Physico-Chemical Characterization of Soil from Ambedkar Colony Ondela Road, Dholpur (Rajasthan)

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***Abstract*—In this study, five soil samples were collected from different locations in Ambedkar Colony near Parkas College on Ondela Road, Dholpur (Rajasthan). The samples were analyzed for various physical and chemical properties, including pH, electrical conductivity (EC), and moisture content, water holding capacity, temperature, chloride, phosphate, alkalinity, carbonate, nitrogen, and organic content. Soil plays a critical role in ecological functions such as food production, biodiversity support, water filtration, climate regulation, and erosion control. The observed differences in soil quality across the sampling sites indicate variable environmental influences and anthropogenic activities. This research underscores the importance of soil testing in agricultural productivity and environmental health.**

***Index Terms*—Physico-chemical, alkalinity, carbonate, bicarbonate, chloride, EC, pH, nitrogen, calcium, phosphates, organic content.**

I. INTRODUCTION

Soil is a heterogeneous mixture of organic and inorganic materials essential for sustaining terrestrial life. It comprises minerals, organic matter, air, and water and forms a critical component of the Earth's biosphere. Soil supports agriculture, biodiversity, climate regulation, and water management. Understanding soil properties helps manage land sustainably, especially in regions like India where climate and geography create diverse soil types.

Unregulated use of chemical fertilizers without soil testing has resulted in nutrient imbalance and declining soil fertility. Soil testing enables precise application of nutrients, enhancing productivity and minimizing environmental impacts. This study focuses on soil samples from Dholpur, Rajasthan, to determine their physical and chemical characteristics and assess their suitability for agriculture and environmental sustainability.

II. MAIN OBJECTIVES

1. To analyze key physico-chemical properties of soil samples collected from Ambedkar Colony, including parameters such as pH, moisture content, specific gravity, unit weight, and hardness.
2. To assess the fertility and suitability of the soil for agricultural, construction, and other land-use purposes based on the measured properties.
3. To identify the presence and concentration of essential nutrients and elements such as calcium, magnesium, sodium, and other minerals in the soil.
4. To evaluate the impact of anthropogenic activities (e.g., urbanization, waste disposal, etc.) on the soil quality in the study area.
5. To provide baseline data that can help in environmental monitoring, soil conservation, and sustainable land-use planning in the region.

III. REVIEW OF LITERATURE

Soil quality plays a vital role in determining land productivity, environmental sustainability, and agricultural potential. Numerous studies have focused on the physico-chemical characterization of soil to assess its health, fertility, and suitability for different uses.

1. Brady and Weil (2008) emphasized that soil physical properties such as texture, structure, moisture content, and bulk density are critical in influencing water retention, aeration, and root penetration. Singh et al. (2014) reported that analyzing the chemical characteristics of soil—such as pH, electrical conductivity,

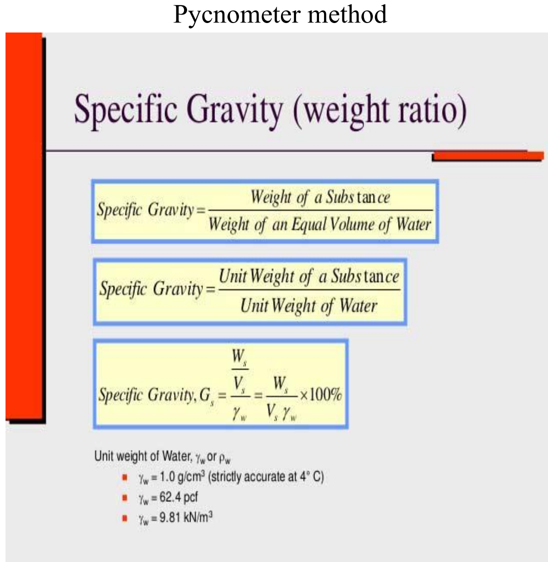
nutrient content (N, P, K), and presence of heavy metals—is essential for monitoring pollution and land degradation.

