

Assessment of soil physical and physico-chemical properties of modukuru village of Tsundur mandal in Guntur district using geospatial tools

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ABSTRACT

A total of 202 surface soil samples from Modukuru village, Tsundur mandal, Guntur district, Andhra Pradesh were collected at 300 m grid interval and assessed for soil physical and physico-chemical properties. Soil physical properties like soil colour, soil texture, Water holding capacity and Aggregate stability. Physico-chemical properties like soil reaction (pH), electrical conductivity and organic carbon. The analytical data were statistically interpreted like range, mean, standard deviation and coefficient of variation were calculated and delineated spatial variability maps for soil reaction (pH), electrical conductivity and organic carbon by using QGIS 3.42 software. Results showed that soils were neutral to slightly alkaline with non-saline with low to medium in organic carbon. Colour of the soils ranged between 5YR to 10YR with value and chroma were 2 to 4 and 1 to 2, respectively. Majority of the soils were clay textured, water holding capacity ranged between 17.5 and 71.3 per cent and aggregate stability of the soils ranged from 28 to 88 per cent. By generation of spatial variability maps it has been concluded that pH, EC and OC plays a major role availability of nutrients and in crop development.

Keywords: *Geographic Information System (GIS), Grid sampling and Spatial variability*

Soil is one of the most vital and non-renewable natural resource that supports plant growth, regulates water and serves as a foundation for agricultural productivity. Understanding the physical and physico-chemical characteristics of soil is essential for sustainable land use planning and efficient crop production. Physical properties such as soil texture, colour, water holding capacity and aggregate stability influence root penetration, water availability and aeration. Similarly, physico-chemical properties like soil reaction (pH), electrical conductivity (EC) and organic carbon (OC) significantly affect nutrient availability, microbial activity and overall soil fertility. Assessment of these parameters enables informed decision-making in agriculture, especially under site-specific nutrient and water management practices. Traditional soil surveys often fall short in capturing the spatial variability that naturally exists within a landscape (Patil *et al.*, 2016). Grid sampling emerges as a systematic and reliable method for collecting soil samples at regular intervals, ensuring representative spatial coverage across the study area. When integrated with Geographic Information System tools

such as QGIS, a tool in producing a soil fertility map of an area, which will help in formulating site specific balanced fertilizer recommendation to the crops and to understand the status of soil fertility spatially and temporally (Indhuja *et al.*, 2023). These maps serve as valuable tools for precision agriculture, helping to optimize inputs and enhance productivity while maintaining soil health. The present study was undertaken to evaluate the soil physical and physico-chemical properties using geospatial tools for Modukuru village of Tsundur mandal in Guntur district.

MATERIALS AND METHODS

The study area Modukuru village is located in Tsundur mandal of Guntur district, Andhra Pradesh shown in Figure 1. The geographical area of Modukuru village is 4185 acres (1694 ha) and total cultivable area is 1394.3 ha. Its geographic limits are ranging between 16.06136^o and 16.08459^o North latitude to 80.34134^o and 80.37050^o East longitude. The soils in the Modukuru village were mainly black soils. They are highly productive and

give good crop yields if irrigated. Modukuru experiences a semi-arid or tropical climate with distinct seasonal variations including hot summers, monsoon season and mild winters. Total annual rainfall in 2024 is 874.9 mm and mean maximum and minimum temperatures are 33.4 °C and 25.4 °C respectively. The major cereal crops grown were paddy, maize, green gram and black gram, horticulture crops were lemon, banana and vegetable crops like cauliflower, brinjal and okra.

Soil samples were collected during summer using a hand-held GPS device on grid points of 300 m interval from a depth of 15 cm by making V-shaped pit using crowbar and spade. Then samples were stored in polythene bags with labels and brought to laboratory. They were shade dried for few days, then pounding was done using wooden hammer and sieved through 4mm and 2 mm sieve and then kept ready for analysis. Soil colour was indicated using Munsell Colour Chart. The mechanical analysis was carried out by Bouyoucos Hydrometer method. The sand (2-0.02 mm), silt (0.02-0.002 mm) and clay (<0.002 mm) fractions were calculated using hydrometer readings. The textural classes were determined on the basis of different proportions of sand, silt and clay by using the textural triangle of USDA (Baruah and Barthakur, 1997). The physical constant water holding capacity of soil samples were determined by following Keen Raczkowski's method as described

