Geospatial Distribution of Physio Chemical Parameter of Ground Water

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Abstract

Groundwater is one of the most essential natural resources supporting domestic, agricultural, and industrial activities, and its quality directly determines the sustainability of human life and ecological balance. The assessment of groundwater quality has become increasingly significant due to growing urbanization, industrialization, and over-extraction of water resources, which lead to contamination and deterioration of water quality. This project focuses on the Geospatial Distribution of Physicochemical Parameters of Groundwater, emphasizing thespatial variability and mapping of key parameters such as pH, alkalinity, acidity, chloride, hardness, turbidity, iron, dissolved oxygen, availabe chlorine, colour , odour and taste using advanced Geographic Information System (GIS) techniques. By integrating field data with spatial interpolation methods such as Inverse Distance Weighting (IDW) or Kriging, the study aims to visualize and analyze the spatial trends of groundwater quality across the study area. The geospatial analysis not only identifies contamination-prone zones but also helps in understanding the influence of natural and anthropogenic factors on groundwater chemistry. Furthermore, Water Quality Index (WQI) is employed to classify the suitability of groundwater for drinking and irrigation purposes, providing a clear and comprehensive representation of the water quality status. The f indings of this project will serve as a valuable tool for planners, environmental engineers, and policymakers to implement effective groundwater management and protection strategies. The integration of geospatial technology with hydrochemical analysis ensures a scientific and systematic approach to sustainable groundwater resource assessment and contributes to the long-term goal of environmental preservation and water security.

Keywords: Groundwater quality, GIS, physicochemical parameters, spatial distribution, water quality index, hadrochemical analysis, contamination mapping, sustainable water management.

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1. Introduction

Groundwater is one of the most valuable natural resources that supports life on Earth and contributes significantly to domestic, agricultural, and industrial needs. It forms the major source off resh water in many parts of the world and plays an in dispensable role in maintaining the ecological balance and promoting sustainable development. However, with rapid urbanization, population growth, and industrial expansion, the quality and quantity of groundwater have been increasingly affected. Excessive exploitation of aquifers and uncontrolled human activities such as the use of fertilizers and pesticides, waste dumping, and industrial effluent discharge have resulted in the contamination of groundwater resources. The quality of groundwater depends on the geological formations, climatic conditions, and anthropogenic factors that influence its physicochemical characteristics. Parameters such as pH, alkalinity, acidity, chloride, hardness, turbidity, iron, dissolved oxygen, available chlorine, colour, odour and taste are important indicators of water quality and determine its suitability for drinking, irrigation, and industrial use. Conventional analysis methods, while useful, often fail to represent spatial variations in groundwater characteristics. To overcome these limitations, modern geospatial tools such as the Geographic Information System (GIS) and Remote Sensing (RS) are now extensively used to analyze, interpret, and visualize spatial distributions of water quality parameters. GIS based mapping provides a powerful means to integrate field and laboratory data, enabling the identification of contamination zones and supporting sustainable groundwater management. Therefore, the geospatial distribution study of physicochemical parameters plays a vital role in understanding the spatial behaviour of groundwater quality and ensuring its safe utilization.

1.1 Objectives of the Study

To assess the groundwater quality of the study area by analyzing physico-chemical parameters and representing their spatial distribution using GIS techniques.

- To collect groundwater samples from selected representative locations within the study area.
- To analyze important physico-chemical parameters such as pH, alkalinity, acidity, chloride, hardness, turbidity, iron, dissolved oxygen, available chlorine, colour, odour, and taste.
- To compare the analyzed water quality parameters with the permissible limits prescribed by WHO and BIS standards.
- To prepare spatial distribution maps of groundwater quality parameters using GIS (QGIS) software.
- To identify areas affected by groundwater contamination within the study area.
- To study the spatial variation of groundwater quality from one location to another.
- To suggest suitable recommendations for proper groundwater management and sustainable use.

1.2 Scope of the Study

- The study is limited to the assessment of groundwater quality in selected wards of Adat Panchayat, Thrissur district.
- The scope includes the collection of groundwater samples from representative locations within the study area.
- The study focuses on the analysis of selected physico-chemical parameters such as pH, alkalinity, acidity, chloride, hardness, turbidity, iron, dissolved oxygen, available chlorine, colour, odour, and taste.
- The analysis is carried out by comparing the observed values with WHO and BIS drinking water standards.
- The scope includes the use of GIS (QGIS) techniques to prepare spatial distribution maps of groundwater quality parameters.

