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Determining Soil Fertility and Quality in Thangallapally Village, Sircilla District, Telangana, through Physico-Chemical Studies

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ABSTRACT

A comprehensive physicochemical analysis of soil was conducted to evaluate various critical parameters, including soil pH, electrical conductivity (EC), organic carbon (OC), available nitrogen (N), phosphorus (P), and potassium (K). Three representative soil samples were collected from a depth of 0–20 cm in Thangallapally village for detailed analysis. The findings indicated that the soil in this region is alkaline, with the pH ranging from 8.33 to 9.06. This pH range confirms the presence of alkaline conditions, which can influence nutrient availability and soil management practices. Electrical conductivity (EC), which indicates the level of soluble salts and overall soil salinity, ranged from 238.33 to 258.33µS/cm. These moderate EC values suggest that the soil is not highly saline, which is beneficial for plant growth. The organic carbon content, which plays a pivotal role in enhancing soil structure, fertility, and water retention, ranged from 0.56% to 0.63%. These values indicate a moderate level of organic matter, which is essential for sustaining soil fertility and microbial activity. Potassium content, an important nutrient for overall plant health, ranged from 785.3 to 858.63 kg/ha, suggesting an adequate supply of this vital nutrient for crop growth. Among other nutrients, available nitrogen was measured between 0.005% and 0.0063%, which is relatively low and may require supplementation for optimal crop production. Phosphorus levels were found to range from 39.76 to 43.76 mg/kg, indicating moderate availability of this critical nutrient, which supports root development, flowering, and fruiting. These results provide valuable insights for farmers, helping them to better understand the current soil conditions in the area. With this information, farmers can make informed decisions on the appropriate fertilizers and soil amendments required to optimize soil fertility, enhance crop yields, and ensure sustainable agricultural practices.

Keywords: *Soil samples; physicochemical parameters, Soil fertility, Thangallapally Village*

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1. Introduction

Soil test-based nutrient management has emerged as a critical strategy for enhancing agricultural productivity. Over recent decades, agricultural practices have shifted away from traditional, less-intensive methods to more modern techniques that heavily rely on chemical fertilizers, pesticides, and irrigation systems. While these methods have contributed to short-term increases in crop yield, the prolonged use of chemical fertilizers has had detrimental effects on soil health. Continuous application of these chemicals has gradually altered the soil's natural properties, leading to a decline in soil fertility and productivity over the long term. Moreover, the excessive use of fertilizers has resulted in the leaching of chemicals into surface and groundwater, posing significant environmental risks [1-5]. Additionally, the growing demand for cash crops has further promoted monoculture cropping systems, which deplete soil nutrients and contribute to the degradation of both water and soil quality [6]. Soil and water are fundamental natural resources necessary for successful crop cultivation. The quality of these resources directly influences agricultural productivity and sustainability. The main objective of this study was to assess the current state of soil quality in a particular region. To achieve this, soil samples were collected from eight different locations, representing a diverse range of conditions within the study area. The samples were then analysed for various key physicochemical properties, including soil pH, electrical conductivity (EC), organic carbon (OC), available nitrogen (N), phosphorus (P), and potassium (K). These parameters are essential for understanding the soil's fertility, nutrient availability, and overall health, providing valuable insights for managing soil resources effectively [7,8].

2. Material and Methods

In 2024, a soil quality survey was carried out in Thangallapally Village, situated in the Siricilla District of Telangana. To ensure representative sampling across the area, three soil samples were collected from different locations within the village at a depth of 0–20 cm. Before sampling, any visible surface vegetation, litter, stones, or plant residues were carefully cleared to avoid contamination from surface material. The layer of soil immediately beneath was then collected and stored in polyethylene bags to maintain sample integrity. The sampling sites, labelled as Station Nos. 1 to 3, were strategically chosen to capture soil variability across different parts of the village.

This approach allowed for a comprehensive analysis of soil properties within the village, supporting a more accurate understanding of the region's soil health and nutrient status.

2.1. Physicochemical analysis

The collected soil samples underwent detailed analysis to assess major physical and chemical quality parameters essential for understanding soil health. Key properties analyzed included soil pH, which indicates soil acidity or alkalinity, and electrical conductivity (EC), a measure of soil salinity. Organic carbon (OC) content was assessed to gauge the organic matter present, which influences nutrient availability and soil structure. The study also measured essential nutrients, including available nitrogen (N), phosphorus (P), and potassium (K). These nutrients are critical for plant growth, as nitrogen supports leaf and stem development, phosphorus contributes to root and flower formation, and potassium aids in overall plant health and disease resistance [9-15].