by Sankaram (1966) and the results were expressed in percentage. Aggregate stability was determined by using Yoder's apparatus (Wet sieving method). The soil reaction (pH) and electrical conductivity (EC) in ratio of soil water extract were measured using standard procedures as described by Jackson (1973). Organic carbon (OC) was determined using Walkley-Black method Walkley and Black (1934) wet oxidation method as outlined by Jackson (1973) and the results were expressed in percentage. Variability of data was assessed using mean, standard deviation and coefficient of variation for the data analyzed represented in Table 2. Ratings for pH, EC and OC were given in Table 1. The results obtained from the physico-chemical analysis (pH, EC and OC) in soil samples in study area were used to generate spatial variability maps by applying Inverse Distance Weighted (IDW) as interpolation tool in QGIS3.42 software, where procedure is represented in Figure 2.

RESULTS AND DISCUSSION

Soil Physical Properties

1. Soil colour

The hue of these soils predominantly ranged from 5YR 10YR, with value and chroma varying from 2 to 4 and 1 to 2, respectively. These Munsell notations indicate that the soils exhibit dark brown to very dark Greyish-brown colours, such colouration can be attributed to the presence of iron compounds in

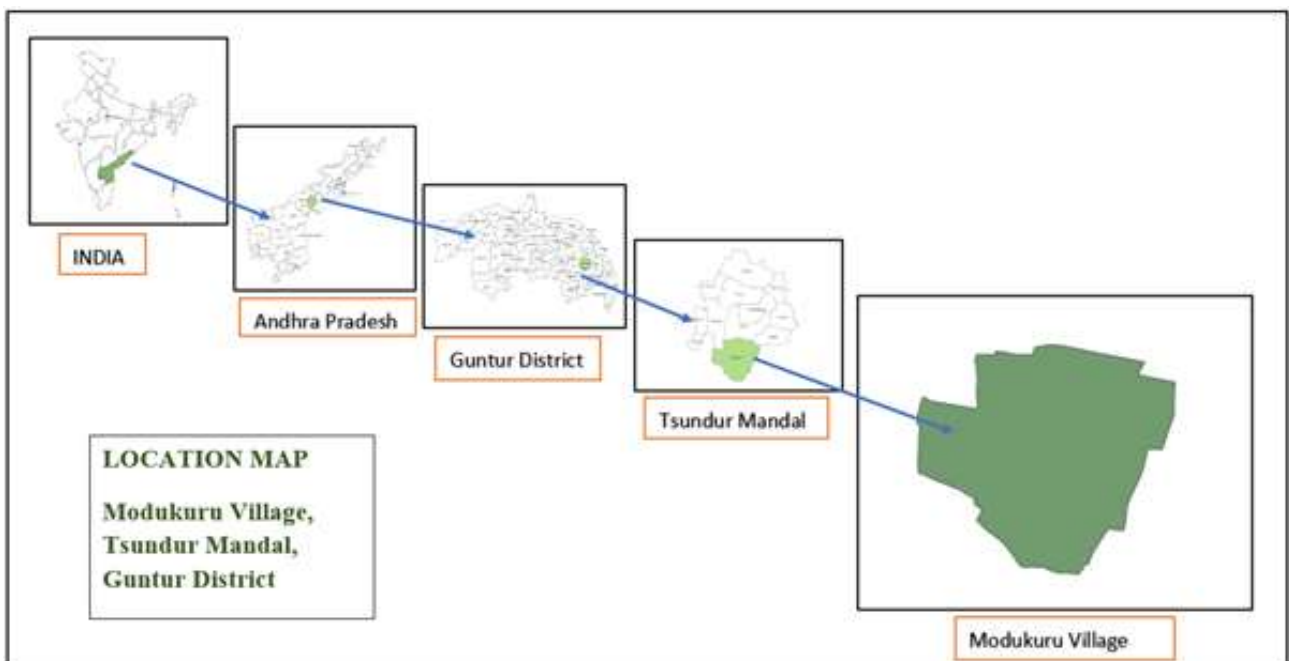
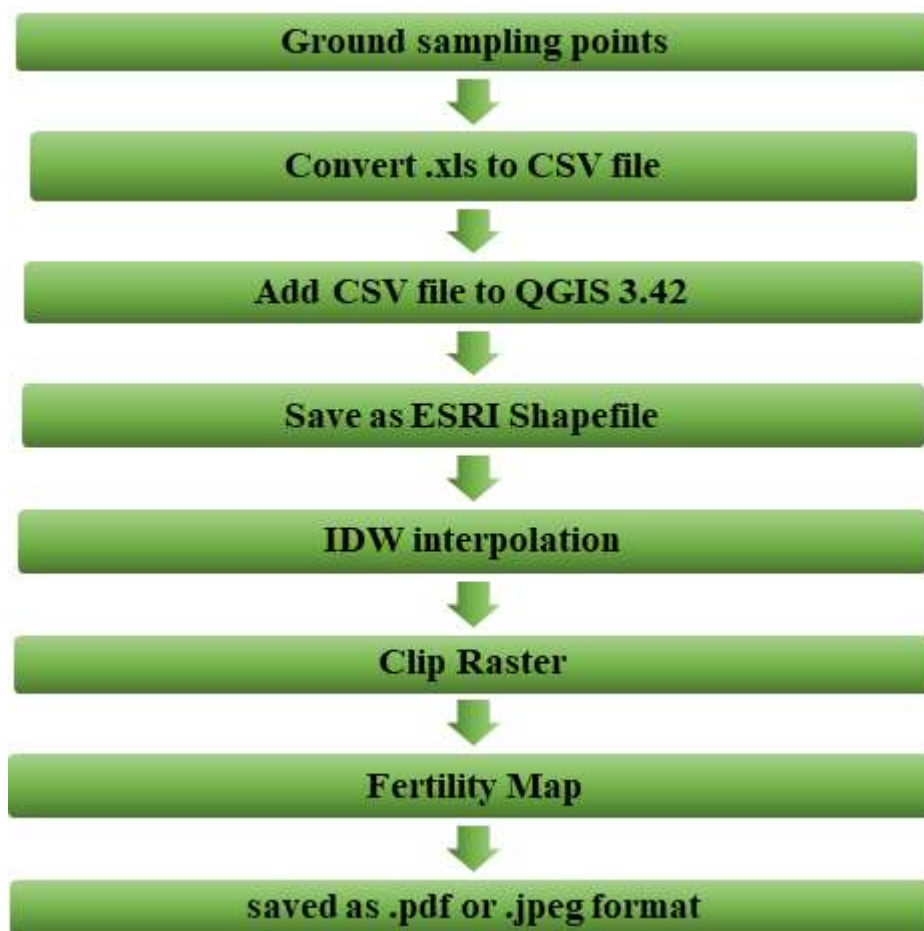


