., Shivlochani. (2022). Analysis of the Physico-Chemical Properties of Red Soil Located in Koranga Mal Village of Jashpur District, Surguja Division of Chhattisgarh, India. International Advanced Research Journal in Science, Engineering and Technology, 9(11), 116-119. Web-link , Researchget
15. Dewangan, S. K., Sahu, K., Tirkey, G., Jaiswal, A., Keshri, A., Kumari, N., Kumar, N., Gautam, S. (2022). Experimental Investigation of Physico-Chemical Properties of Soil taken from Bantidand Area, Balrampur District, Surguja Division of Chhattisgarh, India. International Research Journal of Modernization in Engineering Technology and Science, 04(12), 751-755. Web-link. Researchget
16. Dewangan, S. K., Sahu, R., Haldar, R., & Kedia, S. (2022). Study the physico-chemical properties of black soil of girwani village of balrampur district, surguja division of chhattisgarh, india. Epra International Journal of Agriculture and Rural Economic Research (ARER), 10(11), 53-56. Web-link. Researchget
17. Dewangan, S. K., Sharma, G. K., & Srivasrava, S. K. (2022). Characterization of agriculture Soil of Gangapur area located in Latori, Surguja division of Chhattisgarh. International Journal of Science, Engineering And Technology, 11(1), 1-3. Web-link Researchget
18. Dewangan, S. K., Shrivastava, S. K., Kehri, D., Minj, A., & Yadav, V. (2023). A Review of the Study Impact of Micronutrients on Soil Physicochemical Properties and

Environmental Sustainability. International Journal of Agriculture and Rural Economic Research (ARER), 11(6). Web-link. Researchget

19. Dewangan, S. K., Shrivastava, S. K., Soni, A. K., Yadav, R., Singh, D., Sharma, G. K., Yadav, M., & Sahu, K. (2023). Using the Soil Texture Triangle to Evaluate the Effect of Soil Texture on Water Flow: A Review. International Journal for Research in Applied Science & Engineering Technology (IJRASET), 11(6), 389-390. Web-link Researchget
20. Dewangan, S. K., Shrivastava, S. K., Soni, A. K., Yadav, R., Singh, D., Sharma, G. K., Yadav, M., & Sahu, K. (2023). Using the Soil Texture Triangle to Evaluate the Effect of Soil Texture on Water Flow: A Review. International Journal for Research in Applied Science & Engineering Technology (IJRASET), 11(6), 389-390. Web-link. Researchget
21. Dewangan, S. K., Singh, D., Haldar, R., & Tirkey, G. (2022). Study the Physio-Chemical Properties of Hair Wash Soil of Kardana Village of Jashpur District, Surguja Division of Chhattisgarh, India. International Journal of Novel Research and Development, 7(11), 13-17. Web-link , Researchget
22. Dewangan, S. K., Soni, A. K., & Sahu, K. (2022). Study the Physico-Chemical Properties of Rock Soil of Sangam River, Wadrafnagar, Surguja Division of Chhattisgarh, India. International Journal of Research and Analytical Reviews, 9(4), 119-121. Web-link . Researchget
23. Dewangan, S. K., Yadav, M. K., Tirkey, G. (2022). Study the Physico-Chemical Properties of Salt Soil of Talkeshwarpur Area Located in Balrampur District, Surguja Division of Chhattisgarh, India. International Research Journal of Modernization in Engineering Technology and Science, 4(11), 791-797. Web-link Researchget
24. Dewangan, S. K., Yadav, R., Haldar, R. (2022). Study the Physio-Chemical Properties of Clay Soil of Kandora Village of Jashpur District, Surguja Division of Chhattisgarh, India. EPRA International Journal of Research and Development (IJRD), 7(11), 87-91. Web-link Researchget
25. Dewangan, S. K., Yadav, V., Sahu, K. (2022). Study the Physio-Chemical Properties of Black Soil of Bahora Village of Jashpur District, Surguja Division of Chhattisgarh, India. International Research Journal of Modernization in Engineering Technology and Science, 04(11), 1962-1965. Web-link. Researchget
26. Dewangan, S.K., Kehri, D., Preeti . & Yadav, A.(2022). Study The Physico-Chemical Properties Of Brown Soil Of Gaura Village Of Surajpur District, Surguja Division Of

Chhattisgarh, India. International Journal of Engineering Inventions,11(11),80-83. Web-link. Researchget

27. Dewangana, S. K., Mahantb, M. (2023). Physical Characterization of Soil from BudhaBagicha Area, Balrampur, Chhattisgarh and its Comparative Study with Soils of Other Areas. International Journal of Science, Engineering and Technology, 11(6). Web-link. Researchget
28. Dewangana, S. K., Yadavb, N., & Preetic. (2023). A Study on the Physicochemical Properties of Soil of Butapani Area Located in Self-Flowing Water, Lundra Block, Surguja District, Chhattisgarh, India. EPRA International Journal of Research and Development (IJRD), 8(12). Web-link. Researchget