Spatial Mapping of Ground Water and Its Quality Checking Using Gis

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Abstract
Groundwater is an important component of our nation's fresh water resources. It plays a key role in meeting the water needs of various user-sectors in the nation. The natural resource cannot be optimally used and sustained unless the quality of water is assessed. In the present study, the impact of various industries on groundwater quality around the Kanjikode area in Pudussery panchayat, covering an area of 16.88sq km in Palakkad was carried out. For the study, data collection includes collected water quality data, well locations, landmarks etc. The above said data has been collected from various areas of Pudussery panchayat. After the data collection, base map has been prepared using QGIS software. The water quality database is analysed and then used as attribute database for the preparation of thematic maps showing distribution of various water quality parameters. Water Quality Index has been calculated for various parameters such as pH, Turbidity, Total hardness (TH), Chloride, Total dissolved solids (TDS), Alkalinity, Dissolved Oxygen (DO) and Fluoride. Water Quality Index map is also developed. The results obtained are presented in the form of maps, used for better understanding of present water quality scenario of the study area. Analysis reveals that the groundwater of the region needs specific treatment before put to use.

Keywords: QGIS, Ground water quality, WQI

1. INTRODUCTION

Water is a fundamental resource for life, crucial for ecosystems, agricultural productivity, industrial processes, and human health. Groundwater, in particular, is an essential component of the Earth's freshwater supply, sustaining rural and urban areas where surface water sources may be scarce or unreliable. However, the availability and quality of groundwater resources are increasingly under threat due to rapid urbanization, agricultural practices, and industrial activities that contribute to the contamination and depletion of these vital aquifers. Efficient management and monitoring of groundwater resources have thus become a priority, especially in areas with growing population demands and agricultural or industrial development.

Ground water resources are of high dependence due to its uses for all purposes starting from domestic, agricultural, industrial and commercial. The high dependence resulted in increasing pressure on available ground water resources in terms of quantity and quality. A threat is now posed by an ever-increasing number of soluble or dissolved chemicals from urban, industrial activities and from modern agricultural practices. The chemistry of groundwater reflects inputs from the atmosphere, from soil and water-rock reactions, as well as from pollutant sources such as mining, land clearance, agricultural practices, and acid rainfall, domestic and industrial wastes. Once the groundwater is polluted, its quality cannot be restored by stopping the pollutants from the sources. Therefore, groundwater quality monitoring has become very essential. GIS has emerged as a powerful tool for storing, analyzing, and displaying spatial data and using these data for decision making in several areas including engineering and environmental fields. The existing groundwater quality condition monitoring and management of polluted areas are identified using GIS software.

The use of Geographic Information Systems (GIS) for spatial mapping and quality assessment of groundwater has transformed the way groundwater resources are monitored, analyzed, and managed. GIS is a powerful tool that allows for the integration, visualization, and analysis of multiple layers of spatial and attribute data, making it possible to assess groundwater quality and distribution across large geographic areas effectively. By mapping and analyzing parameters such as depth, aquifer characteristics, contamination levels, and proximity to potential pollutant sources, GIS enables decision-makers to identify areas with water scarcity or contamination risks, facilitating targeted intervention and sustainable resource management. In developing countries like India around 80% of water borne diseases is directly related to poor drinking water quality and unhygienic conditions. Assessment of water quality of drinking water supplies has always been paramount in the field of environmental quality management.

2. STUDY AREA

Pudussery Panchayat, situated in the Palakkad district of Kerala, India, encompasses the towns of Kanjikode, Pudussery Central, Pudussery West, and Walayar. This region is notable for housing Kerala's first Indian Institute of Technology (IIT) and the state's second-largest industrial area. Geologically, Pudussery lies within the Palakkad Gap, a significant mountain pass in the Western Ghats that connects Kerala to Tamil Nadu. This gap influences the area's topography and climate, making it a vital corridor for weather patterns and biodiversity. The terrain is characterized by undulating plains interspersed with rocky outcrops, typical of the Western Ghats' geological formations.

Pudussery Grama panchayat is bounded by parts of Malampuzha block to north-west, Chittoor block to south and Coimbatore district of Tamil Nadu to the east. Kanjikode, a part of Pudussery panchayat is an industrial town located 13 km east of Palakkad. It is one of the growing suburbs of Palakkad city. It is the second largest industrial area in Kerala. As many as 42 iron-smelting factories along with many other Industrial units (textiles, machine parts etc.) are operating from the park. Korayar is one of the tributaries of river Kalpathipuzha, which in turn is a main tributary of the Bharathapuzha River, flows beside the Industrial area. Some of the deep wells in Palakkad district in Chitoor taluk and a few wells in Kanjikode and Muthalamada area also reported to contain fluoride concentration greater than 1 mg/l (Geogenic). The industrial area is located in the Palaghat gap area of the Western Ghats and is almost flat terrain with local undulations and gentle slope. Northern limit of the area is comprised of Western Ghat ranges. Central and southern parts are free of major hills. The high relief northern part is well drained by streams originating from the mountains As it is the second largest industrial hub after Kochi, the local community says liquor manufactures had caused drinking water scarcity in the locality along with Pepsico India’s bottling plant at Pudussery. That allegedly draws nearly 6.5 to 15 lakh litres of groundwater in a day in the place of the permission granted to fetch 2.4 lakh litres of ground water daily. Over exploitation was lowering the drinking water sources of the local people. Moreover, there are many pollutants in ground water like organic and inorganic pollutants, heavy metals, pesticides, fluoride etc.