2. Several regional studies provide context for the present work. Sharma and Soni (2016) analyzed soils in semi-arid zones of Rajasthan and found
3. that human activities like excessive use of fertilizers, poor waste management, and urban encroachment significantly altered soil properties. Similarly, Gupta et al. (2019) studied soil from urban outskirts in Jaipur and observed that improper drainage and industrial runoff led to increased salinity and altered nutrient balance.
4. In a study conducted by Meena et al. (2020) in Bharatpur district (adjacent to Dholpur), soil samples showed variation in pH and hardness depending on proximity to habitation and water bodies. They stressed the need for localized soil monitoring to support sustainable development and land use.
5. Further, Patel et al. (2021) highlighted the importance of micronutrient analysis (e.g., Mg, Ca, Na) in assessing soil fertility in urban and peri-urban settings. They concluded that such studies can inform urban planning and agricultural interventions in growing towns of Rajasthan.
6. Given the limited literature specifically focused on Dholpur district, the present study aims to fill this research gap by providing updated, location-specific data on the physico-chemical properties of soil in Ambedkar Colony, Ondela Road, an area subject to both residential development and changing land use.

IV. MATERIALS AND METHODS

Table: Methods Used for Determining Physico-Chemical Properties of Soil Samples

<table>
<tr><th>S No.</th><th>Property</th><th>Method Used</th><th>Reference/Instrument</th></tr>
<tr><td>1</td><td>Degree of Saturation</td><td rowspan="3">
<table>
<tr><th>Property</th><th>Formula</th><th>Limit</th></tr>
<tr><td>Water content</td><td>$w = \frac{W_w}{W_d} * 100$</td><td>$w \geq 0$</td></tr>
<tr><td>Void ratio</td><td>$e = \frac{V_v}{V_s}$</td><td>$e > 0$</td></tr>
<tr><td>Porosity</td><td>$\eta = \frac{V_v}{V} * 100$</td><td>$0 < \eta < 100\%$</td></tr>
<tr><td>Degree of saturation</td><td>$s = \frac{V_w}{V_v} * 100$</td><td>$0 \leq s \leq 100\%$</td></tr>
<tr><td>Air content</td><td>$a_c = \frac{V_a}{V_v} * 100$</td><td>$0 \leq a_c \leq 100\%$</td></tr>
<tr><td>% air voids</td><td>$\eta_a = \frac{V_a}{V} * 100$</td><td>$0 \leq \eta_a < 100\%$</td></tr>
</table>
</td><td>Laboratory-calculated values</td></tr>
<tr><td>2</td><td>Air Content (%)</td><td>Derived from porosity and saturation</td></tr>
<tr><td>3</td><td>Percentage of Air Voids</td><td>Derived from bulk and dry density</td></tr>
</table>

4	Unit Weight (kN/m³)	📌 **Formula for Unit Weight (γ):** $$\gamma = \frac{W}{V}$$ Where: • γ = unit weight of soil (kN/m³ or lb/ft³) • W = total weight of soil (kN or lb) • V = total volume of soil (m³ or ft³) ✅ **Common Variants:** 1. **Bulk Unit Weight (γ):** Includes both solids and water. $$\gamma = \frac{W_s + W_w}{V}$$ 2. **Dry Unit Weight (γ_d):** Weight of only the soil solids. $$\gamma_d = \frac{W_s}{V}$$ 3. **Saturated Unit Weight (γ_sat):** When all voids are filled with water. $$\gamma_{sat} = \frac{W_s + W_w}{V} \quad \text{(under saturated conditions)}$$ 4. **Effective Unit Weight / Submerged Unit Weight (γ'):** $$\gamma' = \gamma_{sat} - \gamma_w$$ Where γ_w is the unit weight of water (~9.81 kN/m³).	Core cutter method (IS 2720 Part XXIX)
5	Specific Gravity	Pycnometer method  	IS 2720 (Part 3) – 1980
6	pH	pH meter, 1:2.5 soil-to-water suspension	Digital pH meter
7	Hardness	Penetrometer or field texture test	Soil penetrometer / Mohs scale approximation
8	Calcium (Ca) (ppm)	EDTA titration or AAS after extraction with ammonium acetate	EDTA / Atomic Absorption Spectroscopy
9	Sodium (Na) (eps)	Flame photometry after acid digestion	Flame photometer