Figure 1. Location map of study area

Table 1. Ratings for soil parameters

S. No.	Parameter	Rating			Reference
		Slightly acidic	Neutral	Slightly alkaline	
1.	Soil Reaction (pH)	< 6.5	6.5 - 7.3	> 7.3	Jackson (1973)
		Non-saline	Saline		
2.	Electrical Conductivity (EC)	< 2dS m ⁻¹	> 2dS m ⁻¹		
		Low	Medium	High	
3.	Organic Carbon (%)	< 0.5	0.5 - 0.75	> 0.75	Ramamoorthy and Bajaj (1969)

**Figure 2. Methodology for developing soil fertility maps by IDW method**

reduced forms due to periodic waterlogging or poor drainage, which is characteristic of Vertisols. Additionally, the low chroma values suggest a high level of organic matter or prolonged saturation conditions, both of which contribute to the dullness of the soil colour. These observations in accordance with those made by Lakshmi *et al.* (2020)

2. Soil Texture

The analysis of soil texture revealed a variation in soil types from clay to loamy sand. Among the 202 soil samples analyzed for texture 63.87 per cent were clay in texture, 23.27 per cent samples were clay loam in texture, 8.41 per cent samples were sandy clay loam in texture, 2.97 per cent samples were sandy loam in texture, 0.99 and 0.49 per cent samples were sandy clay and loamy sand in texture, respectively. Statistical data was represented in Table 2. The variations in particle size distribution across the study area could

Table 2. Summary and statistics of physical and physico - chemical properties the study area