3. METHODOLOGY

The methodology involves collections of water samples. The water quality database is analyzed and then used as attribute database for the preparation of thematic maps showing distribution of various water quality parameters. The thematic map of groundwater quality parameters, such as pH, TDS, Chloride, Total Hardness, Alkalinity, Turbidity, Fluorine were used for overlay integration analysis to prepare the groundwater quality map of Sangareddy district using Inverse Distance Weighted (IDW) spatial interpolation technique. Finally, the various water quality spatial contour maps were used in GIS for integration analysis to prepare the water quality map.

4. DATA COLLECTION

Data collection for the project began in Pudussery by obtaining ward details from the Panchayat. The Panchayat provided the names of wards with the highest concentration of industries. A survey was conducted in these wards to understand groundwater usage patterns among residents. The survey revealed that the local population does not use groundwater for drinking purposes. Further analysis of the survey data was carried out to identify potential reasons behind this trend and assess its implications for groundwater quality. A total of 35 samples were collected based on the survey.

4.1 ANALYSIS RESULT

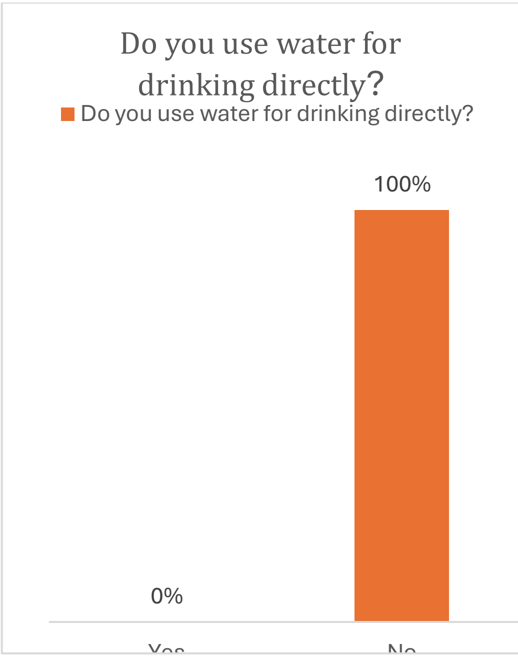

Chart 1: Percentage of Respondents Consuming Untreated Drinking Water

This survey, conducted among 35 individuals. An analysis of the survey responses revealed that none of the respondents use water directly for drinking purposes. This indicates a widespread lack of trust in the quality of available water.

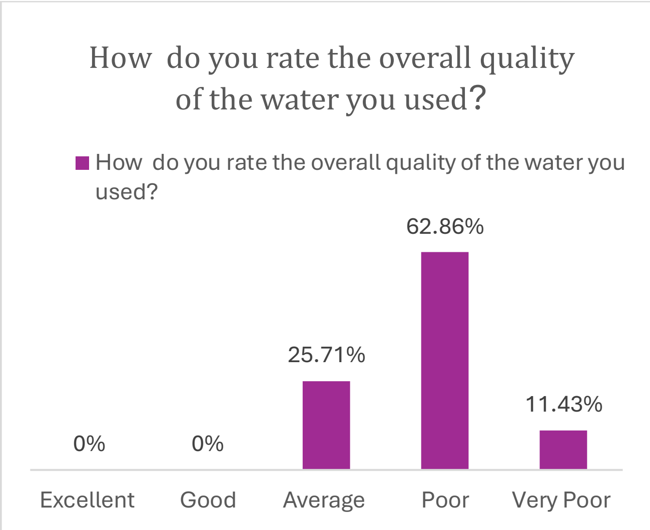

Chart 2: Public Perception of Drinking Water Quality

An analysis of the survey responses regarding water quality perception revealed significant concerns among the respondents. 62.86% of participants rated it as poor, indicating dissatisfaction with its suitability for daily use. Additionally, 25.71% of respondents considered the water quality to be average, suggesting that while not entirely unsuitable, it may have noticeable issues such as taste, odor, or minor contamination. Meanwhile, 11.43% of respondents rated the water quality as very poor, highlighting severe concerns about its usability and potential health risks.

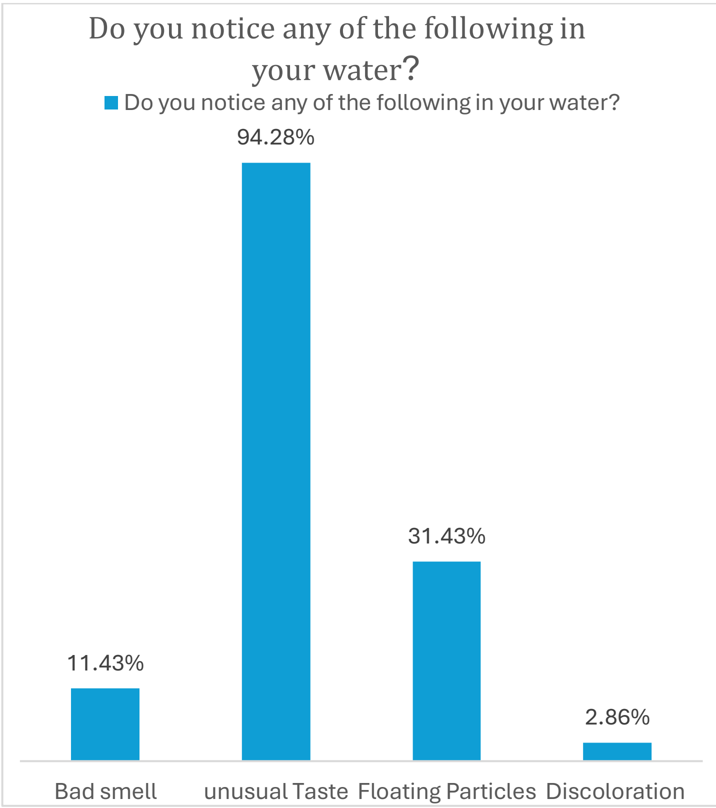

Chart 3: Noticed Characteristics in Drinking Water

Survey responses on water quality observations indicate that most people reported experiencing an unusual taste in their water, highlighting concerns about its potability.

