REVIEW OF RESEARCH
ISSN: 2249-894X
IMPACT FACTOR : 5.7631(UIF)
VOLUME - 14 | ISSUE - 5 | FEBRUARY - 2025

# GROUNDWATER QUALITY ASSESSMENT IN MUNDARGI TALUKA, KARNATAKA: A COMPREHENSIVE STUDY

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## ABSTRACT

*Groundwater quality in Mundargi Taluka, Karnataka, India faces challenges due to various contaminants. This study assessed key physicochemical parameters to evaluate water quality and potential health risks. The objective of the study is to evaluate physicochemical parameters of groundwater samples from diverse locations in Mundargi taluka and to assess the presence and concentration of potential contaminants. The current study was conducted to assess the quality of groundwater of Mundargi taluka of Gadag District (Karnataka), India. For the study from 18 groundwater samples were collected from publically used hand pumps and bore wells. Samples were analyzed for pH, electrical conductivity (EC), total dissolved solids (TDS), fluoride (F), and chemical oxygen demand (COD) using standard procedures. Results were compared with WHO standards and the results showed that the water of many villages was not potable and the pH ranged from 7.91 to 8.95, exceeding WHO limits (6.5-8.5). EC values (19.7-23.6 µS) exceeded permissible limits. TDS concentrations (0.17-5.14 ppt) were within limits. Fluoride levels (1.01-1.14 mg/l) exceeded WHO standards (1.5 mg/l). COD values (66-77 mg/l) significantly surpassed WHO limits (10 mg/l). Groundwater in Mundargi Taluka shows concerning levels of alkalinity, electrical conductivity, fluoride, and organic pollution. These findings indicate potential health risks and the need for immediate intervention to ensure safe drinking water for the local population. Implement regular monitoring, assess contamination sources, upgrade water treatment facilities, and conduct public awareness campaigns to address water quality issues in the region.*

**KEYWORDS:** *Groundwater Quality, Mundargi Taluka, Fluoride, Physicochemical Parameters, Alkaline, Fluorosis.*

## 1. INTRODUCTION

Groundwater serves as a vital resource for numerous communities, particularly in regions with limited or unreliable surface water sources(Sahuquillo, 1985) . In India, especially in rural areas, groundwater quality faces significant challenges due to various contaminants, including arsenic, fluoride, and nitrate (Khurana & Sen, 2021) . The quality of groundwater exhibits considerable variation across regions, influenced by both natural and anthropogenic factors. In Mundargi Taluka, located in Karnataka's Gadag District, groundwater plays a crucial role in sustaining agricultural, domestic, and industrial activities. The quality of this resource is of paramount importance for ensuring the health and well-being of the local population and the sustainability of ecosystems (Aranguren-Díaz et al., 2024) .

However, the region faces challenges related to water scarcity and increasing demand, necessitating a comprehensive understanding of the current state of groundwater quality and the identification of potential threats.

Previous studies conducted in various parts of India have revealed diverse contaminants and quality concerns in groundwater. Specific to Mundargi Taluka, earlier research has indicated concerns regarding fluoride levels and other physicochemical parameters( Arali et al., 2021) (Bharati et al., 2005) . pH values in the region have been found to range from 7.18 to 9.32, indicating alkalinity. Fluoride levels varied from 0.86 to 4.63 mg/L, with a significant portion of samples exceeding recommended limits (Arali et al., 2021). These elevated fluoride levels pose health risks and have been associated with fluorosis in the local population. Similarly, the research By T shekar K Babu identified that more than 90% of the total water samples analyzed in Mundargi Taluk exceeded the WHO 1995 drinking water standards for fluoride content (Shekhar et al., 2006). This high fluoride content has implications for the health status of the consumers. on other hand, Shillong, northeast India, identified acidic pH and the presence of heavy metals in groundwater samples (Jain et al., 2021). In Tamil Nadu, nitrate and phosphate contamination was observed due to sewage effluents and fertilizer applications (Kumar et al., 2008). A comprehensive review of studies conducted between 2000 and 2015 revealed that major groundwater pollutants in India include fluoride, nitrate, arsenic, and various heavy metals, often exceeding permissible limits set by national and international agencies (Dugga et al., 2021).

