STM JOURNALS

International Journal of
Solid State Innovations & Research

Volume 3, Issue 1, 2025
January–June
DOI (Journal): 10.37591/IJSSIR

https://journals.stmjournals.com/ijssir

Case Study IJSSIR

Physicochemical Analysis of Soil Quality Parameters in Tamil Nadu Region: An Analytical Approach Towards Life on Land and SDG 15

R. Vijayaprasath[1,*], M. Anandaraj[1], A. Mohamed Ashik[1]

Abstract

This study examines the physicochemical properties of soil in Tamil Nadu region, supporting SDG 15's framework for sustainable land management. Soil, as a vital non-living component, plays a crucial role in ecosystem functioning by facilitating nutrient cycling, retaining water, and supporting habitats for a wide range of organisms. The work analysis includes key physical parameters like colour, texture, structure, porosity, density, consistency, and temperature, and chemical properties, focusing on both macro and micronutrients. Various soil types (loamy, sandy, chalk, peat, silt, clay) are evaluated for their agricultural suitability and ecosystem functions. The analysis emphasizes soil's role in preventing groundwater contamination and supporting plant stability. This comprehensive assessment aids in understanding soil productivity factors, supporting informed agricultural practices, and contributing to SDG 15's goals of sustainable terrestrial ecosystem management and soil resource conservation in Tamil Nadu's agricultural landscape.

Keywords: Physicochemical, SDG, porosity, density, soil, ecosystem

INTRODUCTION

Soil, the vital superficial layer of earth's crust, represents one of the most fundamental and complex natural systems supporting life on our planet. Known scientifically as "solum", this dynamic medium serves as the cornerstone of terrestrial ecosystems and agricultural productivity. It emerges through the intricate interplay of weathering processes, driven by both climatic factors (including water, light, and temperature) and biological agents (such as plants, animals, and microorganisms) [1].

The complexity of soil lies in its unique composition, incorporating inorganic minerals, organic matter, and diverse living organisms in a delicate balance. This living matrix not only provides essential physical support for plant growth but also functions as a sophisticated natural filtration system, capable of purifying water, neutralizing pathogens, and degrading environmental contaminants. Furthermore, soil plays a crucial role in global biogeochemical cycles, participating in gas exchange processes by absorbing oxygen and methane while releasing carbon dioxide and nitrous oxide [2].

The quality and fertility of soil can be assessed through various physicochemical parameters, including total organic carbon content, available macro nutrients (nitrogen, phosphorus, and potassium), pH levels, electrical conductivity, and physical properties such as texture and bulk density. These characteristics collectively determine soil's capacity to support plant growth, maintain ecosystem health, and provide environmental services [3–10].

***Author for Correspondence**
R. Vijayaprasath
E-mail: rahul.kundiya@vpmmpcoe.org

[1]Student, Department of Electronics and Communication Engineering, Manakula Vinayagar Institute of Technology, Kalitheerthalkuppam, Puducherry, India

Received Date: January 10, 2025
Accepted Date: March 25, 2025
Published Date: April 09, 2025

Citation: R. Vijayaprasath, M. Anandaraj, A. Mohamed Ashik. Physicochemical Analysis of Soil Quality Parameters in Tamil Nadu Region: An Analytical Approach Towards Life on Land and SDG 15. International Journal of Solid State Innovations & Research. 2025; 3(1): 9–15p.

