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COMPARATIVE STUDY OF PHYSICO-CHEMICAL PROPERTIES OF SURFACE AND SUBSURFACE SOILS FROM LAKHANPUR, SURGUJA DISTRICT, CHHATTISGARH, INDIA

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ABSTRACT

This study presents a comparative analysis of the physico-chemical properties of surface and subsurface soils from Lakhanpur in the Surguja district of Chhattisgarh, India, to evaluate their suitability for agriculture. Soil samples were collected from multiple sites and analyzed for parameters including texture (sand, silt, and clay), pH, electrical conductivity (EC), organic carbon, essential nutrients (N, P, K, and micronutrients), cation exchange capacity (CEC), and bulk density. The results revealed significant variations in physical properties, particularly in texture and structure, which influenced water-holding capacity and drainage. Soil pH ranged from slightly acidic to neutral, favoring most crops, while EC values indicated moderate salinity in some locations. Organic carbon levels were generally adequate, enhancing soil fertility, though deficiencies in key nutrients, especially nitrogen and phosphorus, were observed. The study highlights the importance of targeted soil amendments and improved management practices to maintain fertility and optimize agricultural productivity. These findings provide valuable guidance for farmers and land managers to make informed decisions on crop selection, fertilizer application, and soil conservation, thereby supporting sustainable farming and long-term soil health.

Keywords: Organic Carbon, Lakhanpur In The Surguja District, Physico-Chemical Properties, Soil Fertility, Ph, Electrical Conductivity (EC), Soil Texture.

I. INTRODUCTION

- Soil plays a crucial role in our ecosystem as it supplies essential nutrients required for plant growth and development. The fertility and quality of soil directly influence the yield and standard of crops. Lakhanpur in Chhattisgarh is a significant farming region, where a variety of crops are cultivated. Hence, it is important to carry out a detailed study of the soil characteristics of the Lakhanpur area, which will contribute to improving agricultural practices in the region.
- **Study Area:**Lakhanpur, situated in the Surguja district of Chhattisgarh, is a region with considerable agricultural potential. The soil characteristics of this area play a vital role in influencing crop productivity and long-term sustainability.
- **Latitude:** 22.98011° N, **Longitude:** 83.0452° E
- The objective of this study is to perform a physico-chemical analysis of soil samples collected from the Lakhanpur region, focusing on soil texture, pH, electrical conductivity, organic carbon content, and the levels of nitrogen, phosphorus, and potassium. The findings will provide a better understanding of the soil properties in the area and contribute to the improvement of agricultural practices.

II. LITERATURE REVIEW

Understanding the physio-chemical characteristics of soil is vital for determining its fertility, productivity, and environmental health. Several researchers have underlined the importance of analyzing soil properties for better agricultural development and ecological sustainability. This section provides an overview of previous studies on the physico-chemical characteristics of soil, with special reference to the soil from the Lakhanpur area of Surguja district, Chhattisgarh.

1. **Prasad, Mr & Maurya, Dr et al. (2025),**conducted an extensive analysis of soil samples from the Lafri area in Surguja district, Chhattisgarh. Their study revealed that parameters such as pH, electrical conductivity (EC), organic carbon content, and nutrient availability are crucial indicators of soil fertility and play a pivotal role in sustainable agricultural practices. These findings underscore the importance of understanding local soil characteristics to optimize crop yield and implement effective land management strategies.[1]
2. **Kumar,S.& MauryaDr. (2025).**Conducted a comparative study of agricultural soils from Ajirma, Raghunathpur, and Mainpat in the Surguja division revealed significant variations in physical and chemical properties, particularly pH, organic carbon, and nitrogen content. While Mainpat soils showed relatively balanced fertility, Ajirma and Raghunathpur soils exhibited nutrient deficiencies and acidity. The study highlighted the importance of site-specific soil management practices, such as liming for pH correction, organic amendments to restore carbon, and balanced fertilization, to enhance soil productivity and support sustainable agriculture in the region.[2]
3. **Kumar, Rakesh & Aggarwal, et al. (2014),** assessed the soil health and productivity of Kharkhoda and Gohana blocks in Sonipat district, Haryana, by analyzing key physical and chemical properties, including pH, EC, bulk density, hydraulic conductivity, soil organic carbon, and available water retention. The study revealed that soils in most areas were saline (pH < 8, EC > 4 dS m^{-1}) and had subsurface hard pans, leading to poor aeration and limiting crop yields to around 70% of potential. These findings highlight the importance of assessing physical soil constraints for sustainable crop management.[3]
4. Studies on soil morphology, chemistry, and mineralogy revealed that some pedons lacked parental relation with the underlying laterite and developed from re-deposited materials after laterization. Quartz, kaolin, and smectite were the dominant minerals influencing soil fertility and crop suitability. Soils rich in smectite (P3, P4, P7, P8) were suitable for paddy, while Bhata and Matasi were less fertile, highlighting the role of mineralogy and climate in soil management.**(Ramkrushna, 2016).[4]**

