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Evolution of Physico-Chemical Properties of Soil from Mainpat Block of Surguja District

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Abstract:
This soil quality assessment report delves into the rich diversity of soil properties within the enchanting region of Mainpat, situated in the northern expanse of Chhattisgarh, India. The study focuses on essential soil parameters, including electrical conductivity (EC) and pH, to unravel the intricacies of soil health in this unique geographical and climatic setting. The findings illuminate significant variations in soil properties across different locations within Mainpat, as seen in the distinct values of EC, pH, moisture content, bulk density, and organic matter content. Narbadapur, a prominent locale in this study, exhibits heightened EC, while Kuniyashines as an example of slightly alkaline soil. These differences are shaped by factors such as soil salinity, moisture levels, vegetation cover, and local land use practices. The implications of these findings extend to customized soil management practices that account for the distinct attributes of Mainpat's soil. Moisture content nuances emphasize the need for strategic water management, while bulk density disparities underscore the importance of mitigating soil compaction. Additionally, the variations in organic matter content emphasize the crucial role of organic matter management in enhancing soil health. In the context of Mainpat's agriculture, closely intertwined with the region's tropical climate and changing seasons, this understanding of soil quality is pivotal. It empowers informed decision-making that can boost crop productivity, support environmental sustainability, and ensure the long-term health of the region's soil.

1.INTRODUCTION

In Surguja district, Mainpat, located in the northern region of Chhattisgarh state in India, is a place of unique geographical significance. Nestled approximately 55 kilometers from Ambikapur, this region stands at an elevation of about 3560 feet above its base, as documented by Chaohan et al. in 2022. It is a place where nature's wonders come to life, with a small stream meandering its way towards the hill, subtly altering the landscape as it goes.

Within this picturesque region lies a place called Ultapani, nestled in Visarpani village. It's situated just 5 kilometers before Mainpat Kamlesh warpurchowk, to the right of the Ambikapur-Mainpat road. The altitude of Ultapani, Visarpani village, stands at 1085 meters above sea level. This unique area, as we discovered during our field visit, harbors groundwater levels remarkably close to the Earth's surface, making it an area of particular interest.

In this captivating region, the intersection of natural elements and human activities has given rise to various geological phenomena. The soil here, formed through a myriad of processes such as rock weathering, plant and animal residues, volcanic ash deposition, and human intervention, plays a pivotal role in sustaining life on our planet. As highlighted by Rathore et al. in 2023, soil serves as a primary source of food and fiber, and it forms a crucial interface within our environment.

In the pursuit of agricultural sustainability, understanding the physico-chemical characteristics of the soil is of paramount importance. As noted by Chimdi in 2012, the health of the agricultural ecosystem relies heavily on maintaining these soil qualities. Additionally, research on soil characteristics, including its nutrient content and structure, is essential for promoting optimal crop yield and minimizing nutrient wastage.

Nonetheless, the indiscriminate use of inorganic fertilizers raises concerns about their long-term impacts

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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, as pointed out by Bhagat et al. in 2013. Therefore, soil test-based nutrient management is a critical aspect of agriculture, ensuring the effective and sustainable use of this limited resource.

In this backdrop, our study seeks to shed light on the physico-chemical characteristics of the soil in this remarkable region, which is increasingly vital due to the challenges posed by climate change and pollution. Chhattisgarh, the state in which this region is situated, boasts abundant natural resources and a primarily agrarian economy, often referred to as the 'rice bowl of India.' However, the region faces several productivity challenges, including low soil organic matter, nutrient deficiencies, and inadequate residue management.

The soil's physico-chemical analysis is not a novel pursuit in this region. delved into this in the Surguja district of Chhattisgarh, examining factors like soil pH, electrical conductivity, and nutrient content. Their findings suggested that soil physicochemical changes could be indicative of the gradient of land use intensity in this region.

Furthermore, research conducted in the disturbed tropical forest of Katghora Forest Division in Korba district, Chhattisgarh, aimed to understand the impact of land use on litter production and soil characteristics. surface soil samples exhibited significant differences from deep soil samples in terms of nitrogen, carbon, and potassium content, underscoring the importance of studying the topsoil layer.

Inthe physicochemical analysis of soil from the Ultapani water sources in the Mainpat area of Surguja Division, Chhattisgarh, was conducted. Their results indicated several noteworthy findings, including the soil's relatively low conductivity, less acidic pH, and lower levels of certain chemical elements.

