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PHYSICO-CHEMICAL PROPERTIES OF SOIL IN FOREST AND AGRO ECOSYSTEMS IN WARANGAL DISTRICT, TELANGANA STATE, INDIA

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ABSTRACT:

This study investigates the physico-chemical properties of soil in agricultural and forest ecosystems within Warangal District, Telangana, to understand how land use affects soil quality across different seasons. The objective was to compare soil pH, moisture, organic carbon, and electrical conductivity between these ecosystems during winter, summer, and monsoon. Soil samples were systematically collected from both ecosystems in each season and analyzed for the aforementioned parameters. The present study was conducted in the Rajanpalle village in Gudur mandal in Warangal district of Telangana state, India. The results reveal that forest soils generally exhibit higher pH, moisture content, and organic carbon levels compared to agricultural soils, reflecting the benefits of natural vegetation and organic matter accumulation. Specifically, forest soils maintain more stable moisture and organic carbon levels, particularly in winter, while agricultural soils show greater variability, especially in organic carbon content, which decreases in summer. Electrical conductivity remains within safe limits for both ecosystems, although agricultural soils have higher conductivity during the monsoon due to increased soluble salts from irrigation and rainfall. These findings underscore the significant impact of land use on soil properties and highlight the importance of implementing sustainable management practices to improve soil health and productivity in agricultural systems while preserving the advantages of forest ecosystems.

Keywords: pH, Rajanpalle, Electrical conductivity, Organic carbon, Moisture.

1. INTRODUCTION

Understanding the physico-chemical properties of soil is critical for managing and sustaining the productivity of different ecosystems. In Warangal District, Telangana State, India, the differentiation in soil properties between forest and agro ecosystems offers valuable insights into ecological dynamics and land management practices. Forest ecosystems, with their natural vegetation and minimal human interference, often show distinct soil characteristics, including higher organic matter content and better soil structure compared to agro ecosystems, where intensive agricultural practices can lead to significant soil alterations (Bargali, et al., 2018; Fauzi et al., 2023). These differences in soil properties affect nutrient cycling, soil stability, and overall ecosystem health, underscoring the need for a thorough understanding of these variations to promote effective land management strategies and conservation practices.

Soil in forest ecosystems typically benefits from the natural processes of organic matter decomposition and a stable microbial community, leading to higher levels of soil organic carbon and

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improved nutrient retention (Kachhave et al., 1982; Qi et al., 2018). Forest soils usually exhibit a balanced pH and a rich nutrient profile that supports diverse plant and microbial communities. In contrast, agro ecosystems, subjected to frequent tillage, irrigation, and chemical inputs, often experience altered soil properties. These changes include reduced organic carbon levels, increased soil erosion, and variations in pH and nutrient availability, which can affect crop productivity and soil health (Narayana et al., 2021). This contrasting impact highlights the need to evaluate the effects of agricultural practices on soil properties to develop sustainable land management practices.

This study focuses on evaluating the physico-chemical properties of soil in both forest and agro ecosystems within Warangal District. The research aims to provide a comprehensive analysis of how different land use practices influence soil quality, with the goal of informing strategies for enhancing soil management and ecosystem sustainability (Narayana et al., 2021; Gupta et al., 2020). By examining key parameters such as soil pH, organic carbon content, electric conductivity and soil moisture, the study will contribute to a deeper understanding of the interactions between land use and soil health. Therefore, the objecrive of the study is to assess the physico-chemical parameters of soil, including pH, organic carbon content, electric conductivity and soil moisture in both forest and agro-ecosystems across different seasons.

2. MATERIALS AND METHODS

2.1 Selection of Study Area

The present study was conducted in the Rajanpalle village in Gudur mandal in Warangal district of Telangana state, India. It is governed by Rajanpalle Gram Panchayat. It comes under Gudur Community Development Block. It is located 55km towards East from district headquarters in Warangal. Rajanpalle is surrounded by Khanapur mandal towards North, Chennaraopet mandal towards West, Kesamudram mandal towards South, Narsampet towards North, Gudur forest zone is one of the zones in Pakhal wild life sanctuary along with Kothaguda zone. The Rajanpalle village lies between 17°44'56.0"N 79°54'59.3"E.

