International Journal on Science and Technology (IJSAT)

E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

Groundwater Quality Assessment for Drinking Purposes Using the Water Quality Index in Eastern Davangere City, Karnataka, India

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Abstract

Groundwater is a major source of drinking water in urban and semi-urban regions of India, making its quality assessment essential for protecting public health and supporting sustainable water resource management. This study assessed groundwater quality in Eastern Davanagere City, Karnataka, India, using physicochemical analysis and the Weighted Arithmetic Water Quality Index (WQI). A total of 60 groundwater samples were collected from borewells during March and April 2026 and analysed for major physicochemical parameters following standard analytical procedures. The analytical results were evaluated against the Bureau of Indian Standards (BIS IS 10500:2012) drinking water specifications. The calculated WQI values ranged from 16.87 to 93.18, indicating that 3.33% of the samples were classified as excellent, 60.00% as good, 30.00% as poor, and 6.67% as very poor, while no sample was unsuitable for drinking. Elevated concentrations of total dissolved solids, total hardness, and magnesium hardness were the primary factors influencing groundwater quality deterioration at several locations. Overall, groundwater in the study area was generally suitable for drinking; however, continuous monitoring and appropriate management measures are recommended to maintain its long-term quality and sustainability.

Keywords: Groundwater quality, Water Quality Index (WQI), Drinking water, Physicochemical parameters, Groundwater monitoring, BIS IS 10500:2012.

1. Introduction

Groundwater is one of the most important freshwater resources and serves as the primary source of drinking water for domestic, agricultural, and industrial uses in many parts of the world. In India, rapid urbanisation, population growth, and increasing demand for freshwater have significantly increased dependence on groundwater resources. Although groundwater is generally considered more reliable than surface water, its quality is influenced by natural hydrogeological conditions and anthropogenic activities. Therefore, periodic assessment of groundwater quality is essential for protecting public health and supporting sustainable water resource management [1,12,24,29].

Groundwater quality is controlled by various natural processes, including rock–water interaction, mineral weathering, aquifer characteristics, and groundwater recharge, while human activities such as urban expansion, domestic wastewater discharge, agricultural practices, and improper solid waste disposal may further deteriorate water quality. These factors often result in considerable spatial variation in groundwater chemistry, affecting its suitability for drinking purposes. Consequently, regular monitoring of physicochemical parameters is necessary to identify potential contamination and evaluate groundwater quality [4,10,20,29].

The Water Quality Index (WQI) is widely used to express the overall quality of water by integrating multiple physicochemical parameters into a single numerical value. Among the available approaches, the Weighted Arithmetic Water Quality Index has been extensively applied because of its simplicity, reliability, and ease of interpretation. The method enables effective comparison of groundwater quality among different sampling locations and provides useful information for water resource planners and decision-makers [4,24,25,30].

Several studies have successfully applied the WQI approach to evaluate groundwater quality in different regions of India. Recent investigations have also combined WQI with hydrogeochemical interpretation and statistical techniques to improve groundwater quality assessment. These studies indicate that elevated concentrations of dissolved solids and hardness-related parameters are the major factors affecting groundwater quality in many hard-rock aquifer regions [2,3,15,18,26,27].

Although groundwater quality has been investigated in several regions of Karnataka, updated information for the eastern part of Davanagere City remains limited despite rapid urban development and increasing dependence on groundwater for drinking purposes. Therefore, the present study evaluates groundwater quality in Eastern Davanagere City using physicochemical analysis and the Weighted Arithmetic Water Quality Index based on sixty groundwater samples. The analytical results were compared with the Bureau of Indian Standards (BIS IS 10500:2012) drinking water specification to determine groundwater suitability for drinking purposes [8].

2. Study Area

The study was conducted in the eastern part of Davanagere City, Karnataka, India, a rapidly developing urban region in the state's central region (Figure 1). The study area is geographically located between 14.44°N and 14.50°N latitude and 75.88°E and 75.96°E longitude, with an average elevation of approximately 597 m above mean sea level (MSL). Groundwater extracted through borewells is the principal source of drinking water in the area owing to increasing urbanisation and limited availability of surface water resources.

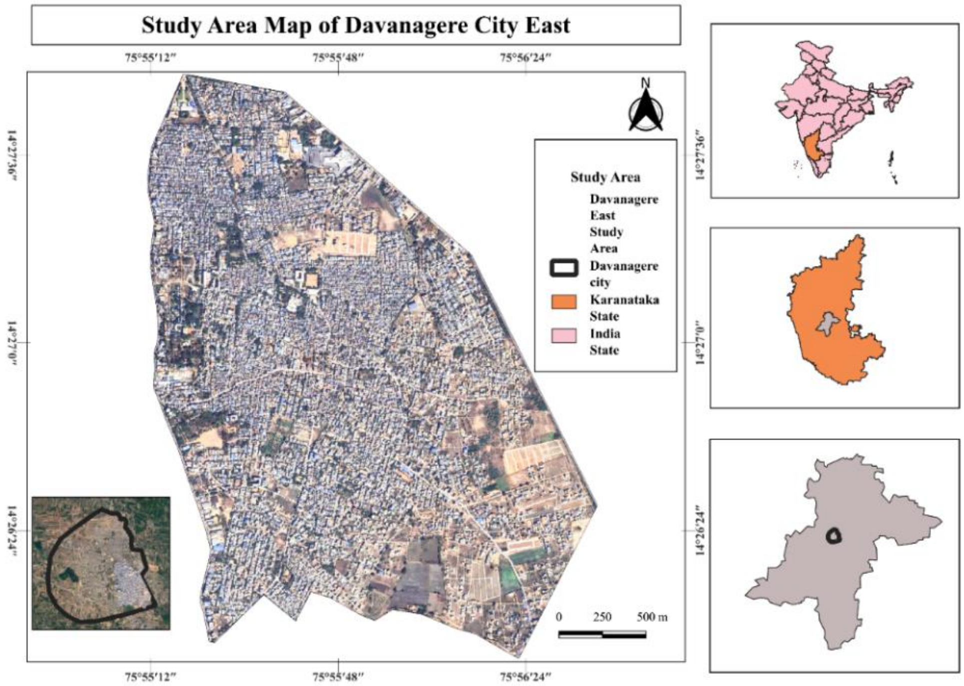

Figure 1. Location map of the study area (Eastern Davanagere City, Karnataka, India).

The study area experiences a semi-arid tropical climate, with hot summers, moderate monsoon rainfall, and mild winters. The average annual rainfall ranges from 600 to 700 mm, most of which is received during the southwest monsoon, while the annual temperature generally varies between 20°C and 38°C. These climatic conditions play an important role in groundwater recharge and seasonal variations in groundwater availability.

Geologically, the area forms part of the Peninsular Gneissic Complex, comprising predominantly granite and gneiss formations. Groundwater occurs mainly within weathered and fractured hard-rock aquifers, where its occurrence and chemical characteristics are controlled by rock weathering, groundwater–rock interaction, and fracture systems. Residential, commercial, educational, and transportation infrastructures, with limited agricultural land, dominate land use. The increasing dependence on groundwater highlights the need for regular monitoring to ensure its suitability for drinking purposes. The principal characteristics of the study area are summarised in Table 1 [8].

Table 1. Principal characteristics of the study area.

Parameter	Description
Study Area	Davanagere City East
State	Karnataka, India
Latitude	14.44°N - 14.50°N
Longitude	75.88°E - 75.96°E
Average elevation	~597 m above MSL
Climate	Semi-arid tropical
Average annual Rainfall	600-700 mm/year
Temperature Range	20°C-38°C
Geology	Granite and gneiss (Peninsular Gneissic Complex)
Primary source of drinking water	Groundwater
Borewell Depth	150-280 ft

3. Materials and Methods

Groundwater quality was evaluated through systematic field sampling, laboratory analysis, and Water Quality Index (WQI) assessment. A total of 60 groundwater samples were collected from representative borewells distributed across the eastern part of Davanagere City. The collected samples were analysed for selected physicochemical parameters following standard analytical procedures, and the analytical results were evaluated using the Weighted Arithmetic WQI to determine groundwater suitability for drinking purposes. The overall methodological framework adopted in the present study is illustrated in Figure 2.