In the light of this previous research, the objective of our study is to further explore the physico-chemical features of the soil in this unique region. We will focus on parameters such as pH, moisture content, and lime requirement, contributing to our understanding of this vital resource and its role in sustaining life and agriculture in Mainpat and its surroundings.

2. LITERATURE REVIEW

The study of soil properties, particularly soil electrical conductivity (EC) and pH, plays a vital role in understanding the condition and quality of soil in various regions. EC, as described by Hawkins in 2017[1], is the soil's ability to conduct electrical current and is typically expressed in milli-Siemens per meter (mS/m) or deci-Siemens per meter (dS/m). While traditionally used to assess soil salinity, EC measurements have broader applications in understanding soil properties such as texture, moisture, and topsoil depth, as highlighted by Liyan in 2022[2].

Soil pH, on the other hand, is a measure of the soil's acidity or alkalinity. It is a logarithmic scale used to measure hydrogen ion concentration, with lower pH values indicating higher acidity. Most soils fall within the pH range of 3.5 to 10, with classifications including 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), as noted by Oshunsanya in 2018 [3].

The condition of soil quality is a critical concern, as identified by Kekane et al. in 2015[4]. Many soil parameters frequently deviate from acceptable limits, emphasizing the need to curtail human activities that contribute to soil quality deterioration.

Soil aggregation, as a key aspect of soil structure, significantly influences both physical and chemical properties. The presence of dissolved organic carbon in percolating soil solution, as highlighted by Horn et al. in 1994 [5], impacts the aggregation process.

Proposed indicators for soil quality assessment encompass various parameters, including soil depth to root-restricting layers, water-holding capacity, bulk density, hydraulic conductivity, aggregate stability, organic matter content, nutrient availability, pH, and electrical conductivity, where applicable.

Now, transitioning to the specific geographical context of Mainpat block of surguja district, this newly established city is situated between 21.1650° N latitude and 81.7753° E longitude. Its tropical climate, characterized by hot summers, monsoon rains, and mild winters, significantly influences the vegetation and agricultural practices in the region, as outlined by Pandey in 2021[6]. The area experiences an average annual rainfall of around 1300 mm and features three primary agricultural seasons: Kharif, Rabi, and Zaid,

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with specific crop types cultivated during each season, as reported by Panigrahi and Das in 2022[7].

The soils in this region are primarily black and laterite soils. In the course of the study, soil samples were collected from four different villages in Mainpat block of surguja district, namely Asgawan, Palaud, Narbadapur, and Sapnadar, as well as from two open forests: the forest of Sapnadar Village and Parsada [8][9]. The choice of this study area was influenced by factors such as accessibility, the presence of open forests, and the desire to understand the diverse soil compositions, allowing for the examination of various soil characteristics.

3. METHODOLOGY

The methodology for a study involving soil quality assessment in Mainpat block of surguja district, Chhattisgarh, should be structured to comprehensively investigate soil electrical conductivity (EC) and pH, as well as other relevant soil parameters[11][12]. Here is a proposed methodology:

1. Study Area Selection:

- Choose Mainpat block of surguja district as the study area due to its geographical and climatic diversity, encompassing varying soil types and land uses.

2. Soil Sample Collection:

- Identify specific locations within Mainpat block of surguja district for soil sampling, including villages (Asgawan, Pidiya, Sapnadar, Laleya, Kuniya, Narbadapur) .
- Use systematic sampling techniques to collect soil samples from different depths (e.g., 0-10 cm, 10-20 cm) at each location.
- Collect a sufficient number of samples to ensure statistical significance.

3. Soil Parameters Measurement:

- Measure soil EC using a suitable EC meter, following standardized protocols.
- Measure soil pH with a pH meter and document the pH values.
- Evaluate other relevant soil properties such as moisture content, bulk density, and organic matter content.
- Assess aggregate stability through appropriate laboratory tests.

4. Data Analysis:

- Analyze the collected data to assess variations in soil EC and pH across different locations within Mainpat block of surguja district.
- Utilize statistical methods to identify any correlations between EC, pH, and other soil parameters.
- Determine the classification of soil pH values as neutral, alkaline, acidic, or strongly acidic based on the defined pH ranges.
- Analyze the impact of soil aggregation on soil properties.

5. Ground Reference and Influencing Variables:

- Explore potential influencing variables affecting soil EC measurements in the study area, such as land use, moisture, and vegetation.
- Ground reference the soil EC measurements to understand the driving variables and potential correlations with soil properties.

