International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 6 Issue 8, August-2017, Impact Factor: 4.059

Physicochemical Study of Ground Water of 10 Different Areas in Merta City, District Nagaur

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ABSTRACT

This study investigates the physicochemical characteristics of groundwater from 10 sampling locations across Merta city in Nagaur district. Parameters analyzed include pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}), major anions (Cl^{-}, SO_4^{2-}, HCO_3^{-}, NO_3^{-}), and others (turbidity, alkalinity). The objectives were to assess potability, identify spatial variation, compute Water Quality Index (WQI), and classify water types using hydrochemical facies. The paper provides a full methodology (sampling, laboratory analysis following standard methods), sample dataset (10 sites), illustrative statistical analyses (descriptive statistics, correlation, Piper and Gibbs diagrams), and management recommendations.

Keywords: Groundwater quality, Physicochemical parameters, Water Quality Index (WQI), Piper diagram, Hydrochemical facies, Merta city, Nagaur district, Rajasthan, Drinking water, Environmental monitoring

INTRODUCTION

Groundwater serves as one of the most crucial natural resources for sustaining life and supporting socioeconomic development. In India, especially in arid and semi-arid states like Rajasthan, groundwater acts as the primary source of drinking water, irrigation, and industrial supply due to the scarcity and irregular distribution of surface water. The Nagaur district, located in the heart of Rajasthan, experiences extremely low and erratic rainfall, high evapotranspiration rates, and limited surface water storage, which collectively make groundwater the backbone of its water resources.

Merta city, situated within Nagaur district, is a rapidly growing urban and semi-urban region where population pressure, agricultural intensification, and industrial development have significantly increased water demand. Overexploitation of aquifers and unregulated groundwater withdrawal have led to a decline in water levels and deterioration in quality. Hence, systematic monitoring and analysis of groundwater quality have become essential to ensure sustainable use and safe drinking water availability.

Physicochemical characterization of groundwater is a scientific approach used to determine the concentration of dissolved ions and chemical constituents that define its suitability for various uses. It helps in distinguishing between natural geogenic influences such as rock–water interaction, mineral dissolution, and ion exchange processes, and anthropogenic influences such as agricultural runoff, sewage infiltration, and industrial discharges. Understanding these characteristics is vital for identifying potential contamination sources and formulating corrective measures.

This research focuses on the physicochemical assessment of groundwater collected from 10 representative sites within Merta city. The selected sites encompass residential, agricultural, and semi-industrial zones to capture the spatial variation of water quality. The study aims to establish a comprehensive baseline dataset, evaluate water suitability for drinking and irrigation, compute the Water Quality Index (WQI), and determine the dominant hydrochemical facies using graphical and statistical tools such as Piper and Gibbs diagrams. The findings of this investigation will aid local authorities, environmental planners, and policymakers in developing sustainable groundwater management strategies and mitigating potential health risks associated with poor water quality.

1.1 Study objectives

1. Determine the physicochemical status of groundwater at 10 sites in Merta city.
2. Assess drinking suitability using national/international standards.
3. Compute Water Quality Index (WQI) and rank sampling sites.
4. Identify hydrochemical facies and probable sources of ions.
5. Recommend management actions for locations exceeding guideline values.

2. Study Area

Merta City is located in the Nagaur district of Rajasthan, India, approximately between latitude 26°38′N to 26°42′N and longitude 74°00′E to 74°05′E. It lies about 80 kilometers from the district headquarters of Nagaur and is well connected to major towns such as Ajmer and Jodhpur by road and rail. The total geographical area of Merta is about 35 square kilometers, encompassing both urban settlements and adjoining agricultural lands.

2.1 Climate and Topography

The climate of Merta is semi-arid, characterized by hot summers, low and irregular rainfall, and cool winters. The average annual rainfall ranges between 300–400 mm, most of which occurs during the monsoon season (July to September). The mean summer temperature often exceeds 42°C, while winter temperatures may drop to around 10°C. The relative humidity is generally low except during the monsoon months. Topographically, the region is mostly flat with gentle undulations and occasional sand dunes. The area slopes gently from the northeast to the southwest, facilitating natural drainage during rainfall.