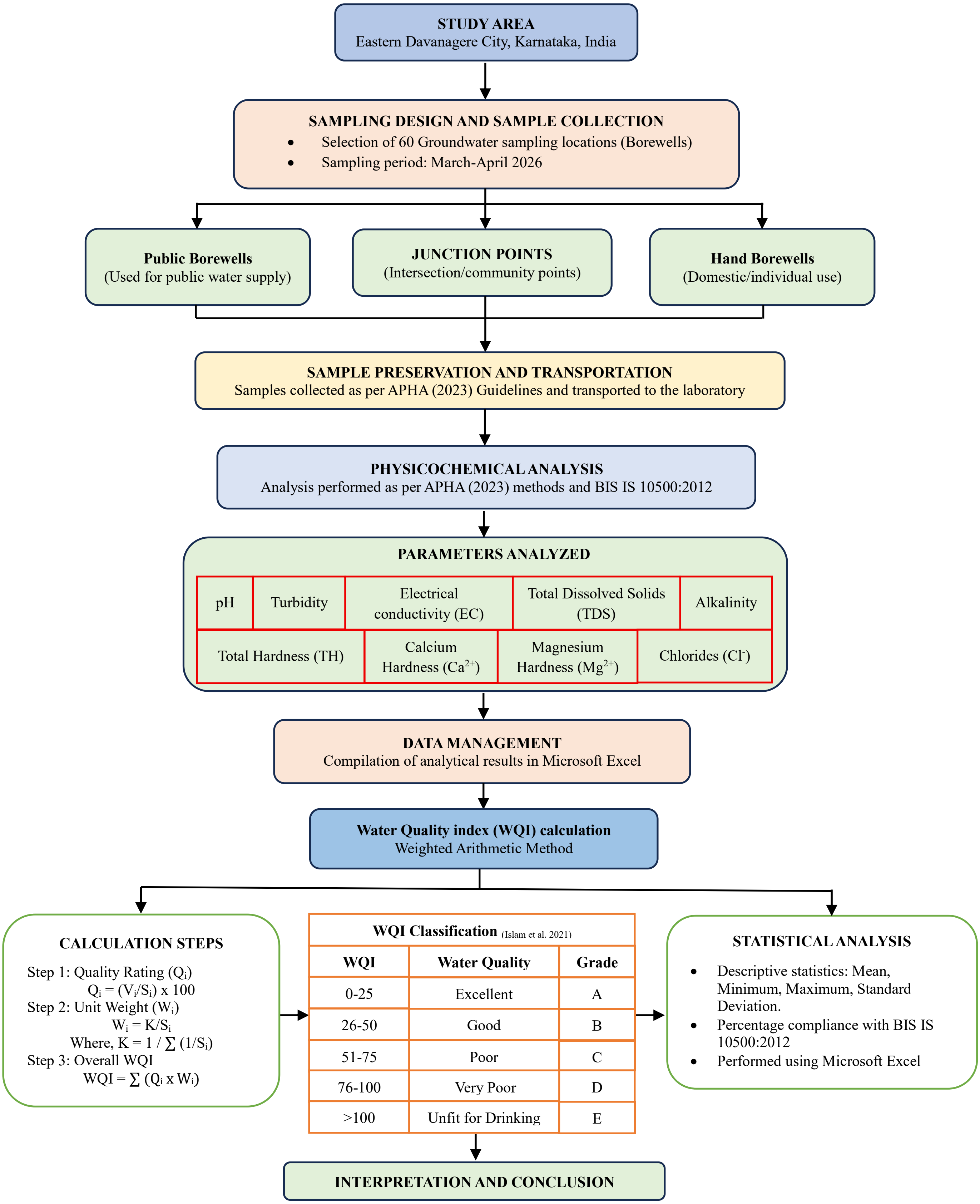

Figure 2. Methodological framework adopted for groundwater quality assessment in Eastern Davanagere City, Karnataka, India.

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4. Groundwater Sampling

Groundwater samples were collected from 60 borewells distributed across the eastern part of Davanagere City, Karnataka, India, during March and April 2026. The sampling locations were selected to provide representative spatial coverage of residential and developing urban areas where groundwater is the primary source of drinking water. The spatial distribution of the sampling locations is presented in Figure 3.

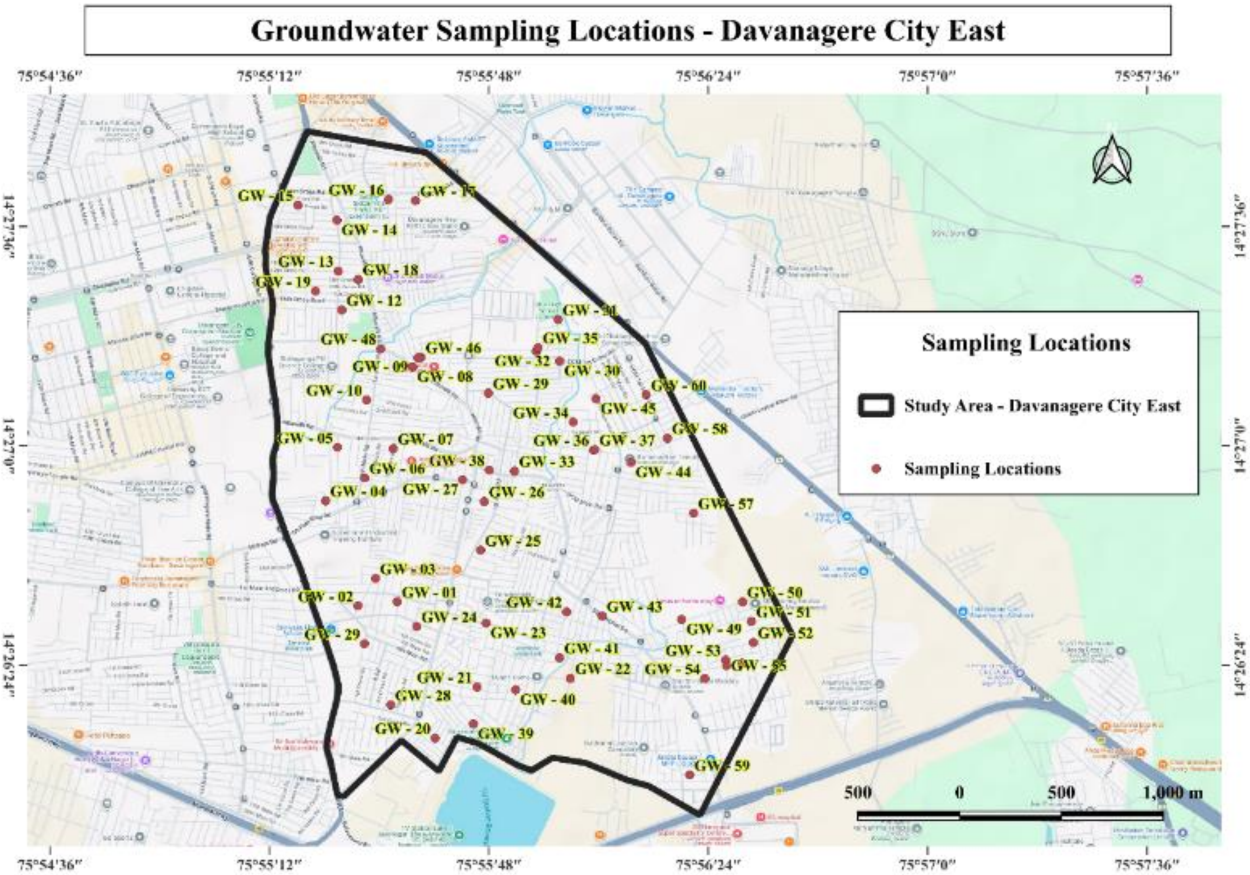

Figure 3. Spatial distribution of groundwater sampling locations (GW-01 to GW-60) in Eastern Davanagere City.

