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GEOCHEMICAL INSIGHTS AND SEASONAL HYDRODYNAMICS OF GROUNDWATER QUALITY IN PARAMATHI VELUR REGION, NAMAKKAL, INDIA

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Abstract: This study assesses the groundwater quality in Paramathivelur Taluk, Namakkal District, during post-monsoon and pre-monsoon seasons, focusing on physicochemical parameters such as TDS, EC, pH, hardness, chlorides, COD, BOD, sulfates, alkalinity, nitrates, and fluorides. Samples were collected from ten locations, and significant seasonal variations were observed, particularly in temperature, TDS, and nitrate levels. Post-monsoon, water temperatures increased to 38.1 - 40.1 °C, while pH values slightly decreased, indicating a dilution effect due to rainfall. Notably, TDS levels increased from 150 - 215 mg/L pre-monsoon to 310 - 480 mg/L post-monsoon, reflecting runoff impacts. The novelty of this study lies in the detailed seasonal comparison of water quality and the identification of geochemical processes through Gibbs plots and spatial maps. The findings suggest that while the water quality generally meets acceptable standards, continuous monitoring is essential to manage long-term impacts, especially on soil salinity and drinking water safety. This study contributes to the wider acquaintance of groundwater quality dynamics in semi-arid sections and highlights the need for sustainable groundwater management practices.

Keywords: Water Quality Index, Paramathivelur Taluk, Groundwater, UV-Spectrophotometry

1. INTRODUCTION

The quality and availability of groundwater are critical for sustaining life, agriculture, and industry, especially in regions where surface water resources are limited. Paramathivelur Taluk, located in Namakkal district, Tamil Nadu, India, is one such region where groundwater plays a vital role in meeting the water demands of the local population (Arveti et al., 2011). This study emphasizes understanding the hydrogeochemical characteristics of surface water in Paramathivelur Taluk through spatial maps, which provide a detailed and visual representation of the water quality across different locations within the taluk (Kilic, 2021). A combination of natural methods, such as the dissolution of minerals, and anthropogenic activities, including agriculture, industrial effluents, and domestic waste influences groundwater quality in any region (Nagarajan et al., 2012). These factors can lead to various chemical constituents in groundwater, which may affect its suitability for irrigation, drinking, and industrial purposes (Rajkumar et al., 2010). Therefore, it is essential to assess the hydrogeochemical characteristics of groundwater to ensure its safe and sustainable use (Sajil Kumar & Kuriachan, 2022). The current study involves the collection of groundwater samples from ten different locations within Paramathivelur Taluk (Sunantha & Vasudevan, 2016). These samples were analyzed to regulate the concentrations of various chemical parameters, which were then mapped using spatial techniques. The resulting maps provide a comprehensive overview of the distribution of different chemical constituents across the taluk, enabling a better understanding of the factors influencing groundwater quality in the area (Venkateswaran & Vediappan, 2013). This information is crucial for local water management authorities and policymakers in making informed decisions regarding groundwater use and conservation in Paramathivelur Taluk.

Water is essential for all life, but environmental pollutants, particularly from industrial effluents like those from the textile industry, can degrade aquatic ecosystems. Vennila et al. (2007) assessed water quality in the Cauvery River at three sites in Namakkal District, revealing that Puthansanthapettai was more polluted than Agaraharam, posing ecological and health risks. Namakkal district in Tamil Nadu, covering 3404 km^2, faces frequent water scarcity and quality issues (Senthilmanickam et al., 2016). Samson & Elangovan (2011) analyzed water from 73 locations, revealing Na-Cl facies dominance and increasing salinity hazards post-monsoon. Groundwater chemistry is primarily influenced by rock interactions, with additional surface and evaporation effects post-monsoon. Kosavampatti Lake in Namakkal district, historically significant, supports groundwater recharge and bird nesting. Myvizhi & Devi (2020) study on the Cauvery River in Tamil Nadu revealed significant heavy metal contamination, especially with lead, cadmium, arsenic, chromium, nickel, and selenium. Conducted during monsoon and post-monsoon seasons, the findings highlighted that industrial effluents from power plants, dyeing industries, and tanneries were major pollution sources, exceeding WHO limits. Groundwater samples from ten locations around Namakkal were analyzed bi-monthly from June to December 2007 for physicochemical parameters like pH, hardness, and contaminants by Karunakaran et al. (2009). The study assessed groundwater suitability for domestic and irrigation use, revealing that in some areas, water quality did not meet WHO and BIS standards. Jothivenkatachalam & Nithya (2011) analyzed groundwater in Namakkal District, Tamil Nadu, assessing various physicochemical and biological parameters. Results were compared with ICMR, USPH, and WHO standards, highlighting significant correlations and potential health risks. In Namakkal district's Oddapalli, groundwater quality is compromised by effluents from the Seshasayee paper mill and Ponni sugar mill. The study found elevated levels of Fe, Ca, Mg, dissolved CO_2, NO_3, SO_4, total solids, and PO_4, while dissolved O_2 was low. The water is unsuitable for drinking and agriculture, highlighting the need for proper effluent treatment. Overall, the groundwater quality was deemed desirable for drinking, with the Groundwater Quality Index (GWQI) map highlighting higher quality in the northern regions. Sensitivity analysis emphasized the importance of monitoring Mg^{2+}, and Na^+ regularly and with increased precision. Khan & Ravikumar (2013) examined the connection between alkalinity and fluoride ion presence in under surface water from Tiruchengode taluk. Samples revealed that higher alkalinity, exceeding permissible limits, promotes fluoride ion release, as OH^- and F^- ions easily exchange in alkaline conditions.