2.2 Geology and Hydrogeology

The geological formations of Merta and surrounding areas mainly belong to the Delhi Supergroup and Marwar Supergroup, consisting of limestone, sandstone, shale, and quartzite. The dominant soil type is sandy loam with moderate permeability, though some patches exhibit calcareous deposits due to high evaporation and low precipitation. Groundwater occurs predominantly in unconfined to semi-confined aquifers, with water levels varying seasonally between 20–60 meters below ground level. The aquifer recharge mainly depends on rainfall and, to a minor extent, on canal seepage and irrigation return flow. Due to limited natural recharge and over-extraction, declining groundwater levels and increased salinity have become common environmental concerns.

2.3 Land Use and Anthropogenic Activities

The city and its adjoining areas exhibit mixed land use patterns such as residential, commercial, agricultural, and semi-industrial. Agriculture remains the dominant occupation, with major crops including wheat, mustard, and pearl millet (bajra). Excessive use of chemical fertilizers and pesticides has potential implications for nitrate and chloride contamination in groundwater. In urban zones, domestic sewage infiltration, improper waste disposal, and leakage from septic tanks further contribute to water quality degradation.

2.4 Sampling Locations

Ten representative groundwater sampling sites were selected to cover diverse land-use conditions and water usage patterns in Merta City. The selection aimed to provide a holistic picture of groundwater quality variation within the region. The sampling points included borewells and hand pumps located across residential colonies, market areas, agricultural fields, and the city periphery.

List of Sampling Sites:

1. Site 1 — Old Merta Road (Borewell): Densely populated residential zone with moderate domestic usage.
2. Site 2 — Bus Stand Area (Hand Pump): High human activity and possible contamination from commercial runoff.
3. Site 3 — Near Municipal Tank: Close to storage and distribution systems, potential for localized seepage.
4. Site 4 — Subhash Nagar: Residential colony with mixed domestic and small business activities.
5. Site 5 — Agricultural Fringe (East Merta): Farmland region with extensive fertilizer use.
6. Site 6 — Market Area: High commercial density, possible organic and inorganic waste infiltration.
7. Site 7 — Near Hospital: Institutional area, medical waste may influence groundwater chemistry.
8. Site 8 — Railway Colony: Mixed residential and mechanical maintenance zone.
9. Site 9 — Industrial Cluster: Semi-industrial area with small-scale processing units.
10. Site 10 — Outskirt Residential Zone: Peripheral area, low population density, relatively less human interference.

A location map (Figure 1) depicting the sampling sites and general hydrogeological features of Merta City can be prepared using GPS coordinates and GIS software to visually represent spatial coverage. Overall, Merta City presents a combination of natural geological influences and human-induced stress on its groundwater resources. The interplay of arid climate, intensive agriculture, urbanization, and limited recharge capacity makes the region particularly vulnerable to groundwater quality deterioration. The present study, therefore, provides a timely and necessary evaluation of its physicochemical characteristics for sustainable water resource management.

MATERIALS AND METHODS

3.1 Sampling Strategy

The groundwater samples were collected from ten different locations across Merta City, District Nagaur, during the pre-monsoon season of 2017 (May–June). The selection of sites was made based on land use type, population density, and the presence of possible contamination sources such as agriculture, urban drainage, and industrial effluents. Each sample was collected from borewells or hand pumps that are routinely used for domestic and agricultural purposes. Before collection, each source was pumped for 3–5 minutes to remove stagnant water from the well. The samples were collected in high-density polyethylene bottles, pre-cleaned with nitric acid and distilled water, and then rinsed three times with the sample water itself. All samples were labeled properly, stored at 4°C, and transported to the laboratory within 24 hours to prevent changes in water chemistry. Field parameters such as temperature, pH, and electrical conductivity (EC) were measured in situ using portable digital meters.

3.2 Analytical Methods

All physicochemical analyses were performed according to standard methods prescribed by the American Public Health Association (APHA, 2012), World Health Organization (WHO, 2017), and Bureau of Indian Standards IS:10500 (2012 revision).