Site-1: Agricultural land (Agro-Ecosystem)

The vegetation of this study area is trees, shrubs, climbers and grasses. Agriculture is common in Rajanpalle village, Gudur Mandal, Warangal Dist. They grow crops in Kharif and Rabi seasons in a year. The common crops that are grown in this area near Gudur forest area are 1 cotton, maize, chilies, and turmeric. Agriculture is the most predominant sector of Gudur Mandal, Warangal District. The farmlands are highly fertile because the lands present near the forest zone of Gudur Mandal. These soils are more fertile due to the seasonal abundance of soil inhabiting Arthropods. The selected area is about 10 acres of agricultural land, and it lies between 17°44'55.5"N 79°55'01.2"E. The distance from the Rajanpalle village to site 1 (Agriculture land) is 31 meters.

Site-2: Forest Land (Forest ecosystem)

The forest area includes sandstones, granites, gneiss of Archean age and sandstones. Phyllites and mica hematites to monalite ores puranas are formed in the form of shales, phyllites and soil to sticking saline soils. The forest has only two types of soils- regular soil occupying 24% of the total area and chaluka soil occupying 76% of the total area. The groundwater occurs in the weathered portions of the granite. The maximum thickness of the weatherized zone is about 17.5m. The selected

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area is about 10 acres of forest land, and it lies between 17°45'00.5"N 79°55'03.7"E. The distance from the Rajanpalle village to site 2 (Forest area) is 410 meters.