This study aims to comprehensively evaluate the spatial and seasonal variations in undersurface water quality in Paramathivelur Taluk, Namakkal District, by analyzing physicochemical parameters such as TDS, EC, pH, hardness, chlorides, COD, BOD, sulfates, alkalinity, nitrates, and fluorides during post-monsoon and pre-monsoon periods. It seeks to assess the impact of seasonal changes on water quality and determine its suitability for agricultural and drinking uses. The research addresses a gap by providing a detailed periodic analysis of the Paramathivelur region and using Gibbs plots to reveal key geochemical processes.

2. MATERIALS AND METHODS

2.1. Samples

In Tamil Nadu, Namakkal district is strategically located and surrounded by numerous major districts. It is bordered by Erode district to the west and Tiruchirappalli district to the east (Tamilchelvan & Muralimohan, 2019). It is surrounded by Karur region to the south and Salem region to the north. Namakkal region, located between latitudes 11º 00'00" N and 11º 34' 48" N, and longitudes 77º 40'15" E and 78º 29' 30" E, has a total area of approximately 3404 square kilometers (Manorama & Paulsamy, 2013). Namakkal, Rasipuram, Tiruchengode, Paramathivelur, Kolli Hills, Sendamangalam, Kumarapalayam, and Mohanur are the eight administrative taluks of the district, included in Figure 1. These taluks contribute to the district's unique cultural and economic landscape, with Namakkal as its administrative hub.

Table 1. Sample details

Sample Code	Name of the location	Location details
P1	Paramathi	11.1525°N, 78.0214°E
P2	Velur	11.1123°N, 78.0031°E
P3	Pothanur	11.1106°N, 77.9898°E
P4	Viranampalayam	11.1339°N, 77.9870°E
P5	Kabilakkuruchi	11.1648°N, 77.9547°E
P6	Pandamangalam	11.1041°N, 77.9638°E
P7	Sittampoondi	11.2563°N, 77.9153°E
P8	Pillikalpalayam	11.1082°N, 77.9323°E
P9	Anangur	11.1220°N, 77.8945°E
P10	Jedarpalayam	11.1529°N, 77.8895°E

The region is noted for its agricultural output, educational institutions, and historical value, particularly the picturesque Kolli Hills, a popular tourist destination (Thamilarasu & Sharmila, 2015). In this study, the water quality of Paramathi Velur taluk has been analyzed using a spatial map (Figure 1), with samples collected from ten different locations within the taluk. Sample details are listed in Table 1.

2.2. Water Quality Index (WQI)

The WQI is an arithmetical depiction that integrates several physicochemical parameters of water into a single value, reflecting the overall water quality for specific uses, such as drinking, agriculture, or industrial purposes (Gobinath & Ramesh, 2023). The WQI assists as a critical tool for water quality management, offering a comprehensive assessment that is easily interpretable by scientists, policymakers, and the general public. The WQI is calculated through a multi-step process, which includes the selection of relevant water quality parameters, the task of weight factors to each parameter, and the normalization of these parameters to a common scale. The first step in determining WQI involves selecting specific water quality parameters that are crucial for evaluating the overall health of the water body. These parameters typically include total dissolved solids (TDS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), dissolved oxygen (DO), pH, nitrates, sulfates, chlorides, and hardness, among others (Mohan et al., 2024). Each selected constraint is assigned a weight (W_i) based on its relative importance in determining water quality. Parameters that have a greater impact on water quality, such as BOD and dissolved oxygen, are assigned higher weights compared to less critical parameters like temperature. The observed values of each parameter are normalized using a rating scale (usually from 0 to 100), where the scale is designed such that higher values indicate better water quality.

The rating scale can be linear or non-linear, depending on the parameter.

The normalized value (q_i) for a parameter can be calculated as:

$$q_i = \left(\frac{V_i - V_{max}}{V_i + V_{max}}\right) x\ 100 \ (1)$$

where: V_i is the observed value of the constraint, V_{max} and V_{min} are the maximum and minimum permissible limits of the constraint, respectively.

Calculation of sub-indices: The sub-index (SI_i) for each limitation is calculated by multiplying the normalized value (q_i) by the weight (W_i) assigned to that parameter:

$$SI_i = W_i + q_i \ (2)$$

Aggregation of SI_i: the complete WQI is then determined by summing the sub-indices for all parameters:

$$WQI = \sum_{i=1}^{n} SIi \ (3)$$

where *n* is the number of parameters considered in the research.

The WQI value provides a clear and concise indication of the water quality. The interpretation of WQI typically follows a categorical scale, such as above 100: very poor water quality, unsuitable; 76-100: poor water quality; 51-75: fairwater quality; 26-50: good water quality; 0-25: excellent water quality for drinking. The WQI is an essential tool in water resource management, as it simplifies complex water quality data into an accessible format. This allows for quick decision-making and prioritization of water treatment efforts. By assessing WQI, authorities can identify water bodies requiring immediate attention, ensuring appropriate measures are taken to protect public health and maintain environmental sustainability.