Water samples were collected in clean polyethene bottles following the procedures recommended by the American Public Health Association (APHA) [5]. Before sample collection, each borewell was allowed to pump for several minutes to obtain representative groundwater. The sample bottles were rinsed with groundwater from the respective sampling location before collection to minimise contamination. All samples were properly labelled, transported to the laboratory under suitable conditions, and analysed within the recommended holding period.

The geographical coordinates of each sampling location were recorded using a handheld Global Positioning System (GPS) receiver to facilitate spatial identification and documentation of the sampling sites. The collected groundwater samples were subsequently analysed for selected physicochemical parameters to evaluate their suitability for drinking purposes.

5. Physicochemical Analysis:

The collected groundwater samples were analysed for pH, alkalinity, turbidity, chlorides, dissolved oxygen (DO), total dissolved solids (TDS), electrical conductivity (EC), total hardness, calcium hardness, and magnesium hardness using standard analytical procedures recommended by the APHA [5]. The analytical results were compared with the Bureau of Indian Standards (BIS) IS 10500:2012 drinking water specifications to evaluate the suitability of groundwater for drinking purposes [8].

The laboratory analyses were carried out using calibrated instruments and standard titrimetric methods. The pH, EC, and TDS were measured using digital meters, while turbidity was determined using a nephelometric turbidity meter. Alkalinity, chlorides, total hardness, calcium hardness, and magnesium hardness were determined by standard volumetric titration methods. Dissolved oxygen was measured using the modified Winkler azide method in accordance with APHA procedures [5]. The analytical methods adopted for each parameter and the corresponding BIS drinking water standards are summarised in Table 2.

Table 2. Analytical methods and instruments used for physicochemical analysis

Sl. No.	**Parameter**	**Unit**	**Analytical Method (APHA, 2023)**	**BIS Desirable Limit**	**BIS Permissible Limit***
1	pH	-	Digital pH meter	6.5-8.5	No relaxation
2	Alkalinity	mg/L as $CaCO_3$	Titrimetric method	200	600
3	Turbidity	NTU	Nephelometric method	1	5
4	Chlorides	mg/L	Argentometric titration	250	1000
5	Dissolved Oxygen (DO)	mg/L	Modified Winkler azide method	-	-
6	TDS	mg/L	Digital TDS meter	500	2000
7	EC	µS/cm	Digital conductivity meter	-	-
8	Total Hardness	mg/L as $CaCO_3$	EDTA titrimetric method	200	600
9	Calcium Hardness	mg/L as $CaCO_3$	EDTA titrimetric method	75	200
10	Magnesium Hardness	mg/L as $CaCO_3$	Calculated from total and calcium hardness	30	100

Standard quality assurance and quality control (QA/QC) procedures were followed throughout the laboratory analysis. All instruments were calibrated before use, and analytical measurements were performed using standard reagents and clean laboratory glassware to ensure the accuracy and reliability of the results. The measured values were compared with the Bureau of Indian Standards (BIS) IS 10500:2012 drinking water specifications to evaluate the suitability of groundwater for drinking purposes [8].

6. Water Quality Index (WQI):

The WQI was used to evaluate the overall suitability of groundwater for drinking purposes by integrating multiple physicochemical parameters into a single numerical value. The Weighted Arithmetic WQI method was adopted because of its simplicity and reliability in groundwater quality assessment [24, 30, 21].

The WQI was computed using nine physicochemical parameters, namely pH, alkalinity, turbidity, chlorides, TDS, EC, total hardness, calcium hardness, and magnesium hardness. Although DO was analysed to assess groundwater quality, it was excluded from the WQI calculation because BIS IS 10500:2012 does not specify a drinking water standard for this parameter [8].

The standard values, ideal values, and calculated unit weights adopted for WQI computation are presented in Table 3. The overall WQI was calculated using Equation (1).

$$WQI = \frac{\sum WiQi}{\sum Wi} \qquad (1)$$

where:

- Wi = unit weight assigned to the *i*th parameter
- Qi = quality rating of the *i*th parameter

Lower WQI values indicate better groundwater quality, whereas higher values indicate progressive deterioration in groundwater quality.

The calculated WQI values were classified into five groundwater quality categories according to the classification proposed by Islam et al. (2021), as presented in Table 4 [21].

Table 3. Standard values, ideal values, and unit weights used for WQI computation.

Parameter	**Standard value (Si)**	**Ideal value (Vo)**	**Unit weight (Wi)**
pH	8.5	7	0.309071
Alkalinity (mg/L)	200	0	0.013136
Turbidity (NTU)	5	0	0.525421
Chlorides (mg/L)	250	0	0.010508
Total Dissolved Solids (mg/L)	500	0	0.005254
Electrical Conductivity (µS/cm)	3000*	0	0.000876
Total Hardness (mg/L as $CaCO_3$)	200	0	0.013136
Calcium Hardness (mg/L as $CaCO_3$)	75	0	0.035028
Magnesium Hardness (mg/L as $CaCO_3$)	30	0	0.087570

*EC standard value (3000 µS/cm) was adopted from the literature for WQI computation because BIS IS 10500:2012 does not specify a drinking water standard for electrical conductivity.

Table 4. Classification of groundwater quality based on the Water Quality Index (adapted from Islam et al., 2021).

WQI	**Water Quality Status (WQS)**	**Water Quality Grading**	**Possible Uses**
0-25	Excellent	A	Suitable for industrial, potable and irrigation use
26-50	Good	B	Acceptable for irrigation, potable, and industrial use
51-75	Poor	C	Suitable for industrial and Irrigation purposes: requires treatment for drinking.
76-100	Very Poor	D	Suitable only for irrigation: not suitable for consumption
>100	Unfit for drinking	E	Proper treatment is required for any kind of usage

7. Results and Discussion

The groundwater quality of the study area was evaluated based on the analysis of ten physicochemical parameters, namely pH, alkalinity, turbidity, chlorides, DO, TDS, EC, total hardness, calcium hardness, and magnesium hardness. The analytical results were compared with the Bureau of Indian Standards (BIS) IS 10500:2012 drinking water specifications to assess the suitability of groundwater for drinking purposes [8]. The descriptive statistics of the analysed parameters are summarised in Table 5, while their spatial distributions are presented in Figures 4-13.

Table 5. Descriptive statistics of physicochemical parameters of groundwater samples collected from Eastern Davanagere City (n = 60).

Parameter	**Unit**	**Minimum**	**Maximum**	**Mean ± SD**	**BIS Desirable Limit**	**Within Limit**	**Exceeding Limit**	**% Exceeding**	**BIS Permissible Limit**
pH	-	6.91	8.95	7.92 ± 0.43	6.5-8.5	56	4	6.67	No relaxation
Alkalinity	mg/L as $CaCO_3$	4.60	52.60	35.50 ± 10.33	200	60	0	0.00	600
Turbidity	NTU	0.23	5.82	1.39 ± 1.34	1	57	3	5.00	5
Chlorides	mg/L	30.00	315.00	98.76 ± 52.65	250	58	2	3.33	1000
DO	mg/L	1.38	16.18	6.82 ± 4.18	-	-	-	-	-

TDS	mg/L	108	900	527.78 ± 144.88	500	24	36	60.00	2000
EC	µS/cm	200	1800	946.67 ± 297.71	-	60	0	0.00	-
Total Hardness	mg/L as $CaCO_3$	101.92	549.02	268.51 ± 93.59	200	17	43	71.67	600
Calcium Hardness	mg/L as $CaCO_3$	78.00	224.49	137.62 ± 34.10	75	60	0	0.00	200
Magnesium Hardness	mg/L as $CaCO_3$	15.92	324.53	130.89 ± 72.06	30	42	18	30.00	100

Note: Drinking water standards are based on BIS IS 10500:2012 [8]. No drinking water standards are specified for DO and EC in BIS IS 10500:2012.