10	Magnesium (Mg) (%)	EDTA titration or AAS after digestion	EDTA / Atomic Absorption Spectroscopy
11	Moisture Content (%)	Oven-drying method (drying at 105–110°C for 24 hrs)	IS 2720 Part II – 1973
12	Temperature (°C)	In-situ measurement at 15 cm soil depth	Soil Thermometer

V. SAMPLE COLLECTION

Five soil samples (S-1 to S-5) were collected from different locations in Ambedkar Colony, Ondela Road Dholpur. Samples were obtained from the topsoil layer (0–15 cm depth) using a soil auger and stored in clean, labeled containers.

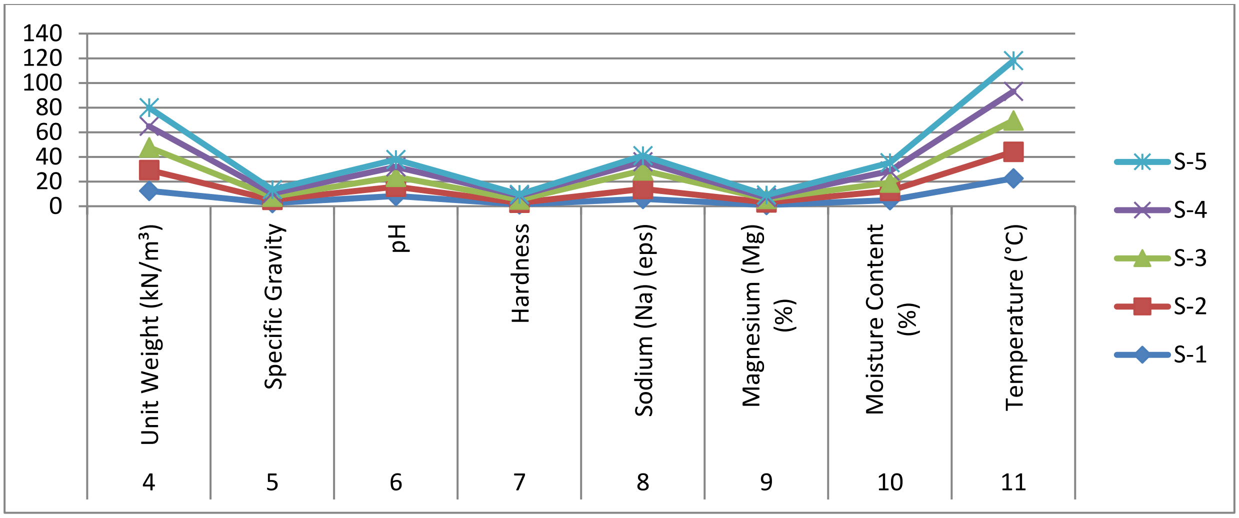
Sample Locations

Soil samples were collected from five distinct points within Ambedkar Colony, Ondela Road, Dholpur (Rajasthan) to capture spatial variability in physico-chemical properties. Each sample was taken at a depth of 0–15 cm using a soil auger, stored in clean, labeled containers, and analyzed in the laboratory

Sample ID	Location Description	Coordinates (Approx.)	Remarks
S-1	Near entrance gate of Ambedkar Colony	26.7095°N, 77.8798° E	Loamy surface, residential waste nearby
S-2	Open land adjacent to Ondela Road	26.7103°N, 77.8821° E	Dry patch with sparse vegetation
S-3	Backyard of residential house near water tank	26.7088°N, 77.8815° E	Slightly damp, domestic activity nearby
S-4	Near public hand pump at colony center	26.7091°N, 77.8804° E	Frequent human activity
S-5	Roadside edge near drain outlet	26.7100°N, 77.8786° E	Possible contamination, clayey