2.3. UV-Vis Spectrophotometer Analysis

In the UV Spectrometer analysis, samples were prepared by taking a specified amount of the stock solution (1 mL) into the specimen holder. The analysis was conducted at a wavelength of 300 nm, which is a commonly used wavelength for detecting the presence of specific contaminants and determining their concentration levels.

3. RESULTS AND DISCUSSION

3.1. Spatial Maps of Paramathivelur Taluk during Pre-monsoon

In investigating the water quality in Paramathi Velur taluk, samples were gathered in the pre-monsoon season from 10 distinct locations. The parameters measured like temperature, pH, chemical oxygen demand, biochemical oxygen demand, total dissolved solids, electrical conductivity, hardness, chlorides, sulfates, alkalinity, nitrates, and fluorides, are included in Table 2. The WQI is graphically presented in Figure 2. The temperature across the locations ranged from 25.0 °C in Jedarpalayam (P10) to 29.2 °C in Velur (P2). The pH values varied between 7.14 in Kabilakkuruchi (P5) and 8.00 in Velur (P2), indicating slightly alkaline conditions. Electrical conductivity (EC) values were highest at Velur (P2) with 912 µS/cm and lowest at Paramathi (P1) with 600 µS/cm.

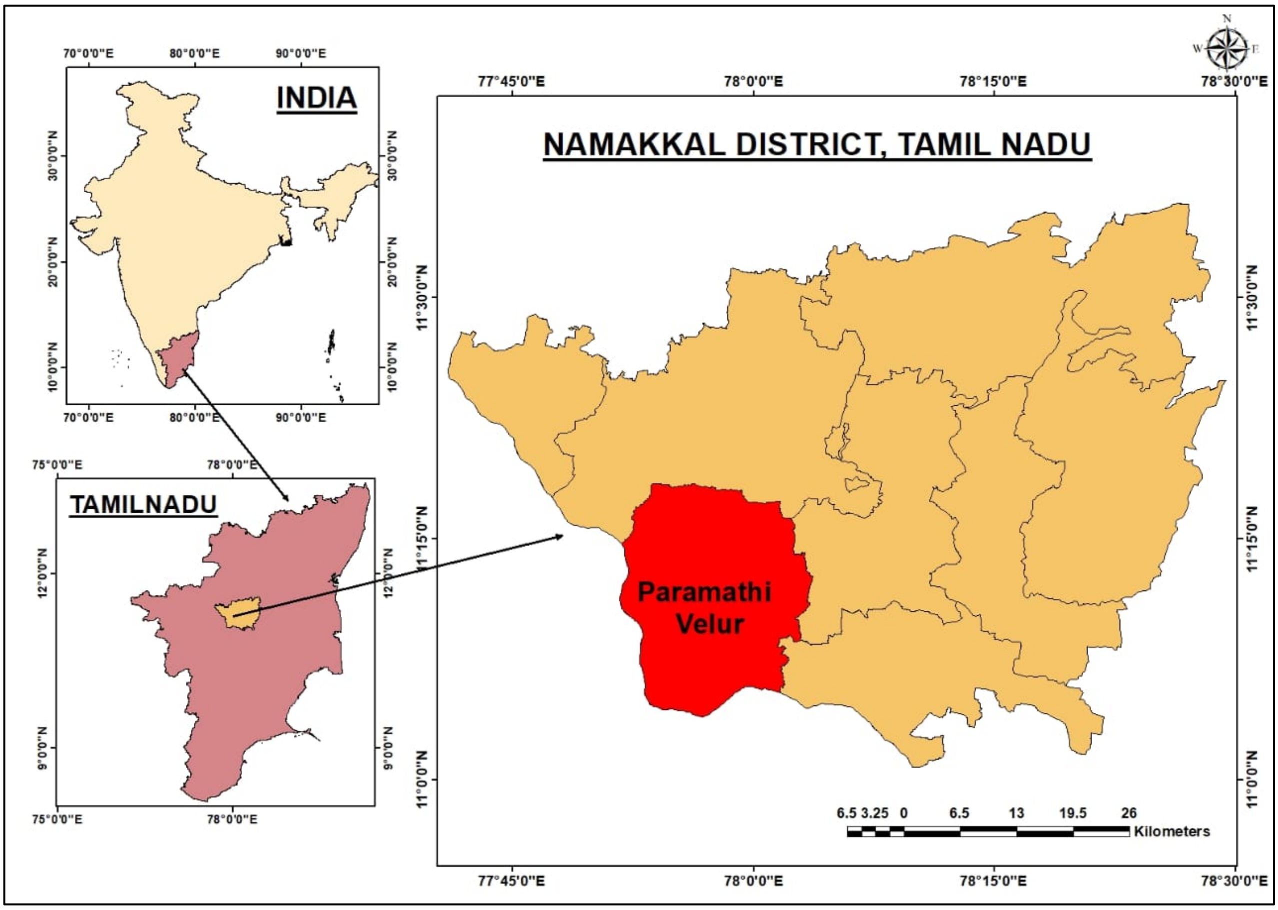

Figure 1. Study area

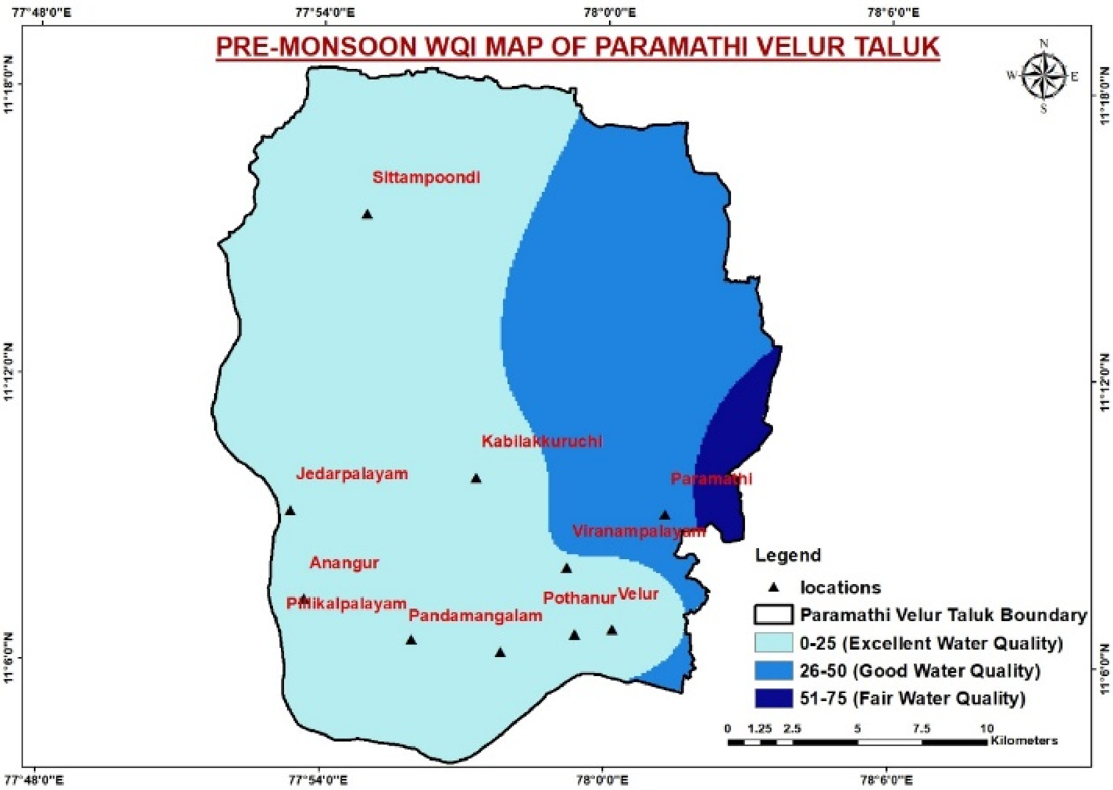

Figure 2. Water quality index of Paramathivelur taluk during pre-monsoon

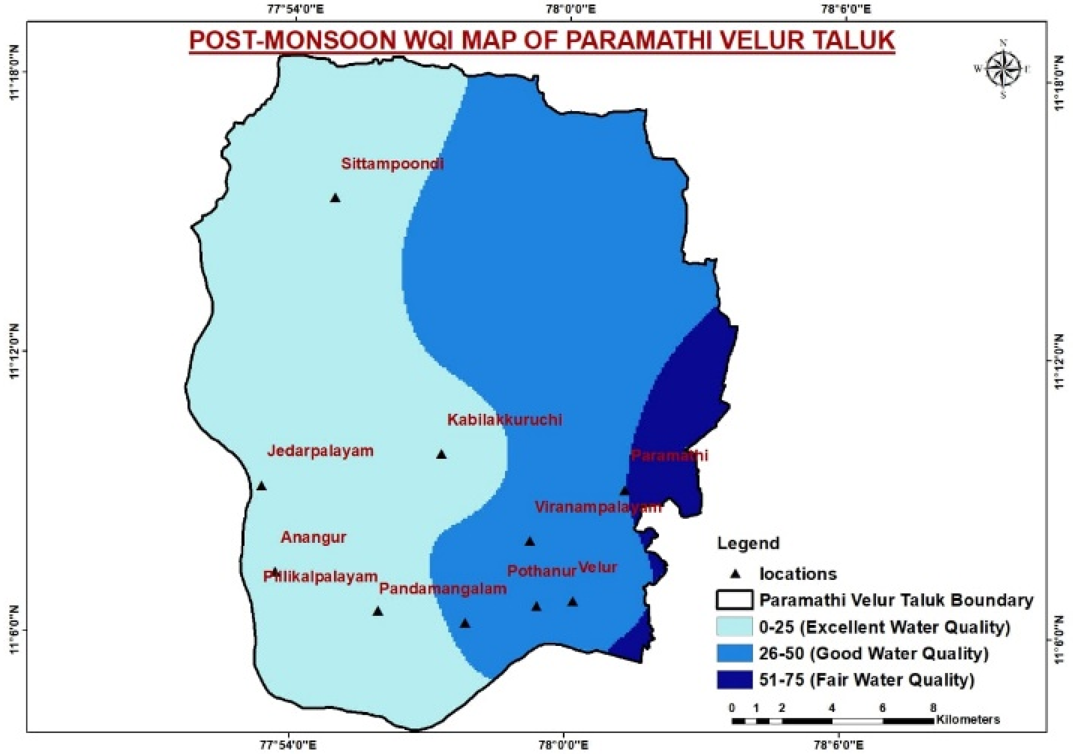

Figure 3. Water quality index of Paramathivelur taluk during pre-monsoon

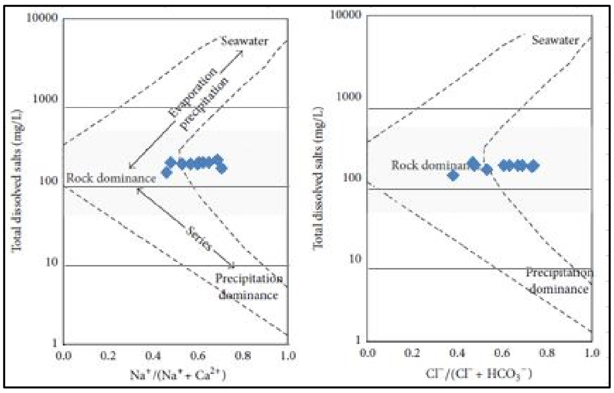

Figure 4. Gibbs plot for Paramathivelur taluk during pre-monsoon

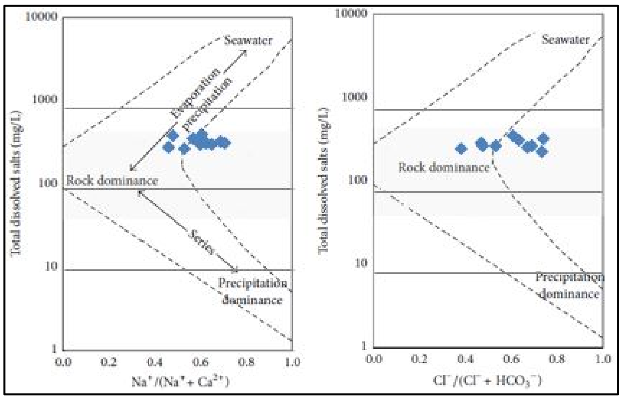

Figure 5. Gibbs plot for Paramathivelur taluk during post-monsoon

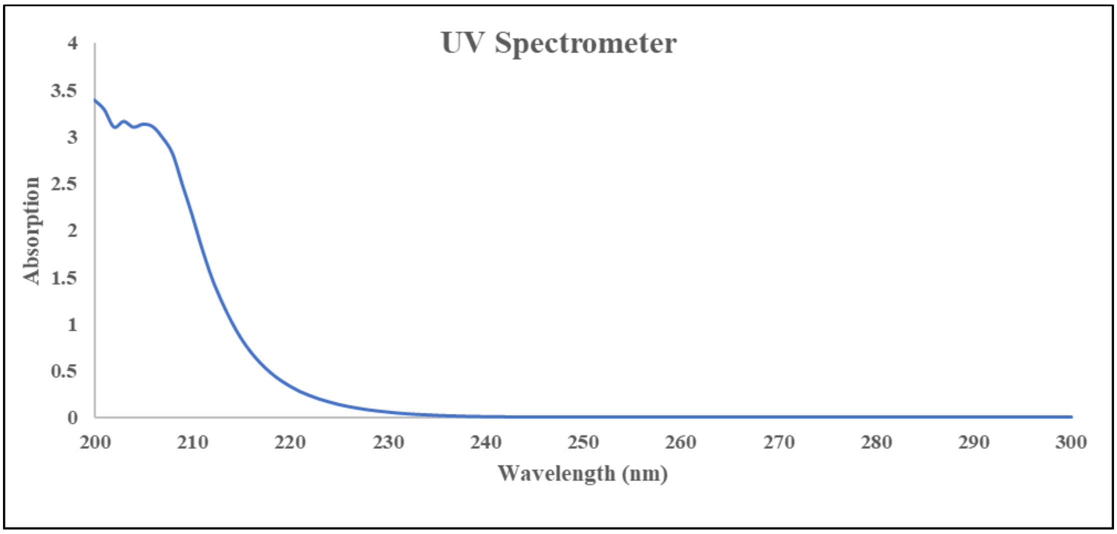

Figure 6. UV Spectrometer analysis

TDS was found to be relatively consistent across locations, ranging from 150 mg/L in Sittampoondi (P7) to 215 mg/L in Paramathi (P1). Hardness levels were highest in Pothanur (P3) at 178 mg/L and lowest in Paramathi (P1) and Jedarpalayam (P10) at 108 mg/L. Chloride absorptions fluctuated from 57 mg/L in Pandamangalam (P6) to 174 mg/L in Kabilakkuruchi (P5). The biochemical oxygen demand (BOD) varied from 2.56 mg/L in Sittampoondi (P7) to 4.5 mg/L in Paramathi (P1), while the chemical oxygen demand (COD) was highest at Paramathi (P1) with 4.7 mg/L and lowest at Jedarpalayam (P10) and Pandamangalam (P6) with 2.1 mg/L. Sulfate levels were highest in Pothanur (P3) at 90 mg/L and lowest in Jedarpalayam (P10) at 33.1 mg/L. Alkalinity ranged significantly, from 89.4 mg/L in Pandamangalam (P6) to 524 mg/L in Velur (P2). Nitrate concentrations were highest in Kabilakkuruchi (P5) and Velur (P2) at 9.35 mg/L and 9.1 mg/L, correspondingly, and lowest in Jedarpalayam (P10) at 5.1 mg/L. Fluoride levels varied from below detectable limits (BDL) in Velur (P2) to 0.47 mg/L in Pillikalpalayam (P8). Overall, the data reflect variations in water quality across the locations, with certain parameters exceeding typical acceptable levels, indicating potential concerns for domestic and agricultural use.