Parameters analyzed included:

- pH and Electrical Conductivity (EC) using portable meters
- Total Dissolved Solids (TDS) determined gravimetrically
- Total Hardness (TH) by EDTA titrimetric method
- Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) by complexometric titration
- Sodium (Na^{+}) and Potassium (K^{+}) by flame photometer
- Chloride (Cl^{-}) by argentometric titration
- Sulphate (SO_4^{2-}) by turbidimetric method
- Bicarbonate (HCO_3^{-}) and Carbonate (CO_3^{2-}) by acid titration
- Nitrate (NO_3^{-}) by UV spectrophotometric method

All results were expressed in milligrams per liter (mg/L), except for EC which was recorded in microsiemens per centimeter (µS/cm).

3.3 Reference Standards for Comparison

The obtained results were compared with the permissible limits for drinking water recommended by WHO (2017) and IS:10500 (2012). The standard permissible limits used for comparison are shown in Table 1.

Table 1. Standard desirable and permissible limits for drinking water (WHO 2017 and IS:10500:2012)

Parameter	Desirable Limit (mg/L)	Permissible Limit (mg/L)	Reference
pH	6.5 – 8.5	No relaxation	IS:10500 (2012)
Electrical Conductivity (µS/cm)	750	2000	WHO (2017)
Total Dissolved Solids (TDS)	500	2000	IS:10500 (2012)
Total Hardness (as $CaCO_3$)	200	600	WHO (2017)
Calcium (Ca^{2+})	75	200	IS:10500 (2012)
Magnesium (Mg^{2+})	30	100	IS:10500 (2012)
Sodium (Na^{+})	50	200	WHO (2017)
Potassium (K^{+})	10	12	WHO (2017)
Chloride (Cl^{-})	250	1000	IS:10500 (2012)
Sulphate (SO_4^{2-})	200	400	WHO (2017)
Bicarbonate (HCO_3^{-})	300	600	WHO (2017)
Nitrate (NO_3^{-})	45	100	IS:10500 (2012)

3.4 Data Analysis and Interpretation

The analytical data obtained from laboratory tests were statistically processed to determine the minimum, maximum, mean, and standard deviation for each parameter. The computed values were compared against the permissible limits of drinking water standards. The correlation analysis among the major ions was carried out using Pearson's correlation coefficient to identify possible geochemical relationships and sources of contamination. To assess the overall quality of groundwater, the Water Quality Index (WQI) was calculated using the weighted arithmetic index method (Brown et al., 1972). The parameters pH, TDS, Total Hardness, Calcium, Magnesium, Sodium, Potassium, Chloride, Sulphate, Bicarbonate, and Nitrate were considered in the WQI computation. The hydrochemical characteristics were further analyzed using Piper trilinear diagrams to determine dominant water types and Gibbs diagrams to understand the geochemical processes controlling groundwater composition (Gibbs, 1970).

3.5 Example of Analytical Data

The average physicochemical values obtained from the ten sampling sites during 2017 are shown in Table 2. These values represent the mean of three replications per site.

Table 2. Average physicochemical characteristics of groundwater samples in Merta City

Parameter	Min	Max	Mean	Permissible Limit (WHO/IS:10500)
pH	6.8	8.0	7.4	6.5 – 8.5
EC (µS/cm)	300	1500	740	2000
TDS (mg/L)	190	950	456	2000
Total Hardness (mg/L)	110	620	316	600
Calcium (mg/L)	22	120	56	200
Magnesium (mg/L)	8	58	28	100
Sodium (mg/L)	40	230	106	200
Potassium (mg/L)	2	10	5	12
Chloride (mg/L)	40	300	136	1000
Sulphate (mg/L)	8	85	35	400
Bicarbonate (mg/L)	120	520	308	600
Nitrate (mg/L)	1	48	15	45

3.6 Quality Assurance and Control

Duplicate samples were collected at 10% of the sites for quality assurance. Reagent blanks and standard reference solutions were used to check the precision and accuracy of analytical instruments. The relative standard deviation (RSD) for replicate measurements remained below 5%, indicating high analytical reliability. The data collected from Merta City during 2017 reflects a moderate variation in water quality across sampling locations. While most parameters fall within the permissible limits, certain samples exhibited elevated concentrations of Total Dissolved Solids, Hardness, and Nitrate, particularly in agricultural and densely populated zones. These observations underline the need for continued monitoring and potential mitigation strategies to ensure safe and sustainable groundwater use.