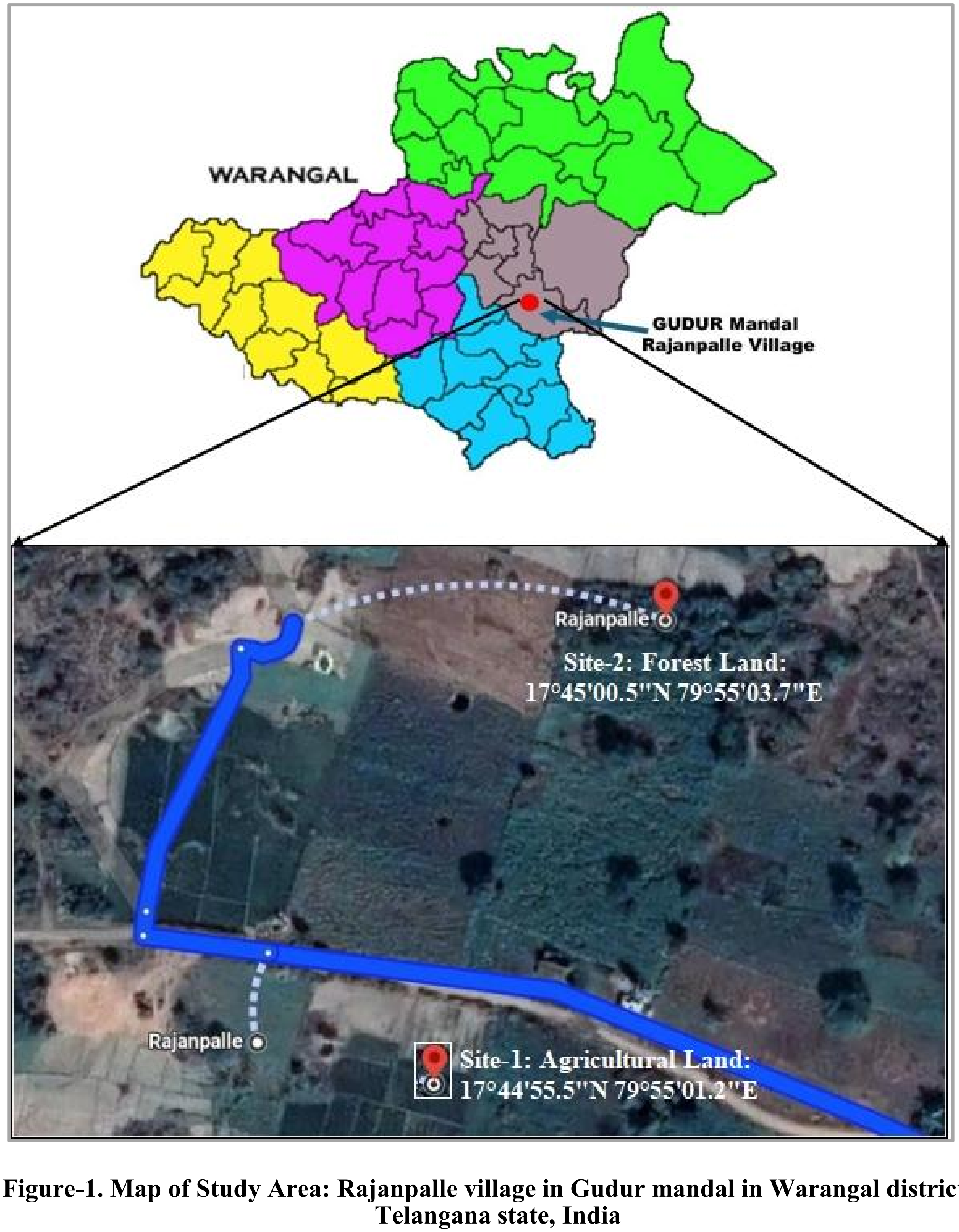

Figure-1. Map of Study Area: Rajanpalle village in Gudur mandal in Warangal district of Telangana state, India

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2.2. Physico-chemical Parameters of Soil :

Soil samples were randomly collected from each plot at every site and transported to the laboratory in cotton bags for analysis. Upon arrival, all soil samples underwent air drying and were then sieved through 2 mm mesh screens.

Soil pH: The pH of the soil was determined in water using a digital pH meter, with a soil-to-water ratio of 1:2 (Asawalam et al., 1999).

Soil Moisture: Soil moisture content was assessed by air drying the samples at 105°C for 24 hours.

Soil organic carbon: The Walkley-Black technique was employed to determine the organic carbon content in the soil samples (Allison, et al, 1975).

***Soil electrical conductivity*:** Electrical conductivity was measured using a conductivity meter, while exchangeable acidity was extracted via the standard procedure (Anjum et al., 2005).

3. RESULTS

3.1. Physico-chemical properties of soil from Agricultural and Forest land

To analyze the results of the physico-chemical parameters provided in the table-1, we can examine the variations in soil pH, soil moisture, organic carbon content, and electrical conductivity across agricultural (Agri) and forest (Forest) ecosystems during different seasons: summer, monsoon, and winter. The table-1 includes mean values and P-values indicating the statistical significance of the differences between the two ecosystems for each parameter in each season.

1. Soil pH:

In summer, the mean soil pH in agricultural areas is 6.64, while in forest areas it is slightly higher at 6.89, with a P-value of 0.006 indicating a statistically significant difference between the two ecosystems. During the monsoon, the mean soil pH is 6.53 for agricultural soils and 6.84 for forest soils, with a P-value of 0.001, showing a highly significant difference. In the winter season, agricultural soils have a mean pH of 6.8, and forest soils have a mean pH of 7.06, with a P-value of 3.16, which is non-significant. This suggests that forest soils are generally more acidic compared to agricultural soils, particularly during the summer and monsoon seasons, but this difference becomes less pronounced in winter.