3.2. Spatial Maps of Paramathivelur Taluk during Post-monsoon

The post-monsoon season analysis of the physicochemical characteristics of water samples from Paramathivelur taluk, as detailed in Table 3, provides significant insights into the water quality across ten different locations. Figure 3 depicts that the water temperature across the locations during the post-monsoon period ranged from 38.1 °C in Jedarpalayam (P10) to 40.1 °C in Pothanur (P3). These relatively high temperatures are typical for post-monsoon periods in semi-arid regions and can influence other water quality parameters such as DO. The pH values varied from 7.10 in Jedarpalayam (P10) to 7.54 in Anangur (P9), representing that the water is a little acidic to neutral across all locations. The pH range suggests that the water remains within the acceptable limits for most agricultural and domestic uses, though it leans slightly towards acidity in some locations. EC values, which indicate the water's ability to conduct electricity (related to its ionic content), ranged from 360 µS/cm in Paramathi (P1) and Kabilakkuruchi (P5) to 680 µS/cm in Anangur (P9). Higher EC values can be indicative of higher concentrations of dissolved salts, which may affect the water's suitability for certain uses. The TDS values varied between 310 mg/L in Viranampalayam (P4) and 480 mg/L in Velur (P2), with the highest value recorded at Anangur (P9) with 450 mg/L. The values suggest that the water quality is within permissible limits, though higher TDS can be a concern for drinking water standards. The concentration of calcium and magnesium ions in water is measured as hardness, and the values in Viranampalayam (P4) and Paramathi (P1) were 124 mg/L and 201 mg/L, respectively. These values indicate that the water is moderately hard, which can affect its suitability for domestic use, particularly in households relying on soap-based cleaning products. Chloride concentrations, indicative of the presence of salts like sodium chloride, ranged from 70 mg/L in Paramathi (P1) to 158 mg/L in Anangur (P9). Chloride levels are within acceptable limits for most uses, though elevated levels could be a concern for sensitive crops if used for irrigation. BOD calculates how much oxygen aerobic microorganisms need to decompose organic matter in water; it reaches from 2.5 mg/L in Jedarpalayam (P10) to 4.38 mg/L in Kabilakkuruchi (P5). These values suggest varying levels of organic pollution, with higher BOD indicating more pollution. COD, a measure of the overall oxygen content needed to oxidize water's organic and inorganic constituents, varied from 2.12 mg/L in Jedarpalayam (P10) to 3.75 mg/L in Sittampoondi (P7). The results show moderate levels of pollutants, consistent with the BOD findings. Sulfate levels ranged from 20 mg/L in Jedarpalayam (P10) to 68.1 mg/L in Anangur (P9). Sulfate concentrations are well within safe limits, but high levels can lead to issues such as a laxative effect when used as drinking water. Alkalinity, which reflects the water's ability to neutralize acids, wide-ranging from 90.7 mg/L in Jedarpalayam (P10) to 156 mg/L in Viranampalayam (P4). These values indicate that the water has a good buffering capacity, which is beneficial in maintaining pH stability. Nitrate levels extended from 1.6 mg/L in Jedarpalayam (P10) to 3.8 mg/L in Velur (P2). Nitrates are essential for plant growth but high concentrations can be harmful to infants and pregnant women when present in drinking water. Fluoride concentrations were found to be relatively low, ranging from 0.13 mg/L in Jedarpalayam (P10) to 0.36 mg/L in Velur (P2). These levels are well within WHO-suggested limits for consumption, minimizing the risk of dental fluorosis or other health issues. Overall, the post-monsoon analysis reveals that while the water quality in Paramathivelur taluk generally meets the standards for most uses, there are variations in certain parameters that could influence its suitability for specific applications such as drinking, agriculture, and industrial use.

