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Estimation of Electrical Conductivity (EC) of Arpa River Based Soil of Bilaspur Chhattisgarh

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Abstract: ***This research explores the investigation and significance of electrical conductivity in the quality of agricultural soil. Soil electrical conductivity is an indirect measurement that is associated with several physical and chemical characteristics of soils. The electrical conductivity (EC) of the soil is directly correlated with the concentration of nutrients and inversely correlated with the soil depth. The soil electrical conductivity (EC) values are indicative of the salinity level in the soil. greater EC values correspond to greater salt concentrations in the soil, whereas lower EC values indicate lower salt concentrations. A total of six soil samples were collected from various points along the Arpa River and sent to the soil test laboratory for examination. All samples were analysed using conventional techniques. For this investigation, one of the crucial soil parameters that was taken into consideration is electrical conductivity (EC). The objective of this study is to assess agricultural land using electrical conductivity. The measured electrical conductivity ranges from 0.4 to 0.7 dS/m. The anticipated value is between 0 and 2 decisiemens per metre (dS/m). All soil samples exhibit a standard level of electrical conductivity. Soil electrical conductivity (EC) measurements and total dissolved solids (TDS) may be used to determine the necessary quantity of NPK (nitrogen, phosphorus, potassium) fertilisers.***

Keywords: Electrical conductivity, Salt concentration, Total dissolved solid (TDS), agriculture, soil

I. INTRODUCTION

Soil is a heterogeneous medium composed of a variable mixture of water, solid particles, and air. The electrical conductivity of soil arises from the presence of dissolved and loosely adsorbed ions within the aqueous phase. These ions primarily comprise major inorganic cations (Na+, Mg2+, Ca2+, K+) and anions (Cl-, SO42-, HCO3-, CO32-, NO3-) commonly found in the Earth's crust.

In the absence of an external electric field, ions exhibit random Brownian motion within the soil matrix, resulting in no net macroscopic electric current. However, when subjected to an electric field, cations migrate towards the lower potential region while anions move towards the higher potential area, facilitating electrical conduction. Electrical conductivity (EC) is defined as the proportionality constant relating current density (J) to electric field strength (E), expressed as $J = \sigma E$. This parameter quantifies the material's ability to conduct electricity. As the reciprocal of resistivity (ρ), EC is typically measured in deciSiemens per meter (dS/m) or milliSiemens per centimeter (mS/cm). A higher EC value correlates with increased salt concentration within the soil.

Electrical conductivity (EC) is a rapid, inexpensive, and non-destructive method for assessing soil quality. It directly correlates with the concentration of ions in the soil solution, with higher EC values indicative of increased ion content. While EC varies with soil depth, its variability tends to be lower in upland profiles [1].

EC measurements provide valuable insights into several soil properties, including cation exchange capacity, texture, drainage, salinity, organic matter content, and subsoil characteristics [2]. Soil moisture content significantly influences EC, as water acts as a medium for ion transport. Monitoring EC can aid in tracking organic matter mineralization within the soil [3]. Moreover, EC is employed to estimate soluble salt and nutrient concentrations [4]. Table 1 presents a detailed overview of EC values and their implications for soil health.

S.no.	Value of E.C.	Effect
1	< 1 (ds/cm)	It is normal soil
2	1-2 (ds/cm)	Critical for germination
3	2-3 (ds/cm)	Critical for soil sensitive crops growth
4	> 3 (ds/cm)	It is severely injurious to crops

Table 1 . Value of E.C. and its effect

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A. *Factors Influencing Soil Electrical Conductivity*

Soil electrical conductivity (EC) is a fundamental parameter in soil science and agriculture, providing valuable insights into soil physical and chemical properties, particularly with respect to water and nutrient dynamics. Several key factors influence soil EC, including moisture content, temperature, texture, salinity, and vegetation cover.