The groundwater quality exhibited noticeable spatial variation across the study area. Most physicochemical parameters were within the permissible limits prescribed by BIS IS 10500:2012; however, elevated concentrations of total dissolved solids and hardness-related parameters were observed at several sampling locations. These variations are primarily associated with local hydrogeological conditions and groundwater-rock interactions, with possible contributions from urban activities. The results and their implications are discussed in the following subsections.

8. Acid-base and Aesthetic Parameters

The acid-base and aesthetic characteristics of groundwater were evaluated using pH, alkalinity, and turbidity, which are important indicators of water quality and drinking water acceptability. The descriptive statistics of these parameters are presented in Table 5, while their distributions are illustrated in Figures 4-6.

pH:

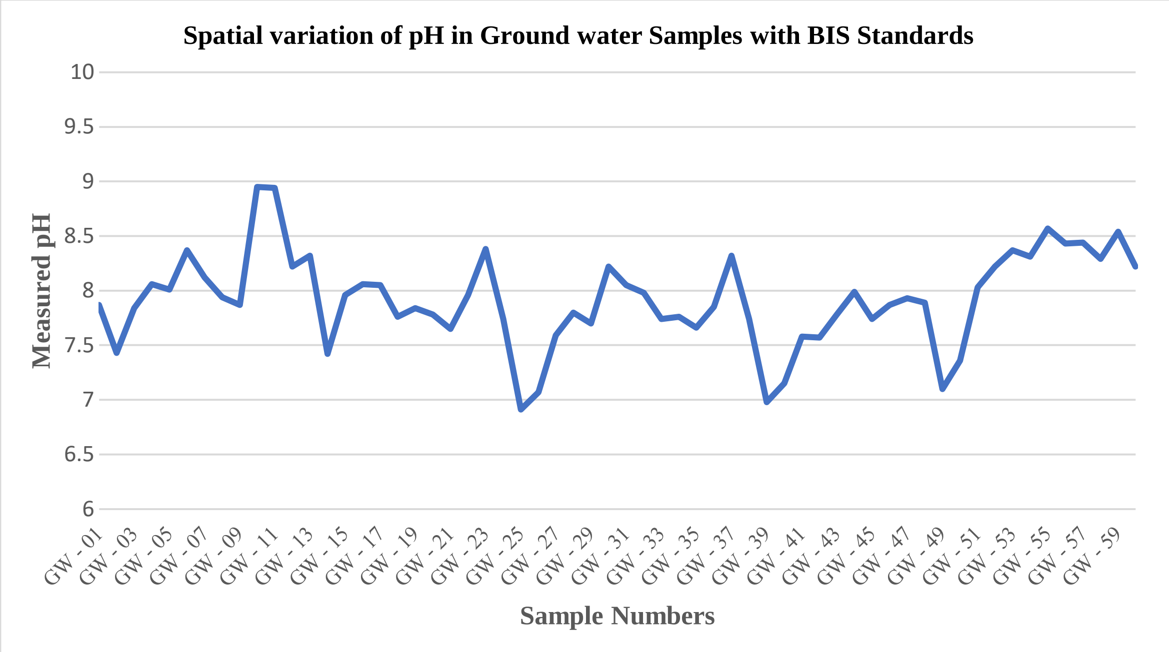

Figure 4. Distribution of pH in groundwater samples.

The measured pH values ranged from 6.91 to 8.95, with a mean value of 7.92 ± 0.43 (Table 5). Most groundwater samples (56 of 60; 93.33%) were within the acceptable pH range of 6.5-8.5 prescribed by BIS IS 10500:2012, while four samples (6.67%) slightly exceeded the upper acceptable limit. The predominance of neutral to slightly alkaline groundwater reflects the influence of mineral weathering within the granitic and gneissic aquifer system and indicates favourable conditions for drinking water.

Alkalinity:

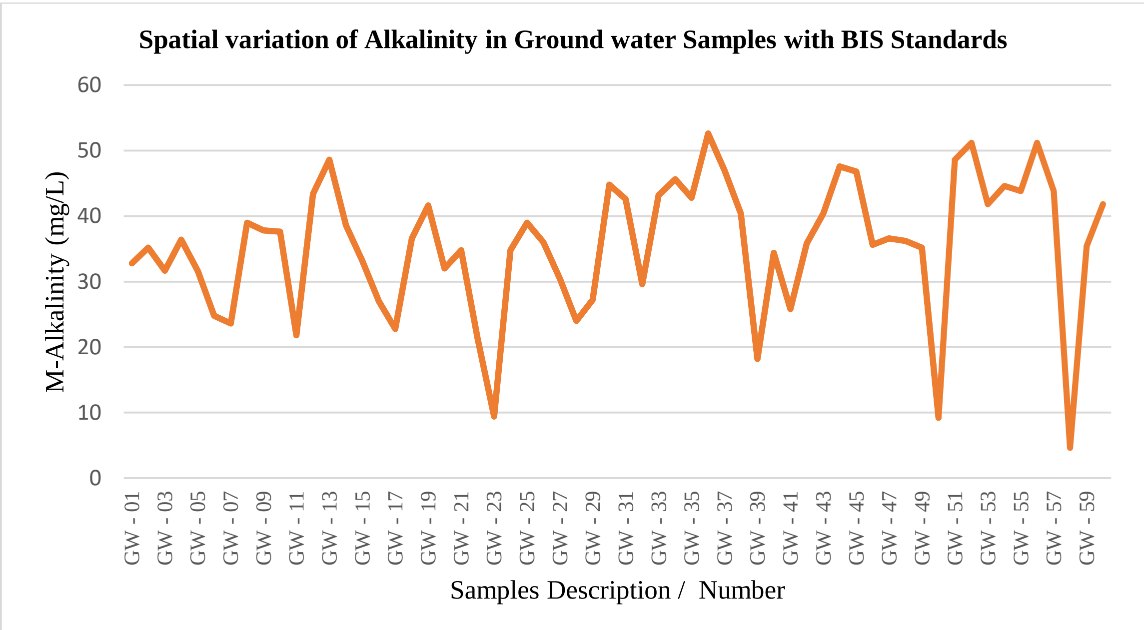

Figure 5. Distribution of alkalinity in groundwater samples.

Alkalinity varied from 4.60 to 52.60 mg/L as $CaCO_3$, with an average value of 35.50 ± 10.33 mg/L as $CaCO_3$ (Table 5). All groundwater samples were well below the desirable limit of 200 mg/L specified by BIS IS 10500:2012, indicating satisfactory buffering capacity and no alkalinity-related concerns for drinking water. The observed alkalinity is primarily attributed to the natural dissolution of carbonate and bicarbonate minerals in the aquifer.

Turbidity:

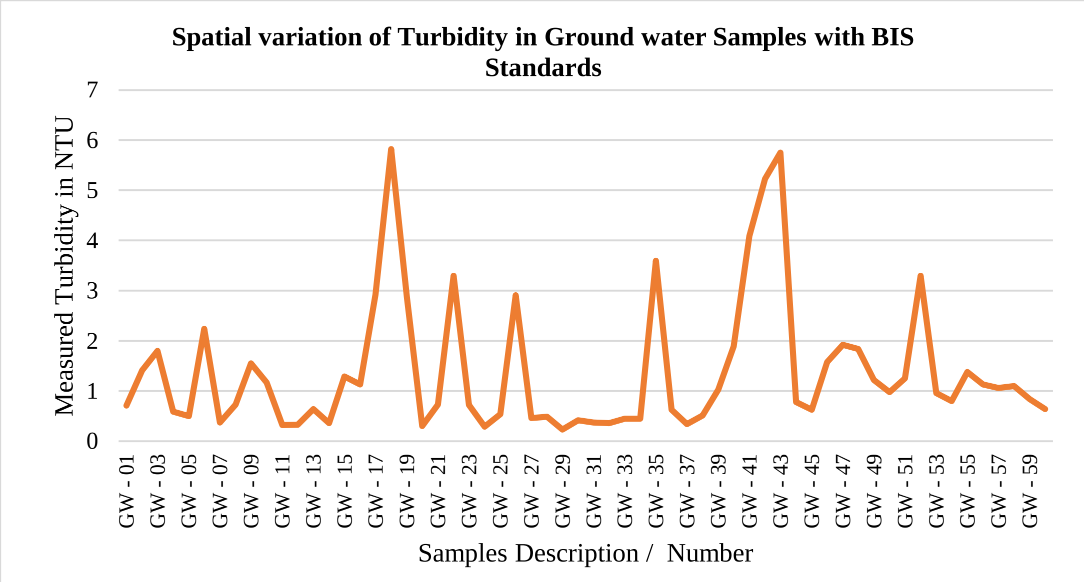

Figure 6. Distribution of turbidity in groundwater samples.