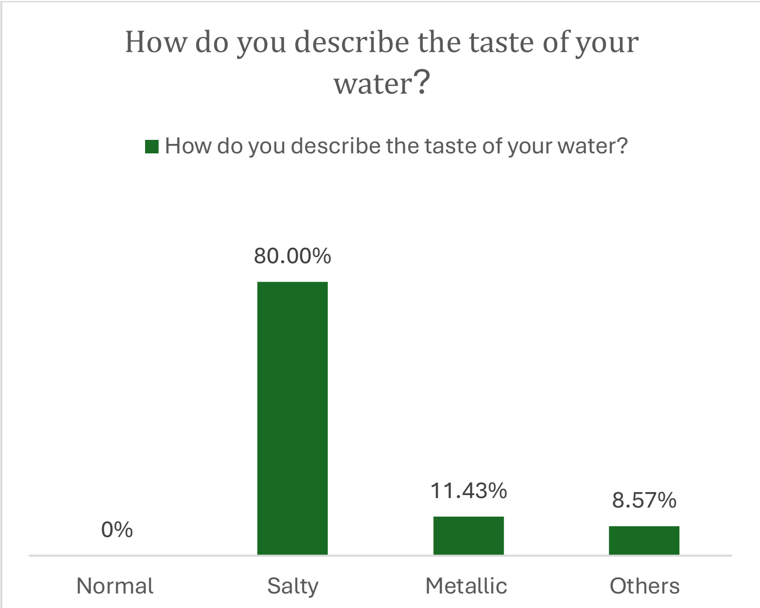

Chart 4: Perceived Taste of Drinking Water

Survey results on water taste perception indicate that most respondents described the water as having a salty taste. This suggests the possible presence of high levels of dissolved salts, such as chloride or sulfate, which could be linked to industrial discharge, groundwater contamination, or natural mineral deposits.

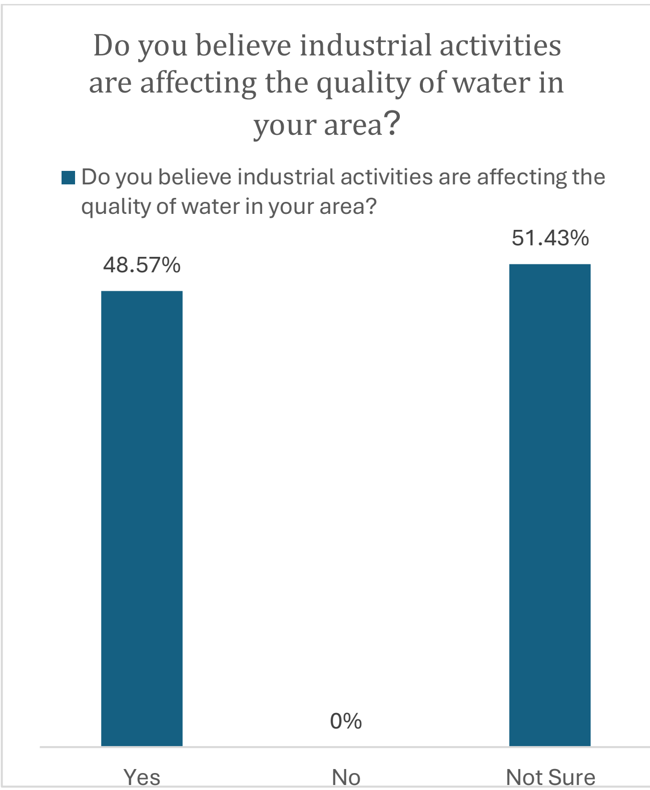

Chart 5: Influence of Industrial Activities on Water Quality

Survey findings indicate that most respondents believe industrial activities are affecting the quality of water in their area. This suggests concerns regarding potential contamination from industrial discharge, chemical pollutants, or groundwater depletion.

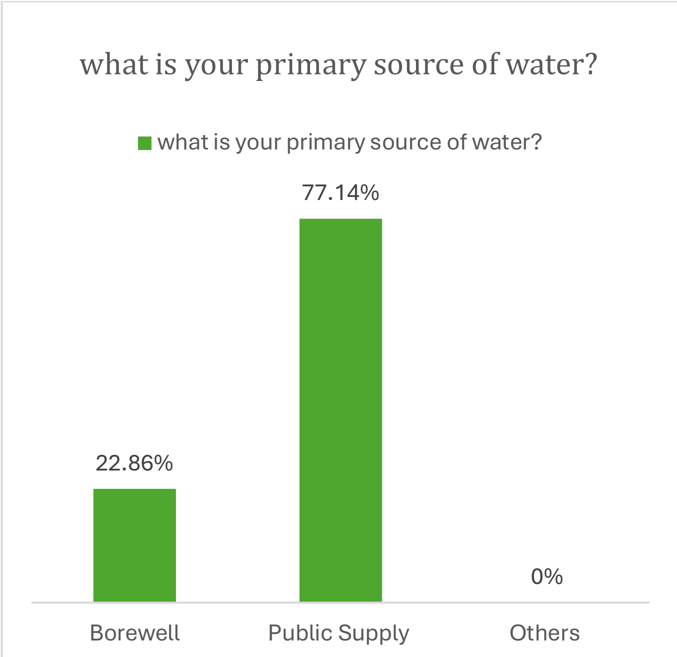

Chart 6: Public Dependency on Various Water Sources

Survey results show that most respondents rely on public water supply, while no one uses a normal well. This suggests concerns over groundwater quality or contamination. The findings highlight the need for groundwater assessment and ensuring the reliability of the public water supply system.