Given these concerns, this study aims to conduct a comprehensive assessment of groundwater quality in Mundargi Taluka. The research will focus on evaluating various physicochemical parameters, including pH, electrical conductivity (EC), total dissolved solids (TDS), fluoride (F), and chemical oxygen demand (COD). By analyzing samples from different locations within the taluka, this study seeks to provide valuable insights into the current state of groundwater quality, identify potential contamination sources, and inform the development of targeted management strategies.

## 2. AIMS AND OBJECTIVES OF THE STUDY

1). To assess the groundwater quality in Mundargi Taluka, Gadag District, Karnataka, by analyzing various physicochemical parameters.
2). To evaluate the concentrations of key water quality indicators, including pH, electrical conductivity (EC), total dissolved solids (TDS), fluoride (F), and chemical oxygen demand (COD).
3). To investigate the relationship between different water quality parameters using statistical analysis and correlation studies.
4). To provide recommendations for groundwater quality management and pollution control measures in Mundargi Taluka.

## 3. SIGNIFICANCE OF THE STUDY

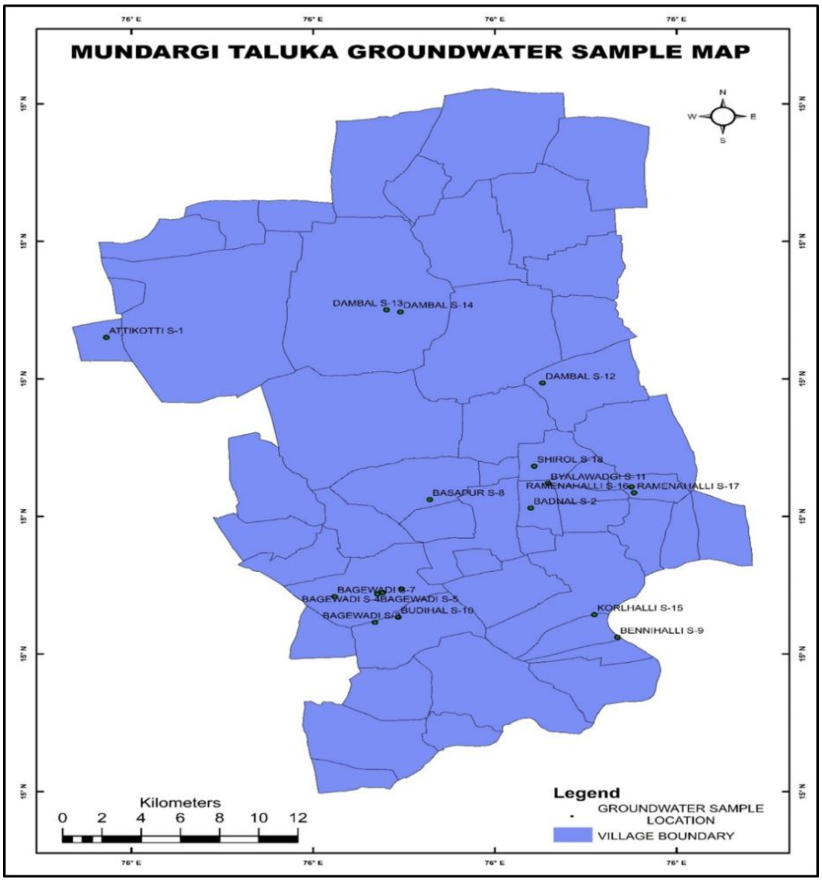
The study assessed groundwater quality in Mundargi Taluka, Karnataka, addressing concerns about potential contamination and water suitability for various applications. It is significant because: 1. Groundwater is a critical resource for communities in regions with limited surface water. 2. It supports agricultural, domestic, and industrial activities in the area. 3. The study helps understand the current state of groundwater quality and identifies potential threats. 4. It provides insights for developing targeted groundwater management strategies and pollution control measures.