III. MATERIAL AND METHODS

Study Area Description

The present investigation was carried out in the Lakhanpur region of Surguja district, Chhattisgarh, India, which is characterized by gently undulating topography, forested landscapes, and moderate agricultural activity. The study area lies within a subtropical climatic zone with distinct seasonal variations. To assess spatial variability in soil characteristics, samples were collected from five georeferenced sites located at varying distances within the Lakhanpur region:

- **Amera (Lakhanpur – Centre):** 23.1502º N, 83.0665º E
- **Amera (Lakhanpur – 1 km):** 23.1428º N, 83.0741º E
- **Amera (Lakhanpur – 2 km):** 23.1354º N, 83.0816º E
- **Piparkhar (Lakhanpur):** 23.1229º N, 83.0913º E
- **Singitana (Lakhanpur):** 23.1118º N, 83.0987º E

Each location represents a different distance from the Amera (Lakhanpur) center, forming a spatial transect that facilitates comparative evaluation of soil physico-chemical and nutrient variations across the region.

Sample Collection:

Soil samples were collected from two distinct depths at each site to study vertical variation in soil properties:

- **Surface soil:** 0–15 cm
- **Subsurface soil:** 15–30 cm

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At each location and depth, composite soil samples were prepared by thoroughly mixing five subsamples collected randomly within a 10-meter radius to ensure representativeness. Sampling was performed using a stainless steel auger and spade to avoid contamination. The collected soil samples were air-dried in shade, gently crushed using a wooden roller, and sieved through a 2 mm mesh prior to laboratory analysis following standard procedures (Jackson, 1973; Piper, 1966).

Laboratory Analysis:

- **Soil pH and Electrical Conductivity (EC):** Determined from a 1:2.5 soil-to-water suspension using a standardized digital pH meter and conductivity meter (Jackson, 1973).
- **Organic Carbon (%):** Assessed by the chromic acid wet oxidation technique proposed by Walkley and Black (1934).
- **Available Nitrogen (kg/ha):** Estimated through the alkaline permanganate procedure developed by Subbiah and Asija (1956).
- **Available Phosphorus (kg/ha):** Determined by the Olsen method, suitable for neutral to alkaline soils (Olsen et al., 1954).
- **Available Potassium (kg/ha):** Measured with a flame photometer following extraction using neutral normal ammonium acetate (Tandon, 2005).
- **Sulphur (ppm):** Analyzed by the turbidimetric method after extraction with 0.15% calcium chloride ($CaCl_2$).
- **Micronutrients – Boron (B), Zinc (Zn), Iron (Fe), Manganese (Mn), and Copper (Cu):** Extracted with DTPA (Diethylenetriaminepentaacetic acid) solution and quantified using Atomic Absorption Spectrophotometry following the procedure of Lindsay and Norvell (1978).

Data Presentation and Analysis

All experimental data were systematically organized in tabular form to compare spatial (site-wise) and vertical (depth-wise) variations. Descriptive statistical tools were applied to identify patterns and differences. The variation in nutrient levels and physico-chemical characteristics between surface and subsurface soils served as the foundation for evaluating soil fertility and overall quality within the study area.