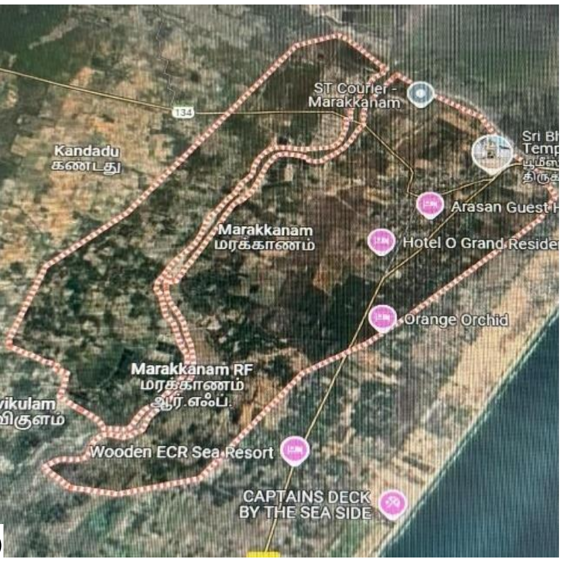
METHODS AND MATERIALS

Soil Physicochemical Analysis

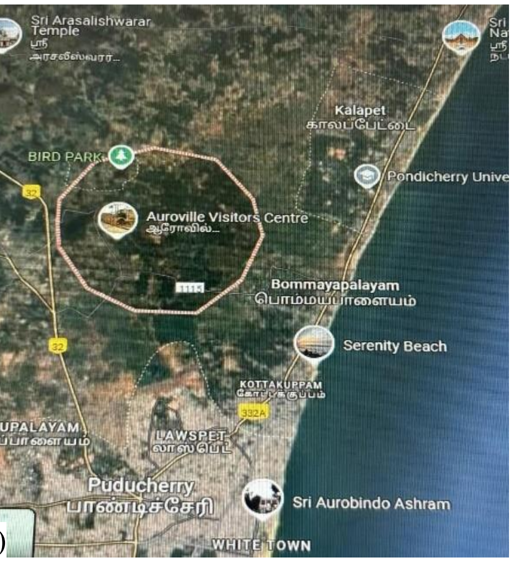
List of physicochemical parameters and their test methods is shown in Table 1. The soil samples were analysed using a standardized procedure to examine key physical and chemical properties, including colour, pH, electrical conductivity, nitrogen (N), chloride (Cl), sulfate (SO_4), sodium (Na), potassium (K_2O), sulfur (S), and carbon (C). Soil samples were collected from three different locations in three different ecosystems: seashore Auroville (Latitude 11055'N and Longitude 7904917.40'E), Marakanam (Latitude 12.1890N and Longitude 79.92490E), and Poondiyankuppam (Latitude 13.07690N and Longitude 80.18960E) in the Palk Strait coastal region of Tamil Nadu, India. A spade was used to remove surface-contaminated dirt to a depth is shown in Figure 1(a)–(c).

Table 1. List of physicochemical parameters and their test methods.

S.N.	Physicochemical parameter	Unit	Test method
1.	Cation exchange capacity	meq/100g	EPA 9081 - 1986
2.	Magnesium as Mg	mg/kg	SMSLA/WT/SOP/021 - 2024
3.	Phosphorous as P	mg/kg	IS 10158 - 1982 (Reaffirmed 2019)
4.	Potassium as K	mg/kg	IS 10158 - 1982 (Reaffirmed 2019)
5.	Total Nitrogen as N	mg/kg	IS 14684 - 1999 (Reaffirmed 2019)
6.	Sulphate	%	SMSLA/WT/SOP/012 - 2024
7.	Conductivity at 25°C	µS/cm	IS 14767 - 2000 (Reaffirmed 2021)
8.	pH at 25°C	NA	IS 2720 (Part 26) - 1987 (Reaffirmed 2021)
9.	Iron	mg/kg	EPA 3050 B - 1996



(a)
Seashore Auroville



(b)
Marakanam

(c)
Poondiyankuppam

Figure 1. (a)–(c) Soil samples were collected from three different locations in three different ecosystems.

Sample Collection and Study Area

Soil samples were gathered from three distinct ecosystems at different locations: Seashore Auroville (Latitude 11.0955°N, Longitude 79.8217°E), Marakanam (Latitude 12.1890°N, Longitude 79.9249°E), and Poondiyankuppam (Latitude 13.0769°N, Longitude 80.1896°E) within the marine environment of the Palk Strait coastal region in Tamil Nadu, India. To ensure uncontaminated samples, the top 2 cm of surface soil was removed using a spade. Samples were then collected by digging V-shaped holes up to a depth of 20 cm, and the extracted soil was placed in a clean plastic bucket. The collected soil was labelled according to the respective locations, air-dried, and allowed to form small cubes due to the wind before being securely stored in clean plastic bags for further laboratory analysis [11–17].

pH

The pH scale calculates Hydrogen ion quantity in a solution (Figure 2). Jackson used a potentiometric pH meter to measure the pH of the soil using a 2.5 soil water suspension ratio [18]. The alkaline side is represented by the pH value, which is higher than 7. An indicator of saline or salt-impacted soil is alkalinity. A soil type is classified as acidic if its pH is less than 6.0, as normal if its pH is between 6 and 8.5, and as alkaline if its pH is greater than 8.5 [18]. The pH varied from 7.1 to 8.3, with a mean of 7.52, a unique deviation of 0.30, and a coefficient of variation of 4.0% (Table 1). The farmed lands' pH level.