## 4. MATERIALS AND METHODS

### 4.1 Study Area

The study area of Mundargi taluka is situated in the northern part of Karnataka State, India, and falls within the administrative boundaries of Gadag District(Gazetteer of India, 2011). The latitudinal and longitudinal extent of Mundargi taluka lies between the latitudinal and longitudinal extent of Mundargi taluka between 15°00' and 15°30' North latitude and 75°45' and 76°15’ E. At Mundargo taluk, Gadag district a study is conducted to analyse the water quality as shown in fig 1. The 18 water samples are taken and all of them are tested in the lab using conventional methods. The Analysed water quality parameters included pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Fluoride (F), and Chemical Oxygen Demand (COD), following APHA standards. Results were compared with WHO and United States Salinity Laboratory standards. Statistical analyses included WQI calculation, correlation analysis, and t-tests, with scatter plots, box plots, and a correlation heat map generated. GIS techniques visualized the spatial distribution of groundwater quality.

**Fig.1.Study area**




#### 4.1.1 *Sample Details*

Eighteen groundwater samples were collected from Mundargi Taluka, Gadag District, Karnataka, India, using standard procedures, stored in 100 ml sealed plastic bottles, labeled, and recorded with GPS coordinates (S1-S18). Mundargi taluka locations 18 sample details are shown in table no 1 with latitudes and longitudes collected using GPS.

**Table 1 GPS locations of Samples collected (Mundargi taluka)**

| SI No | Location name | Sample no | Longitude | Latitude |
|---|---|---|---|---|
| 1 | Attikotti | S-1 | 15.275084 | 75.655175 |
| 2 | Badnal | S-2 | 15.171786 | 75.849824 |
| 3 | Bagewadi | S-3 | 15.102461 | 75.778391 |
| | | S-4 | 15.120474 | 75.781907 |
| | | S-5 | 15.119653 | 75.779481 |
| | | S-6 | 15.122654 | 75.790442 |
| | | S-7 | 15.118044 | 75.759861 |
| 4 | Basapur | S-8 | 15.212222 | 75.882261 |
| 5 | Bennihalli | S-9 | 15.09346 | 75.889521 |
| 6 | Budihal | S-10 | 15.105624 | 75.788986 |
| 7 | Byalawadgi | S-11 | 15.186641 | 75.857688 |
| 8 | Dambal | S-12 | 15.247448 | 75.855201 |
| | | S-13 | 15.291813 | 75.783704 |
| | | S-14 | 15.290568 | 75.790046 |
| 9 | Korlhalli | S-15 | 15.107149 | 75.878995 |
| 10 | Ramenahalli | S-16 | 15.184592 | 75.896002 |
| | | S-17 | 15.180975 | 75.897162 |
| 11 | Shirol | S-18 | 15.197089 | 75.851411 |

## 5. RESULTS AND DISCUSSION

Samples collected from 18 locations at Mundargi taluka are subjected to a series of tests. The results and observations of the tests performed are presented in the tables 2 and 3 as shown below.