Turbidity values ranged from 0.23 to 5.82 NTU, with a mean value of 1.39 ± 1.34 NTU (Table 5). Fifty-seven samples (95.00%) complied with the BIS permissible limit of 5 NTU, whereas three samples (5.00%) marginally exceeded this limit. Elevated turbidity at a few locations may be associated with suspended particles or localised disturbances during groundwater abstraction. Overall, the low turbidity levels indicate that groundwater was generally clear and aesthetically acceptable for drinking purposes.

9. Salinity and Ionic Characteristics

The salinity and ionic characteristics of groundwater were evaluated using TDS, EC, and chlorides, which are important indicators of dissolved mineral content and groundwater chemistry. The descriptive statistics of these parameters are presented in Table 5, while their distributions are shown in Figures 7-9.

Total Dissolved Solids (TDS):

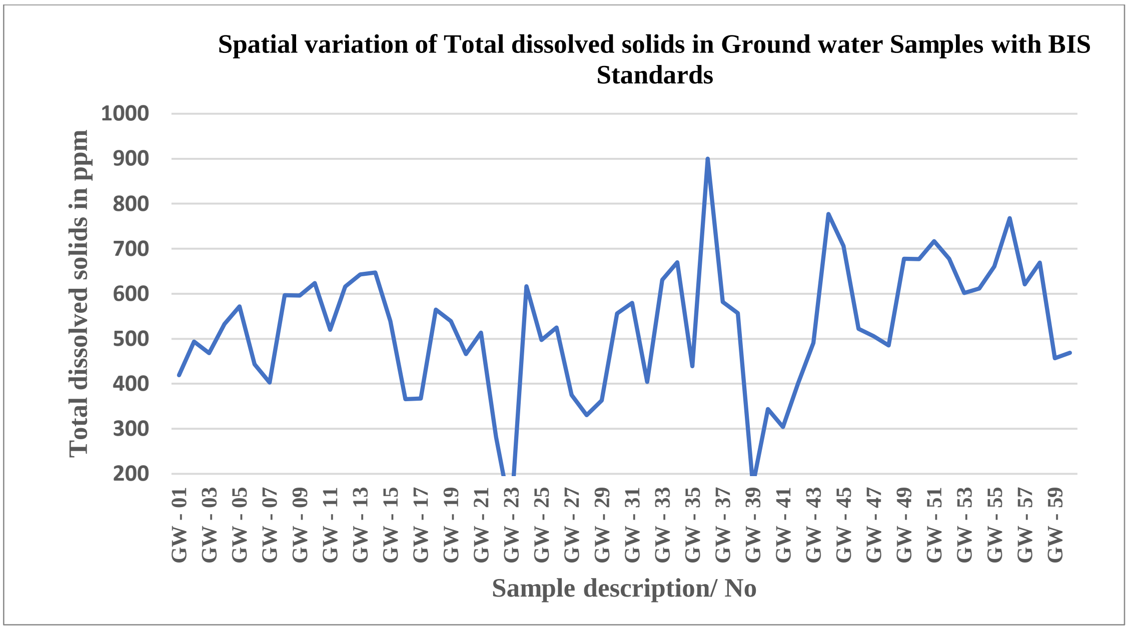

Figure 7. Distribution of TDS in groundwater samples.

The TDS concentration ranged from 108 to 900 mg/L, with a mean value of 527.78 ± 144.88 mg/L (Table 5). Based on BIS IS 10500:2012, 24 samples (40.00%) were within the desirable limit of 500 mg/L, whereas 36 samples (60.00%) exceeded this limit but remained below the permissible limit of 2000 mg/L. Elevated TDS concentrations indicate increased mineral dissolution during groundwater movement through the aquifer and may affect the palatability of drinking water. Nevertheless, all groundwater samples remained within the permissible BIS limit.

Electrical Conductivity (EC):

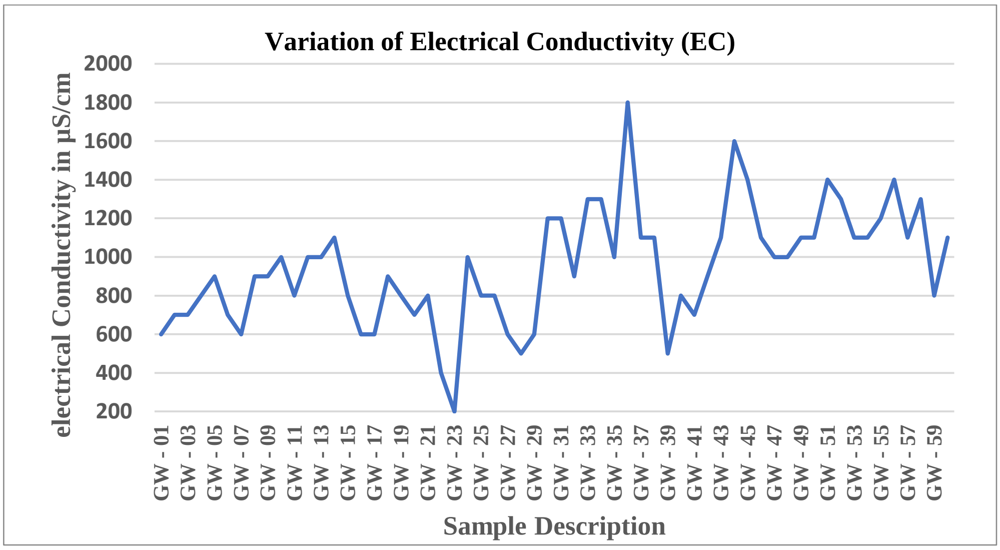

Figure 8. Distribution of electrical conductivity (EC) in groundwater samples.

Electrical conductivity varied from 200 to 1800 µS/cm, with an average value of 946.67 ± 297.71 µS/cm (Table 5). The observed EC values indicate moderate mineralisation of groundwater across the study area. A positive relationship between EC and TDS was observed because dissolved ionic constituents primarily control the electrical conductivity of groundwater. Areas with relatively high EC generally corresponded to locations exhibiting elevated TDS concentrations, reflecting increased dissolved salt content

Chlorides:

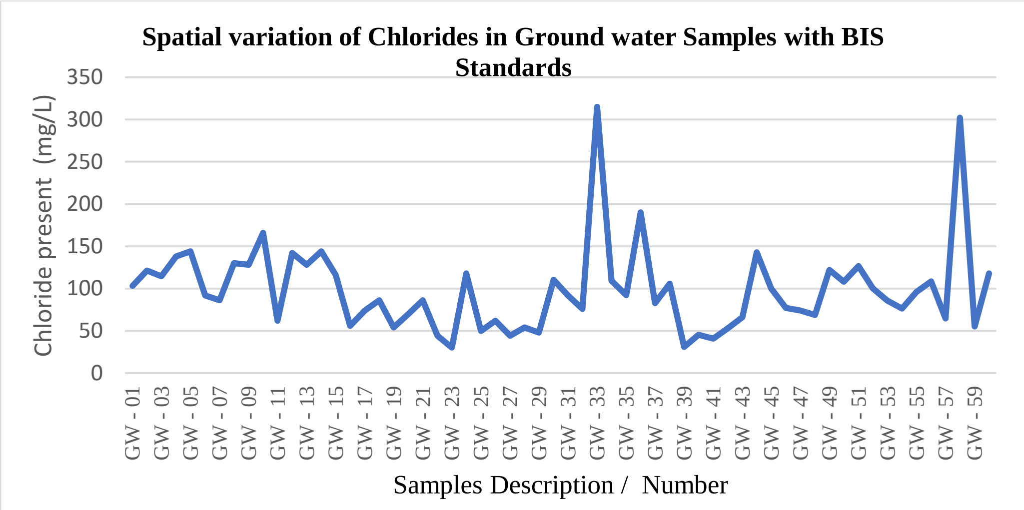

Figure 9. Distribution of chloride concentration in groundwater samples.