5. RESULTS AND DISCUSSION

5.1 pH

pH is a significant parameter in evaluating acidity or alkalinity of water. The computation of pH is to determine the intensity or alkalinity and measures the concentration of hydrogen ions. The study area pH value ranges from 7-9. The study area pH value classified into three categories of Good (6.5 to 8.5) and Moderate (8.5 to 9.2) and poor (>9.2).

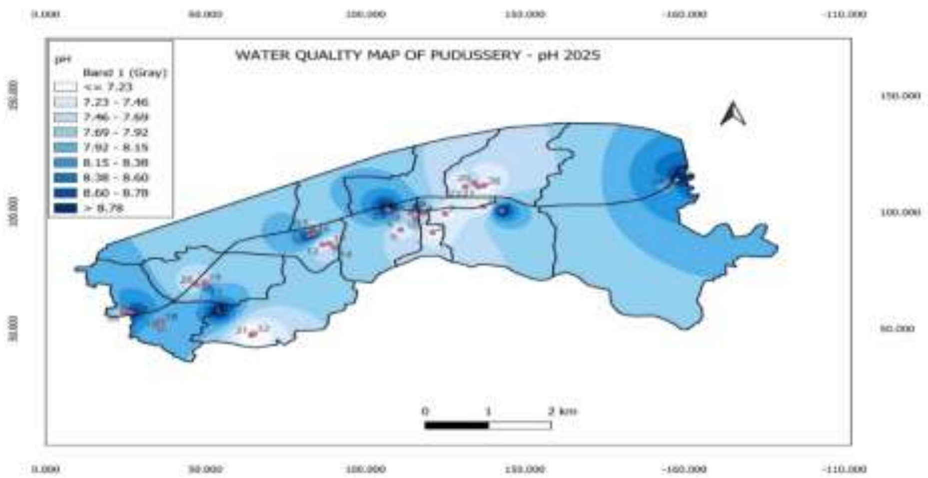

Fig 1: pH Map

5.2 TURBIDITY

As per IS 10500-2012, the standard value of turbidity for drinking water is 5 NTU. The turbidity value varies between 0.3-4.2 mg/L. High turbidity can interfere with disinfection and water treatment processes and provide a medium for microbial growth and contamination**.**

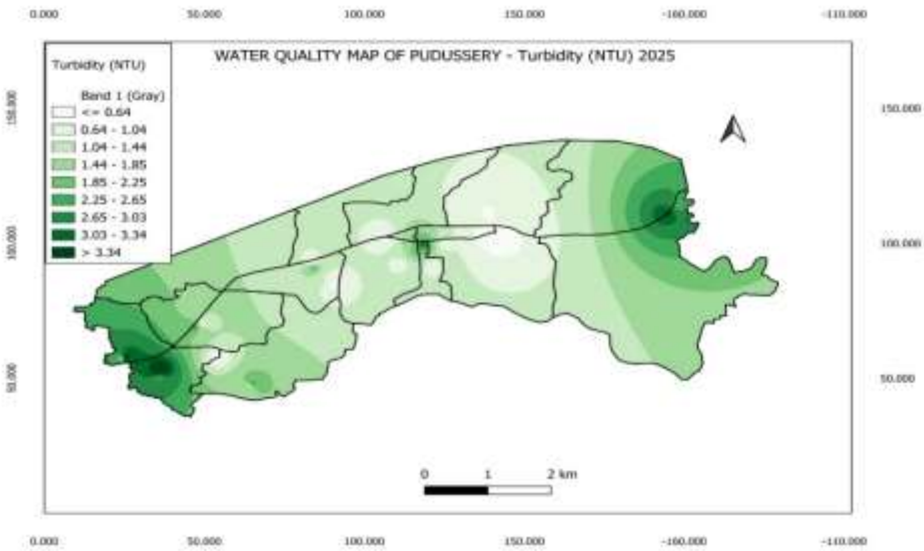

Fig 2: Turbidity Map

5.3 HARDNESS

According to the BIS, the ideal Total Hardness for drinking water is below 200mg/L and the max permissible limit is 600mg/L. It is recommended that people with kidney problem should drink pure water having Hardness level below 100mg/L for better recovery.