Electrical Conductivity

The capability of the soil to carry electricity is a critical feature. It shows how much soluble salt is present in the soils overall. Ions in the soil sample are measured by the conductivity value. The cations of clay and colloidal particles are swapped out for the cations of soil and salt solutions in proportional amounts throughout this process. Cation exchange describes the process in which cations are exchanged between soil and a salt solution. CO_3, HCO_3, and PO_4 are anions, while cations include Ca, Mg, Na, and K. The conductivity levels can vary based on the soil's chemical characteristics. An EC of less than 4 indicates a regular soil type. An EC value of 0.50 to 0.73 dSm^{-1} is found in a soil from the study location. EC values lower in all soil samples (Figure 3).

Organic Carbon

Organic matter is an important soil component that improves soil fertility. Soil organic carbon is the basis of soil fertility. It raises soil organic carbon, which improves soil fertility and health, and releases nutrients for plant growth [18]. The information is provided in Table 2. The range of organic carbon is 0.52 to 0.72% (Figure 4).

Nitrogen

Using the alkaline permanganate technique, the amount of nitrogen that was available was decided [19]. Nitrogen is an essential nutrient for plants to develop their canopy. In addition to causing yellowish green leaves to grow more slowly, a nitrogen deficiency also lowers protein yields and content. All soil samples have low nitrogen levels [18]. The Marathwada soil had a high to medium level of available potassium (Figure 5).

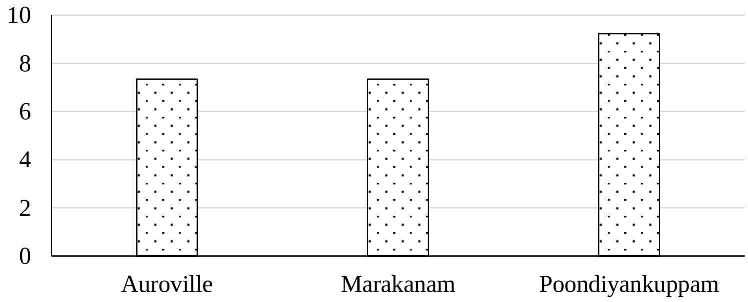


Figure 2. pH scale calculates hydrogen ion quantity in a solution.

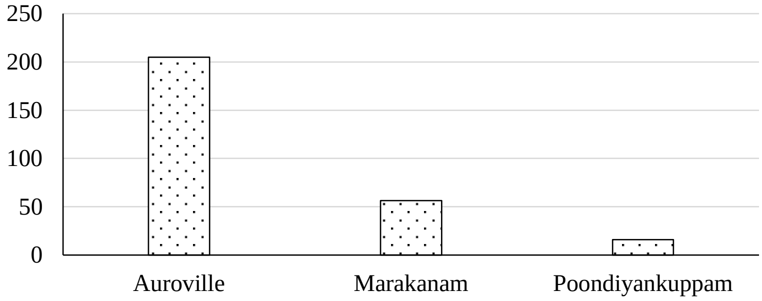


Figure 3. Electrical conductivity in all soil samples.

Table 2. Comparative analysis of soil quality parameters across three locations.

S.N.	Parameter	Unit	Auroville (A)	Marakanam (B)	Poondiyankuppam (C)
1	Nitrogen	mg/kg	BLQ (LOQ 5.0)	629	336
2	Iron	mg/kg	1946.23	44	7213
3	Organic carbon	meq/100 g	0.46	BLQ (LOQ 10.0)	BLQ (LOQ 10.0)
4	Magnesium	mg/kg	28	3070	2107
5	Potassium	mg/kg	71	880	1098
6	pH	SU	7.35	7.34	9.23
7	Conductivity	mmho/cm	2590	43.3%	8.3%
8	Phosphorus	kg/ha	28	36.9%	14.6%
9	CEC	CMP/kg	BLQ (LOQ 10.0)	19.5%	77.1%