Chloride concentrations ranged from 30.00 to 315.00 mg/L, with a mean value of 98.76 ± 52.65 mg/L (Table 5). Most groundwater samples (58 of 60; 96.67%) were within the desirable limit of 250 mg/L, while only two samples (3.33%) slightly exceeded this value. However, all samples remained below the permissible limit of 1000 mg/L specified by BIS IS 10500:2012. The generally low chloride concentrations indicate limited influence of anthropogenic contamination, whereas the elevated values observed at a few locations may be associated with localised urban activities or natural groundwater–rock interactions.

10. Hardness characteristics

The hardness characteristics of groundwater were assessed using total hardness, calcium hardness, and magnesium hardness. These parameters are important indicators of groundwater mineralization and are primarily influenced by the dissolution of calcium- and magnesium-bearing minerals within the aquifer. The descriptive statistics are presented in Table 5, while their distributions are shown in Figures 10–12.

Total Hardness:

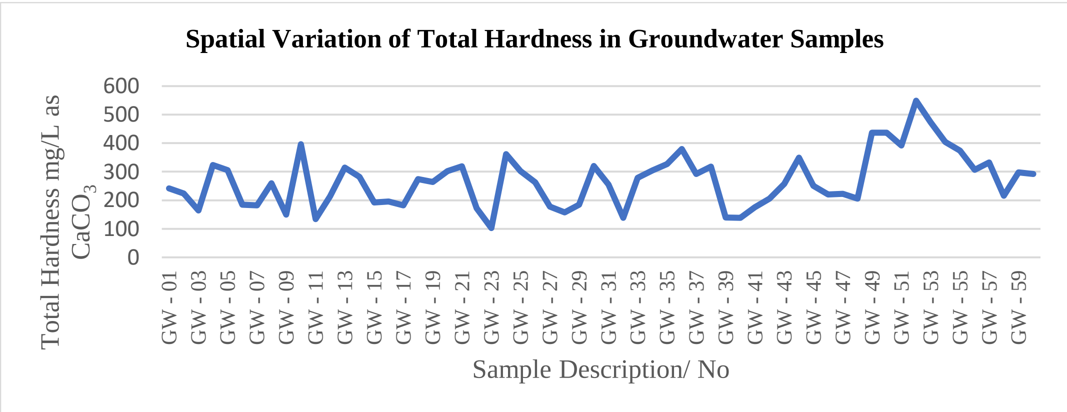

Figure 10. Distribution of total hardness in groundwater samples.

Total hardness ranged from 101.92 to 549.02 mg/L as $CaCO_3$, with a mean value of 268.51 ± 93.59 mg/L as $CaCO_3$ (Table 5). Based on BIS IS 10500:2012, 17 samples (28.33%) were within the desirable limit of 200 mg/L, whereas 43 samples (71.67%) exceeded this limit. However, all groundwater samples remained below the permissible limit of 600 mg/L, indicating that groundwater was acceptable for drinking with respect to total hardness. The elevated hardness observed at several locations is mainly attributed to natural groundwater–rock interactions within the granitic and gneissic aquifer system.

Calcium Hardness:

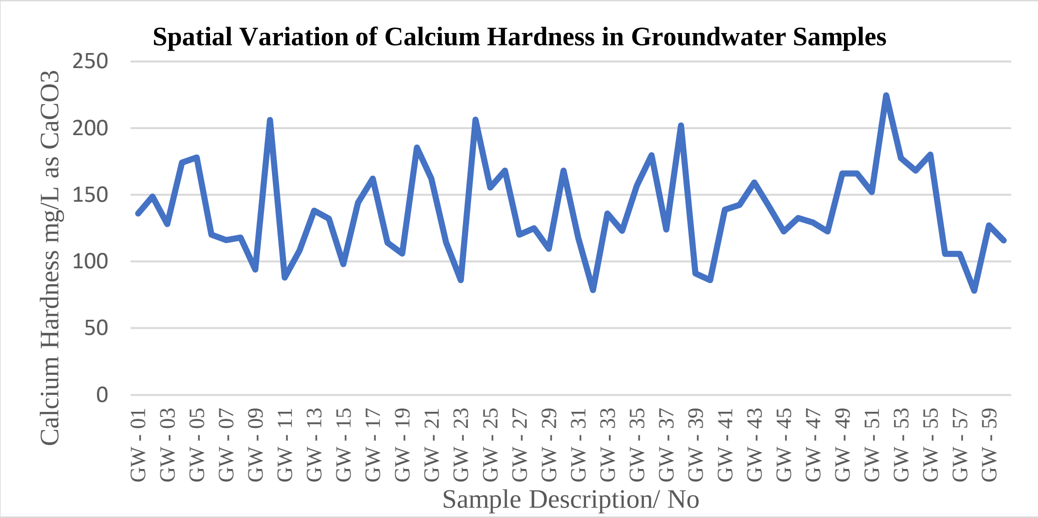

Figure 11. Distribution of calcium hardness in groundwater samples.

Calcium hardness varied from 78.00 to 224.49 mg/L as $CaCO_3$, with an average value of 137.62 ± 34.10 mg/L as $CaCO_3$ (Table 5). Only three samples (5.00%) exceeded the BIS permissible limit of 200 mg/L, while the remaining 57 samples (95.00%) complied with the standard. These results indicate that calcium hardness was generally within acceptable limits throughout the study area.

Magnesium Hardness:

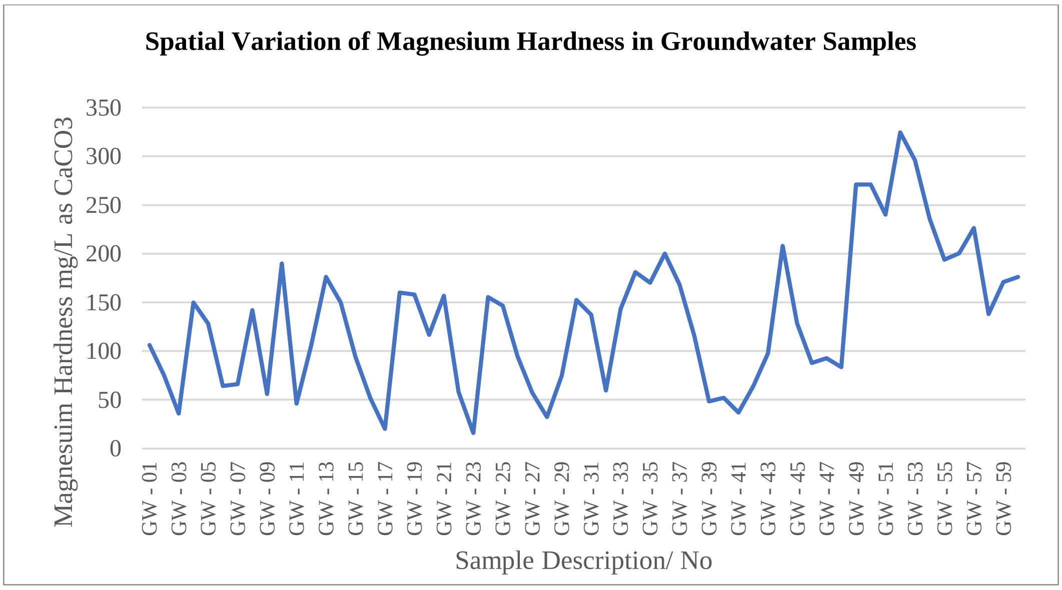

Figure 12. Distribution of magnesium hardness in groundwater samples.