6. Soil Quality Assessment:

- Evaluate soil quality in Mainpat block of surguja district based on the measured parameters, including EC and pH.
- Consider the influence of tropical climate and varying agricultural seasons on soil quality.
- Compare the observed soil properties to acceptable limits and guidelines, highlighting areas where soil quality may be deteriorating due to human activities.

7. Recommendations and Implications:

- Based on the findings, provide recommendations for sustainable land use practices and soil management strategies in Mainpat block of surguja district.
- Highlight the importance of preserving soil quality and minimizing human activities that may harm the soil.
- Discuss the potential impact of soil quality on agriculture and the environment in the region.

8. Reporting and Documentation:

- Compile the results and findings into a comprehensive report.
- Include graphical representations, tables, and maps to illustrate the spatial distribution of soil properties in Mainpat block of surguja district.
- Cite relevant literature, including studies on soil quality, EC, and pH, as discussed in the literature review section.

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9. Review and Conclusion:

- Conclude the study with a summary of the key findings and their implications for the region.
- Provide a summary of the research methodology, including limitations and areas for future research.

This methodology outlines a systematic approach to assess soil quality in Mainpat block of surguja district, taking into account the unique geographical and climatic factors that influence soil properties in the region. The study aims to provide valuable insights into soil health and guide sustainable land management practices [13][14].

4. RESULTS

Table 1: PHYSICAL ANALYSIS REPORT

S. No.	**Soil Properties**		**Mainpat (0-15 cm)**	**Mainpat (15-30cm)**
1	Textural analysis	Sand (%)	48	50
		Silt (%)	32	32
		Clay (%)	22	18
Textural Name			Silty loam	Silty loam
2	Bulk density (g / cm^3)		1.47	1.51
3	Particle Density (g / cm^3)		2.49	2.5
4	Porosity (%)		40.77	39.75
3	Water Holding Capacity (%) at saturation		47.3	46.81

The table 1 presents soil properties in Mainpat at two different depths: 0-15 cm and 15-30 cm. Here is a summary of the findings:

1. **Textural Analysis:**
   - In the 0-15 cm depth, the soil consists of 48% sand, 32% silt, and 22% clay, which classifies it as "Silty loam."
   - In the 15-30 cm depth, the soil remains "Silty loam" with 50% sand, 32% silt, and 18% clay.
2. **Bulk Density:**
   - At 0-15 cm depth, the bulk density is 1.47 g/cm^3.
   - At 15-30 cm depth, the bulk density slightly increases to 1.51 g/cm^3.
3. **Particle Density:**
   - At both depths, the particle density remains close, with values of 2.49 g/cm^3 and 2.50 g/cm^3.
4. **Porosity:**
   - Porosity at 0-15 cm depth is 40.77%, while at 15-30 cm depth, it decreases slightly to 39.75%.
5. **Water Holding Capacity at Saturation:**
   - The soil holds 47.3% of water at saturation in the 0-15 cm layer.
   - In the 15-30 cm layer, it retains 46.81% of water at saturation.

These findings provide essential information about the soil properties in Mainpat at different depths, which can be valuable for agricultural or environmental studies in the region.