2. Soil Moisture (%):

The mean soil moisture in agricultural soils during summer is 56.145%, while in forest soils it is 52.090%, with a P-value of 1.65 indicating non-significant differences. In the monsoon season, agricultural soils have a mean moisture content of 54.763%, compared to 51.490% in forest soils, with a P-value of 0.03, which is significant. During winter, agricultural soils have 50.836% moisture, whereas forest soils have 63.363%, with a P-value of 4.85, indicating highly significant differences. This shows that forest soils generally retain more moisture, especially in winter, which could be attributed to the higher organic matter and canopy cover in forest ecosystems.

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3. Organic Carbon (%):

In summer, organic carbon content is 1.056% in agricultural soils and 1.176% in forest soils, with a P-value of 0.02, indicating a significant difference. During the monsoon, agricultural soils have 0.892% organic carbon, while forest soils have 1.0709%, with a P-value of 0.0003, showing a highly significant difference. In winter, the organic carbon content is equal in both ecosystems at 1.056% for agricultural and 1.176% for forest soils, with a P-value of 0.02, indicating a significant difference. Forest soils consistently show higher organic carbon content across seasons, which is expected due to greater accumulation of organic matter from leaf litter and reduced disturbance.

4. Electrical Conductivity (Siemens/m):

During summer, the mean electrical conductivity in agricultural soils is 0.272 Siemens/m, while in forest soils it is 0.274 Siemens/m, with a P-value of 0.9, indicating non-significant differences. In the monsoon season, the conductivity is 1.0527 Siemens/m in agricultural soils and 1.0890 Siemens/m in forest soils, with a P-value of 0.81, also non-significant. In winter, the electrical conductivity is 0.692 Siemens/m in agricultural soils and 0.358 Siemens/m in forest soils, with a P-value of 0.16, indicating non-significant differences. This suggests that the electrical conductivity is generally similar between the two ecosystems across seasons, with slight variations that are not statistically significant.

The analysis reveals that forest soils generally have higher pH, organic carbon content, and moisture levels compared to agricultural soils, especially notable during the monsoon and winter seasons. The differences in pH and organic carbon are statistically significant, highlighting the impact of land use on these soil properties. However, soil moisture and electrical conductivity show less variation between the ecosystems, with differences not always reaching statistical significance.

Table-1. Physico-chemical properties of soils from Agricultural and Forest land during the different seasons

Season	Mean values of Soil Sample (n=10)	Soil Physico-chemical Parameters during Different Seasons							
		Soil PH		Soil moisture (%)		Organic carbon (%)		Electro Conductivity (Siemens/m)	
		Agri	Forest	Agri	Forest	Agri	Forest	Agri	Forest
Summer	Range (mean)	6.64	6.89	56.145	52.090	1.056	1.176	0.272	0.274
	P value	0.006		1.65		0.02		0.9	
Monsoon	Range (mean)	6.53	6.84	54.763	51.490	0.892	1.0709	1.0527	1.0890
	P value	0.001		0.03		0.0003		0.81	
Winter Season	Range (mean)	6.8	7.06	50.836	63.363	1.056	1.176	0.692	0.358
	P value	3.16		4.85		0.02		0.16	

(p>0.05=non-significant value; p<0.05=significant differences in the abundancesbetween two habitats; p<0.01=highly significant values)

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3.2. pH of the soil in Agriculture and Forest land during different seasons

The mean values of soil pH in agricultural and forest land exhibit notable trends across different seasons. In agriculture land, the pH ranges from 6.53 in monsoon to 6.8 in winter, while in forest land, the pH ranges from 6.84 in monsoon to 7.06 in winter (Figure-2). This suggests that soil pH tends to be slightly higher in forest land compared to agricultural land across all seasons. Furthermore, both land types show a decrease in pH during the transition from winter to monsoon, indicating potential seasonal variations in soil acidity or alkalinity. These findings may have implications for nutrient availability, microbial activity, and overall soil health, highlighting the importance of understanding and managing soil pH dynamics in agricultural and forest ecosystems throughout the year.