1) *Moisture Content:* Water serves as the primary charge carrier in soil, facilitating ion movement and electrical current flow. As soil moisture content increases, ion mobility is enhanced, resulting in a corresponding increase in EC. Conversely, as soil dries, ion mobility is restricted, leading to a decrease in EC. The relationship between soil moisture and EC is often non-linear, with EC values typically increasing rapidly at lower moisture contents and more gradually at higher moisture levels.
2) *Temperature:* Soil temperature exerts a significant influence on EC by affecting ion kinetic energy. Elevated temperatures increase the vibrational energy of ions, enhancing their mobility and, consequently, increasing EC. Conversely, lower temperatures reduce ion mobility, leading to decreased EC. The impact of temperature on EC is generally more pronounced in saline soils due to the higher concentration of ions.
3) *Texture:* Soil texture, characterized by the relative proportions of sand, silt, and clay, indirectly influences EC by affecting soil water retention and pore space distribution. Sandy soils, with their larger and more interconnected pores, tend to have lower water-holding capacities and, consequently, lower EC values compared to clayey soils. Clayey soils, with their smaller pore sizes and higher specific surface area, retain more water and exhibit higher EC values. However, the relationship between texture and EC can be complex and influenced by other factors such as soil structure and organic matter content.
4) *Salinity:* Soil salinity, defined as the concentration of soluble salts, is a major determinant of EC. Salts dissociate into ions in solution, increasing the number of charge carriers and enhancing electrical conductivity. As salinity increases, EC values rise proportionally. Salinity is a critical factor affecting agricultural productivity, as high salt concentrations can impair plant growth and development.
5) *Vegetation Cover:* Vegetation cover can indirectly influence soil EC through its impact on soil moisture and organic matter dynamics. Transpiration by plants can reduce soil moisture content, leading to lower EC values. Additionally, root exudates and organic matter decomposition can contribute to increased ion concentrations and higher EC values. The type and density of vegetation cover can therefore influence the spatial and temporal variability of soil EC.
6) *Other Factors:* Several other factors can influence soil EC, including soil compaction, bulk density, and the presence of specific ions. Soil compaction reduces pore space and restricts water and ion movement, leading to lower EC values. Conversely, increased bulk density can enhance ion mobility and increase EC. The specific types of ions present in the soil solution can also affect EC, with divalent cations generally having a stronger influence on EC than monovalent cations. Understanding the factors influencing soil EC is essential for interpreting EC measurements and using them effectively for soil management and environmental monitoring. The number of fertilizers applied to the soil also affects its EC value [8].

II. EXPERIMENTAL METHOD

A. *Soil Electrical Conductivity Measurement and Sample Preparation*

Soil electrical conductivity (EC) is a fundamental parameter in soil science and agriculture, providing valuable insights into soil physical and chemical properties. Its measurement is typically conducted using calibrated EC meters or probes, which function by determining soil electrical resistance. These instruments offer a rapid, precise, and reliable method for assessing EC in situ.

To conduct this study, soil samples were systematically collected from diverse locations along the Apra River, encompassing Pendra Road, Sendri, Indra Setu, Chhatghat, Darrighat, and Bartori. Upon collection, the soil samples were subjected to a drying process to remove excess moisture. Subsequently, the dried soil was mechanically reduced in size through crushing and sieving to obtain a fine-grained material.

This processed material was further oven-dried at a temperature of 110°C for a duration of 24 hours to ensure complete desiccation. The resulting moisture-free soil material is henceforth referred to as the Material Under Testing (MUT) and served as the basis for subsequent analyses.

B. *Preparation of Sample*

After collecting the sample the soil is dried and crushed. Now sieving process is followed to gain fine powder form of soil sample and remove the coarser particles from the soil. The sieved out particles are then dried in hot air oven to a temperature around 110^{o}C for 24 hours in order to remove any trace of moisture. The sample now called MUT (Material Under Testing).

III. RESULT AND DISCUSSION

In this paper EC is measured with calibrated electrical conductivity meters or probes.Table 2. shows the experimental results of EC of different soil samples.

S.No.	Sample No.	Sample site name	Electrical conductivity(dS/m)	Normal value
1.	Sample 1	Pendra-road (origin point)	0.4	0-2 dS/m
2.	Sample 2	Sendari	0.6	
3.	Sample 3	Indra setu	0.4	
4.	Sample 4	Chhatghat	0.7	
5.	Sample 5	Darrighat	0.7	
6.	Sample 6	Bartori	0.5	

Table 2. Experimental values of EC for all soil samples

In present study the electrical conductivity of all six sample is in salt free (0-2) range and it indicates that the study area fairly good for agriculture with respect to EC.

IV. CONCLUSION

The cultivation of robust and productive paddy crops necessitates a comprehensive understanding of the intricate interplay between various environmental and agronomic factors. Key determinants of crop development include the precise application of fertilizers, the maintenance of optimal water temperatures, the regulation of soil moisture levels, and the judicious selection of suitable soil types.

Central to this complex matrix is soil electrical conductivity (EC), a critical parameter that provides invaluable insights into soil health, fertility, and overall suitability for crop production. By accurately interpreting EC measurements, agricultural practitioners can make informed decisions regarding essential soil management practices such as irrigation scheduling, fertilization strategies, and crop selection.