VI. OBSERVATION AND RESULTS

S.No.	Parameter	S-1	S-2	S-3	S-4	S-5
1	Degree of Saturation	0	0.25	0.5	0.75	1
2	Air Content (%)	17.5	19.8	20.5	18.7	20.6
3	Percentage of Air Voids	0.74	0.65	0.7	0.65	0.7
4	Unit Weight (kN/m³)	12.5	16.9	18.25	17.26	14.99
5	Specific Gravity	2.6	2.55	2.65	2.66	2.99
6	pH	8.3	7.5	8	8.05	6.12
7	Hardness	1.55	1.2	2.6	3.1	1.2
8	Calcium (Ca) (ppm)	1500	2000	500	1000	3000
9	Sodium (Na) (eps)	6	8	15	7	5
10	Magnesium (Mg) (%)	1	2	3	1	2
11	Moisture Content (%)	4.938	7.544	6.667	9.345	6.746
12	Temperature (°C)	22.6	21.6	25.4	23.5	24.9


140
120
100
80
60
40
20
0
Unit Weight (kN/m³)
Specific Gravity
pH
Hardness
Sodium (Na) (eps)
Magnesium (Mg) (%)
Moisture Content (%)
Temperature (°C)
4
5
6
7
8
9
10
11
S-5
S-4
S-3
S-2
S-1