❖ **Results of soil samples (top surface) from various places of Lakhanpur block, Surguja district.**

Parameters	Sample1 (Amera)	Sample 2 Amera 1km	Sample 3 Amera 2km	Sample 4 Piparkhar	Sample5 Singitana
Ph	5.56	5.92	5.98	5.93	5.58
Electric Conductivity	0.11	0.12	0.18	0.32	0.17
Organic carbon	0.60	0.75	0.84	0.75	0.60
Available Nitrogen	227.0	263.00	295.00	263.00	228.00
Phosphorus	15.50	12.00	12.80	13.00	16.00
Potash	297.00	275.00	310.00	278.00	297.00
Zinc	0.3	0.2	0.2	0.2	0.2
Copper	0.1	0.1	0.2	0.1	0.2
Iron	1.4	0.6	1.0	1.5	0.8
Boron	0.2	0.2	0.2	0.2	0.2
manganese	0.6	0.9	0.8	0.6	0.4

❖ **Result of 15–30 cm soil samples collected from the bottom surface at various locations of Lakhanpur block, Surguja district.**

Parameter	Sample 1 Amera	Sample 2 Amera 1 km	Sample 3 Amera 2km	Sample 4 Piparkhar	Sample5 Singitana
Ph	5.60	5.96	6.00	5.96	5.54
Electric Conductivity	0.17	0.16	0.20	0.32	0.18
Organic carbon	0.54	0.77	0.80	0.78	0.58
Available Nitrogen	216.00	268.00	282.00	269.00	225.00
Phosphorus	16.50	12.80	13.50	15.00	17.00
Potash	300.00	282.00	306.00	295.00	306.00
Zinc	0.2	0.3	0.3	0.3	0.4
Copper	0.1	0.1	0.1	0.1	0.2
Iron	1.4	1.4	1.5	1.5	1.4
Boron	0.2	0.2	0.2	0.2	0.2
Manganese	0.9	0.9	0.6	0.6	0.8

IV. RESULT AND DISCUSSION

This study analyzed surface and subsurface soil samples from five locations in the Lakhanpur region: Amera (Center), Amera (1 km), Amera (2 km), Piparkhar, and Singitana. The results reflect variations in pH, electrical conductivity, macronutrients (N, P, K), organic carbon, and micronutrients (S, B, Zn, Fe, Mn, Cu). The spatial and depth-wise differences in these soil parameters are discussed below:

1. Soil pH:

The pH values of both surface and subsurface (depth) soil samples were analyzed to assess the soil reaction (acidity or alkalinity) in the study area.

- For surface soil samples, the pH values ranged from **5.56 to 5.98,** with an average value indicating a moderately acidic nature.
- Similarly, for depth soil samples, the pH values varied between **5.54 and 6.00,** also reflecting a moderately acidic reaction.
- According to the pH classification (Table: pH Level Range), both surface and subsurface soils fall within the moderately acidic range **(5.5–6.5).** This suggests that the soils are slightly acidic in nature, which may influence the availability of certain nutrients and the overall soil fertility.(Jackson, 1973).

2. Electrical Conductivity (EC):

The electrical conductivity (EC) of both surface and depth soil samples was measured to assess soil salinity.

- For surface soil samples, EC values ranged from 0.11 to 0.32 dS/m, while depth soil samples showed values between 0.16 and 0.32 dS/m. According to the standard classification:
  - < 1.0 dS/m – Normal
  - 1.0–2.0 dS/m – Slightly saline
  - 2.0–3.0 dS/m – Moderately saline
  - 3.0 dS/m – Highly saline

- All samples from the Lakhanpur area, Chhattisgarh, fall within the normal range, indicating that the soils are non-saline. This suggests that salinity is not a limiting factor for crop growth in the study area. (Ullman, J.L.,2013)

3. Organic Carbon (%):

The organic carbon (OC) content of surface and subsurface soils was evaluated and categorized as low (<0.50%), medium (0.50–0.75%), and high (>0.75%) (Lindsay, 1979). The results are summarized below:

- **Surface Soils (0–15 cm):**
  - OC values ranged from 0.60% to 0.84%.
  - Samples 2, 3, and 4 showed high OC (>0.75%), while samples 1 and 5 were medium (0.60%).
  - Overall, surface soils are moderately to highly fertile with significant organic matter content.
- **Subsurface Soils (15–30 cm)**
  - OC values ranged from 0.54% to 0.80%.
  - Samples 2, 3, and 4 exhibited high OC (>0.75%), while samples 1 and 5 were medium (0.54–0.58%).
  - Indicates good carbon retention at depth, though slightly lower than topsoil in some locations.
- **General Observations:**
  - Both surface and subsurface soils demonstrate medium to high OC, reflecting adequate soil fertility.
  - Higher OC in topsoil highlights organic matter accumulation typical of surface layers.(Lindsay,W. L.,1979).