**Table 2 Experimental Analysis of sample 1 to 18**

| Sample Name & No | | pH | TDS | EC | F- | COD |
|---|---|---|---|---|---|---|
| **Attikotti** | S1 | 8.41 | 0.2 | 19.7 | 1.13 | 72 |
| **Badnal** | S2 | 8.6 | 0.25 | 21.3 | 1.08 | 71 |
| **Bagewadi** | S3 | 8.95 | 0.21 | 20.9 | 1.03 | 71 |
| | S4 | 8.46 | 0.2 | 21.5 | 1.02 | 75 |
| | S5 | 8.5 | 0.2 | 21.5 | 1.01 | 74 |
| | S6 | 8.5 | 0.22 | 21.5 | 1.07 | 74 |
| | S7 | 8.86 | 0.23 | 21.3 | 1.04 | 77 |
| **Basapur** | S8 | 8.7 | 0.34 | 59.3 | 1.08 | 71 |
| **Bennihalli** | S9 | 8.51 | 1.65 | 24.7 | 1.05 | 73 |
| **Budihal** | S10 | 8.76 | 0.22 | 21.5 | 1.08 | 75 |
| **Byalawadgi** | S11 | 8.8 | 0.2 | 21.2 | 1.10 | 73 |
| **Dambal** | S12 | 8.61 | 0.41 | 21.7 | 1.12 | 66 |
| | S13 | 8.72 | 0.44 | 21.7 | 1.14 | 69 |
| | S14 | 8.42 | 0.48 | 21.8 | 1.10 | 72 |
| **Korlhalli** | S15 | 8.5 | 0.21 | 21.2 | 1.10 | 71 |
| **Ramenahalli** | S16 | 7.91 | 0.2 | 22.1 | 1.06 | 77 |
| | S17 | 8.28 | 0.19 | 22.2 | 1.06 | 76 |
| **Shirol** | S18 | 8.2 | 0.2 | 21.2 | 1.11 | 74 |

**Table 3 Statistical Evaluations of Groundwater samples collected in and around Mundargi taluk of Gadag district and values of WHO Standards.**

| Parameters | Minimum | Maximum | Mean | Median | SD | WHO | |
|---|---|---|---|---|---|---|---|
| | | | | | | Acceptable | Allowable |
| pH | 7.91 | 8.95 | 8.537333 | 8.505 | 0.251636 | 6.5 – 8.5 | 6.5 – 9.2 |
| EC | 19.7µS | 59.3µS | 23.68333 | 21.5 | 8.938499 | 400 µS/cm × 0.40 ppm - | - |
| TDS | 0.2ppt | 1.65ptt | 0.336111 | 0.215 | 0.340634 | 1500ppm =1.05 ppt | 1500 |
| F | 1.01mg/l | 1.14 mg/l | 1.076667 | 1.08 | 0.037573 | 1.5 mg/l | 1.0 |
| COD | 66mg/l | 77 mg/l | 72.8333 | 73 | 2.812786 | 200 mg/l | 20.0 |

*All parameters are expressed in ph., F, COD, are in mg/l and TDS is in ppt, EC is in ppm*
*Source: ISSN 2319–1414 and WHO Standards Source: ISSN: 0973-4945*

### 5.1 pH Analysis

According to this study, the pH values of the groundwater samples from Mundargi taluka in the Gadag district ranged from 7.91 8.95. The highest pH value (8.95 was recorded in Sample S3 Bagewadi, whereas the lowest pH value (7.91 was found in Sample S16 Ramenahalli. The study noted that these pH levels exhibit unusual changes and are higher than the permissible limit set by the World Health Organization (WHO), which recommends a pH range of 6.5 to 8.5 for drinking water (Nwachukwu et al., 2021). Researchers have suggested that pH levels exceeding the acceptable range may affect the mucous membranes of the cells. The elevated pH levels observed in Sample S16 Ramenahalli could potentially lead to adverse health effects for those consuming water (Talpur et al., 2024). high alkalinity may cause irritation to the eyes, skin, and digestive system and could also affect the efficacy of water treatment processes Alvarenga & Mannis, 2005). Further investigation of the sources of these unusually high pH levels is warranted to develop appropriate mitigation strategies and to ensure the safety of the local water supply.

### 5.2 An assessment of Electrical Conductivity (EC)

EC values ranged from 19.7µS to 23.6µS. All the samples exceeded the permissible limit of 1.05 ppt. The elevated electrical conductivity (EC) values indicate the presence of dissolved ions in the water samples (Olajire & Imeokparia, 2001) (Thirumalini & Joseph, 2009). This increase in conductivity suggests potential contamination from diverse sources including industrial effluents, agricultural runoff, and natural mineral deposits. Additional investigations are warranted to identify the specific contributors to these heightened EC levels and to evaluate their potential impacts on water quality and ecosystem integrity. The observed exceedances and elevated EC values underscore the need for a comprehensive assessment of the water quality parameters and potential pollution sources in the study area.