Magnesium hardness ranged from 15.92 to 324.53 mg/L as $CaCO_3$, with a mean value of 130.89 ± 72.06 mg/L as $CaCO_3$ (Table 5). Forty-two samples (70.00%) complied with the adopted standard value of 100 mg/L, whereas 18 samples (30.00%) exceeded this value. Elevated magnesium hardness contributed to the increase in total hardness and influenced the Water Quality Index values at several locations.
Overall, the hardness characteristics indicate that groundwater quality is predominantly controlled by natural geological processes rather than anthropogenic contamination. Although elevated hardness was observed in several samples, all groundwater samples satisfied the BIS permissible limit for total hardness, suggesting that hardness does not pose a significant constraint on the use of groundwater for drinking purposes.

11. Dissolved Oxygen

The dissolved oxygen (DO) concentration was determined to evaluate the oxygenation status of groundwater and to provide supplementary information on groundwater quality. Although DO was analysed in this study, it was not included in the WQI because BIS IS 10500:2012 does not prescribe a drinking water standard for this parameter. The descriptive statistics are presented in Table 5, and the distribution of DO is shown in Figure 13.

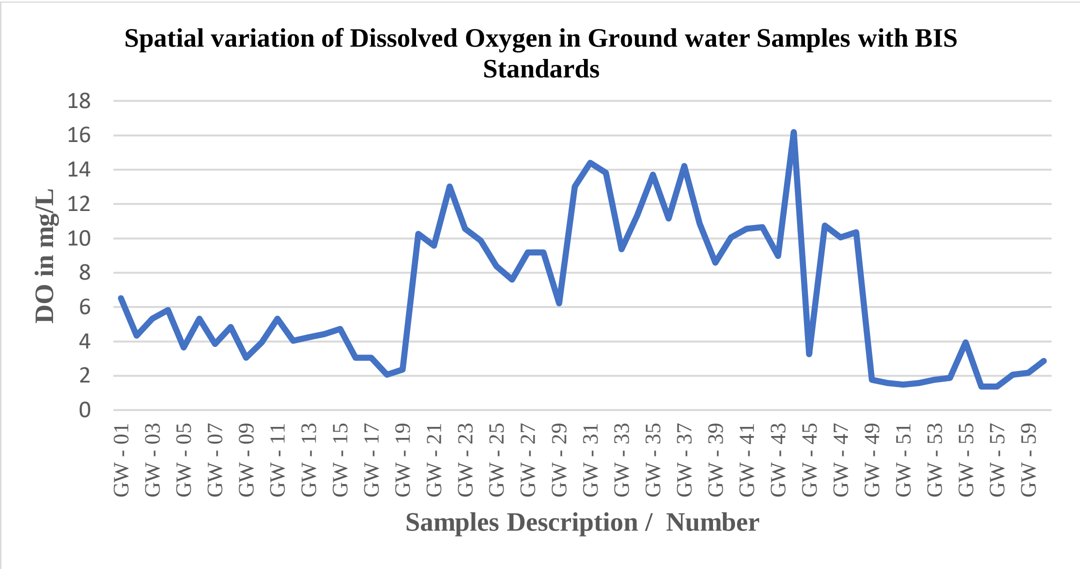

Figure 13. Distribution of dissolved oxygen in groundwater samples.

The measured DO concentrations ranged from 1.38 to 16.18 mg/L, with a mean value of 6.82 ± 4.18 mg/L (Table 5). Considerable spatial variation was observed among the sampling locations. Higher DO concentrations may be associated with groundwater recharge, shallow aquifer conditions, or localised aeration during sampling, whereas lower values indicate relatively oxygen-deficient groundwater. Since dissolved oxygen is not a regulated drinking water quality parameter under BIS IS 10500:2012, the observed variations do not directly determine the suitability of groundwater for drinking. However, DO provides useful information on groundwater conditions and complements the interpretation of the overall hydrochemical characteristics.

The overall assessment of physicochemical parameters indicates that groundwater quality in the study area is generally satisfactory for drinking purposes. Nevertheless, elevated concentrations of total dissolved solids, total hardness, and magnesium hardness at several locations contributed to the deterioration of groundwater quality and influenced the calculated Water Quality Index values.

12. Water Quality Index Assessment

The overall suitability of groundwater for drinking purposes was evaluated using the Weighted Arithmetic WQI, which integrates the combined effects of selected physicochemical parameters into a single numerical value representing the overall groundwater quality. The calculated WQI values ranged from 16.87 to 93.18, indicating variations in groundwater quality among the sampled locations. The variation in WQI values for the 60 groundwater samples is illustrated in Figure 14, while the groundwater quality classification based on the calculated WQI values is summarized in Table 6.

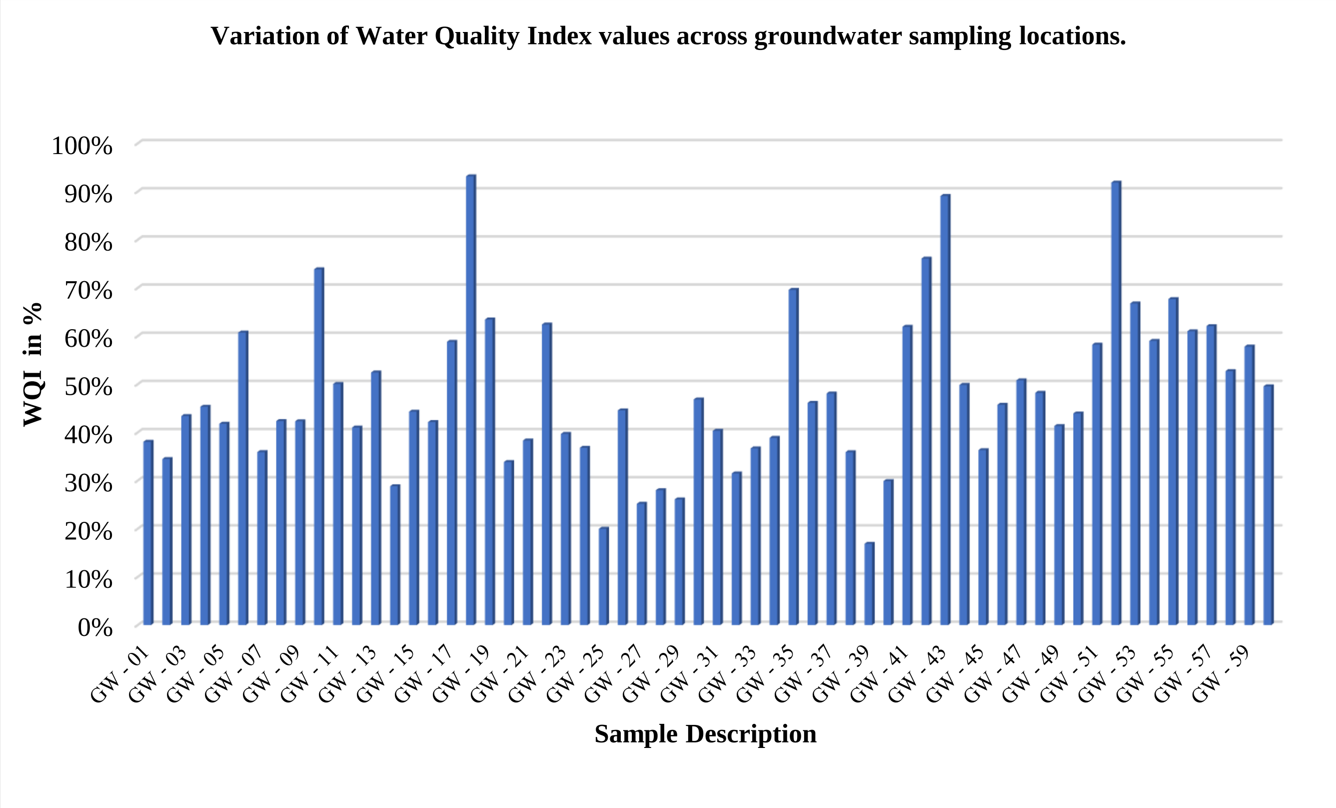

Figure 14. Variation of Water Quality Index (WQI) values for groundwater samples (GW-01 to GW-60).