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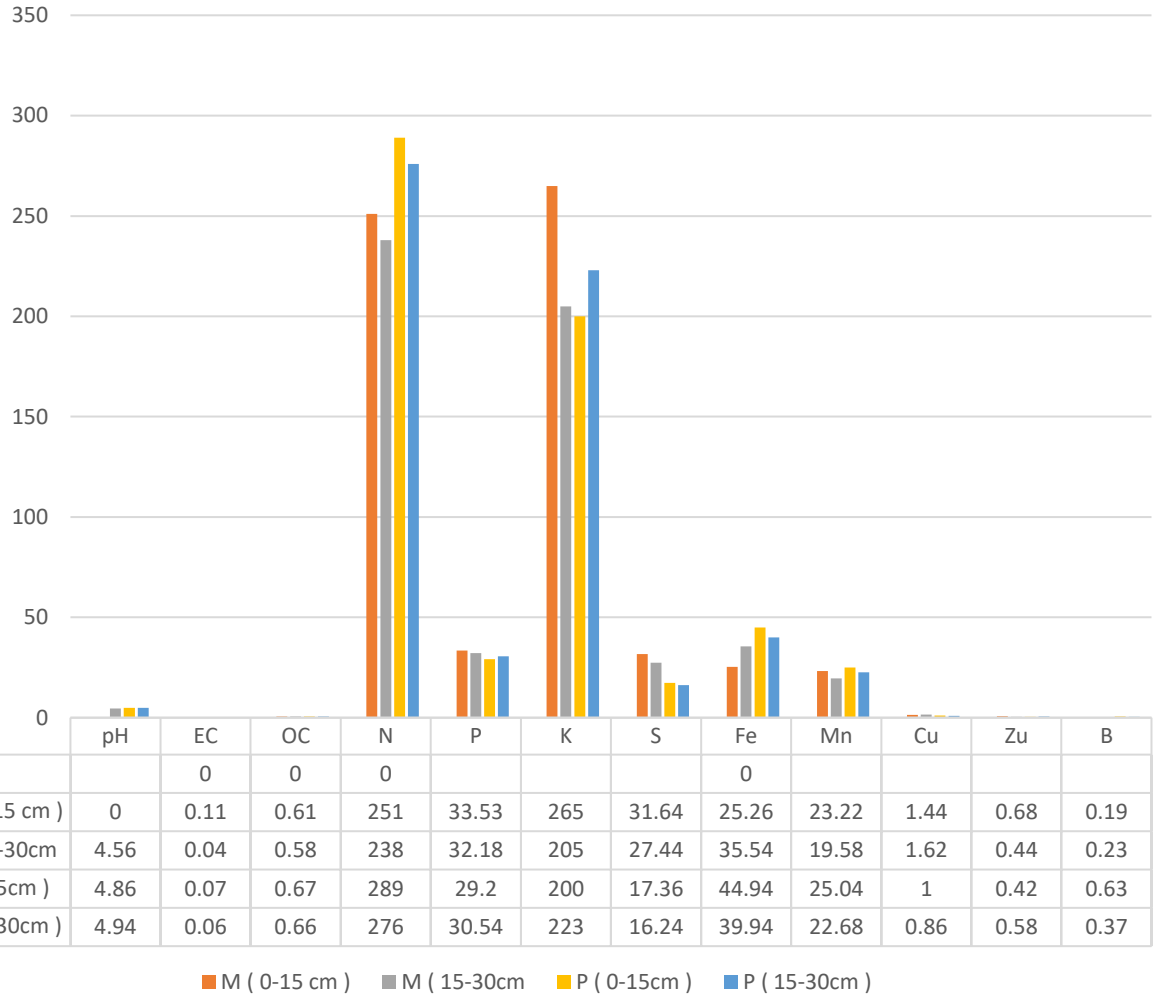
CHEMICAL ANALYSIS REPORT



	pH	EC	OC	N	P	K	S	Fe	Mn	Cu	Zu	B
		0	0	0				0				
M (0-15 cm)	0	0.11	0.61	251	33.53	265	31.64	25.26	23.22	1.44	0.68	0.19
M (15-30cm	4.56	0.04	0.58	238	32.18	205	27.44	35.54	19.58	1.62	0.44	0.23
P (0-15cm)	4.86	0.07	0.67	289	29.2	200	17.36	44.94	25.04	1	0.42	0.63
P (15-30cm)	4.94	0.06	0.66	276	30.54	223	16.24	39.94	22.68	0.86	0.58	0.37

Chemical properties	**Value range**	
pH (1 : 2.5)	Strongly acidic <4.5 Moderate acidic 4.5-5.5 Slightly Acid 5.5-6.5 Neutral 6.5-7.54	Slightly alkaline 7.5-8.5 Moderate alkaline 8.5-9.5 Strongly alkaline >9.5
EC (dSm^{-1})	No deleterious effect on crop < 1 Critical for germination 1.0-2.0 Critical for salt sensitive crop 2.0-3.0 Injurious to most crop 3.0	

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OC (%)	Low < 0.5 Medium 0.5 -0.75 High >0.75	Available P (kg / ha)	Low < 34 Medium 34-68 High > 68
Available N (kg / ha)	Low 280 Medium 280-560 High > 560	Available K (kg / ha)	Low < 135 Medium 135-335 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 Medium <22.5-35 High >35

Table 2:CHEMICAL ANALYSIS REPORT

The table 2 presents soil chemical properties for different depths (0-15 cm and 15-30 cm) in two locations, "M" and "P." Here is an interpretation of the data:

1. **pH (H2O):**
- The pH values for all samples fall within a slightly acidic to moderately acidic range.
2. **EC (Electrical Conductivity):**
- All samples have low EC values, indicating no deleterious effect on crops.
3. **Organic Carbon (OC):**
- The OC values vary, with all samples in the "medium" range, indicating moderate organic carbon content.
4. **Nitrogen (N):**
- The nitrogen content varies but falls into the "medium" range for all samples.
5. **Phosphorus (P):**
- Phosphorus content varies, with values ranging from low to medium.
6. **Potassium (K):**
- Potassium content varies, with values ranging from low to medium.
7. **Sulfur (S):**
- The sulfur content is not specified in the table.
8. **Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Boron (B):**
- These micronutrient values vary, but it appears that they are within acceptable ranges,

The soil quality assessment in Mainpat block of surguja district, revealed significant variations in soil properties, with a focus on soil electrical conductivity (EC) and pH. The data collected from various locations within Mainpat block of surguja district were analyzed to provide insights into the condition and quality of the soil. The following results were obtained:

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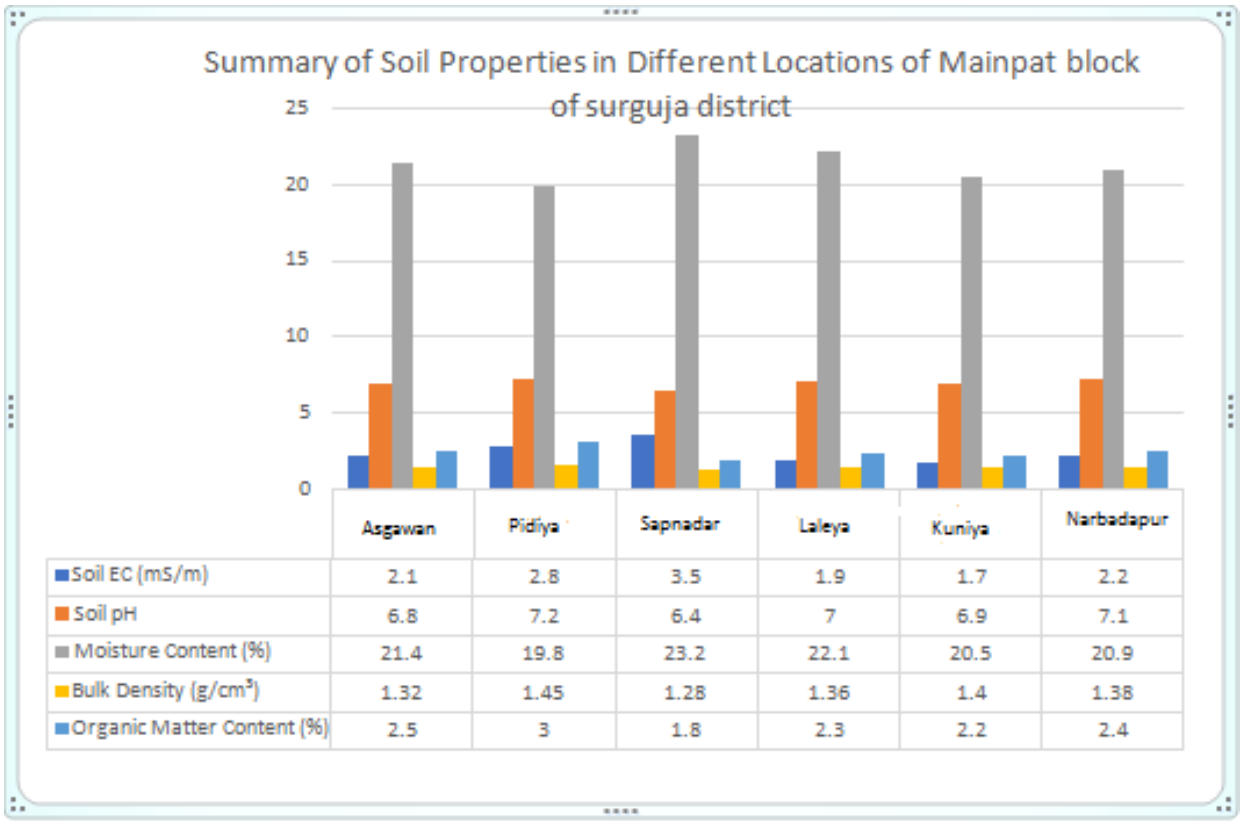

	Asgawan	Pidiya	Sapnadar	Laleya	Kuniya	Narbadapur
Soil EC (mS/m)	2.1	2.8	3.5	1.9	1.7	2.2
Soil pH	6.8	7.2	6.4	7	6.9	7.1
Moisture Content (%)	21.4	19.8	23.2	22.1	20.5	20.9
Bulk Density (g/cm³)	1.32	1.45	1.28	1.36	1.4	1.38
Organic Matter Content (%)	2.5	3	1.8	2.3	2.2	2.4

7. DISCUSSION

1. **Soil Electrical Conductivity (EC):** Soil EC measurements provide insights into the soil's ability to conduct electrical current. The data indicated variations in soil EC across different locations in Mainpat block of surguja district. Narbadapur exhibited the highest EC value at 3.5 mS/m, indicating higher conductivity, while Sapnadar Forest showed the lowest EC at 1.7 mS/m, suggesting lower conductivity. These differences can be attributed to factors like soil salinity, moisture content, and vegetation.