### 5.3 Evaluation of Total Dissolved Solids (TDS)

TDS concentrations ranged from 0.17 ppt to 5.14 ppt. The maximum value was observed at Station S3 Tambragundi (5.14 ppt), whereas the minimum was at Station S1 Doni (0.17 ppt). All TDS measurements fell within the permissible limit of 1.50 ppt, classifying the groundwater as nonsaline. The spatial variation in TDS concentrations across the study area suggests that localized factors influence groundwater quality. Despite the wide range observed, the overall non-saline classification indicates that groundwater is generally suitable for various applications. Further investigation of the geological and anthropogenic factors contributing to higher TDS values at Station S3, Tambragundi, could provide valuable insights into water resource management in the region.

### 5.4 Fluoride Concentration Analysis

The fluoride concentrations ranged from 1.01 to 1.14 mg/l. The highest content was found in Dambal S13 (1.14 mg/l), and the lowest in Bagewadi S5 (1.01 mg/l). All fluoride measurements exceeded the World Health Organization (WHO) permissible limit of 1.5 mg/l, indicating a high fluoride concentration in groundwater samples. Elevated fluoride levels in groundwater pose significant health risks, particularly to dental and skeletal health (Alharbi & El-Sorogy, 2023) (Ahmad Dar & Kurella, 2023). The consistent exceedance of WHO guidelines across all samples suggests a widespread issue in the region's groundwater supply. Further investigation of the geological and anthropogenic factors contributing to these high fluoride concentrations may be necessary to develop effective mitigation strategies.

### 5.5 Chemical Oxygen Demand (COD) Measurement

The study of Chemical Oxygen Demand (COD) in groundwater samples from Mundargi taluka in the Gadag district revealed significant findings. COD values ranged from 66 to 77 mg/l across the sampling stations, with the highest value (77 mg/l) observed at station S16 Ramenahalli and the lowest (66 mg/l) at station S12 Dambal. Notably, all sampling stations exceeded the World Health Organization's (WHO) permissible limit of 10 mg/l. These high COD values indicate a substantial presence of organic matter in the groundwater samples, which is related to water quality in the region.(Lv et al., 2021). Elevated COD levels can lead to oxygen reduction in water bodies due to microorganism decay, potentially damaging aquatic life in the affected areas. (Chaudhry et al., 2022).. This study highlights the need for regular monitoring and assessment of the groundwater quality in the study area to prevent further contamination.