- The study helps in identifying spatial variation and possible contamination zones in groundwater within the Panchayat.
- The scope of the study is confined to water quality assessment only and does not include groundwater quantity estimation or seasonal variation analysis.

2. Materials And Methods

2.1 Materials Used

The materials used for the present study are grouped under the following categories:

- Groundwater samples
- Laboratory equipment and chemicals
- Software and spatial data (QGIS and shapefiles)

2.1.1 Groundwater Sample

Sand Groundwater samples are the primary material used for this study. The samples were collected from selected representative locations in different wards of Adat Panchayat, Thrissur district.

Details of Sample Collection

- Samples were collected from open wells, tap water, and other groundwater sources.
- Clean and sterilized plastic bottles were used for sample collection.
- Bottles were rinsed with sample water before final collection.
- Samples were collected carefully to avoid contamination.
- Each sample was properly labeled with sample ID, ward number.

Information Recorded

For each groundwater sample, the following details were recorded:

- Sample identification number
- Ward number
- Location name
- Type of groundwater source
- Latitude and longitude

Sample No	Ward No	Water collected area	Latitude	Longitude
1	19	House	10°32’35.07”N	76°8’37.34”E
2	9	River	10°32’44.65”N	76°10’50.62”E
3	10	House	10°33’5.42”N	76°10’22.53”E
4	11	House	10°33’7.84”N	76°10’34.22”E
5	13	House	10°33’10.47”N	76°9’57.87”E

6	5	Hospital	10°33’45.73”N	76°10’5.41”E
7	5	House	10°33’33.59”N	76°9’57.87”E
8	8	School	10°33’38.32”N	76°9’40.33”E
9	1	Church	10°33’50.46”N	76°8’25.92”E
10	2	Canteen	10°33’50.46”N	76°9’6.28”E

Table 1: Groundwater Samples

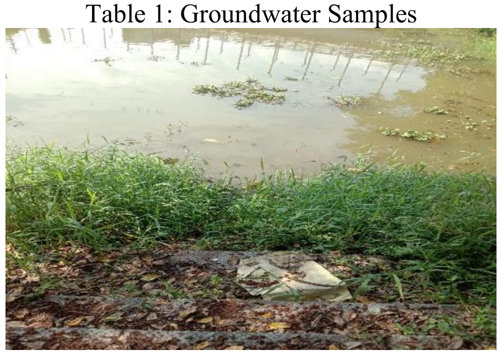

Figure 1 : Water sample from river

2.1.2 Laboratory Equipment and Chemicals

The following laboratory equipment and chemicals were used for the analysis of groundwater samples:

- Sample collection bottles
- Beakers and conical flasks
- Measuring cylinders
- pH meter
- Turbidity meter
- Dissolved Oxygen (DO) testing apparatus
- BOD bottles
- Standard chemicals and reagents

All instruments were calibrated before use, and testing was carried out following standard laboratory procedures.

Figure 2 : Standard Chemicals and Reagents

2.1.3 Software and Spatial Data Used

QGIS Software

QGIS (Quantum Geographic Information System) is an open-source GIS software used in this study to prepare spatial maps of groundwater quality parameters.

QGIS was used to:

- Import latitude and longitude data of sampling locations
- Load shapefiles of administrative boundaries
- Prepare spatial distribution maps

Shapefiles Used

Shapefiles represent geographic boundaries in digital format. The following shapefiles were used:

- India boundary shapefile
- Kerala state boundary shapefile
- Thrissur district boundary shapefile