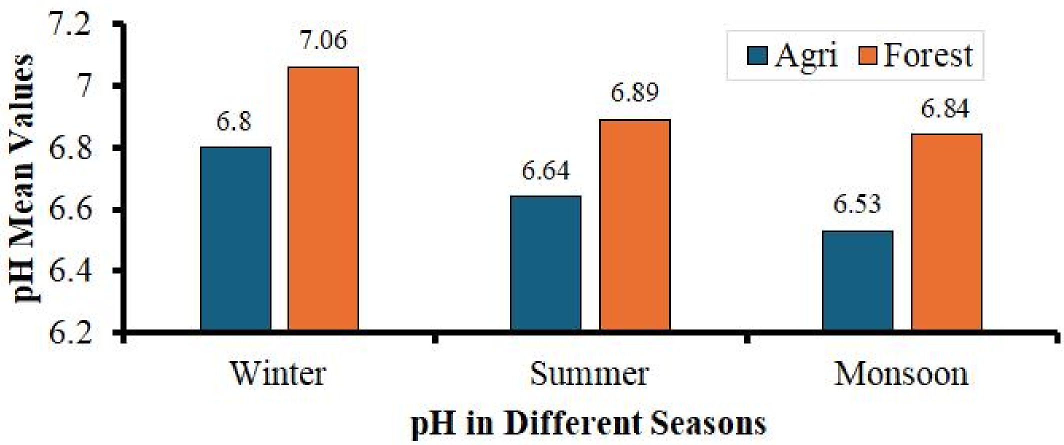

Figure-2. pH of soil in Agriculture and Forest land during different seasons

3.3. Soil Moisture in Agriculture and Forest land during different seasons:

The percentage of soil moisture in agricultural and forest land demonstrates distinct patterns across different seasons. In agriculture land, soil moisture percentages range from 50.84% in winter to 56.145% in summer, while in forest land, they range from 63.36% in winter to 51.49% in monsoon (Figure-3). Notably, forest land consistently exhibits higher soil moisture percentages compared to agriculture land across all seasons, indicating potentially greater water retention capacity in forest ecosystems. However, both land types experience fluctuations in soil moisture content throughout the year, with generally higher levels observed in winter and lower levels in monsoon. These variations could be influenced by factors such as rainfall patterns, vegetation cover, soil texture, and land management practices. Understanding the dynamics of soil moisture in agricultural and forest land is crucial for effective water management strategies, sustainable land use practices, and ecosystem health preservation.

3.4. Organic Carbon in Agriculture and Forest land during different seasons

The percentage of soil organic carbon in agricultural and forest land exhibits notable variations across different seasons. In agriculture land, organic carbon percentages range from 0.892% in monsoon to 1.056% in both winter and summer, while in forest land, they range from 1.0709% in monsoon to 1.176% in both winter and summer (Figure-4).

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These findings suggest that forest land generally contains slightly higher levels of organic carbon compared to agriculture land throughout the year. However, both land types experience fluctuations in organic carbon content across seasons, with a slight decrease observed in monsoon compared to winter and summer. These variations could be influenced by factors such as vegetation type, litter decomposition rates, soil microbial activity, and land management practices. Understanding the dynamics of soil organic carbon is crucial for assessing soil fertility, carbon sequestration potential, and the overall health of agricultural and forest ecosystems.