	Sand	Silt	Clay	WHC	TWSA	O.C	pH	E.C (dS m ⁻¹)
	(%)						(1:2.5)	
Range	Aug-84	May-37	Nov-78	17.5 – 71.2	28 – 88	0.21 – 0.79	6.10 – 7.69	0.13 – 1.96
Mean	27.1	19.1	47.6	49.1	57.4	0.49	7.2	0.4
Standard deviation	14.5	5.65	12.6	9.76	17.3	0.13	0.17	0.26
C.V (%)	53.7	29.5	26.4	19.8	30.1	25.8	2.42	65.6

TWSA: Total water stable aggregates

be attributed to several factors, including the nature of the parent material, the extent of weathering and the patterns of sediment deposition. Higher clay content could result from slower weathering processes and reduced erosion, which contribute to the formation of clay loam and clay textures within the region. Similar observations were reported by Sashikala *et al.* (2019)

3. Water Holding Capacity(WHC)

Soil samples were analyzed for water holding capacity (WHC), which varied between 17.5 and 71.3 per cent, with an average of 49.1 per cent, a standard deviation of 9.76 and a coefficient of variation of 19.8 per cent. Among the various soil textures, clay soils recorded the maximum WHC at 71.2 per cent, while loamy sand showed the minimum at 17.5 per cent. This wide variation in WHC is primarily influenced by differences in clay, silt, and organic carbon content. Higher content of organic carbon and clay records high water retention due to high specific surface area. Comparable findings were reported by Pulakeshi *et al.* (2014).

4. Aggregate stability

Analysis of 202 soil samples showed that aggregate stability ranged from 28 to 88 per cent. Among the different textural classes, clay soils exhibited the highest stability, with values reaching 88 per cent, while some sandy loam and sandy clay loam samples showed little to no aggregation. Soil aggregation is strongly influenced by factors such as organic matter, clay content, and overall texture, which are critical in binding soil particles. Organic matter promotes microbial activity and supports the formation of stable aggregates, while finer particles like clay enhance cohesion and structural strength. Similar

observations were reported by Aziz and Karim (2016) and Haghghi *et al.* (2010).

Soil Physico Chemical Properties**1. Soil Reaction (pH)**

The soils were neutral to slightly alkaline with pH ranged from 6.10 to 7.69 with mean of 7.20, standard deviation of 0.17 and a coefficient of variation of 2.42 percent shown in Table 2. The spatial variability mapping of soil pH indicated that approximately 0.99 per cent of the total area covering 13.8 ha exhibited a slightly acidic reaction. A major portion of the study area accounting for 74.7 per cent (1042.2 ha) was found to be neutral in reaction and about 24.2 per cent of the area (338.3 ha) was characterized as slightly alkaline in soil reaction depicted in figure 3. The neutral to slightly alkaline nature of the soils might be due to the composition of the parent material, retention of basic cations in the soil, leading to the interaction between fertilizers and soil colloids, resulting a neutral to alkaline pH. (Sharma *et al.*, 2008) and (Shalima devi and Anil kumar 2010).

2. Electrical Conductivity (EC)

The soil electrical conductivity (EC) in the study area ranged from 0.13 to 1.96 dS m⁻¹, with an average of 0.40 dS m⁻¹. The standard deviation was 0.26 and the coefficient of variation was 65.61 per cent (Table 2). Since all EC values were below 2 dS m⁻¹, the soils were classified as non-saline. The spatial variability mapping of soil EC is depicted in figure 4. The non-saline nature of the soils could be due to the consistent use of good-quality, non-saline irrigation water, the presence of efficient drainage systems and adequate rainfall might result from the leaching of soluble salts into deeper soil layers. The low rate of evaporation, favourable soil properties and adoption

of sustainable farming practices may have supported the maintenance of low salinity levels in the soils. (Jagadish *et al.*, 2017 and Sashikala *et al.*, 2019).