Table 1 Methods used for estimation of physical chemical parameters

S. No.	Parameter	Method for Estimation
1	Color	By viewing
2	pH	pH meter
3	EC	Conductometry
4	Organic carbon	Wet oxidation
5	Phosphorous	Colorimetry
6	Nitrogen	Alkaline permanganate
7	Potassium	Flame photometry

3. Results and discussion

The values of the soil's physicochemical parameters are provided in Table No. 2. Each soil sample's color was visually examined, and all samples were found to be black. This black coloration typically suggests a high organic matter content, which can enhance soil fertility and moisture retention. Additionally, the color can provide insights into mineral composition and aeration, both of which influence soil quality and crop productivity.

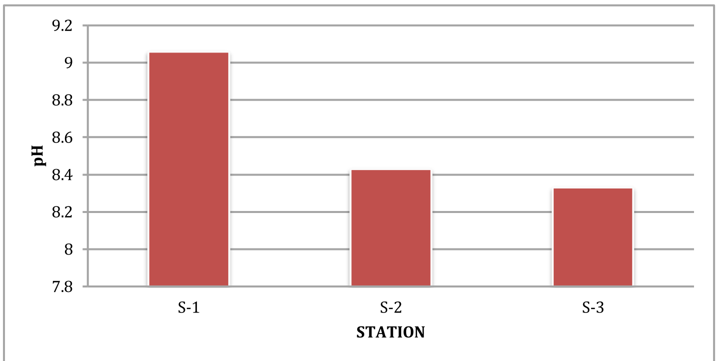
Table 2: Results of Physicochemical parameters of the study area

S. NO	PARAMETER	UNITS	S-1	S-2	S-3
1	**Color**	Observation	Black	Black	Black
2	**pH**	-	9.06	8.43	8.33
3	**Electric Conductivity**	µs/cm	258.33	238.33	248.33
4	**Potassium**	mg/kg	858.63	785.3	815.3
5	**Organic Carbon**	% by mass	0.6	0.566	0.633
6	**Phosphorous**	mg/kg	39.76	40.43	43.76
7	**Nitrogen**	% by mass	0.005	0.0063	0.005

**S- Station ** All parameter results were the average of triplicate taken for the analysis*

3.1. pH

Soil pH is a measure of the concentration of hydrogen ions in a solution, providing insight into soil acidity or alkalinity. In this study, soil pH was measured using a potentiometric pH meter, following Jackson's method with a 1:2.5 soil-to-water suspension ratio. The measured pH values indicated an alkaline tendency, with all values above 7, classifying the soil as alkaline. Alkalinity in soil often signals saline or salt-affected conditions, which can influence nutrient availability and crop growth.
Soil pH levels categorize soil types: values below 6.0 indicate acidic soil, whereas values ranging from 6.0 to 7.0 are generally neutral. The pH of these samples ranged from 8.33 to 9.06, indicating an alkaline soil type, particularly when pH exceeds 8.5. Such alkalinity may require management practices to optimize the soils productivity and support plant health.

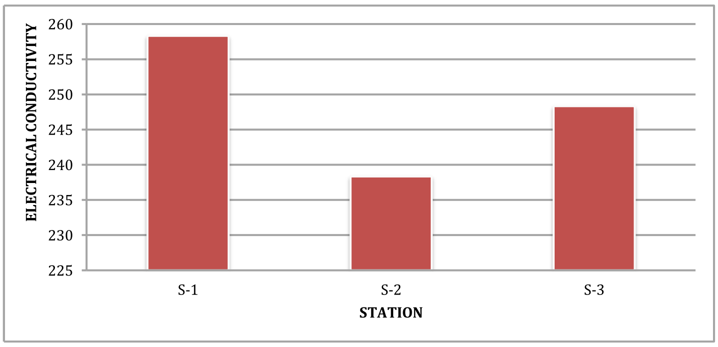


Graph: No.1: pH of soil sample at three stations studied

3.2. Electrical conductivity

Electrical conductivity (EC) is a crucial property in soil analysis as it reflects the total concentration of soluble salts present in the soil. This measurement serves as an indicator of ion availability, which can impact soil fertility and crop health. EC values reveal the level of ions present, which includes essential cations and anions involved in nutrient exchange.