Adat Panchayat boundary shapefile

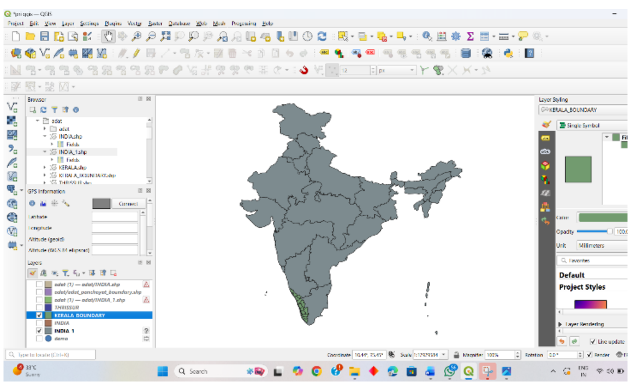

Figure 3: Location of study area in India

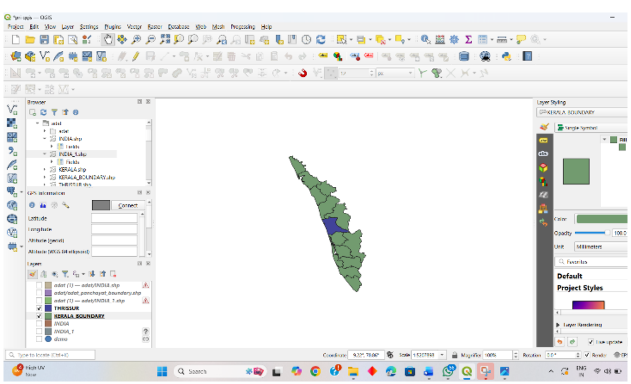

Figure 4: Location of study area in Kerala

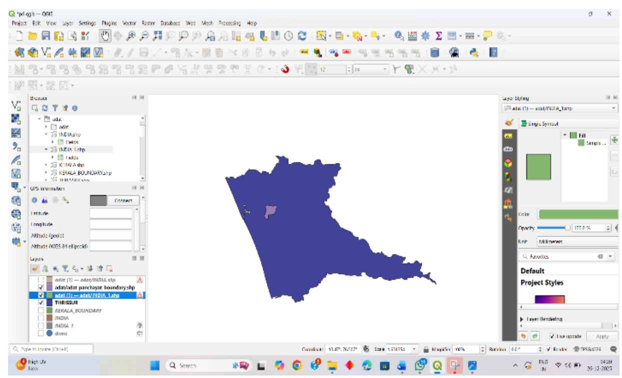

Figure 5: Location of study area Thrissur District

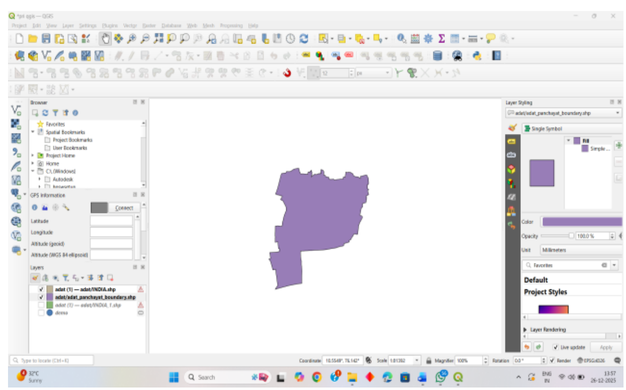

Figure 6: Adat panchayat

2.2 Methodology

The methodology adopted for this study was carried out in a systematic and step-wise manner to ensure reliable results.

2.2.1 Selection of Study Area

Adat Panchayat, located in Thrissur district of Kerala, was selected as the study area. The Panchayat consists of several wards and relies mainly on groundwater for domestic use. Representative locations were selected to study spatial variation in groundwater quality.

2.2.2 Collection of Groundwater Samples

- Sampling locations were identified within selected wards.
- Samples were collected using clean bottles.
- Bottles were sealed immediately after collection.
- Samples were transported carefully to the laboratory for analysis.

2.2.3 Laboratory Analysis of Groundwater Samples

The collected groundwater samples were analyzed for the following physico-chemical parameters:

- pH
- Alkalinity
- Acidity
- Chloride
- Total hardness
- Turbidity
- Dissolved Oxygen (DO)
- Available chlorine
- Colour
- Odour
- Taste

All analyses were carried out following IS / APHA standard methods. The obtained values were recorded for further comparison.

2.2.4 GIS-Based Spatial Analysis Using QGIS

- Latitude and longitude of sampling locations were entered into QGIS.
- Shapefiles of India, Kerala, Thrissur, and Adat Panchayat were loaded.
- Sampling points were plotted over the Panchayat boundary.
- Spatial distribution maps were prepared for analysis.

2.3 Summary of Methodology

The methodology involved systematic groundwater sampling, laboratory analysis of physico-chemical parameters, and GIS-based spatial mapping using QGIS and shapefiles. This approach helps in understanding the spatial variation of groundwater quality within the study area.

3. Literature Review

3.1 General

Groundwater is a vital natural resource extensively used for drinking, domestic, agricultural, and industrial purposes. The quality of groundwater is influenced by geological formations, land use patterns, anthropogenic activities, and waste disposal practices. Physico-chemical analysis of groundwater plays a crucial role in assessing its suitability for drinking and identifying contamination sources. In recent years, Geographic Information System (GIS), remote sensing, and statistical techniques have been widely applied to analyze and visualize the spatial variation of groundwater quality parameters. The present study is supported by earlier research works that focus on physicochemical characterization, groundwater quality index (WQI), and GIS-based spatial analysis.