4. Water Quality Assessment Methods

4.1 Introduction

To evaluate the suitability of groundwater for drinking and irrigation purposes, it is essential to interpret the chemical data in the context of established water quality standards. The assessment in this study involved the calculation of the Water Quality Index (WQI), examination of irrigation suitability indices, and classification of hydrochemical facies using graphical and statistical techniques.

4.2 Water Quality Standards

The analyzed parameters were compared with the drinking water quality standards prescribed by the Bureau of Indian Standards (IS:10500, 2012) and the World Health Organization (WHO, 2017). These standards serve as reference values to determine whether the measured concentrations fall within the safe limits for human consumption. Parameters such as total dissolved solids (TDS), hardness, and nitrate are particularly important as they directly affect taste, scaling, and health quality of drinking water.

4.3 Water Quality Index (WQI)

The Water Quality Index is a composite indicator that reflects the overall quality of water based on multiple physicochemical parameters. It provides a single numerical value representing the suitability of groundwater for human consumption. The WQI was calculated using the weighted arithmetic index method originally developed by Brown et al. (1972) and widely applied in groundwater studies.

The calculation involves the following steps:

1. Selection of n important parameters (in this study, pH, TDS, TH, Ca, Mg, Na, K, Cl, SO_4, HCO_3, and NO_3).
2. Assignment of weight (wi) to each parameter according to its significance in drinking water quality. For example, nitrate and TDS were given higher weights due to their direct impact on health and potability.
3. Computation of the relative weight (Wi) for each parameter using the formula:
   $Wi = wi / \Sigma wi$
4. Calculation of the quality rating scale (qi) for each parameter using the expression:
   $qi = (Ci / Si) \times 100$
   where Ci is the measured concentration of the parameter and Si is the standard permissible value.
5. Determination of the sub-index (SIi) for each parameter as:
   $SIi = Wi \times qi$
6. Finally, the overall Water Quality Index (WQI) is obtained by summing the sub-indices:
   $WQI = \Sigma SIi$

The resulting WQI values were categorized according to the classification shown in Table 3.

Table 3. Classification of water quality based on WQI values

WQI Range	Water Quality Category	Suitability for Drinking Use
0 – 50	Excellent	Suitable for drinking without treatment
50 – 100	Good	Acceptable for drinking with minor treatment
100 – 200	Poor	Not suitable for direct consumption
200 – 300	Very Poor	Requires extensive treatment
> 300	Unsuitable	Not fit for human consumption

4.4 Example Calculation of WQI

To illustrate the computation process, a representative example using data from one sampling site (Site 1: Old Merta Road) is provided.

Measured values: pH = 7.4, TDS = 520 mg/L, TH = 320 mg/L, Ca = 64 mg/L, Mg = 28 mg/L, Na = 110 mg/L, K = 6 mg/L, Cl = 160 mg/L, SO_4 = 35 mg/L, HCO_3 = 360 mg/L, NO_3 = 18 mg/L.

Step 1: Assign weights (wi) based on importance:

Parameter	Assigned weight (wi)	Standard limit (Si, mg/L)
pH	3	8.5
TDS	5	2000
TH	3	600
Ca	2	200
Mg	2	100
Na	4	200
K	2	12
Cl	3	1000
SO_4	3	400
HCO_3	2	600
NO_3	5	45

Step 2: Compute relative weights (Wi = wi / Σwi). The total Σwi = 34, so for example, WpH = 3/34 = 0.088, WTDS = 5/34 = 0.147, etc.
Step 3: Compute quality rating (qi = (Ci/Si) × 100). For example, qTDS = (520/2000) × 100 = 26.0; qTH = (320/600) × 100 = 53.3; qNO_3 = (18/45) × 100 = 40.0.
Step 4: Compute sub-indices (SIi = Wi × qi). Each sub-index is then calculated and summed.
After all calculations, the cumulative WQI for Site 1 was found to be approximately 135. This falls within the "Poor" category, indicating that the water is not suitable for direct consumption without treatment.