### 5.6 Statistical Analysis

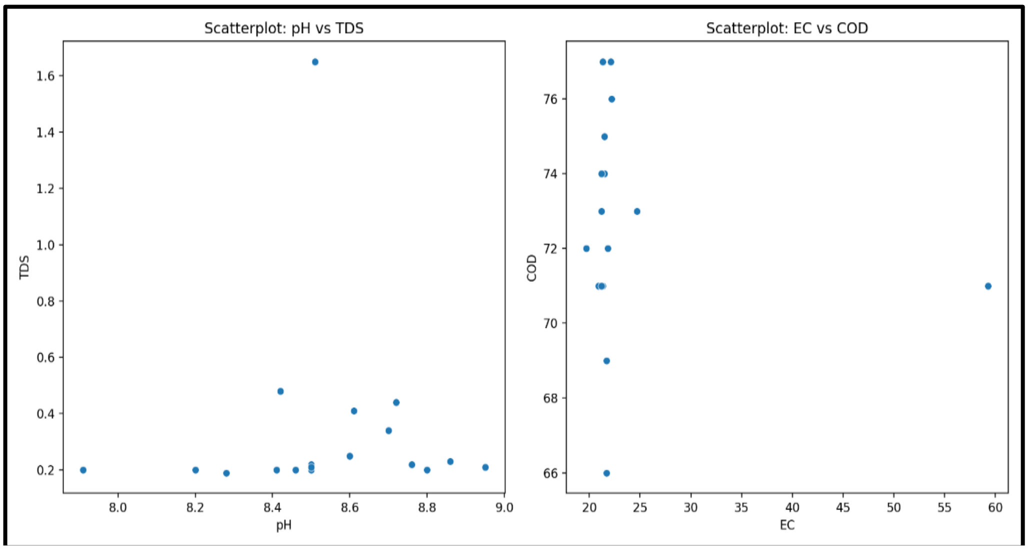



**Fig 2 Scatter plots between pH-TDS and EC-COD**

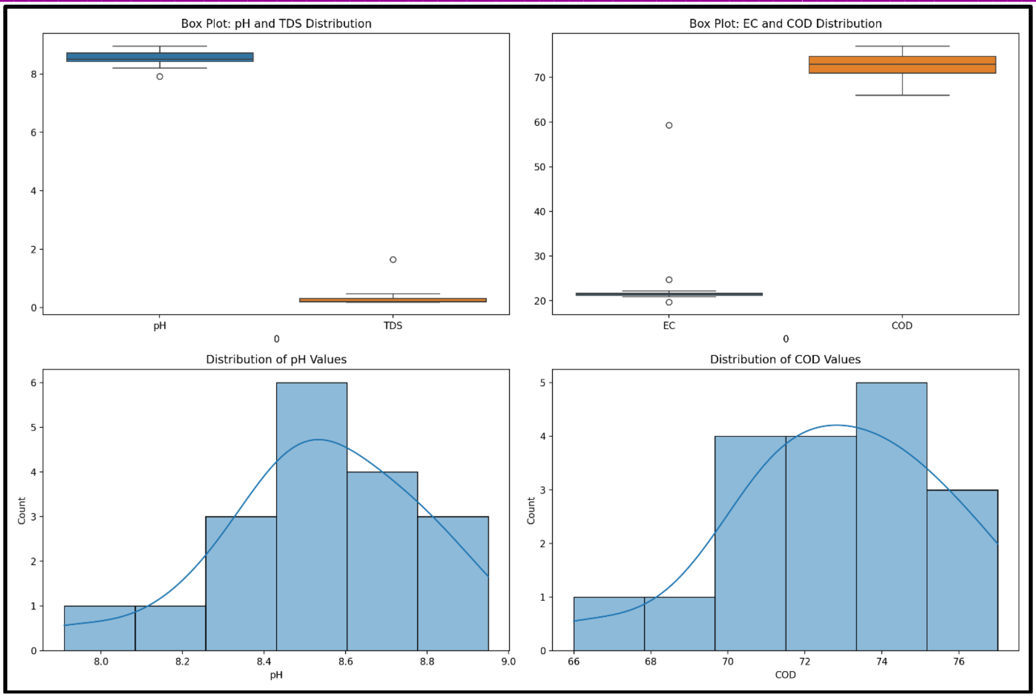



Fig 3 Box plot showing pH-TDS and EC-COD

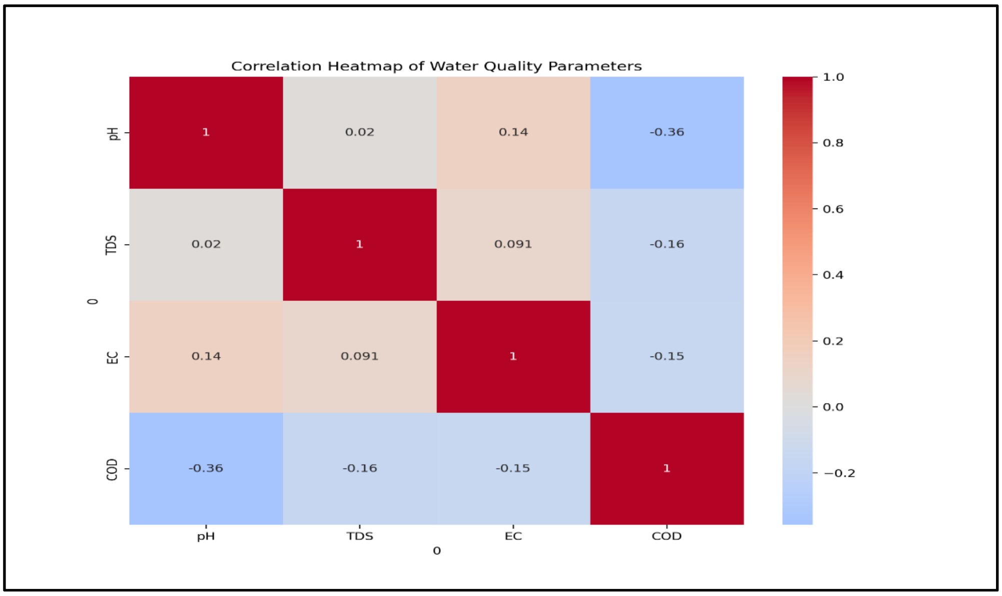



Fig 4 A comprehensive correlation heat map showing relationships between pH-TDS and EC-COD

To evaluate the relationships between parameters (e.g., pH vs. TDS or EC vs. COD), a t-test was conducted to compare the water quality parameters across different villages.

### 5.6.1 Correlation Analysis of Water Quality Parameters

A correlation analysis was performed to evaluate the relationships between pH, TDS, EC, and COD. The correlation coefficient for pH vs. TDS was 0.02, indicating a very weak positive correlation. This suggests that changes in pH have almost no linear relationship with TDS levels in groundwater samples. Similarly, the correlation coefficient between EC and COD was -0.15, indicating a weak negative correlation. This implies that as the EC increased, COD tended to decrease slightly, but the relationship was not strong. These weak correlations suggest that the parameters are largely independent of each other and that other factors may influence their values. The scatterplots further support this conclusion as no clear linear patterns were observed between the variables.

### 5.6.2 T-Test Analysis for Spatial Variations

T-tests were conducted to compare the means of pH vs. TDS and EC vs. COD. For pH vs. TDS, the t-statistic was 82.16 with a p-value of approximately 4.00e-38, indicating a significant difference between the means of these two parameters. Similarly, for EC vs. COD, the t-statistic was -22.25 with a p-value of approximately 9.45e-16, indicating a statistically significant difference. These results suggest that the means of the compared parameters are not equal and that the differences are unlikely to have occurred by chance. Despite weak correlations, the statistical significance highlights that while the parameters differ in magnitude, they do not exhibit strong linear relationships.