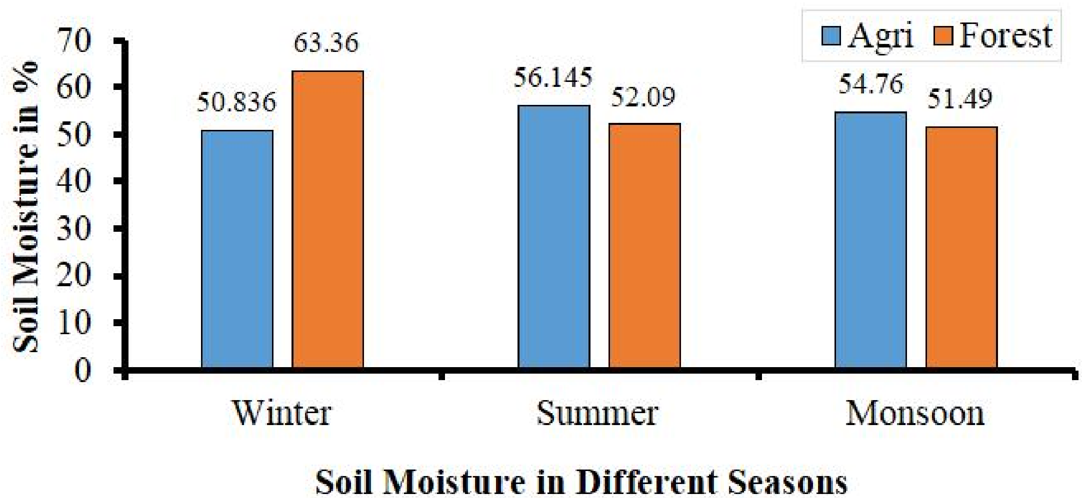

Figure-3. Percentage of Soil Moisture in Agriculture and Forest land during different seasons

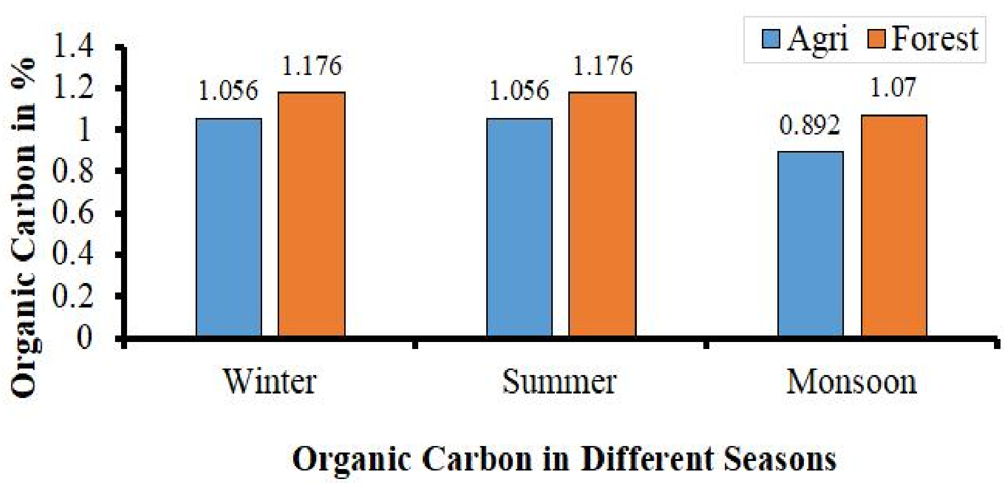

Figure-4. Percentage of Organic Carbon in Agriculture and Forest land during different seasons

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3.5. Electric Conductivity in Agriculture and Forest land during different seasons

Soil electrical conductivity in Siemens per meter (Siemens/m) reveals distinct patterns across different seasons and land types. In agriculture land, conductivity values range from 0.272 Siemens/m in summer to 1.05 Siemens/m in monsoon, while in forest land, they range from 0.274 Siemens/m in summer to 1.08 Siemens/m in monsoon (Figure-5). Notably, agriculture land generally exhibits higher conductivity compared to forest land, particularly during the monsoon season. This suggests potential differences in soil mineral content, nutrient levels, and salinity between the two land types. Additionally, both agriculture and forest land experience an increase in electrical conductivity during the monsoon season compared to winter and summer, indicating a possible influx of ions and nutrients with increased moisture levels. These variations may be influenced by factors such as land management practices, vegetation cover, soil texture, and hydrological processes. Understanding soil electrical conductivity dynamics is crucial for assessing soil fertility, nutrient availability, and salinity levels, and for informing appropriate land management strategies in agricultural and forest ecosystems.