4. Available Nitrogen (kg/ha):

- **Classification of Available Nitrogen in Soil:**

Category	Nitrogen Content (kg/ha)	Fertility Rating
< 280	Low	Deficient
280 – 560	Medium	Moderate
> 560	High	Adequate

- The available nitrogen content in the surface and subsurface soil samples of the Lakhanpur area, Chhattisgarh, ranged from 216.00 to 295.00 kg/ha. In surface soils, nitrogen values varied between 227.00 and 295.00 kg/ha, indicating low to medium availability. The highest nitrogen concentration (295.00 kg/ha) was recorded in **Sample 3**, while the lowest (227.00 kg/ha) was found in **Sample 1.**
- In subsurface soils, nitrogen values ranged from 216.00 to 282.00 kg/ha, also falling within the low to medium category. The maximum value (282.00 kg/ha) occurred in **Sample 3**, and the minimum (216.00 kg/ha) in **Sample 1**.
- Overall, the soils of the Lakhanpur region exhibit low to medium nitrogen fertility, indicating the need for nitrogen enrichment through appropriate fertilization practices to enhance crop productivity. (Subbiah, B.V. and Asija, G.L.1956)

5. Available Phosphorus (kg/ha):

- The phosphorus content in the soil samples ranged from 12.00 to 16.00 kg/ha at the surface and 12.80 to 17.00 kg/ha at depth.
- The highest phosphorus value was recorded in Depth Sample-5 (17.00 kg/ha), while the lowest was observed in Surface Sample-2 (12.00 kg/ha).
- The mean phosphorus concentration was 13.86 kg/ha for surface samples and 14.96 kg/ha for depth samples, indicating slightly higher values in the subsurface layer.
- Overall, phosphorus availability showed minimal variation with depth, suggesting good phosphorus retention and moderate mobility within the soil profile.

6. Available Potassium (kg/ha):

- Potassium content in the soil samples ranged from 275.00 to 310.00 kg/ha.
- The highest potassium value was recorded in Surface Sample-3 (310.00 kg/ha), while the lowest was observed in Surface Sample-2 (275.00 kg/ha).
- In the subsurface (depth) layer, potassium values ranged between 282.00 and 306.00 kg/ha, which were slightly higher than the surface values, indicating that a small amount of potassium has moved downward and accumulated in the lower soil layer.
- This minor variation between surface and depth may be due to crop uptake from surface soil and retention of potassium by clay minerals in deeper layers.

7. Boron (mg/kg):

- **Uniform Boron Content:**The boron content in both surface and subsurface soil samples was found to be uniform, with a consistent value of 0.2 mg/kg across all sampling sites. This indicates a homogenous distribution of boron throughout the soil profile in the study area.
- **Lack of Vertical Variation:** The absence of variation between surface and depth samples suggests that boron mobility is limited within the soil column. This stability may be attributed to low leaching losses or minimal external boron inputs through fertilizers or irrigation water.
- **Soil Homogeneity and Parent Material Influence:** The uniformity of boron concentration implies similar soil texture, mineral composition, and parent material throughout the sampled depth. It also indicates that biological activities such as root uptake or organic matter decomposition have not significantly altered boron levels between layers.
- **Sufficiency and Environmental Implication:** The measured value (0.2 mg/kg) lies near the lower sufficiency range for most crops, indicating that the soil may be marginally deficient in available boron. Therefore, periodic monitoring or controlled supplementation might be necessary to maintain optimum boron availability for sustainable crop growth.

8. Zinc (mg/kg):

- **Zinc Content Variation:** The zinc content in surface soil ranged from 0.2 to 0.5 mg/kg, while in subsurface samples it varied from 0.2 to 0.4 mg/kg. This shows a slight increase in zinc concentration in the surface layer compared to the subsurface.
- **Below Critical Limit:** All observed zinc values were below the critical limit of 0.6 mg/kg, indicating deficiency of available zinc in both surface and subsurface soils of the study area. This suggests that the soil may not provide sufficient zinc for optimal plant growth without external supplementation.
- **Higher Zinc in Surface Layer:** The relatively higher zinc concentration in surface soil could be attributed to crop residue accumulation, organic matter decomposition, and fertilizer application near the surface, whereas lower values in subsurface layers might result from limited mobility of zinc and adsorption by clay minerals.
- **Nutrient Management Implication**: The overall low zinc status highlights the need for zinc-enriched fertilizers or micronutrient management practices to maintain soil fertility and improve crop productivity. Periodic soil testing is also recommended to monitor zinc dynamics under different land-use systems.