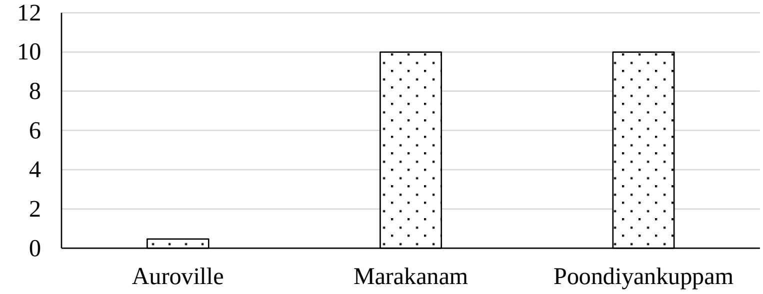


Figure 4. Organic carbon present in the soil sample.

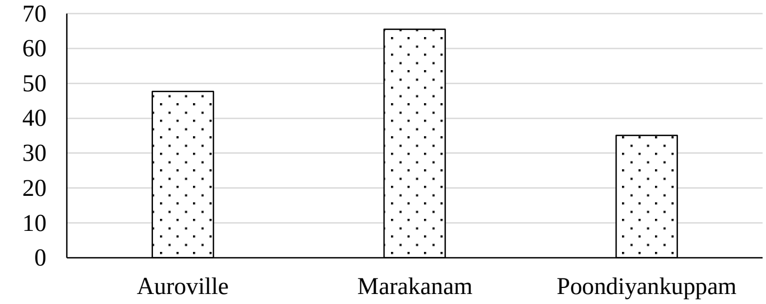


Figure 5. Amount of nitrogen present in all soil samples.

Phosphorous

The essential substance for soil level is phosphorous. It is a crucial substance of all living cells. It is essential for growth, cell division, root development and elongation, seed and fruit maturation, and early ripening. It also facilitates the transfer and storage of energy. Phosphorous levels in the study area range from 15.11 to 54.13 kg/ha (Figure 6). Figure 5 Fertility, Status of the research field 3.6. Potassium is essential for several plant physiological functions.

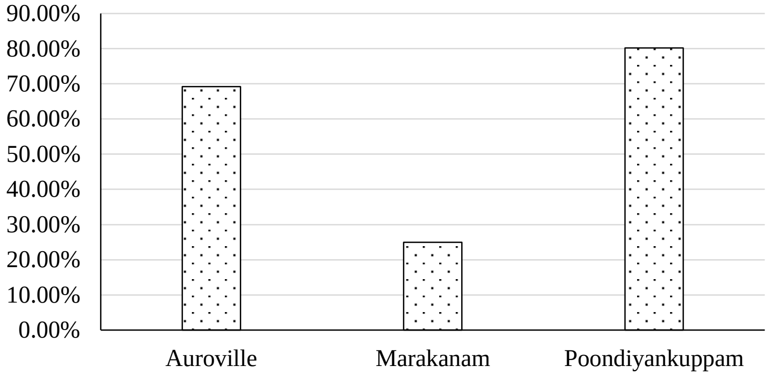


Figure 6. Phosphorous levels in the study area.

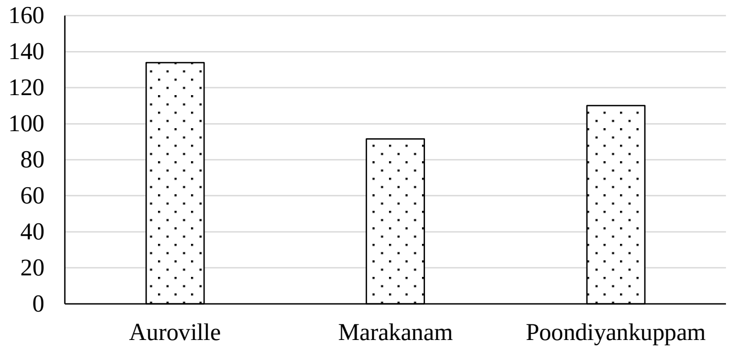


Figure 7. Potassium data available in all soil samples.