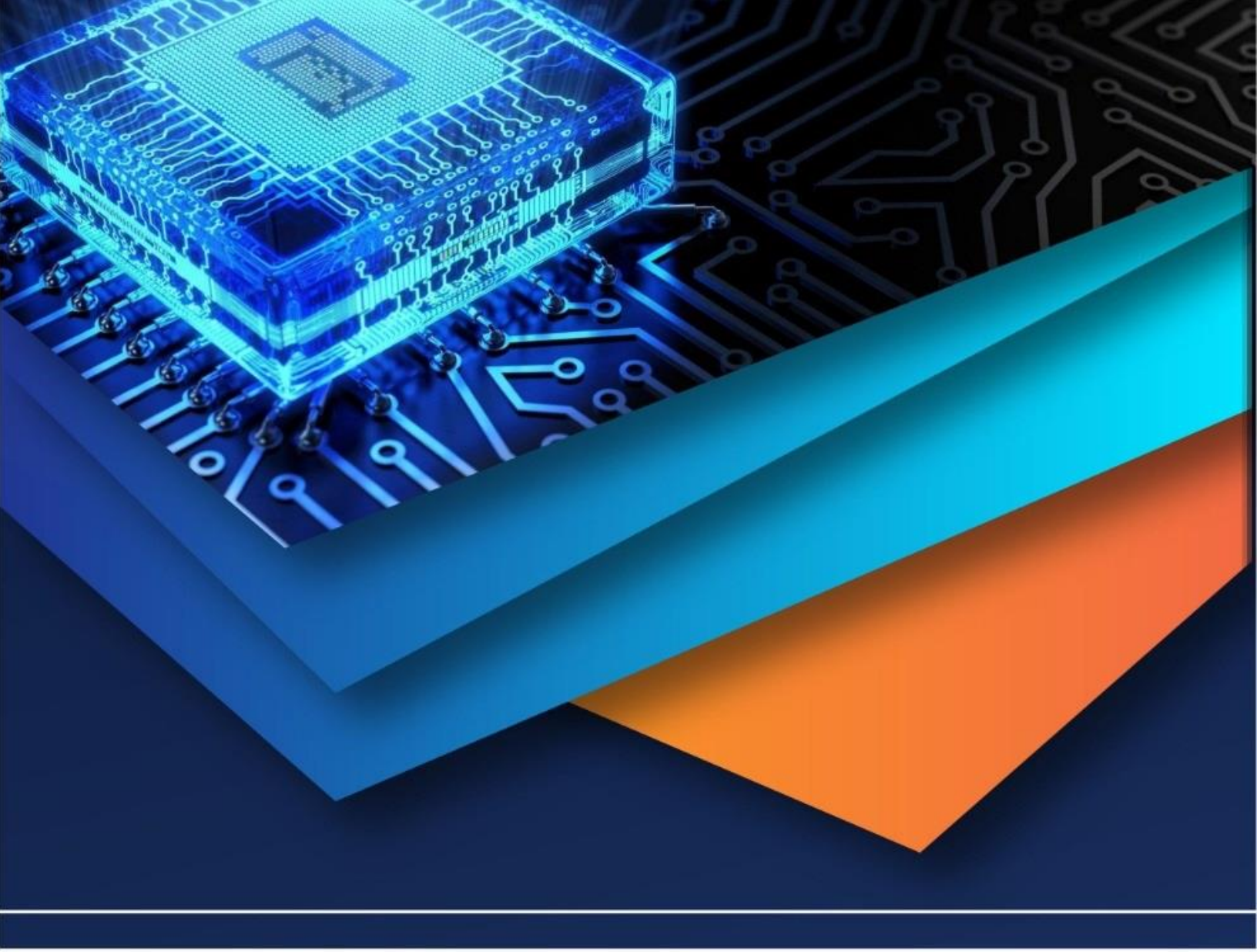
Regular monitoring of soil EC is instrumental in identifying potential imbalances or stresses that may be adversely affecting crop growth and development. Through the implementation of targeted corrective actions, such as amending soil pH, applying appropriate fertilizers, or improving drainage, producers can optimize soil conditions and enhance crop performance. Moreover, a comprehensive understanding of the relationship between EC and other soil properties, including salinity, texture, and organic matter content, is essential for developing effective and sustainable soil management strategies.

Ultimately, the successful integration of soil EC measurements into precision agriculture frameworks can lead to significant improvements in crop yield, quality, and resource efficiency while minimizing environmental impacts.

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