9. Iron(mg/kg):

- Iron content in surface soil ranged from **0.6 to 1.5 mg/kg,** with the highest at Sample-4 and the lowest at **Sample-2.**
- In depth (subsurface) soil, Fe content was nearly uniform **(1.4–1.5 mg/kg)** across all samples.
- All recorded values were below the critical limit of **4.5 mg/kg,** indicating iron deficiency in the study area soils.
- The lower Fe concentration in surface soil may be due to oxidation or leaching, while stable subsurface levels suggest limited Fe movement.

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10. Manganese (mg/kg):

- The manganese content in surface soil samples ranged from 0.4 to 0.9 mg/kg, while in depth samples it ranged from **0.6 to 0.9 mg/kg.**
- The highest Mn concentration (0.9 mg/kg) was observed in both surface **(Sample-2)** and depth layers **(Sample-1, 2),** whereas the lowest **(0.4 mg/kg)** was found in surface **Sample-5.**
- All recorded manganese values are well below the critical limit **(3.5 mg/kg),** indicating a deficiency of manganese in both surface and subsurface soils.
- Slightly higher Mn content in depth samples suggests downward movement of Mn through leaching or reduced plant uptake from lower layers.

11. Copper (mg/kg):

- The copper content in surface soil samples ranged from **0.1 to 0.2 mg/kg,** while in depth samples it also varied between **0.1 and 0.2 mg/kg.**
- The maximum Cu concentration **(0.2 mg/kg)** was recorded in surface **samples 3and 5,** and depth sample 5, whereas the minimum **(0.1 mg/kg)** was found in most other samples.
- The overall Cu content in both surface and subsurface soils was very low, indicating a deficiency of available copper in the study area.
- The similarity in Cu levels at both depths suggests limited vertical movement of copper and low availability due to strong adsorption to soil minerals or organic matter.

❖ **Comparison of Surface and Depth Soil Properties in Lakhanpur Block, Surguja District:**

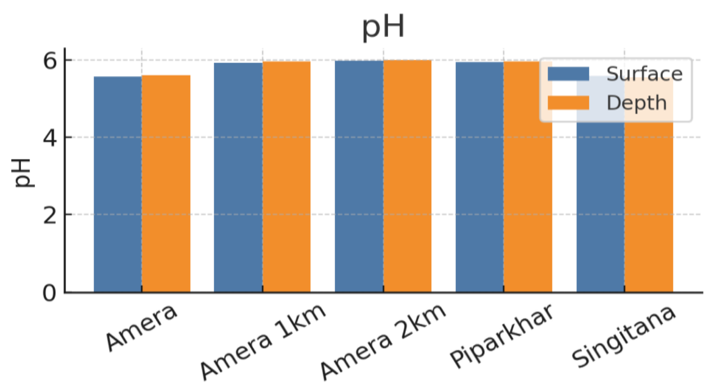

Figure 1: Comparison of Surface and Depth soil **pH values** at differentlocations in Lakhanpur Block.

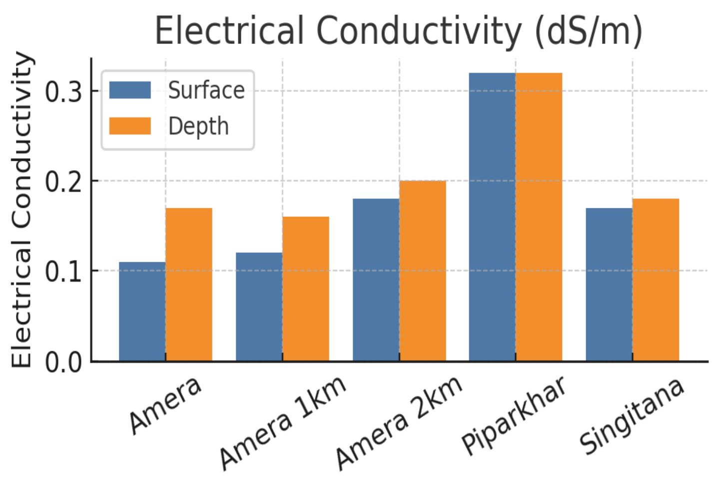

Figure 2: Comparison of Surface and Depth soil **Electrical Conductivity (dS/m)** values at different locations in Lakhanpur Block.