The comparison of physicochemical parameters between the post-monsoon and pre-monsoon periods in Paramathivelur Taluk reveals significant seasonal variations in water quality. Temperatures were notably higher post-monsoon, ranging from 38.1 °C to 40.1 °C, compared to 25.0 °C to 29.2 °C in the pre-monsoon period, reflecting the typical seasonal temperature increase. The pH values slightly decreased post-monsoon (7.10 to 7.54) due to the dilution effect of rainfall, compared to a range of 7.14 to 8.00 pre-monsoon. Electrical conductivity (EC) decreased from 600 - 912 µS/cm pre-monsoon to 360 - 680 µS/cm post-monsoon, indicating a dilution of dissolved salts. Despite this, total dissolved solids (TDS) increased post-monsoon (310 - 480 mg/L) than the pre-monsoon (150 - 215 mg/L), possibly due to runoff introducing more dissolved materials. Hardness values remained relatively similar across both periods, with a slight increase post-monsoon. Chloride levels showed consistent concentrations between the two periods, suggesting stable sources of contamination. BOD and COD both slightly decreased post-monsoon, likely due to the dilution of chemical and organic pollutants. Sulfate levels also dropped post-monsoon, from 33.1 - 90 mg/L to 20 - 68.1 mg/L. Alkalinity saw a significant decrease post-monsoon, from 89.4 - 524 mg/L to 90.7 - 156 mg/L, reflecting reduced buffering capacity in the water. Nitrate and fluoride concentrations also decreased post-monsoon, with nitrates dropping from 5.1 - 9.35 mg/L to 1.6 - 3.8 mg/L, and fluorides from 0.47 mg/L to 0.13 - 0.36 mg/L, likely due to the dilution effects of the increased water volume. Overall, these changes highlight the influence of seasonal rainfall on water quality, with dilution generally reducing the concentrations of many contaminants, while runoff and other factors may contribute to increased levels of certain parameters like TDS.

For agricultural use, water quality is primarily assessed based on parameters such as EC, TDS, sodium hazards, and hardness. The EC values ranged from 360 to 680 µS/cm, which are within acceptable limits for irrigation purposes, indicating that the water has a moderate salinity hazard. However, the TDS levels post-monsoon (310 - 480 mg/L) are slightly higher than pre-monsoon (150 - 215 mg/L), which could affect soil salinity over time if not managed properly. Hardness levels, which also influence the suitability for irrigation, remained relatively stable, with values slightly increasing post-monsoon. The chloride content, which can be detrimental to certain crops at high levels, remained fairly consistent across both seasons, indicating stable levels of salt intrusion or contamination. Given these factors, the water is generally suitable for agriculture, but continuous monitoring is essential to prevent long-term soil salinity and ensure sustainable farming practices. Regarding drinking water suitability, the assessment involves parameters such as pH, TDS, hardness, chlorides, nitrates, sulfates, and fluoride concentrations. The pH values during both periods were within the WHO-suggested range for drinking water (6.5 to 8.5), signifying the water is not overly acidic or alkaline. However, post-monsoon TDS values were on the higher side (310 - 480 mg/L), nearing the upper limit for palatability according to WHO guidelines, which might affect the taste and acceptability of the water. The hardness levels, although stable, are approaching the threshold where water begins to be classified as hard, potentially leading to issues like scaling in pipes and household appliances. Chloride levels were consistent but should be monitored, as excessive chloride can lead to hypertension and other health issues.

The reduction in nitrate levels post-monsoon is a positive sign, but concentrations should remain low

Table 2. Physico-chemical parameters of water samples collected during pre-monsoon

Parameter	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Temperature	28.1	29.2	27.2	26.1	27.5	27.1	26.7	25.1	26.4	25.0
pH	7.97	8.00	7.91	7.53	7.14	7.51	7.55	7.71	7.99	7.2
EC	600	912	901	714	750	724	715	800	627	740
TDS	215	200	194	190	196	201	150	173	199	200
Hardness	130	143	178	108	156	152	138	110	144	108
Chlorides	106	132	156	128	174	57	131	125	131	111
BOD	4.5	3.1	3.1	3.88	4.24	2.7	2.56	3.88	3.7	2.71
COD	4.7	3.4	3.24	3.1	3.75	2.1	2.32	3.01	3.21	2.10
Sulphates	67.2	60	90	84.6	47.2	42.2	36.4	40.9	67.5	33.1
Alkalinity	191	524	201	197	145	89.4	177.2	189.2	184	188
Nitrates	7.52	9.1	7.65	9.35	9.1	6.1	6.2	6.1	7.11	5.1
Fluorides	0.21	BDL	0.31	0.45	0.41	0.32	0.32	0.47	0.39	0.29
WQI	49	51	28	26	30	29	26.8	24	25	21

Table 3. Physico-chemical parameters of water samples collected during post-monsoon

Parameter	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Temperature	39.6	39.9	40.1	39.2	39.7	39.5	39.4	38.4	39.2	38.1
pH	7.3	7.12	7.21	7.26	7.3	7.26	7.41	7.28	7.54	7.10
EC	360	490	450	360	540	450	460	450	680	500
TDS	390	480	360	310	420	370	330	370	450	351
Hardness	201	164	155	124	136	173	165	164	175	126
Chlorides	70	131	145	145	125	127	97	102	158	91
BOD	3.8	3.9	3.4	4.3	4.38	3.8	2.62	3.39	3.99	2.5
COD	3.1	3.2	3.12	2.9	2.91	2.94	3.75	3.4	3.44	2.12
Sulphates	42.4	40.8	38	32	39	40	21.4	38.4	68.1	20
Alkalinity	102	148	138	156	109	151	99.1	100.1	108.1	90.7
Nitrates	2.8	3.8	2.25	2.64	2.36	2.56	2.91	2.71	2.1	1.6
Fluorides	0.29	0.36	0.24	0.22	0.21	0.19	0.18	0.16	0.24	0.13
WQI	51	56	38	36	31	30	30	25	26	22