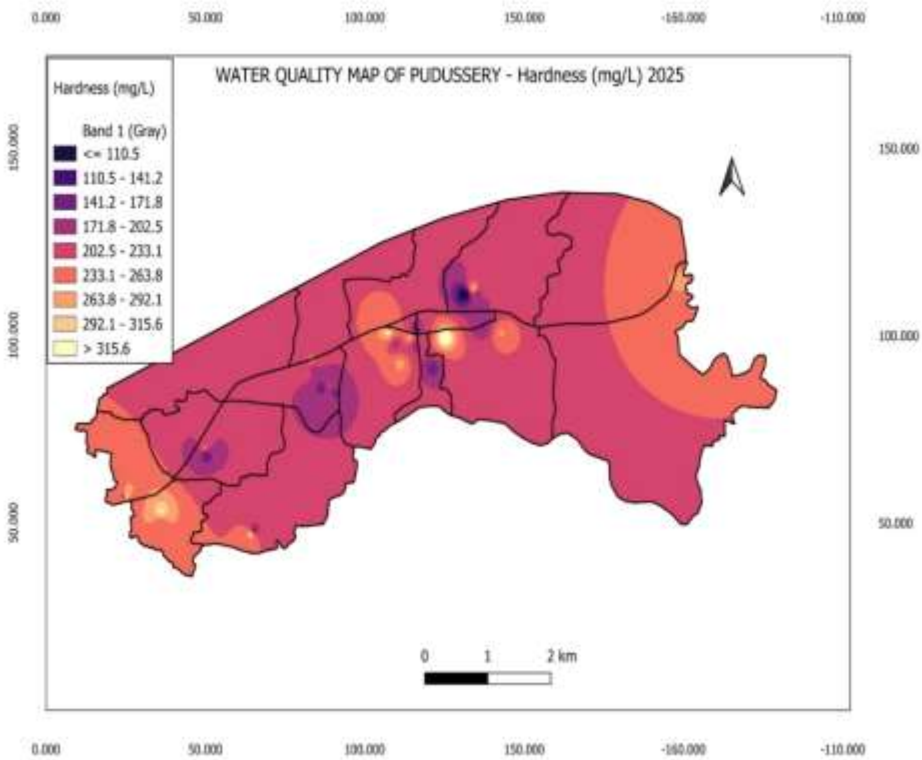

Fig 3: Hardness Map

Table 1: Hardness Range

HARDNESS IN Mg/L	DEGREE OF HARDNESS
0-75	SAFE
75-150	MODERATELY HARD
150-300	HARD
>300	VERY HARD

5.4 TOTAL DISSOLVED SOLIDS

The WHO sets out guidelines for drinking water quality that include the recommendation that water with TDS below 300 ppm is considered safe for drinking. Here the analysis of TDS for the study area shows the minimum 500 mg/L and maximum of 14000 mg/L. The higher the TDS, the more minerals are dissolved in the water. It can lead to gastrointestinal problems such as stomach pain and diarrhea and in extreme cases cause kidney diseases, liver diseases.

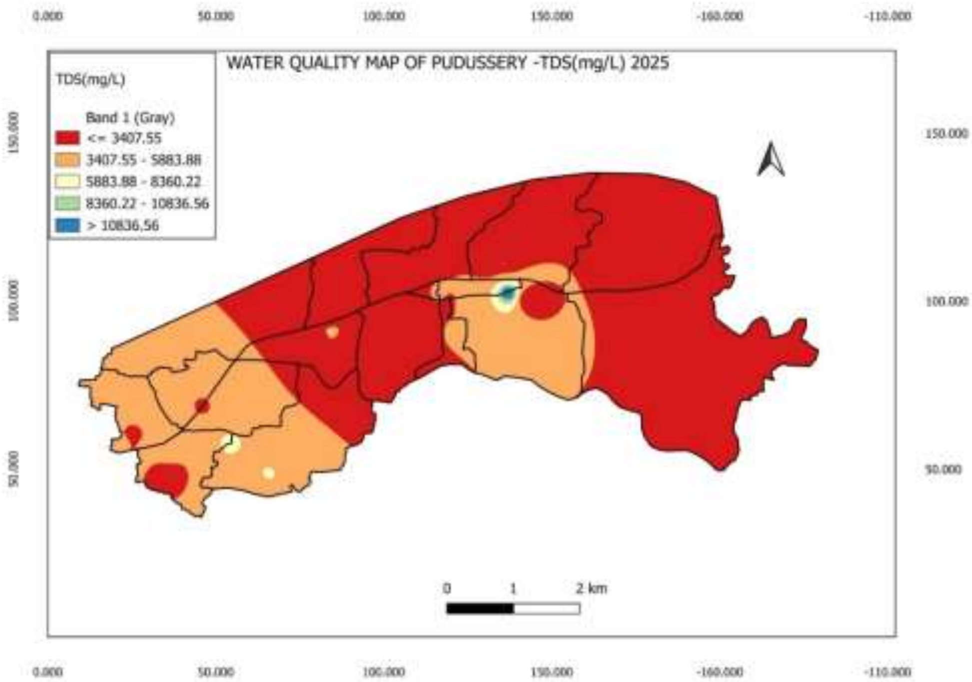

Fig 4: TDS Map

5.5 ALKALINITY

As per IS 10500-2012, the standard value of alkalinity is 250 mg/L. Here the value of phenolphthalein alkalinity is zero, only methyl alkalinity is present. Therefore hydroxide alkalinity and carbonate alkalinity are zero, only bicarbonate alkalinity is present. Alkalinity in water indicates its capacity to neutralize acids, primarily due to the presence of bicarbonates, carbonates, and hydroxides. Higher alkalinity levels help stabilize pH, preventing sudden fluctuations that could harm aquatic life. However, excessive alkalinity may indicate contamination from industrial or agricultural sources, potentially affecting water quality.