3.2 Review of Previous Studies

Apoorva, Agrahari, Shukla and Mathur (July 2020) carried out a study titled "Physico-Chemical Analysis of Ground Water Using GIS and GPS: A Case Study of Sahjanwa and Piprauli Block of Gorakhpur District, U.P." The study involved the analysis of groundwater samples collected from multiple locations and evaluated parameters such as pH, electrical conductivity, total dissolved solids, hardness, chlorides, sulphates, and nitrates. GIS and GPS techniques were used to map the spatial distribution of groundwater quality. The results indicated that GIS-based analysis is effective for identifying contaminated zones and understanding spatial variability in groundwater quality.

Memon et al. (March 2021) conducted a study titled "Statistical Analysis and Physicochemical Characteristics of Groundwater Quality Parameters: A Case Study." The research focused on the application of statistical tools to analyze groundwater quality parameters including TDS, hardness, sulphates, chlorides, and pH. The study highlighted strong correlations among several parameters and emphasized the importance of statistical analysis in understanding groundwater quality trends and contamination characteristics.

Qureshi et al. (August 2021) presented a study titled "Assessment of Physicochemical Characteristics in Groundwater Quality Parameters." Groundwater samples were analyzed to evaluate their suitability for drinking purposes by comparing results with WHO and national drinking water standards. The study concluded that several physicochemical parameters exceeded permissible limits in certain areas, indicating the need for regular groundwater quality monitoring and management.

Gintamo et al. (April 2022) conducted a study titled "Determination of the Physicochemical Quality of Groundwater and its Potential Health Risk for Drinking in Oromia, Ethiopia." The research assessed groundwater quality by analyzing major physicochemical parameters and evaluating associated health risks. The results showed that some parameters exceeded acceptable limits, posing potential health risks to local communities. The study emphasized the importance of continuous monitoring and groundwater protection strategies.

Dandge and Patil (December 2021) studied "Spatial Distribution of Ground Water Quality Index Using Remote Sensing and GIS Techniques." The research involved the calculation of groundwater quality index using physicochemical parameters and GIS-based spatial mapping. The study demonstrated that GIS techniques are effective in classifying groundwater quality zones and identifying areas unsuitable for drinking purposes.

Aishwarya (2021) conducted a study titled "Assessment of Spatial Distribution of Physico-Chemical Parameters of Groundwater around Kodungaiyur Dump Yard." The study analyzed the impact of solid waste dumping on nearby groundwater quality using GIS techniques. The results revealed significant deterioration of groundwater quality near the dump yard, highlighting the influence of anthropogenic activities on groundwater contamination.

Shakeel Ahmed et al. (2022) carried out a study titled "Assessment of Groundwater Quality in Rural Areas of Taluka Dokri, Sindh, Pakistan, through Physicochemical Parameters." The research evaluated groundwater quality in rural areas using various physicochemical parameters. The findings indicated that a considerable percentage of groundwater samples were unsuitable for drinking due to high salinity and dissolved solids, stressing the need for treatment before consumption.

Rajshekhar Kumar and Shailza Verma (2025) conducted a study titled "Assessment of Drinking Water Quality Using QGIS for Bhopal City in Madhya Pradesh." The study analyzed groundwater quality using physicochemical parameters and GIS-based interpolation techniques. Spatial distribution maps were prepared to identify safe and unsafe zones for drinking water. The study concluded that QGIS is a powerful tool for groundwater quality assessment and urban water management.

3.2 Research Gap and Relevance of the Present Study

The reviewed literature shows that several researchers have carried out groundwater quality assessment using physico-chemical parameters, statistical analysis, and GIS-based spatial distribution techniques. Studies by Apoorva et al. (2020), Dandge and Patil (2021), and Rajshekhar Kumar and Shailza Verma (2025) demonstrate the effective application of GIS and QGIS tools in mapping groundwater quality variations. Other studies such as those by Memon et al. (2021), Qureshi et al. (2021), and Gintamo et al. (2022) highlight the importance of physicochemical analysis and statistical interpretation in evaluating groundwater suitability for drinking purposes.

However, these studies are confined to specific regions such as Gorakhpur District, Sindh Province, Oromia Region, Kodungaiyur dump yard area, and selected urban or rural locations outside Kerala. None of the reviewed studies focus on the groundwater quality assessment of Adat Panchayat, Thrissur District, using physicochemical parameters combined with GIS-based spatial analysis.