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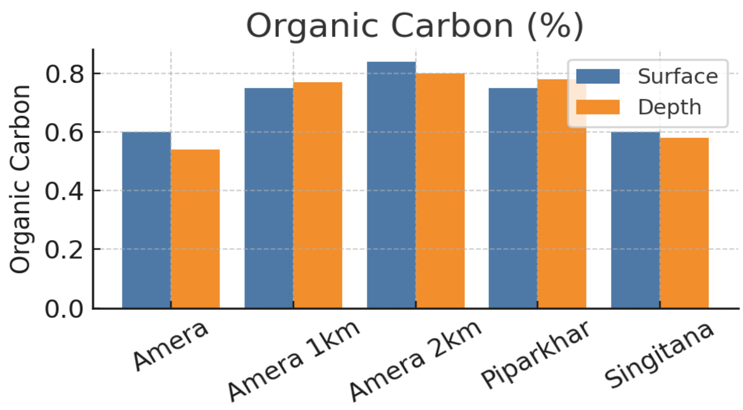

Figure 3: Comparison of Surface and Depth soil **Organic Carbon (%) values** at different locations in Lakhanpur Block.

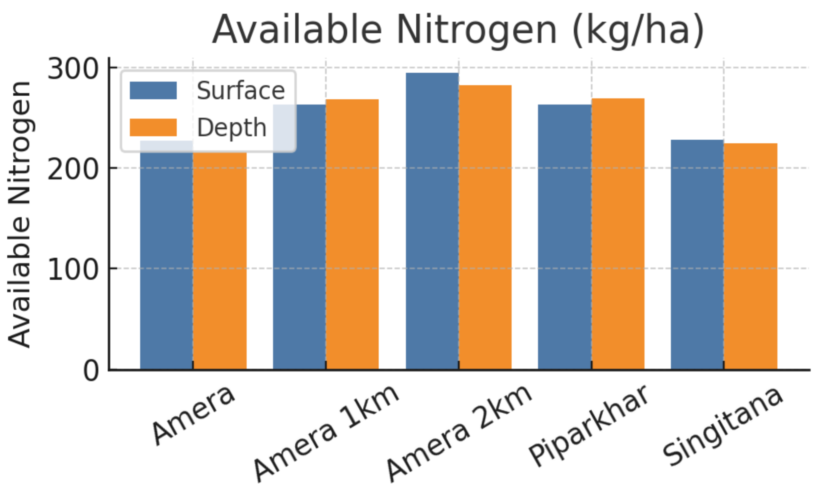

Figure 4: Comparison of Surface and Depth soil **Available Nitrogen (kg/ha)** values at different locations in Lakhanpur Block.

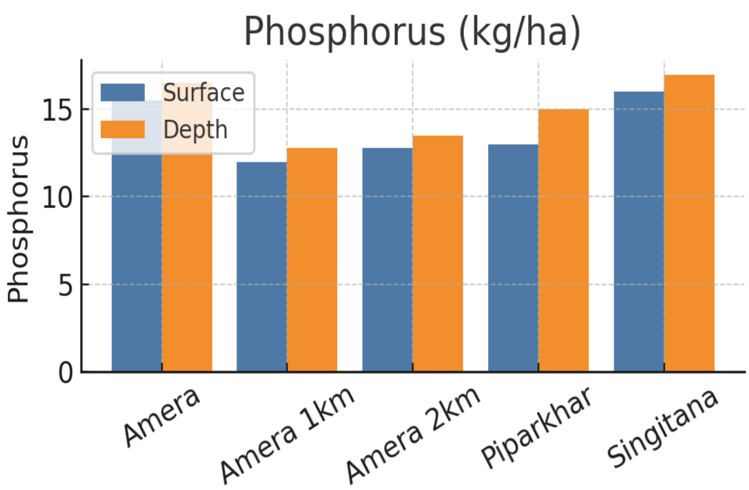

Figure 5: Comparison of Surface and Depth soil **Phosphorus (kg/ha)** values at different locations in Lakhanpur Block.