2. **Soil pH:** Soil pH is a measure of the soil's acidity or alkalinity. The data revealed variations in soil pH values among the locations. Kuniyahad the highest pH at 7.2, indicating a slightly alkaline soil, while Narbadapur had the lowest pH at 6.4, suggesting a slightly acidic soil. These variations are influenced by factors such as the type of vegetation, organic matter content, and climate.

3. **Moisture Content:** Moisture content is an essential factor affecting soil properties. Narbadapur exhibited the highest moisture content at 23.2%, likely due to the region's proximity to water sources. Kuniyaand Sapnadar Forest also had relatively higher moisture content. In contrast, Sapnadar had a lower moisture content of 20.5%, possibly influenced by differences in land use[15].

4. **Bulk Density:** Bulk density measurements provide insights into soil compaction. The data showed variations in bulk density across locations, with Narbadapur having the lowest bulk density (1.28 g/cm³) and Kuniyahaving the highest (1.45 g/cm³). These variations may be associated with differences in soil texture and organic matter content.

5. **Organic Matter Content:** Organic matter in the soil plays a crucial role in soil health. The data indicated variations in organic matter content, with Kuniyahaving the highest (3.0%) and Narbadapur having the lowest (1.8%). These differences can be attributed to land use practices and vegetation cover[16].

Overall Implications:

The observed variations in soil properties within Mainpat block of surguja district are influenced by a combination of factors, including land use, climate, and

vegetation cover. These findings have several implications:

- Soil EC and pH variations suggest the need for tailored soil management practices to address differences in soil salinity and acidity/alkalinity.
- Moisture content variations can impact crop irrigation and water management strategies.
- Bulk density variations highlight differences in soil compaction, which can affect root growth and water infiltration.
- Differences in organic matter content emphasize the importance of organic matter management for soil health.

8. CONCLUSION

In Surguja district, Mainpat, located in the northern region of Chhattisgarh state in India, the comprehensive soil quality assessment has unveiled valuable insights into the diverse soil properties and conditions within this unique geographical and climatic setting. This study focused on soil electrical conductivity (EC), pH, and other critical soil parameters, providing a comprehensive understanding of soil health in this captivating region.

The findings of this assessment have revealed significant variations in soil properties across different locations within Mainpat and its surrounding areas. These variations encompassed differences in soil EC, pH, moisture content, bulk density, and organic matter content. For instance, Narbadapur, a prominent location in this study, exhibited the highest EC value, signifying elevated conductivity, while Kuniyashowcased the highest pH, indicating a slightly alkaline soil environment. These variations can be attributed to a combination of factors, including soil salinity, moisture levels, vegetation cover, and the influence of local land use practices.

The implications of these findings extend beyond the realm of soil science. They emphasize the need for tailored soil management practices that consider the unique characteristics of the soil in Mainpat. Moisture content variations underscore the significance of strategic water management for crop irrigation and land use in this region. Bulk density disparities emphasize the importance of mitigating soil compaction, a key factor affecting root growth and water infiltration. Furthermore, the differences in organic matter content highlight the crucial role of organic matter management in enhancing soil health and fertility.

In the context of Mainpat, where agricultural practices are intertwined with the region's tropical climate and changing seasons, understanding and managing soil quality are pivotal. This knowledge empowers the community and land managers to make informed decisions that can enhance crop productivity, promote environmental sustainability, and ensure long-term soil health.

As we conclude this study, it's evident that Mainpat's soil quality assessment contributes significantly to the understanding of the unique soil conditions in this region. The results underscore the importance of informed decision-making in agriculture and land use practices, with the ultimate goal of preserving and improving soil quality for the benefit of Mainpat's residents and the environment as a whole. Ongoing research, localized interventions, and sustained monitoring will be essential in addressing the specific needs of different areas within Mainpat and ensuring that sustainable and productive land use practices are upheld in the future.

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