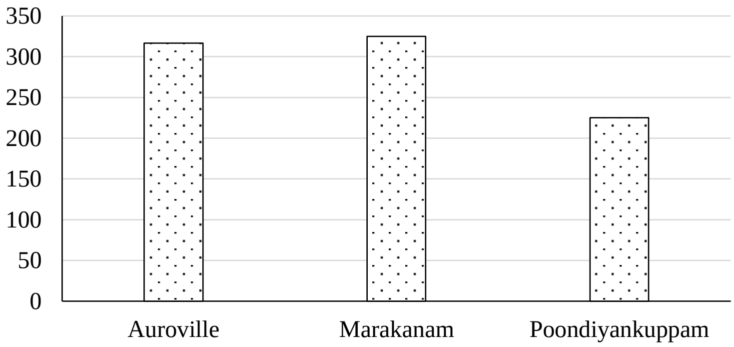


Figure 8. Magnesium content in soil.

Potassium

Potassium is necessary for several plant physiological functions. Potassium is a necessary ingredient for producing standard-quality crops. It mainly serves a catalytic function. The potassium data available varies from 125.31 and 630.15 kg/ha. Most soil samples had a high level of accessible potassium [18]. The Marathwada soil had a moderate to medium available potassium level (Figure 7) [18–20].

Magnesium

A necessary ingredient for the growth and development of plants is magnesium (Mg). Magnesium is a crucial component of the chlorophyll molecule in plant tissue and plays a role in many physiological and biochemical processes within plants. Hence, poor and stunted plant growth is the result of a lack of chlorophyll if magnesium is insufficient. The production of enzyme activators and chlorophyll are the two primary functions of magnesium in plants. A sufficient magnesium supply is necessary for energy transmission, protein synthesis, and photosynthesis. Only a minor fraction of the total magnesium content in soil (which is 0.05–0.5%) exists in forms that plants can utilize (Figure 8).

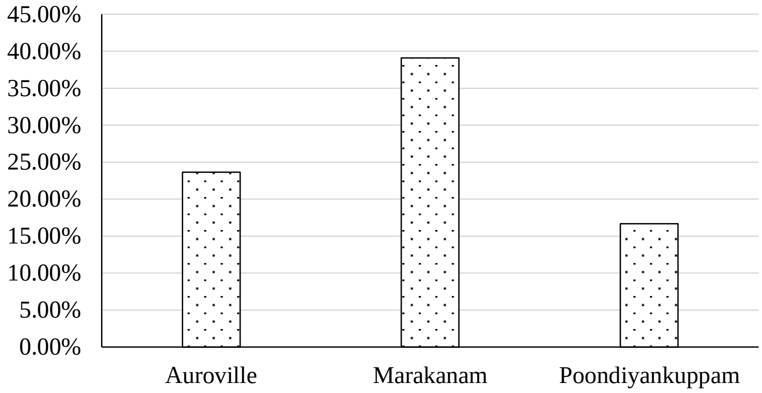


Figure 9. Availability of iron.

Iron

Strangely, anaerobic circumstances produced by wet soils with abundant organic matter and low soil oxygen levels make iron more available to plants at potentially harmful amounts. Additionally, iron is essential for certain acidic soils to become hazardous due to its participation in essential activities like photosynthesis (Figure 9).

CONCLUSION

The soil analysis from Auroville, Marakanam, and Poondiyankuppam reveals diverse soil characteristics that align with SDG 15's mission to protect, restore, and promote sustainable use of terrestrial ecosystems. To achieve sustainable land management, each location requires specific interventions. Marakanam, with its optimal nitrogen levels (629 mg/kg) and neutral pH (7.34), presents an opportunity for immediate sustainable agriculture while protecting soil biodiversity. For Poondiyankuppam's high iron content (7213 mg/kg) and alkaline conditions (pH 9.23), implementing sustainable forest management and agroforestry practices could help balance soil chemistry. Auroville's acidic soil (pH 5.30) could benefit from organic matter addition and conservation agriculture techniques to combat land degradation. The consistently low organic carbon levels across sites indicate a need for sustainable soil management practices, including crop rotation, organic farming, and reduced tillage. These strategies would support SDG 15's targets of restoring degraded land, enhancing biodiversity, and promoting fair resource sharing while ensuring sustainable food production. Marakanam's superior conductivity and phosphorus levels make it ideal for demonstrating how sustainable agriculture can coexist with ecosystem protection.