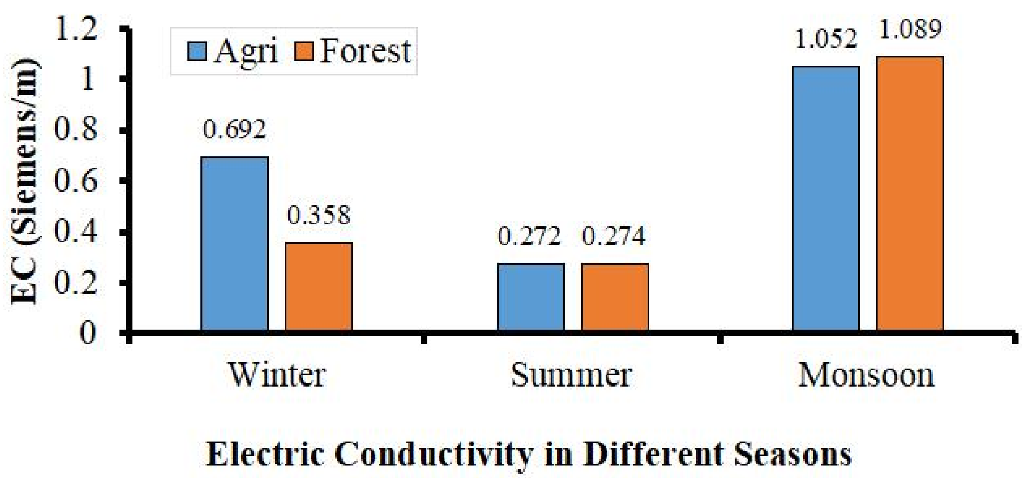

Figure-5. Electric Conductivity in Agriculture and Forest land during different seasons

3.6. Categorization of physicochemical properties of soil from agricultural and forest land

The analysis of soil parameters across winter, summer, and monsoon seasons reveals notable differences between agricultural (Agri) and forest (Forest) ecosystems. Forest soils consistently exhibit higher pH values, moisture content, and organic carbon levels compared to agricultural soils, reflecting the effects of vegetation cover and organic matter accumulation. Specifically, forest soils maintain a slightly higher pH and significantly greater moisture and organic carbon throughout the year, with forest moisture peaking in winter and organic carbon levels generally exceeding those of agricultural soils. In contrast, agricultural soils show variability, particularly in organic carbon, which decreases in summer. Electrical conductivity (EC) remains within the safe range for both ecosystems, with agricultural soils showing a higher mean EC during the monsoon due to increased soluble salts from rainfall and irrigation. Overall, these differences underscore the impact of land use on soil properties, with forest soils demonstrating enhanced organic content and moisture retention, while agricultural soils exhibit more fluctuation, highlighting the need for sustainable management practices to maintain soil health and productivity in different ecosystems.

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Table-2. Categorization of physico-chemical properties (pH, Soil moisture, Organic carbon and Electric conductivity) of soils from agricultural and Forest land during different seasons