The variation in WQI values shown in Figure 14 indicates that most groundwater samples exhibited relatively low WQI values corresponding to the Excellent and Good water quality categories, whereas comparatively fewer samples recorded higher WQI values representing the Poor and Very Poor categories. None of the groundwater samples exceeded a WQI value of 100, indicating that all sampled groundwater sources remained below the threshold classified as Unfit for Drinking.

Table 6. Distribution of groundwater samples based on Water Quality Index (WQI) classification.

Classification of WQI Values					
WQI	**(WQS)**	**Water Quality Grading**	**Possible Uses**	**Number of Samples**	**% of Samples**

0-25	Excellent	A	Suitable for domestic consumption, agricultural irrigation, and industrial use	2	3.33%
26- 50	Good	B	Acceptable for domestic consumption, agricultural irrigation, and industrial use	36	60.00%
51-75	Poor	C	Suitable for irrigation and industrial applications, but treatment is necessary before drinking use.	18	30.00%
76-100	Very Poor	D	Suitable only for irrigation; unsuitable for drinking purposes	4	6.67%
>100	Unfit for Consumption	E	Adequate treatment is necessary before using it for any purpose.	0	0.00%

Classification adapted from Islam et al. (2021).

As presented in Table 6, 36 groundwater samples (60.00%) were classified as Good, representing the dominant groundwater quality category in the study area. In addition, 2 samples (3.33%) were categorised as Excellent, while 18 samples (30.00%) and 4 samples (6.67%) were classified as Poor and Very Poor, respectively. Importantly, no groundwater sample was classified as Unfit for Drinking, indicating that groundwater quality in the study area was generally suitable for drinking purposes, although treatment may be required at selected locations exhibiting comparatively higher WQI values.

The predominance of the Good groundwater quality category demonstrates that most groundwater sources satisfy the drinking water quality requirements specified in BIS IS 10500:2012. The occurrence of Excellent groundwater at a few sampling locations reflects favourable hydrogeochemical conditions and comparatively lower concentrations of dissolved constituents. In contrast, groundwater classified as Poor and Very Poor exhibited relatively higher concentrations of dissolved solids and hardness-related parameters, resulting in elevated WQI values.

The variation in WQI values was primarily influenced by the combined effects of TDS, total hardness, magnesium hardness, and turbidity. Among these parameters, turbidity exerted a comparatively greater influence on the calculated WQI because of its higher unit weight in the Weighted Arithmetic WQI method. Elevated concentrations of TDS, Total hardness, and magnesium hardness also contributed substantially to higher WQI values, reflecting increased groundwater mineralisation associated with natural groundwater–rock interactions. Localised anthropogenic activities, including domestic wastewater infiltration, septic system leakage, and intensive groundwater abstraction, may have further contributed to groundwater quality deterioration at a limited number of sampling locations.

Overall, the WQI assessment indicates that groundwater quality in Eastern Davanagere City is predominantly controlled by natural hydrogeochemical processes, while localised human activities contribute to groundwater quality deterioration at selected locations. Although most groundwater samples were classified as Excellent or Good, continuous groundwater quality monitoring and appropriate groundwater management practices are recommended to maintain groundwater quality and ensure its long-term suitability for drinking purposes.

13. Comparison with Previous Studies

To validate the findings of the present investigation, the groundwater quality results were compared with selected studies conducted in different parts of India using the Weighted Arithmetic WQI method. A comparison of the dominant WQI categories and the major factors influencing groundwater quality is presented in Table 7.

Table 7. Comparison of the present study with selected groundwater quality investigations in India.

Study	Study area	Dominant WQI category	Major factors affecting groundwater quality
Ramakrishnaiah et al. (2008) [1].	Tumkur, Karnataka	Good	Groundwater-rock interaction and dissolved minerals
Deepika et al. (2020) [8].	Udupi, Karnataka	Good	Natural hydrogeochemical processes
Kumar et al. (2022) [15].	Ramanathapuram, Tamil Nadu	Good-Poor	TDS and hardness-related parameters
Ali et al. (2024) [19].	Agra, Uttar Pradesh	Good-Poor	Mineralisation and anthropogenic activities
Pareta et al. (2024) [20].	Udaipur, Rajasthan	Good-Poor	Hardness, dissolved solids and land-use influences
Gautam et al. (2024) [21].	India	Good	Dissolved solids and hydrogeochemical processes
Shetty and Patil (2025) [22].	Karnataka	Good	Hydrogeochemical conditions and groundwater mineralisation
Present study	Eastern Davanagere City, Karnataka	Good	TDS, turbidity, hardness-related parameters, and groundwater–rock interaction

The groundwater quality characteristics observed in the present study are generally consistent with those reported in previous investigations conducted in hard-rock aquifer regions of India. As shown in Table 7, the predominance of the good groundwater quality category, together with a smaller proportion of Poor and Very Poor water quality classes, agrees well with the findings reported in earlier studies conducted in Karnataka and other parts of the country [1,8,15,19].

The present investigation identified TDS, total hardness, magnesium hardness, and turbidity as the principal parameters influencing the calculated WQI values. Similar observations have been reported in previous groundwater quality studies, where increased mineralisation and hardness-related constituents were identified as the major factors controlling groundwater quality [15,20,21]. These similarities indicate that groundwater chemistry in Eastern Davanagere City is primarily governed by natural groundwater–rock interactions within the granitic and gneissic formations of the Peninsular Gneissic Complex.

Although most groundwater samples were classified as Excellent or Good, a limited number of samples belonged to the Poor and Very Poor categories, indicating localised groundwater quality deterioration. Similar localised variations have been attributed to urbanisation, domestic wastewater infiltration, septic system leakage, and intensive groundwater abstraction in previous studies [19, 20, 21, 22]. However, the absence of groundwater samples in the Unfit for Drinking category suggests that groundwater quality in the study area remains comparatively suitable for drinking purposes.

Overall, the close agreement between the present findings and previously published investigations confirms the applicability of the Weighted Arithmetic Water Quality Index as a reliable tool for assessing groundwater suitability for drinking purposes [1,2,15]. The baseline information generated in this study provides useful scientific evidence for groundwater quality monitoring and supports sustainable groundwater resource management in Eastern Davanagere City.

14. Conclusion

The present study assessed the groundwater quality of Eastern Davanagere City, Karnataka, using physicochemical analysis and the Weighted Arithmetic Water Quality Index (WQI). Sixty groundwater samples collected from borewells were analysed and compared with the drinking water standards prescribed in BIS IS 10500:2012. The results showed that most physicochemical parameters were within the acceptable or permissible limits, although elevated concentrations of total dissolved solids, total hardness, and magnesium hardness were observed at a few locations. The calculated WQI values ranged from 16.87 to 93.18, with 3.33% of the samples classified as Excellent, 60.00% as Good, 30.00% as Poor, and 6.67% as Very Poor, while no sample was categorised as Unfit for Drinking. These findings indicate that groundwater in the study area is generally suitable for drinking purposes, although localised treatment is recommended at locations exhibiting comparatively higher WQI values. The observed variations in groundwater quality are primarily associated with natural groundwater–rock interactions, with localised anthropogenic activities contributing to quality deterioration at selected locations. The baseline information generated in this study provides useful scientific data for groundwater quality monitoring and supports sustainable groundwater resource management and drinking water planning in Eastern Davanagere City.

15. Acknowledgements

The authors gratefully acknowledge the laboratory facilities and technical support provided by the Department of Studies in Civil Engineering, University BDT College of Engineering (UBDTCE), Davanagere, Karnataka, India. The authors also acknowledge the academic support provided by Visvesvaraya Technological University (VTU), Belagavi, Karnataka, India, which facilitated the successful completion of this research.

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