to prevent health risks, especially for infants. The fluoride content, although within permissible limits, should be monitored to avoid long-term health impacts such as dental fluorosis. Effective groundwater management in Paramathivelur Taluk requires a comprehensive approach that includes regular assessment and monitoring of water quality and quantity, alongside the implementation of recharge enhancement techniques such as rainwater harvesting and artificial recharge structures. Sustainable agricultural practices, including water-efficient irrigation methods and crop selection suited to local conditions, are crucial to reducing groundwater depletion. Pollution control measures, such as ensuring proper effluent treatment by industries and promoting responsible agrochemical use, are essential to prevent contamination. Engaging the community through awareness programs and involving local stakeholders in water management initiatives can foster collective responsibility for groundwater conservation. Additionally, enforcing groundwater extraction regulations, providing incentives for conservation practices, and supporting research and development efforts are vital to sustaining groundwater resources in the taluk. By adopting these strategies, Paramathivelur Taluk can ensure the long-term availability and quality of groundwater for agriculture and domestic use.

3.3. GIBBS Plot

A Gibbs plot is a crucial tool for understanding the geochemical processes that shape groundwater chemistry, such as rock-water precipitation, evaporation, and interaction. In this analysis, the ratios Na/(Na+Ca) and Cl/(Cl+HCO_3) were plotted against TDS to identify the dominant processes influencing the water quality in the studied area and presented graphically in Figure 4 and Figure 5. The Na/(Na+Ca) ratio ranged from 0.4578 to 0.6987, indicating varying degrees of sodium dominance, likely due to ion exchange processes in clay-rich aquifers. The Cl/(Cl+HCO_3) ratio, ranging from 0.2253 to 0.4461, suggests the influence of evaporation, with higher values indicating greater chloride concentration, possibly due to the evaporation of water or seawater intrusion. The variation in TDS values, from 310 to 480 mg/L, reflects the overall mineral content, with higher values pointing to increased mineral dissolution or evaporation effects. Together, these ratios on the Gibbs plot help in assessing the water's suitability for agriculture and understanding the key geochemical processes at play in the groundwater system.

3.4. UV Spectrometer Analysis

The absorbance readings obtained at 300 nm provide insights into the concentration of the target analyte within the samples and are presented graphically in Figure 6. Higher absorbance values typically indicate a higher concentration of the analyte, whereas lower values suggest lower concentrations. The results for the different analyzed samples revealed a consistent trend where samples from Anangur, Paramathi, and Velur showed higher absorbance compared to other locations in this taluk. The variation in absorbance across the samples suggests potential differences in pollution sources or levels of contamination across the sampling sites. These findings are critical for understanding the extent of contamination and guiding subsequent steps in water treatment or further investigation. Future studies could expand on these findings by exploring other wavelengths or employing complementary analytical techniques to verify and enhance the strength of the results.

4. CONCLUSION

1. The study of groundwater quality in Paramathivelur Taluk reveals significant seasonal variations influenced by the pre-monsoon and post-monsoon periods. Temperature increased post-monsoon from 25.0 °C - 29.2 °C to 38.1 °C - 40.1 °C, while pH levels became slightly more neutral, ranging from 7.14 - 8.00 pre-monsoon to 7.10 - 7.54 post-monsoon. EC and TDS exhibited opposite trends, with EC decreasing significantly from 600 - 912 µS/cm to 360 - 680 µS/cm post-monsoon, while Total Dissolved Solids increased from 150 - 215 mg/L to 310 - 480 mg/L. Hardness values showed a minor increase post-monsoon, reflecting stable water hardness with a pre-monsoon range of 108 - 178 mg/L and a post-monsoon range of 124 - 201 mg/L.

2. Chloride levels remained stable, indicating consistent sources of contamination, with values fluctuating from 57 - 174 mg/L pre-monsoon to 70 - 158 mg/L post-monsoon. Both BOD and COD saw slight reductions post-monsoon due to the dilution of pollutants by rainfall. Sulfate concentrations and alkalinity decreased post-monsoon, from 33.1 - 90 mg/L to 20 - 68.1 mg/L and 89.4 - 524 mg/L to 90.7 - 156 mg/L, respectively, reflecting the dilution effect. Nitrate levels significantly decreased from 5.1 - 9.35 mg/L pre-monsoon to 1.6 - 3.8 mg/L post-monsoon, while fluoride levels also dropped from below detectable levels to 0.47 mg/L pre-monsoon to 0.13 - 0.36 mg/L post-monsoon.

3. The UV Spectrometer analyses revealed key organic and inorganic contaminants in Paramathi Velur Taluk's drinking water, highlighting areas with higher pollution levels. Regular monitoring and targeted water treatment are essential to ensure water safety and address localized contamination, safeguarding public health and maintaining water quality.

4. Overall, the study highlights the impact of monsoon rainfall on groundwater quality, with most parameters remaining within acceptable limits for drinking and agricultural use. However, the observed increase in TDS and slight changes in hardness post-monsoon emphasize the need for continuous monitoring and sustainable management practices to preserve groundwater quality in the region. Geochemical processes, including evaporation, ion exchange, and mineral dissolution, as confirmed by Gibbs plot analysis, play an important role in shaping groundwater chemistry, underscoring the importance of tailored management strategies to ensure long-term resource sustainability.

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