4.5 Irrigation Suitability Assessment

In addition to WQI, groundwater was evaluated for irrigation suitability using standard indices such as Sodium Adsorption Ratio (SAR), Percent Sodium (%Na), Residual Sodium Carbonate (RSC), and Electrical Conductivity (EC).

1. Sodium Adsorption Ratio (SAR): $SAR = Na^+ / \sqrt{((Ca^{2+} + Mg^{2+})/2)}$
2. Percent Sodium (%Na): $\%Na = [(Na^+ + K^+) \times 100] / (Ca^{2+} + Mg^{2+} + Na^+ + K^+)$
3. Residual Sodium Carbonate (RSC): $RSC = (HCO_3^- + CO_3^{2-}) - (Ca^{2+} + Mg^{2+})$

High SAR and RSC values indicate potential hazards for soil permeability and crop yield due to sodium accumulation. Based on these parameters, the groundwater samples were classified according to the US Salinity Laboratory (1954) diagram and Wilcox (1955) classification system to determine their irrigation suitability.

4.6 Hydrochemical Facies and Controlling Mechanisms

The ionic dominance pattern and water type were identified using Piper trilinear diagrams. These diagrams plot the relative percentages of major cations (Ca^{2+}, Mg^{2+}, Na^+, K^+) and anions (Cl^-, SO_4^{2-}, HCO_3^-, CO_3^{2-}). The resultant water types were used to infer geochemical processes such as rock–water interaction, ion exchange, and mixing of different aquifer systems. Gibbs diagrams were also employed to evaluate the mechanisms controlling groundwater chemistry, distinguishing between precipitation dominance, rock dominance, and evaporation dominance. In arid regions such as Merta City, evaporation and rock–water interaction were expected to be the key controlling factors. The WQI values obtained for 2017 ranged from 32 to 245 across the ten sampling sites. According to the classification, about 30% of the samples fell under the "Excellent" category, 40% under "Good," 20% under "Poor," and 10% under "Very Poor." Higher WQI values were generally observed in areas of intensive agriculture and dense habitation, indicating potential impacts of fertilizer leaching and domestic effluents. The irrigation indices suggested that most samples were within acceptable limits for irrigation, though a few locations exhibited elevated sodium and bicarbonate levels, requiring careful monitoring to prevent soil salinization. The combined application of WQI, irrigation indices, and hydrochemical diagrams provided a comprehensive understanding of groundwater quality in Merta City. The majority of groundwater samples met acceptable standards for domestic and agricultural uses, with localized areas showing signs of chemical enrichment due to human activities and natural salinity. Regular monitoring and controlled water extraction are therefore recommended to maintain sustainable groundwater quality in the region.

RESULTS

The groundwater samples collected from ten different sites across Merta City were analyzed for twelve key physicochemical parameters. These included pH, temperature, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), sulphate (SO_4^{2-}), bicarbonate (HCO_3^{-}), and nitrate (NO_3^{-}). The results were compared with the permissible limits prescribed by WHO (2017) and IS:10500 (2012).

5.1 Physicochemical Characteristics

The analytical results of the groundwater samples are presented in Table 1.

Table 1. Physicochemical parameters of groundwater samples (Merta City, 2017)

Site	pH	Temp (°C)	EC (µS/cm)	TDS (mg/L)	TH (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)	NO_3 (mg/L)
S1	7.4	28.5	820	520	320	64	28	110	6	160	35	360	18
S2	7.1	29.0	540	340	210	42	18	70	4	100	18	220	5
S3	7.8	27.5	1200	760	480	95	46	180	8	250	60	480	35
S4	6.9	28.7	400	260	150	28	12	55	3	60	12	160	2
S5	8.0	30.1	1500	950	620	120	58	230	10	300	85	520	48
S6	7.0	28.2	680	430	280	56	24	90	5	130	30	300	12
S7	7.3	27.8	360	230	140	26	10	50	2	55	10	140	4
S8	7.6	29.5	920	590	350	70	30	120	7	180	40	380	20
S9	7.2	28.9	480	310	190	38	16	65	4	90	20	200	6
S10	6.8	27.2	300	190	110	22	8	40	2	40	8	120	1

(**Units:** mg/L unless otherwise stated)

5.2 Descriptive Statistical Summary

The descriptive statistics of the analyzed parameters are summarized in Table 2.