Therefore, the present study is relevant as it applies established physicochemical testing methods and GIS techniques, as adopted in the reviewed literature, to assess groundwater quality in Adat Panchayat. The study aims to generate localized groundwater quality information that can support water resource management and drinking water safety assessment in the study area.

4. Expected Results and Discussion

4.1 General

This chapter presents the expected results and discussion of the physicochemical and geospatial analysis of groundwater quality in the study area. Groundwater samples collected from different locations are analyzed for selected physicochemical parameters such as pH, residual chlorine, available chlorine, chloride, alkalinity, acidity, dissolved oxygen, hardness, colour, odour, and taste. The laboratory results are expected to be integrated with Geographic Information System (GIS) techniques to analyze and visualize the spatial variation of groundwater quality parameters across the study area.

4.2 Expected Physicochemical Characteristics of Groundwater

Based on groundwater chemistry and previous regional studies, the following results are expected:

pH values are expected to range from neutral to slightly alkaline across most sampling locations, reflecting natural groundwater–rock interaction. Residual and available chlorine are expected to be absent or present in negligible quantities, indicating untreated groundwater sources. Chloride concentrations are expected to show spatial variation, with relatively higher values in locations influenced by domestic activities or agricultural runoff. Alkalinity is expected to be moderate and may vary spatially due to differences in bicarbonate concentration and aquifer material. Acidity is expected to be low at most locations, maintaining stable groundwater chemistry. Dissolved oxygen (DO) levels are expected to be low and relatively uniform, which is characteristic of groundwater environments. Total hardness is expected to vary from soft to moderately hard, depending on local geological formations. Colour, odour, and taste are expected to be acceptable in most locations, indicating good aesthetic quality of groundwater.

4.3 Geospatial Distribution of Physicochemical Parameters

GIS-based spatial interpolation of groundwater quality data is expected to generate thematic maps for each physicochemical parameter. These maps will illustrate spatial variation patterns across the study area. Areas with slightly higher chloride and hardness values may be identified near zones of increased human activity. Regions showing uniform pH and alkalinity values are expected to indicate stable hydrogeochemical conditions. Spatial distribution maps of DO and acidity are expected to show minimal variation, confirming their limited sensitivity to surface activities. The geospatial analysis helps in identifying localized zones of concern and comparatively safe zones, which may not be evident from numerical analysis alone.

4.4 Discussion on Spatial Influence and Groundwater Quality

The expected spatial variation in groundwater quality parameters highlights the influence of local geology, land use, and anthropogenic activities. Variations in chloride and hardness concentrations across different locations may indicate the impact of domestic wastewater infiltration and mineral dissolution processes. The integration of laboratory results with GIS allows effective visualization of groundwater quality trends and supports better interpretation of spatial relationships between sampling locations and water quality parameters.

4.5 Suitability of Groundwater for Drinking Based on Spatial Analysis

Based on the expected geospatial distribution patterns, groundwater in most parts of the study area is anticipated to be suitable for drinking purposes. However, isolated locations showing comparatively higher concentrations of certain parameters may require treatment before consumption. The spatial analysis assists in identifying areas where groundwater quality management measures may be required.

4.6 Summary

The expected results indicate that the combined use of physicochemical analysis and GIS-based spatial distribution is an effective approach for groundwater quality assessment. The study is expected to provide location-specific groundwater quality information that can support drinking water safety assessment and sustainable groundwater management.

5. Conclusion

The present study focuses on the assessment of groundwater quality through physicochemical analysis and its geospatial distribution using GIS techniques. Groundwater samples collected from different locations in the study area were analyzed for parameters such as pH, residual and available chlorine, chloride, alkalinity, acidity, dissolved oxygen, hardness, colour, odour, and taste to evaluate their suitability for drinking purposes.

The study demonstrates that physicochemical parameters provide essential information regarding the chemical and aesthetic quality of groundwater. The integration of laboratory analysis with GIS-based spatial representation enhances the understanding of spatial variation in groundwater quality across the study area. The preparation of thematic maps for individual parameters helps in identifying location-specific variations and potential zones of concern.

The application of geospatial techniques enables effective visualization of groundwater quality patterns, which cannot be easily interpreted through numerical data alone. Such spatial analysis is useful for identifying comparatively safe zones and areas that may require further monitoring or treatment.

Overall, the study highlights the importance of combining physicochemical testing with GIS-based spatial analysis for groundwater quality assessment. The findings of this study are expected to provide baseline information on groundwater quality in the study area and support future planning, monitoring, and sustainable management of groundwater resource.

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