REFERENCES

1. Ghare PM, Kumbhar AP. Study on physicochemical parameters of soil sample. Int Adv Res J Sci Eng Technol. 2021; 8(9): 171–87.
2. Bania A, Sheoran V. Analysis of Soil Quality Using Physicochemical Parameters with Emphasis on Fluoride from The Backfilled Mining Areas of Sanu Mines, Jaisalmer, Rajasthan, India. Int J Aquatic Science. 2021 Jun 1; 12(3): 121–31.
3. Gedam SB. Physicochemical analysis of selected agricultural soil samples in Bramhapuri Taluka of Chandrapur district, Maharashtra. International Journal of Current Science (IJCSPUB). 2022; 12(1): 188–97. www. ijcspub.
4. Bharti V, Kaushal D, Kumar S, Thakur A, Rana DS, Kumar M, Kant S. Molecular interaction studies on the binding ability of hydrated zinc sulphate with aqueous solution of ascorbic acid at different temperatures. Z für Phys Chem. 2022 Oct 1; 236(10): 1339–56.
5. Jenifer P, Samuel AS. Study of Physicochemical Characteristics of Agricultural Soils of Tuticorin District, Tamil Nadu, India. Asian J Pharm Res. 2016; 6(1): 21–3.
6. Osman KT. Plant nutrients and soil fertility management. In: Soils: Principles, properties and management. Dordrecht: Springer; 2013; 129–59.

7. Pattnaik BI, Chaturvedi NI, Kar DA. Germination and seedling growth of some selected agricultural crops under various abiotic stresses. Int J Pharm Pharm Sci. 2016; 8(7): 360–4.
8. Minami K. Soil and humanity: Culture, civilization, livelihood and health. Soil Sci Plant Nutr. 2009 Oct 1; 55(5): 603–15.
9. Kumar R, Meena R, Sharma BD, Saroj PL. Production technology of pomegranate in arid region. Bikaner, India: ICAR-Central Institute for Arid Horticulture; 2018; 1–34.
10. Marathe RA, Sharma JY, Babu KD. Identification of suitable soils for cultivation of pomegranate (Punica granatum) cv Ganesh. Indian J Agric Sci. 2016 Feb 1; 86(2): 227–33.
11. Renard KG. Predicting soil erosion by water: a guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE). US Department of Agriculture, Agricultural Research Service; 1997.
12. Sarwade VD, Bodkhe YT, Pawar DK, Lokhende PD, Gawai KR, Misal S. Comparative studies on selected chemical properties of soil of “Zikri” area of Jamkhed Tahasil of Ahemednagar (Maharashtra). RASAYAN J Chem. 2010 Aug; 03(02): 299–304.
13. Adugna G. A review on impact of compost on soil properties, water use and crop productivity. Acad Res J Agric Sci Res. 2016 Mar; 4(3): 93–104.
14. Daji JA, Kadam JR, Patil ND. A Textbook of Soil Science. India: Media Promoters and Publishers; 1980.
15. Solanki HA, Chavda NH. Physico-chemical analysis with reference to seasonal changes in soils of Victoria Park reserve forest, Bhavnagar (Gujarat). Life Sci Leafl. 2012;8:62–8.
16. Oseni OA, Ekperigin MM, Akindahunsi AA, Oboh G. Studies of physiochemical and microbial properties of soils from rainforest and plantation in Ondo state, Nigeria. Afr J Agric Res. 2007 Nov 1; 2(11): 605–9.
17. Schlesinger WH, Reynolds JF, Cunningham GL, Huenneke LF, Jarrell WM, Virginia RA, Whitford WG. Biological feedbacks in global desertification. Science. 1990 Mar 2; 247(4946): 1043–8.
18. Johnston AE, Poulton PR, Coleman K. Soil organic matter: its importance in sustainable agriculture and carbon dioxide fluxes. Adv Agron. 2009 Jan 1; 101: 1–57.
19. Dandwate SC. Analysis of soil samples for its physicochemical parameters from Sangamner city. GSC Biol Pharm Sci. 2020; 12(2): 123–8.
20. Kardol P, Martijn Bezemer T, Van Der Putten WH. Temporal variation in plant–soil feedback controls succession. Ecol Lett. 2006 Sep; 9(9): 1080–8.