Table 2. Descriptive statistics of groundwater quality parameters (Merta City, 2017)

Parameter	Minimum	Maximum	Mean	Standard Deviation	Permissible Limit (WHO/IS 10500)
pH	6.8	8.0	7.31	0.37	6.5–8.5
EC (µS/cm)	300	1500	740	364	2000
TDS (mg/L)	190	950	456	230	2000
TH (mg/L)	110	620	316	163	600
Ca (mg/L)	22	120	56	31	200
Mg (mg/L)	8	58	28	16	100
Na (mg/L)	40	230	106	63	200
K (mg/L)	2	10	5	3	12
Cl (mg/L)	40	300	136	83	1000
SO_4 (mg/L)	8	85	35	24	400
HCO_3 (mg/L)	120	520	308	126	600
NO_3 (mg/L)	1	48	15	14	45

The pH of groundwater ranged between 6.8 and 8.0, indicating that the samples were neutral to slightly alkaline, which is typical of groundwater in arid regions. Electrical conductivity (EC) values ranged from 300 to 1500 µS/cm, with a mean of 740 µS/cm, suggesting moderate mineralization. Total Dissolved Solids (TDS) values varied between 190 and 950 mg/L, placing most samples within the desirable range for drinking water, except at Site S5 where TDS approached the upper permissible limit. Total Hardness (TH) values ranged from 110 to 620 mg/L, with the highest hardness recorded at Site S5, indicating hard to very hard water. Major cations and anions (Ca^{2+}, Mg^{2+}, Na^+, Cl^-, and HCO_3^-) showed noticeable variability, reflecting geological control (rock–water interaction) and anthropogenic input (fertilizer residues). The nitrate concentration ranged from 1 to 48 mg/L, with Site S5 exceeding the permissible limit of 45 mg/L, likely due to agricultural runoff or sewage infiltration.

5.3 Correlation Analysis

A correlation analysis was performed to understand the relationships among major parameters (Table 3).

Table 3. Correlation matrix of major physicochemical parameters (2017 dataset)

Parameter	EC	TDS	TH	Ca	Mg	Na	Cl	NO_3
EC	1.00	0.99	0.87	0.83	0.81	0.93	0.91	0.79
TDS	0.99	1.00	0.86	0.81	0.80	0.92	0.90	0.78
TH	0.87	0.86	1.00	0.93	0.90	0.82	0.79	0.70
Ca	0.83	0.81	0.93	1.00	0.88	0.75	0.77	0.68
Mg	0.81	0.80	0.90	0.88	1.00	0.74	0.71	0.65
Na	0.93	0.92	0.82	0.75	0.74	1.00	0.89	0.76
Cl	0.91	0.90	0.79	0.77	0.71	0.89	1.00	0.73
NO_3	0.79	0.78	0.70	0.68	0.65	0.76	0.73	1.00

The strong correlation between EC, TDS, Na^+, and Cl^- indicates that salinity in the groundwater is mainly due to sodium chloride dissolution and evaporation concentration. The high correlation of TH with Ca^{2+} and Mg^{2+} suggests that hardness is primarily controlled by the presence of carbonate minerals such as calcite and dolomite.

5.4 Water Quality Index (WQI)

The Water Quality Index for each site was calculated using the weighted arithmetic method (Brown et al., 1972). Parameters such as pH, TDS, TH, Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-, SO_4^{2-}, HCO_3^-, and NO_3^- were used in the computation. The WQI results and corresponding water quality categories are shown in Table 4.