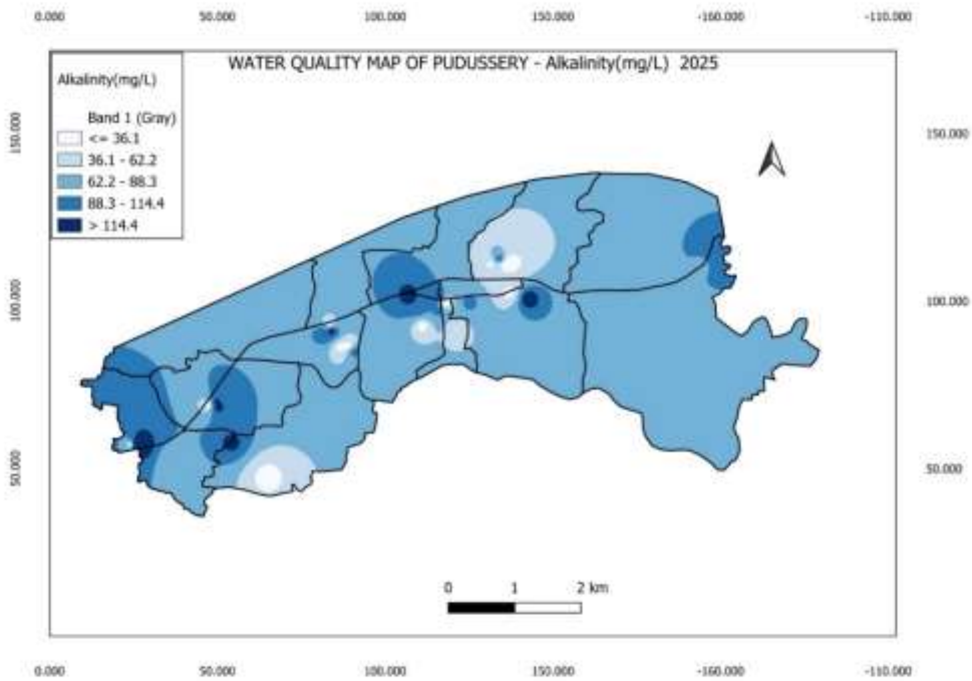

Fig 5: Alkalinity Map

5.6 DISSOLVED OXYGEN

As per IS 10500-2012, the acceptable limit of DO in drinking water is 4-8 mg/L. High DO levels speed up corrosion in water pipes. Dissolved oxygen (DO) is a key indicator of water quality and aquatic ecosystem health. Higher DO levels generally signify good water quality, supporting aquatic life by providing essential oxygen for respiration. Low DO levels, often caused by pollution, excessive organic matter, or high water temperatures, can lead to hypoxia, making the water unsuitable for fish and other aquatic organisms.

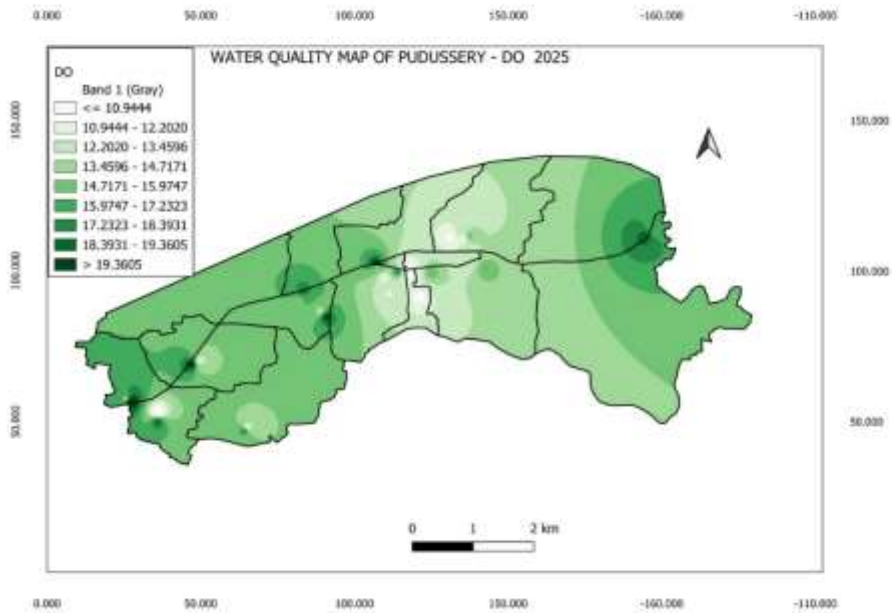

Fig 6: DO Map

5.7 FLUORIDE

As per BIS standards, the desirable and permissible limit of drinking water for fluoride is 1 mg/L. Here fluoride ranges from 0.1 to 1.6 mg/L. excessive fluoride levels can lead to dental and skeletal fluorosis, causing discoloration of teeth and bone-related issues. Prolonged exposure to high fluoride concentrations may also affect kidney and neurological health.

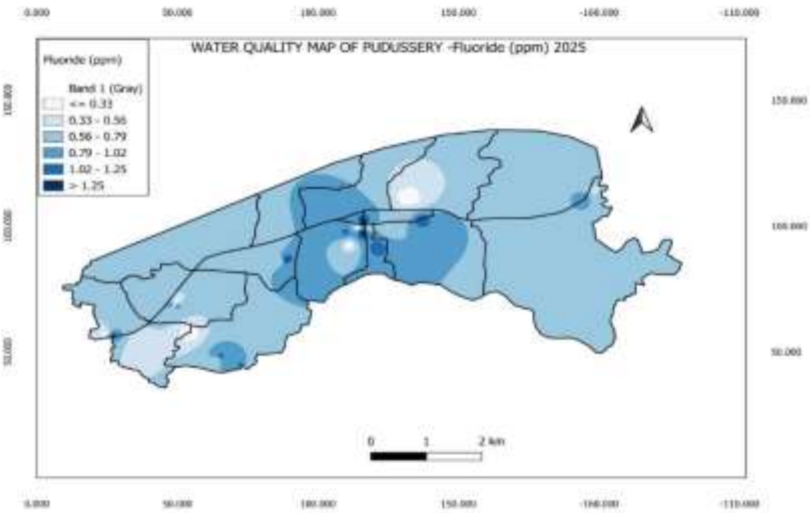

Fig 7: Fluoride Map

5.8 CHLORIDE

As per IS 10500-2012, the acceptable limit of chloride is 250 mg/L. The presence of a high concentration of chloride produces a salty taste in drinking water. Also, it leads to corrosion of metal pipes and infrastructure. In moderate concentrations, chloride is not harmful and contributes to the taste of water. However, excessive chloride levels (>250 mg/L) can lead to water salinity, corrosion of pipelines, and an unpleasant salty taste.