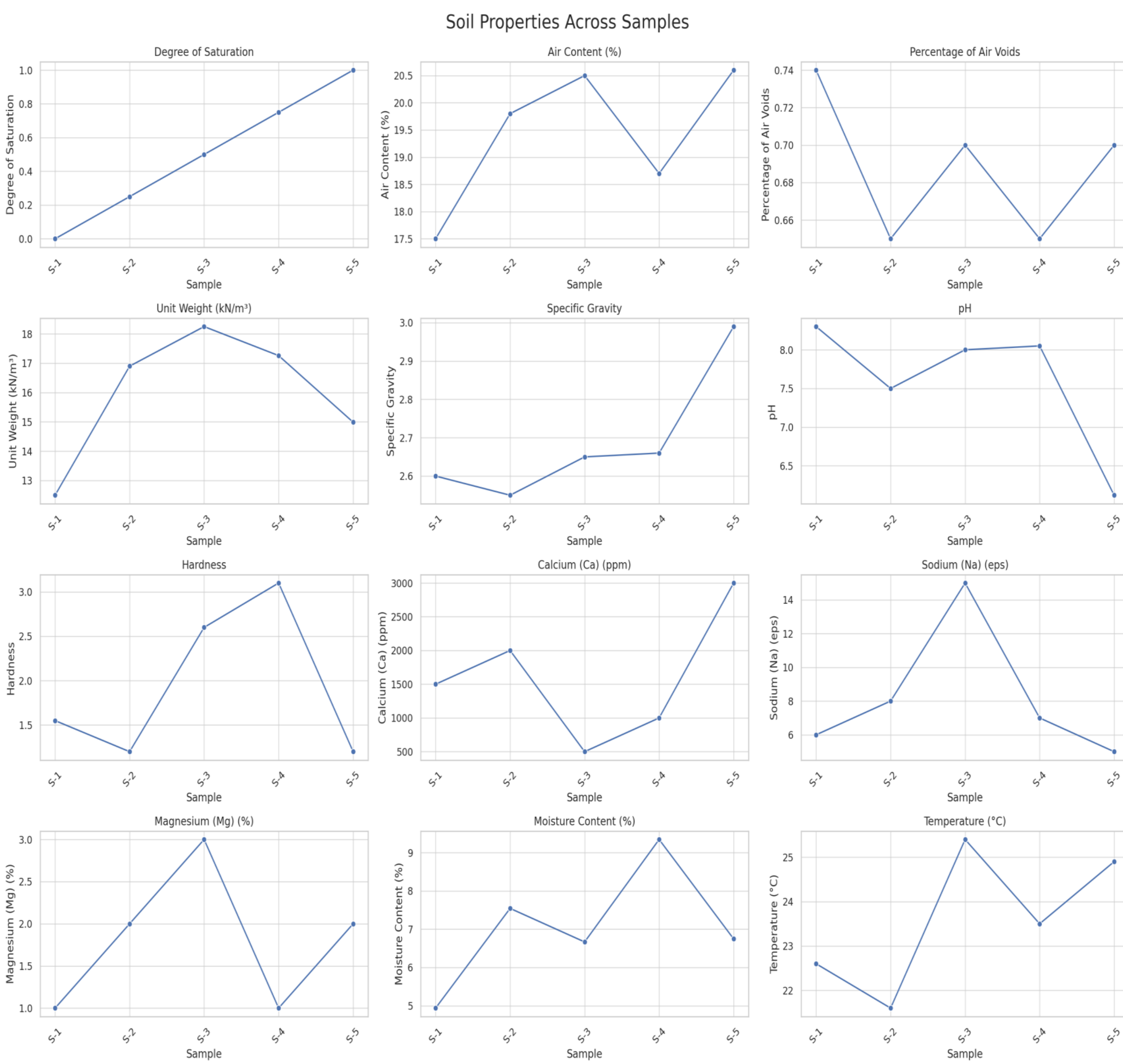

Soil Properties Across Samples
Degree of Saturation
Air Content (%)
Percentage of Air Voids
Unit Weight (kN/m³)
Specific Gravity
pH
Hardness
Calcium (Ca) (ppm)
Sodium (Na) (eps)
Magnesium (Mg) (%)
Moisture Content (%)
Temperature (°C)
Sample
S-1
S-2
S-3
S-4
S-5

Figure: Soil Sample analysis

VII. DISCUSSION

Soil supports agriculture, carbon storage, biodiversity, and water filtration. This research underscores the diverse characteristics of soil across a small geographic area, shaped by environmental and human factors. Parameters like pH, moisture, texture, and nutrient levels directly affect plant growth and ecosystem services.

Soil pollution, largely driven by human activities, degrades these functions. Therefore, soil conservation and periodic monitoring are crucial to preserve this irreplaceable resource. Future studies should explore seasonal variations and include microbiological and heavy metal analyses.

The physico-chemical analysis of five soil samples (S-1 to S-5) collected from Ambedkar Colony, Ondela Road, Dholpur (Rajasthan), revealed significant variability in their properties, reflecting diverse environmental and geochemical conditions across the area.

1. Degree of Saturation: The degree of saturation ranged from 0 (S-1) to 1.00 (S-5), indicating a progression from dry to fully saturated soil. S-1 was completely dry, while S-5 exhibited maximum water saturation, suggesting potential influence from water accumulation or drainage patterns.

2. Air Content and Percentage of Air Voids: Air content values were highest in S-5 (20.6%) and lowest in S-1 (17.5%). The percentage of air voids remained fairly consistent across the samples, ranging between 0.65 and 0.74. These values indicate moderate porosity levels, affecting water retention and aeration.

3. Unit Weight: The unit weight was lowest in S-1 (12.50 kN/m³) and highest in S-3 (18.25 kN/m³), suggesting denser soil composition in S-3. S-5 exhibited a relatively lower unit weight (14.99 kN/m³) despite high saturation, possibly due to organic matter or finer particles reducing bulk density.

4. Specific Gravity: Specific gravity varied between 2.55 (S-2) and 2.99 (S-5), showing a trend toward denser mineral content in S-5. Soils with higher specific gravity typically indicate greater concentrations of heavy minerals.

5. pH: Soil pH values ranged from acidic (6.12 in S-5) to moderately alkaline (8.3 in S-1). This variability affects nutrient availability and microbial activity. S-1 and S-4 had near-optimal pH for agricultural productivity, while S-5's acidic nature might hinder crop growth without amendment.

6. Hardness: Hardness levels were relatively low in S-2 and S-5 (1.2), indicating softer soil, whereas S-4 showed the highest hardness (3.1), suggesting a more compact and potentially less penetrable structure.

7. Calcium (Ca): Calcium concentration varied significantly from 500 ppm (S-3) to 3000 ppm (S-5). High levels in S-5 and S-2 point toward calcareous soil characteristics, potentially enhancing soil structure but posing risks of nutrient imbalance if unmonitored.