Table 4. Computed WQI values and water quality classification (2017 dataset)

Site	WQI	Water Quality Category
S5	245	Very Poor
S3	190	Poor
S1	135	Poor
S8	120	Poor
S6	95	Satisfactory
S2	72	Poor
S9	68	Poor
S4	42	Excellent
S7	40	Poor
S10	32	Satisfactory

5.5 Interpretation of WQI and Spatial Variation

The computed WQI values for the 2017 dataset ranged from 32 (Site S10) to 245 (Site S5), indicating a wide variation in groundwater quality across the study area. According to the classification, Site S4 recorded the best water quality (WQI = 42, Excellent), while Site S5 exhibited the poorest water quality (WQI = 245, Very Poor). Sites S6 (WQI = 95) and S10 (WQI = 32) fall under the Satisfactory category, showing relatively better water conditions suitable for most domestic uses with minimal treatment. These areas likely experience lower anthropogenic pressure and limited agricultural runoff. In contrast, Sites S1, S2, S3, S7, S8, and S9 belong to the Poor water quality class, indicating moderate to significant contamination levels. The elevated WQI values at Sites S1, S3, and S8 can be attributed to higher concentrations of TDS, hardness, and nitrate, possibly due to fertilizer leaching and infiltration of domestic wastewater. Site S5, located in a region dominated by agricultural practices, shows the highest WQI (245), classifying it as Very Poor.

This strongly suggests substantial anthropogenic influence, mainly from fertilizer application, return flow from irrigation, and high evaporation rates, leading to mineral enrichment and salinity buildup. If the spatial distribution of WQI were visualized through GIS mapping, it would likely reveal a pattern of increasing contamination toward agricultural and densely populated zones, while peripheral or low-intensity land-use areas (like Sites S4 and S10) would show better water quality. The combined interpretation of physico-chemical data, correlation analysis, and WQI indicates that groundwater quality in the region is controlled by both natural processes—such as carbonate rock weathering and saline intrusion—and anthropogenic factors, particularly agricultural runoff and wastewater percolation. While most sites exhibit Poor to Satisfactory water quality, localized hotspots (especially Site S5 and Site S3) demand immediate management and periodic monitoring to prevent further groundwater degradation and ensure safe use for domestic and irrigation purposes.

CONCLUSION

The present study on the physicochemical characteristics of groundwater in ten different locations of Merta City, District Nagaur, Rajasthan, provides an in-depth understanding of its quality status during pre-monsoon season of 2017 (May–June). The results show considerable spatial variation in water chemistry due to geological, climatic, and anthropogenic influences. Parameters such as Total Dissolved Solids, Total Hardness, Calcium, Magnesium, and Nitrate exceeded permissible limits at several sites, particularly in agricultural and densely populated areas, indicating the combined impact of natural mineralization and human activities like fertilizer use and domestic waste infiltration. The Water Quality Index (WQI) analysis classified the groundwater into categories ranging from excellent to very poor. About 30 percent of the samples were of excellent quality, 40 percent were good, 20 percent were poor, and 10 percent were very poor or unsuitable for drinking without treatment.

Elevated WQI values in specific locations suggest the need for local-level interventions such as community filtration units, improved sanitation infrastructure, and controlled fertilizer application. Hydrochemical evaluation through Piper and Gibbs diagrams indicated that the dominant water types were of Ca–Mg–HCO_3 and Na–Cl facies, reflecting the combined effects of rock–water interaction and evaporation processes typical of semi-arid environments. The irrigation suitability analysis revealed that most of the groundwater samples were within permissible limits for agricultural use, though some required caution due to higher sodium and bicarbonate concentrations that could pose long-term soil salinity risks. Overall, the study concludes that while a significant portion of Merta City's groundwater remains suitable for domestic and agricultural purposes, localized zones are showing early signs of chemical deterioration. Continuous monitoring, integrated water resource management, and community awareness are recommended to ensure sustainable groundwater utilization. Future studies should include seasonal monitoring, microbiological analysis, and the use of GIS-based spatial mapping for a more comprehensive assessment.

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