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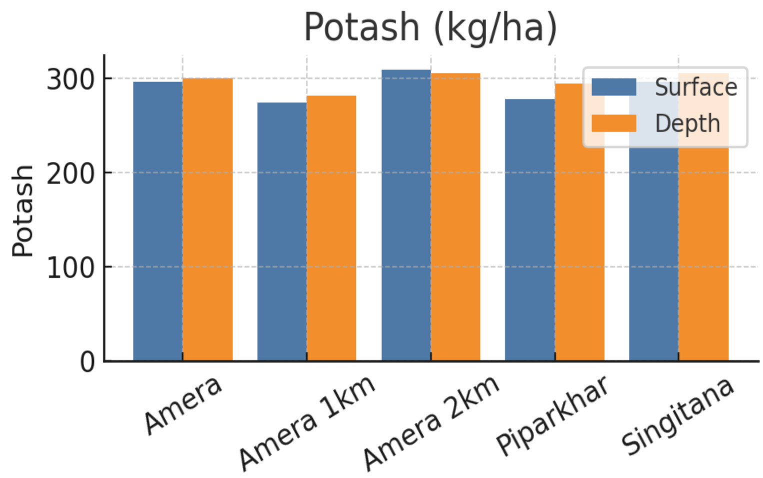

Figure 6: Comparison of Surface and Depth soil **Potash (kg/ha)** values at different locations in Lakhanpur Block.

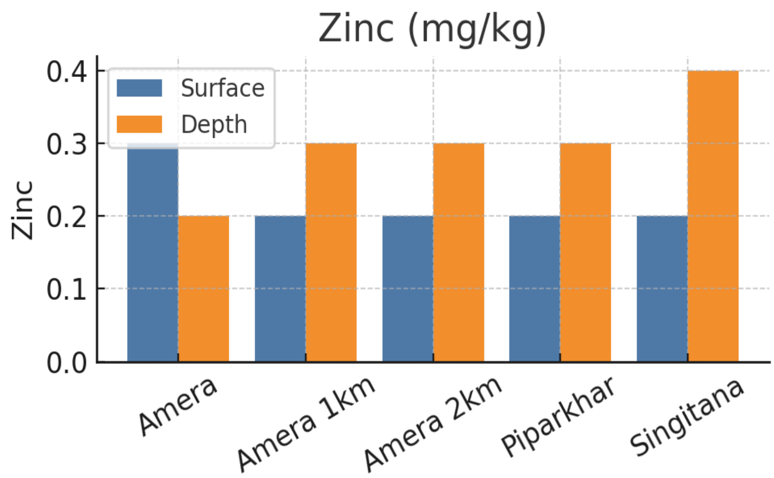

Figure 7: Comparison of Surface and Depth soil **Zinc (mg/kg)** values at different locations in Lakhanpur Block.

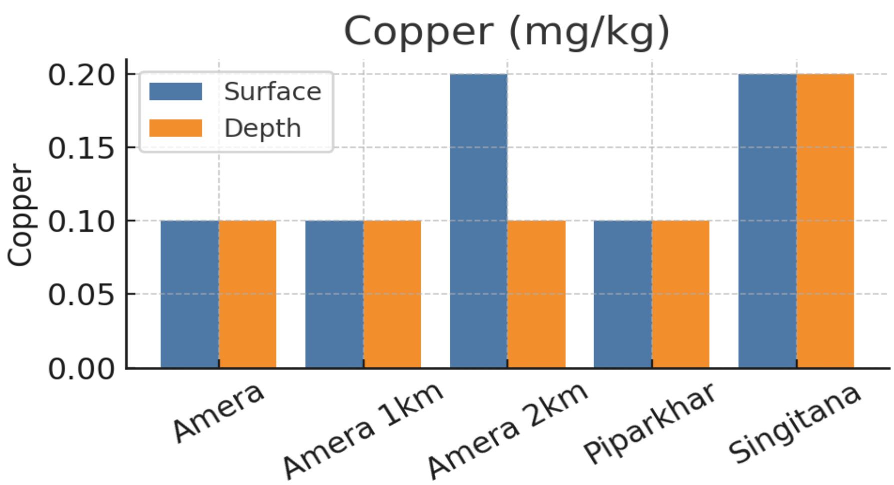

Figure 8: Comparison of Surface and Depth soil **Copper (mg/kg)** values at different locations in Lakhanpur Block.