8. Sodium (Na): Sodium levels were highest in S-3 (15 eps), implying possible sodic conditions that could lead to soil dispersion and reduced permeability. The lowest Na content was observed in S-5 (5 eps), indicating comparatively better soil health.

9. Magnesium (Mg): Magnesium content ranged from 1% to 3%, with S-3 showing the highest level. Mg is essential for chlorophyll formation, and its abundance in S-3 may benefit plant nutrition if balanced with Ca and K.

10. Moisture Content:Moisture content varied widely, from 4.938% (S-1) to 9.345% (S-4). Higher moisture in S-4 aligns with its moderate saturation and indicates better water-holding capacity, crucial for supporting vegetation.

11. Temperature: Soil temperatures ranged from 21.6°C (S-2) to 25.4°C (S-3). Variations may result from differences in moisture content, shading, and exposure, affecting microbial activity and nutrient cycling.

Overall Interpretation

- S-1 appears dry and alkaline with lower density and minimal moisture.
- S-2 shows balanced moisture and high calcium content.
- S-3 exhibits high density, temperature, and sodium levels, possibly indicating compacted or saline-prone soil.
- S-4 offers a favorable mix of properties for agricultural use.
- S-5 is highly saturated, acidic, and rich in calcium and specific gravity, suggesting heavy and potentially waterlogged soil.

These findings underline the heterogeneity of soil characteristics in the study area, which must be considered for land use planning, crop selection, and soil management.

Soil Composition

Average composition observed across samples:

- Minerals: 45–60%
- Water: 20–30%
- Air: 5–25%
- Organic Matter: 2–5%

Specific Gravity and Degree of Saturation

- Specific Gravity (Gs): Used to estimate void ratio, porosity, and unit weight.
- Degree of Saturation (Sr): Calculated to assess water retention and infiltration potential.

Soil Texture and Separates

Samples showed variation in texture ranging from sandy loam to clay loam. Texture was determined based on the relative proportions of sand, silt, and clay:

- Sand: Provides aeration and drainage
- Silt: Retains moisture
- Clay: Holds nutrients and water

Chemical Properties

- pH: Ranged from slightly alkaline to moderately alkaline
- EC: Low soluble salt content
- Nitrogen: Low levels across all samples
- Phosphates: Medium availability
- Potassium: High availability
- Organic Carbon: Varied; mostly low to moderate

Air Content and Environmental Relevance

Soil air had higher CO_2 and water vapor concentrations compared to atmospheric air, reflecting microbial and root activity. Air content is critical for plant respiration, root health, and soil biota.

VIII. CONCLUSION

The physico-chemical characterization of soil samples from Ambedkar Colony, Ondela Road, Dholpur (Rajasthan) demonstrates substantial variability in key parameters such as saturation, pH, unit weight, mineral content, and moisture. This variability reflects the complex interplay of natural and anthropogenic factors influencing soil formation and quality in the region.

The findings indicate that:

- Some areas (e.g., S-1 and S-5) show extremes in moisture and pH, which may limit their suitability for certain crops without proper management.
- S-4 emerges as the most balanced sample, making it potentially more favorable for agricultural applications.
- High calcium and sodium content in S-2 and S-3, respectively, warrant monitoring to prevent long-term soil degradation or salinization.

Overall, the study highlights the need for site-specific soil management practices to optimize land use and agricultural productivity. Regular monitoring and tailored amendments (e.g., liming acidic soils or improving drainage) will be crucial in maintaining soil health and ensuring sustainable development in the area.This study highlights the importance of soil analysis in understanding its health and productivity. The soils in Ambedkar Colony, Dholpur, were found to be:

- Slightly to moderately alkaline
- Low in organic carbon and available nitrogen
- Medium in phosphorus and high in potassium

Such findings help tailor fertilizer recommendations, ensuring sustainable agriculture and environmental conservation. Soil testing must be a regular practice to monitor fertility and adapt farming strategies accordingly.

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