## 6. CONCLUSIONS AND RECOMMENDATIONS:

Elevated COD levels indicate organic pollution from untreated sewage or industrial effluents, risking aquatic ecosystems and human health, requiring immediate action. Advanced wastewater treatment and stricter industrial discharge regulations could reduce COD levels and improve water quality. Fluoride and COD levels in most groundwater samples exceed limits, necessitating regular monitoring and assessments to prevent further contamination. A comprehensive approach is recommended, including regular sampling across 18 stations with standardized protocols. Real-time monitoring systems should be considered for key locations. Expanding tested parameters and establishing a centralized database would improve understanding of contamination patterns. Priority should be given to areas with high fluoride concentrations, and sources of high COD levels should be investigated. Existing water purification plants should be assessed and upgraded if needed. Hydrogeological studies are essential to understand aquifer systems and contamination pathways, and collaboration with health authorities is crucial. Community awareness programs should engage local populations in conservation efforts. The impact of agricultural practices on groundwater quality should be evaluated, with stricter regulations on extraction and usage. Artificial recharge methods should be explored to improve groundwater quality and quantity. Assessing the effectiveness of agricultural techniques in minimizing contamination is recommended. Guidelines for sustainable groundwater management should balance stakeholder needs. Innovative treatment and purification technologies should be investigated. Regular quality control checks on laboratory analysis procedures are necessary for accurate data collection.

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