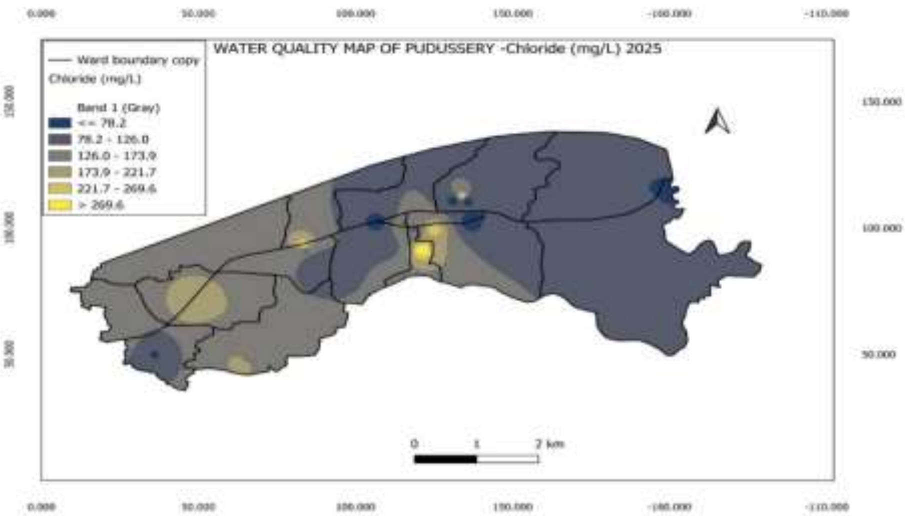

Fig 8: Chloride Map

6. WATER QUALITY INDEX

The WQI has been determined using the drinking water quality standard recommended by the World Health Organization. WQI is a mathematical expression that can be used to determine the quality of groundwater in different locations. It helps indicate whether water quality is good, meeting standards to protect aquatic life, whether it is of moderate concern or is poor and doesn't meet expectations. In this study the WQI was considered for human consumption and for drinking purpose.

For computing WQI, three steps are followed

Step-1 Each of the parameters has been assigned a weight (wi) according to its relative importance in the overall quality of water for drinking purposes (table 2) the maximum weight of 5 has been assigned to the parameter nitrate due to its major importance in water quality assessment. Magnesium which is given the minimum weight of 2 as magnesium by itself may not be harmful

Step-2 The relative weight (Wi) is computed from the following equation

$$Wi = \frac{wi}{\sum_{i=1}^{n} wi}$$

Wi= is the relative weight,
wi =is the weight of each parameter and
wi = K/Si
K=1/∑Si
n= is the number of parameters

Step-3 A quality rating scale (qi) for each parameter is assigned by dividing its concentration in each water sample by its respective standard according to the guidelines laid down in the BIS and the result multiplied by 100:

$$qi = \frac{Ci}{Si} \times 100$$

qi is the quality rating
Ci is the concentration of each chemical parameter in each water sample in mg/L
Si is the Indian drinking water standard for each chemical Parameter in mg/l according to the guidelines of the BIS 10500: 1991.
qi is the rating based on concentration of its parameter and n is the number of parameters. Based on the WQI values, the ground water quality is rated as excellent, good, poor, very poor and unfit or unsuitable for drinking.

Table 2: Water Quality Index Range

Water Quality Index	Description
0-50	EXCELLENT
51-100	GOOD
101-200	POOR
201-300	VERY POOR
>300	UNFIT FOR DRINKING (UFD)