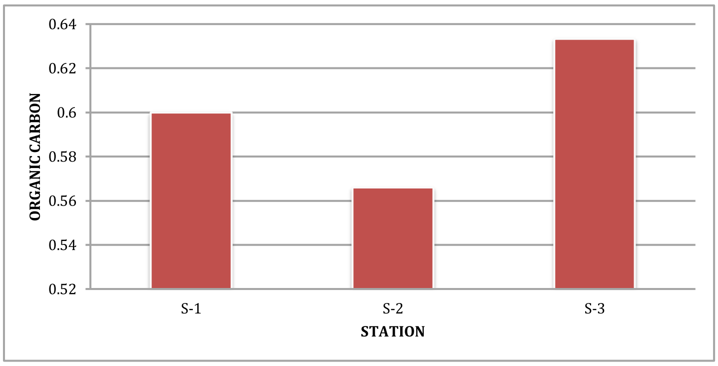
During the measurement process, cations from the soil's clay or colloidal particles are exchanged with those in the soil and salt solution, a process known as cation exchange. Key cations involved in this process include calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K), along with anions such as carbonate (CO_3), bicarbonate (HCO_3), and phosphate (PO_4).
The EC values can vary significantly based on the soil's chemical properties. A soil with an EC below 400 µS/cm is generally considered to have normal salinity levels, supporting healthy plant growth. In this study, the EC of soil samples from the study area ranged between 238.33 and 258.33 µS/cm, indicating low salinity. These lower EC values suggest favourable conditions for crop cultivation, with minimal salt stress affecting plant uptake of water and nutrients.



Graph: No.2: Electrical conductivity (µs/cm) of soil sample at three stations studied

3.3. Organic carbon

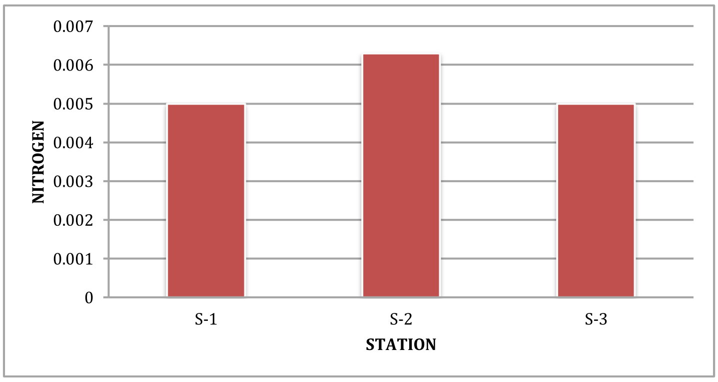
Organic matter plays a vital role in enhancing soil fertility by contributing essential nutrients and improving soil structure. Soil organic carbon, a key component of organic matter, forms the foundation of soil fertility. It releases nutrients gradually, supporting steady plant growth and enhancing overall soil health and productivity. Increasing organic carbon content in soil not only supplies nutrients but also improves soil's physical properties, such as water retention and aeration, which are essential for root development and microbial activity [16]. The data presented in Table 2 shows that the soil organic carbon content in the study area ranges from 0.56% to 0.63%, indicating a medium level of organic carbon. This moderate proportion suggests a healthy nutrient supply for crops while also supporting soil's long-term fertility and resilience.



Graph: No.3: Organic carbon (% by mass) of soil sample at three stations studie

3.4. Nitrogen

Available nitrogen in the soil was determined using the ML Jackson method [23]. Nitrogen is a crucial nutrient for plants, particularly for the development of healthy foliage and overall plant canopy growth. A deficiency of nitrogen often leads to stunted plant growth, yellowing of leaves, reduced protein content, and lower crop yields. Nitrogen is typically one of the most limiting nutrients in soil, and its availability directly impacts plant health and productivity. In the soil samples analysed, nitrogen levels were found to be low across all samples. The nitrogen content ranged from 0.0053% to 0.0063%, indicating a medium proportion of nitrogen by mass. Although the nitrogen levels are considered moderate, they may not be sufficient to support optimal plant growth, suggesting that additional nitrogen supplementation may be needed for improved crop yields.