3. Soil organic carbon

The organic carbon content of soils in the study area exhibited a wide range, from 0.21 to 0.79 per cent, with an average of 0.49 per cent, standard deviation was recorded at 0.13 and the coefficient of variation was 25.88 per cent (Tables 2). The spatial variability of soil organic carbon depicted in figure 5, indicated

that 0.99 per cent of the study area (13.8 ha) exhibited high organic carbon content. A major portion of the area, approximately 51.49 per cent (717.9 ha), was found to have medium organic carbon content, while the remaining 47.52 per cent (662.6 ha) showed low organic carbon content. Moderate levels of organic carbon could be due to incorporation of organic materials and crop rotation practices, which contribute to periodic enrichment of soil organic matter. On the other hand, low levels of organic carbon may be associated with suboptimal soil management practices,

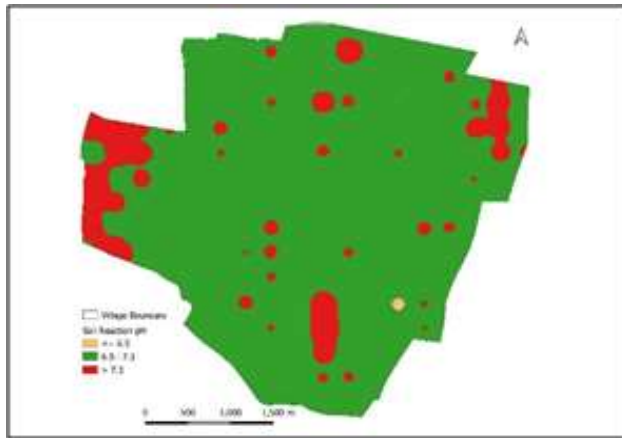


Fig. 3. Spatial variability of soil reaction (pH)

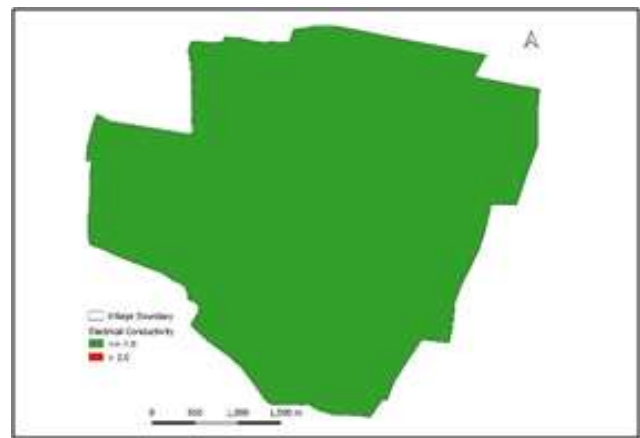


Fig. 4. Spatial variability of electrical conductivity

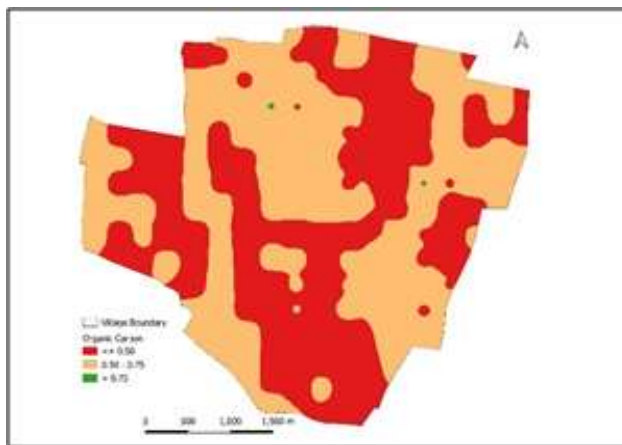


Fig. 5. Spatial variability of soil organic carbon

such as the minimal application of organic inputs, continuous cropping without adequate rest periods and poor land use strategies. (Sashikala *et al.*, 2021, Indhuja *et al.*, 2024 and Yavanika *et al.*, 2021)

CONCLUSION

From this study, the evaluation of physical and physico-chemical properties of soils in Modukuru

village has highlighted noticeable differences across the study area. Most of the soils were clayey in nature, contributing to better water retention and structural stability. The variation in soil colour indicated differences in mineral composition and organic matter status. The soils were generally neutral to slightly alkaline and free from salinity, making them suitable for a wide range of crops. Organic carbon content was found to be low to medium, suggesting the potential benefit of adding organic amendments to maintain soil fertility. The spatial distribution maps developed using QGIS provided a clear picture of how properties like pH, EC and OC vary across the study area. These results emphasize the importance of regular soil testing and the use of geospatial tools for precise soil fertility management and sustainable agricultural practices.

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