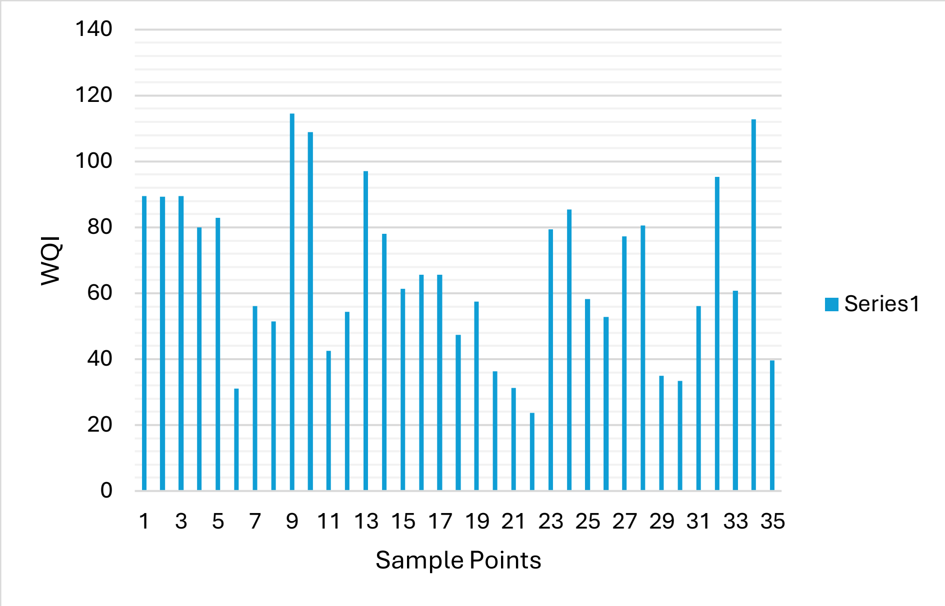

Chart 7: Water Quality Index

7. CONCLUSION

The specific conclusions derived from the study are presented below: The report on the spatial mapping of ground water quality in Pudussery, Palakkad, sheds light on the critical importance of assessing and monitoring water quality in the region. The findings reveal significant variations in water quality parameters and Water Quality Index (WQI) values across different areas, emphasizing the need for targeted water treatment measures before its consumption The spatial analysis of groundwater quality in the study area underscores the necessity for implementing treatment measures before utilizing the groundwater. By pinpointing the major pollutants like hardness and total dissolved solids (TDS) through spatial mapping, the study offers valuable insights into the current groundwater quality status. This information is essential for devising suitable management practices to safeguard groundwater sources and ensure sustainable water usage. It is recommended to conduct regular monitoring of hardness and TDS levels, particularly in areas where values exceed the desired thresholds as depicted on the map. Addressing these primary pollutants and establishing effective monitoring protocols can aid in enhancing water quality standards and preserving the groundwater reservoirs in the study area. The results presented in the report serve as a valuable resource for policymakers, environmental agencies, and local authorities to implement strategies aimed at improving water quality, protecting public health, and ensuring sustainable water use practices in the Pudussery area. By addressing the challenges identified in this study, stakeholders can work towards enhancing water quality standards and promoting the long-term well-being of the community and the environment.

Methods to remove /reduce Hardness and TDS.

The hardness of Water - It is caused due to the presence of minerals in the water like salts of Calcium or Magnesium.

It is of two types –

Temporary Hardness - It contains only bicarbonate salts of Magnesium and Calcium. It can be removed by boiling. For example, CaHCO3, MgHCO3 etc.

Permanent Hardness - It contains Chlorides and Sulphates salts of Calcium and Magnesium. It cannot be removed by boiling. For example, MgCl2, CaSO4 etc.

Removing of Temporary Hardness - The temporary hardness can be removed by the process like: Boiling - The process of heating any substance at its boiling temperature.

Clarks Method - In this method, hard water is treated with Slaked lime or Lime water $Ca(OH)_2$ to remove temporary hardness.

Removing of Permanent Hardness - The permanent hardness can be removed by the process like: Gan's Permutit Method - In this method, hardness is removed by using Permutit or Zeolites.

Calgon's Process - In this method, the formation of complex Calgon takes place which helps in ionizing the complex anions from the hard water Ion Exchange Resin Method - In this method, Sodium ions (Na^+) are used to coat an exchange medium in the softener in order to remove the hardness of water.

Synthetic Resins Method In this method, we use synthetic ion-exchange resins ($R\ Na^+$), which is insoluble in water. When it is added to water, an exchange between RNa^+ and Ca^{2+} or Mg^{2+} ions occurs. This process frees water from Ca^{2+} or Mg^{2+} ions. So, water no longer remains hard, and it becomes soft.

TDS removal techniques

1. Reverse Osmosis (R.O.)

Reverse Osmosis removes TDS by forcing the water, under pressure, through a synthetic membrane. The membrane contains microscopic pores which will allow only molecules smaller than 0.0001 microns to pass through. As the molecules of dissolved metals and salts are large compared to the water molecules, water squeezes through the membrane leaving the metals and salts behind.

2. Distillation The process involves boiling water to produce water vapor. The water vapor rises to a cool surface where it is condensed back into the liquid form. The dissolved salts are unable to vaporize and remain in the boiling solution.

3. Deionisation (DI) In this process, water is passed through a positive and negative electrode. The ion selective membranes enable the positive ions to separate from the water and move towards the negative electrode. The end result is de-ionized water with high purity. However, the water is first passed through a reverse osmosis unit first in order to remove the non-ionic organic contaminants. 4. Installing a Water Softener to Reduce Water TDS Level A water softener is another option for reducing TDS levels in water when we talk about how to reduce TDS in water at home. These units work by removing certain minerals, such as calcium and magnesium, which can contribute to high TDS levels. However, it is important to note that water softeners may not be effective in removing.

other types of minerals and salts.

Activated carbon filters: Activated carbon is one of the most popular means of filtering out TDS from water. It works by trapping beneficial minerals like calcium and magnesium while removing unwanted contaminants through adsorption.

By passing untreated water through an activated carbon filter, particles, chemicals, bacteria, and other harmful contaminants will be captured by the porous surface of the charcoal. This makes it one of the most efficient methods to eliminate chlorine, heavy metals, sediment, and other pollutants from your drinking water. Activated carbon may reduce organic matter by 90% and heavy metals by 70-80%.

The advantage of using activated carbon filters over alternative methods is their ability to trap particles much smaller than those that can be removed by mechanical filtration or any other type of media filter.

The absorption process used by these filters provides superior purification while at the same time conserving resources because they don't require backwashing as many other types of filters do. This type of filtration can improve taste and odor and reduce chlorine levels. One of the primary anticipated outcomes of this project is the identification of patterns in groundwater quality across different areas.

REFERENCES

1. Arjun Ram, H.K. Pandey, “Groundwater quality assessment using water quality index (WQI) under GIS framework”, Springer Nature (2021)
2. Chaitanya B. Pandey, “Assessment of groundwater potential zonation of Mahesh River basin Akola and Buldhana districts, Maharashtra, India using remote sensing and GIS techniques”, Springer Nature (2018)
3. Hanaa A. megahed, “GIS-based assessment of groundwater quality and suitability for drinking and irrigation purposes in the outlet and central parts of Wadi El-Assiuti, Assiut Governorate, Egypt”, Springer Nature (2020)
4. Soniya Grace, “A Geospatial Analysis of Ground Water Quality Mapping using GIS in Sangareddy District”, IRJET (2020)
5. Swetha, T.V., Remitha, R., Girish G, “Groundwater Quality Assessment and Water Quality Index (WQI) Mapping of Phreatic Aquifer, Palakkad District, Kerala”, Springer Nature (2023).