Soil Parameters	Reference Values	Winter		Summer		Monsoon	
		Agri	Forest	Agri	Forest	Agri	Forest
pH	Range	6.5-7.2 (6.8)	6.7-7.3 (7.06)	6.1-7.2 (6.64)	6.2-7.3 (6.89)	5.8-7.2 (6.53)	6.3-7.3 (6.84)
	Acidic (<6.5)	0	0	3	3	4	1
	Neutral (6.5-7.5)	10	10	7	7	6	9
	Alkalic (>7.5)	0	0	0	0	0	0
Soil Moisture	Range (Mean)	24.8-32.6 (50.83)	29.2-39.4 (63.36)	26.4-36.1 (56.14)	24.1-34 (52.09)	26-37 (54.76)	26-34 (51.49)
	Low (<20%)	0	0	0	0	0	0
	Normal (20-40%)	10	10	10	10	10	10
	High (>40%)	0	0	0	0	0	0
Electro Conductivi ty	Range (Mean)	0.2-0.17 (0.69)	0.6-0.19 (0.35)	0.11-0.19 (0.272)	0.12-0.19 (0.274)	0.5-0.14 (1.05)	0.5-0.15 (1.08)
	Safe (<0.8)	4	1	0	0	2	4
	Normal (0.8-2.5)	6	9	10	10	8	6
	Unsafe (>2.5)	0	0	0	0	0	0
Organic Carbon	Range (Mean)	0.29-0.75 (1.05)	0.42-0.75 (1.17)	0.39-0.72 (0.59)	0.46-0.73 (0.66)	0.19-0.71 (0.89)	0.32-0.73 (1.07)
	Low (<0.5)	0	0	0	0	0	0
	Normal (0.5-0.75)	10	10	10	10	10	10
	High (>0.75)	0	0	0	0	0	0

4. DISCUSSION

The analysis of soil pH, soil moisture content, organic carbon content and electrical conductivity in Table-2 during the summer season reveals interesting insights. While significant differences in soil pH and moisture content between agricultural and forest soils are observed, with p-values of 0.006 and 0.02 respectively, aligning with findings from previous studies by Wang et al, (2016).

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These differences may be attributed to various factors such as land management practices and vegetation cover, highlighting the importance of considering these variations for soil health assessment. Conversely, the non-significant difference in organic carbon content and electrical conductivity, with p-values of 1.65 and 0.9 respectively, contrasts with studies by Wardle et al, (2002), emphasizing the need for further exploration into the factors influencing these soil properties across different habitats during the summer season. This comparison underscores the complexity of soil dynamics and the necessity of comprehensive assessments to understand the nuances of soil characteristics in agricultural and forest ecosystems.

The analysis of soil organic carbon variations in agricultural and forest land across seasons, as discussed, aligns with recent studies by Zhang et al. (2002) and Chen et al. (2002). The consistent trend of slightly higher organic carbon levels in forest land compared to agriculture land throughout the year suggests potential differences in carbon sequestration capacity and soil fertility between the two land types.

Recent studies in soil science have provided further insights into the patterns of soil electrical conductivity (EC) across different seasons and land types, corroborating the findings outlined. Research by Badorreck et al. (2012) highlighted the influence of soil mineral content, nutrient levelsand salinity on soil EC, underscoring potential differences between agricultural and forest ecosystems.

5. CONCLUSION

The comparison of soil physico-chemical properties between agricultural and forest ecosystems in Warangal District highlights significant variations influenced by land use and seasonal changes. Forest soils consistently exhibit higher pH, moisture, and organic carbon levels, underscoring their enhanced capacity for nutrient retention and moisture regulation compared to agricultural soils. These differences are particularly pronounced in winter and monsoon seasons, with forest soils showing greater stability in moisture and organic content. Agricultural soils, on the other hand, display more variability, especially in organic carbon levels, which are affected by seasonal practices and disturbances. Electrical conductivity remains within safe levels across both ecosystems, though it increases in agricultural soils during the monsoon. These findings emphasize the critical need for tailored land management strategies to improve soil health and sustainability in agricultural settings while preserving the beneficial attributes of forest ecosystems. The analysis indicates that forest soils generally have higher pH, moisture, and organic carbon levels compared to agricultural soils. Electrical conductivity is comparable between the two ecosystems, though it increases in agricultural soils during the monsoon. Forest soils show more stability in organic carbon and moisture, whereas agricultural soils fluctuate more with seasonal changes. These observations highlight the impacts of land use on soil properties and underscore the need for targeted management practices to enhance soil health in different ecosystems.

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