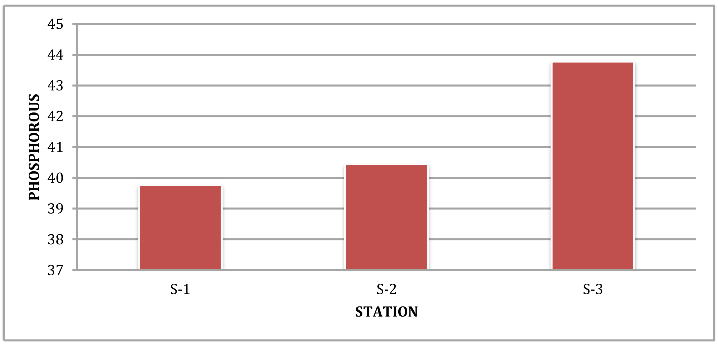


Graph 4: Nitrogen % by mass of soil sample at three stations studied

3.5. Phosphorous

Phosphorus is often referred to as the "master key" element in soil quality due to its critical role in plant growth and development. It is an essential nutrient found in every living cell, playing a pivotal role in processes such as cell division, root development and elongation, seed and fruit development, and early ripening. Phosphorus also contributes to energy storage and transfer within plants, supporting various metabolic processes essential for growth and reproduction [17].

In the study area, the phosphorus content in the soil ranged from 39.76 to 43.76 mg/kg. These levels are important for promoting healthy root systems and ensuring robust plant growth, particularly for crops that require significant phosphorus for optimal yields. The phosphorus present in the soil supports the energy needs of the plants and helps in the efficient formation of seeds and fruits, contributing to overall crop quality and productivity.



Graph 5: Phosphorous (mg/kg) of soil sample at three stations studied

3.6. Potassium

Potassium is a vital nutrient that plays a key role in various physiological processes within plants. It is essential for the production of high-quality crops, as it aids in critical functions such as photosynthesis, protein synthesis, and enzyme activation. Potassium also helps regulate water balance within plants, improving their resistance to drought and disease. Its catalytic role is integral to plant metabolism and overall health. In the study area, the available potassium content in the soil ranged from 785 to 858 mg/kg. Most of the soil samples showed high levels of available potassium, indicating that the soils are well-supplied with this essential nutrient. High potassium availability is beneficial for promoting robust plant growth, enhancing crop yield, and improving the quality of harvested produce. This suggests that potassium management may not be a limiting factor for crop production in the study area.

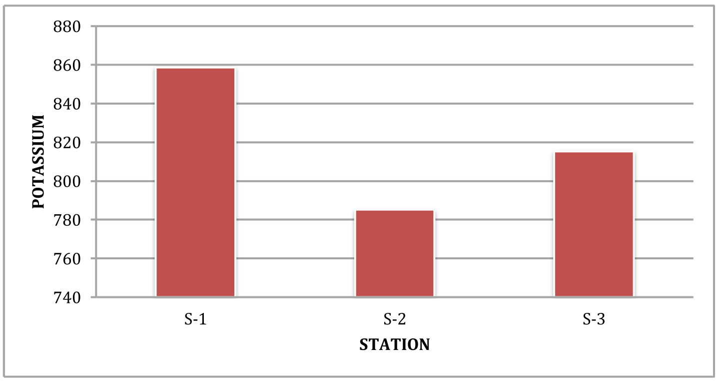


Figure 6: Potassium (mg/kg) by mass of soil sample at three stations studied

4.0. Conclusion

The soil quality assessment in the study area indicated a moderate level of organic carbon, essential for soil structure and fertility. Nutrient levels were higher in irrigated fields, likely due to nearby industries, intensive farming, and the cultivation of high-demand cash crops like sugarcane, cotton, and fruits, which involve significant fertilizer and chemical use. Overall, soil pH in the area was normal, supporting various crops; however, low levels of available phosphorus were noted, highlighting the need for phosphorus supplementation. This nutrient assessment provides valuable guidance for farmers and policymakers. Farmers can use these findings to tailor fertilizer use to actual soil needs, enhancing productivity while conserving resources. For policymakers, this data supports efforts to promote sustainable, long-term soil health management.

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