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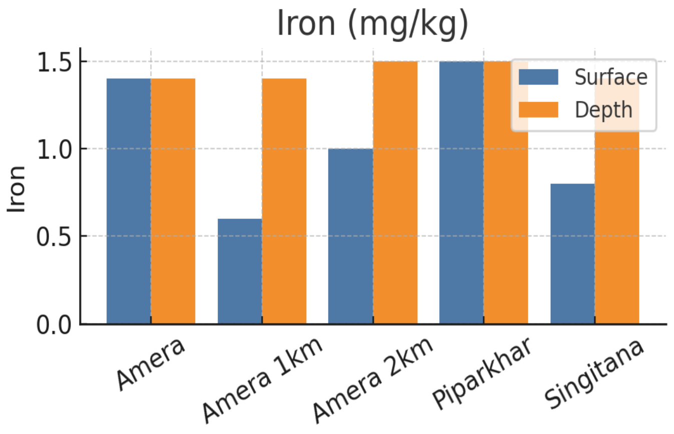

Figure 9: Comparison of Surface and Depth soil **Iron (mg/kg)** values at different locations in Lakhanpur Block.

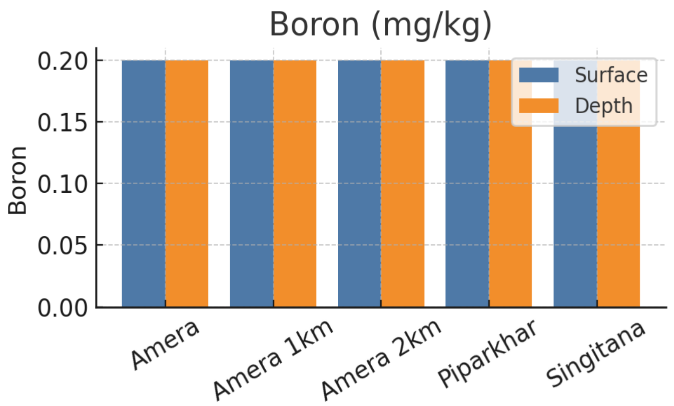

Figure 10: Comparison of Surface and Depth soil **Boron (mg/kg) values** at different locations in Lakhanpur Block.

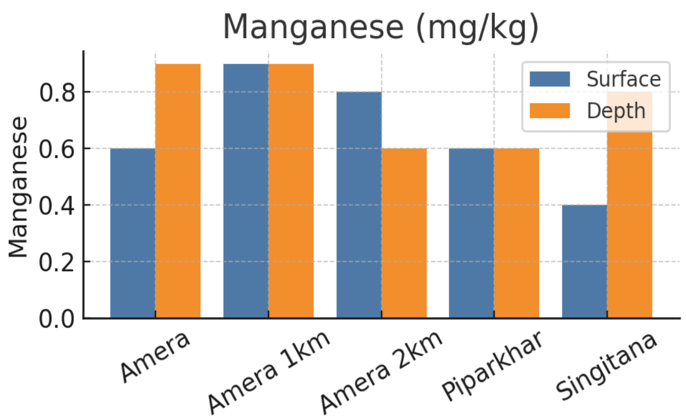

Figure 11: Comparison of Surface and Depth soil **Manganese (mg/kg) values** at different locations in Lakhanpur Block.

V. CONCLUSION

The present study on the physico-chemical properties of surface and subsurface soils from Lakhanpur, Surguja District, revealed notable variations across different soil parameters. Surface soils generally exhibited slightly higher values of organic carbon, available nitrogen, and potash, reflecting better nutrient availability compared to subsurface layers. In contrast, pH and micronutrient levels (Zn, Cu, Fe, B, Mn) showed minor variations between surface and depth, indicating relative stability of these properties with soil depth. Electrical conductivity values were higher in subsurface soils at certain locations, suggesting localized accumulation of soluble salts.The present study on the physico-chemical properties of surface and subsurface soils from Lakhanpur, Surguja District, revealed notable variations across different soil parameters. Surface soils generally exhibited slightly higher values of organic carbon, available nitrogen, and potash, reflecting better nutrient availability compared to subsurface layers. In contrast, pH and micronutrient levels (Zn, Cu, Fe, B, Mn) showed minor variations between surface and depth, indicating relative stability of these properties with soil depth. Electrical conductivity values were higher in subsurface soils at certain locations, suggesting localized accumulation of soluble salts.

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