Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(4), 2911-2919 | ISSN:2251-6727

Chemical & Microbial Insights: Banaskantha Water Study

Dishaben A Ranpura[1] , Bharti Patel[1] Narendra Kumar Sharma[1], Jigar Y Soni[1]

[1].Department of Chemistry, Faculty of Basic and Applied Sciences, Madhav University, Pindwara, Sirohi (Rajasthan), India 307032

(Received: 16 June 2025 Revised: 20 July 2025 Accepted: 19 August 2025)

KEYWORDS

Water Quality Assessment, Physicochemical Parameters, Microbial Contamination, Groundwater (Banaskantha) , Public Health

ABSTRACT:

This study evaluates the physicochemical and microbial quality of drinking water from seven talukas in Banaskantha district, Gujarat, a semi-arid region reliant on groundwater. Key parameters including pH, fluoride, TDS, conductivity, turbidity, chloride, total hardness, and coliform bacteria were analyzed. Results showed spatial variability, with Bhabhar exhibiting elevated TDS (1580 mg/L), conductivity (3522 µS/cm), chloride (624.81 mg/L), and hardness (470 mg/L). Fluoride remained within safe limits, while coliform counts (22–50 MPN/100 mL) exceeded BIS standards in all samples, indicating microbial contamination. The findings highlight public health concerns and theneed for targeted water quality management and monitoring in the region.

1. Introduction

Access to clean and safe drinking water is recognized as a fundamental human right and a critical determinant of public health, socio-economic development, and environmental sustainability (UN-Water, 2021). Despite significant global progress under initiatives such as the United Nations Sustainable Development Goal 6 (SDG-6), which aims to ensure universal access to clean water and sanitation by 2030, many rural regions in developing nations continue to face serious challenges related to water quality and safety (WHO & UNICEF, 2022; Kaur et al., 2023). In India, groundwater serves as the primary source of drinking water for over 65% of the population and more than 85% of rural inhabitants, making its safety and sustainability a national priority (Ministry of Jal Shakti, 2023; Singh & Rao, 2021).

Gujarat, located in western India, is classified as a water-stressed state, with groundwater accounting for approximately 74% of total drinking water supply in rural areas (CGWB, 2022; Mehta et al., 2020). Northern districts such as Banaskantha experience semi-arid climatic conditions, erratic monsoon rainfall, and high evapotranspiration rates, further aggravating water scarcity (Jani et al., 2023). The district spans over 12,703 km² and includes 14 talukas, with a population projected at 3.5 million in 2023 (Census of India, 2011; Rathod & Patel, 2024). Due to limited surface water availability, rural residents depend almost exclusively on bore wells, tube wells, and hand pumps for drinking and domestic use (Patel & Sharma, 2019; Rao et al., 2021).

The region's groundwater is affected by both geogenic and anthropogenic factors, such as the presence of fluoride-bearing minerals, extensive agricultural activity, unregulated use of chemical fertilizers and pesticides, and improper solid waste disposal (Pandya et al., 2020; Thakor et al., 2021; Sharma & Desai, 2023). These inputs contribute to elevated concentrations of dissolved ions and microbial pollutants, particularly in rural settlements with limited sanitation infrastructure (Chaudhari et al., 2024; Goswami et al., 2020). Previous studies in Gujarat have highlighted critical contamination trends involving fluoride, TDS, chloride, and coliform bacteria, though most have lacked district-level or seasonal specificity (Bhatt & Shah, 2023; Saxena et al., 2019).

Water quality assessments typically involve testing a suite of physicochemical parameters such as pH, fluoride, TDS, electrical conductivity (EC), turbidity, chloride, and total hardness (TH), along with microbial indicators such as total and fecal coliforms (Seth et al., 2025; Khan et al., 2024). These microbial markers signal contamination from human and animal waste, posing substantial health risks if left unmonitored (Ruhela et al., 2024; Ali et al., 2020). However, routine water monitoring in rural India frequently excludes microbiological analysis, leading to underreporting of public health risks from waterborne diseases like cholera, diarrhea, and typhoid (Niti Aayog, 2021; Iyer & Kulkarni, 2022).

At present, there is a shortage of consolidated and up-to-date groundwater quality data for the Banaskantha region. Existing records are often fragmented, outdated, or focused narrowly on singular contaminants like fluoride (Bamaniya et al., 2024; Chauhan et al., 2021). A comprehensive study that integrates both chemical and microbial parameters is urgently needed, especially

Journal of Chemical Health Risks
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JCHR (2025) 15(4), 2911-2919 | ISSN:2251-6727

given the area's growing reliance on groundwater and its vulnerability to pollution (Ghosh et al., 2020; Rajput et al., 2023).

Access to safe drinking water remains a persistent challenge in rural Banaskantha, despite global and national efforts aligned with SDG-6. With over 85% of India's rural population dependent on groundwater, regions like Banaskantha—marked by semi-arid conditions and limited surface water—are highly vulnerable to contamination. Both natural factors (e.g., fluoride-rich geology) and human activities (e.g., agricultural runoff, inadequate sanitation) degrade water quality. Yet, current monitoring practices often neglect microbial risks, exposing communities to severe health threats. These gaps reinforce the need for comprehensive, region-specific water quality surveillance and sustainable groundwater management strategies.

Objectives of the Study:

This study aims to bridge this knowledge gap by assessing the physicochemical and microbial quality of drinking water from rural sources in seven talukas of Banaskantha district. The specific objectives include:

- To analyze key water quality parameters—pH, fluoride, TDS, EC, turbidity, chloride, TH, and coliform counts—across the selected talukas.
- To identify spatial trends and regions with physicochemical or microbial contamination posing health risks.
- To generate baseline data to support sustainable groundwater management, public health interventions, and community awareness programs.

2. Review of Literature

Water quality assessments are central to public health, especially in arid and semi-arid regions like Banaskantha district, Gujarat, where groundwater serves as the primary drinking water source. Water quality is commonly evaluated through physicochemical and microbial parameters, with both geogenic and anthropogenic factors contributing to contamination (Chaudhari et al., 2024; Suthar et al., 2010).

Several studies have documented the variability of groundwater chemistry in Gujarat, highlighting elevated levels of total dissolved solids (TDS), fluoride, nitrate, and chloride in northern districts such as Banaskantha (Patel & Shah, 2021; Dave et al., 2019). High fluoride levels, exceeding WHO permissible limits, are especially problematic, contributing to endemic fluorosis in rural communities (Solanki & Patel, 2022; Meena et al., 2020). Similarly, nitrate contamination is often linked to excessive use of nitrogenous fertilizers in agriculture (Jain et al., 2023; Sharma et al., 2018).

Microbial contamination remains a pressing concern in rural India, with studies confirming the presence of coliform bacteria and *E. coli* in drinking water sources, often due to poor sanitation and shallow borewell construction (Rajesh et al., 2021; Kumar & Rautela, 2016). In Banaskantha, microbial pollution is exacerbated by intermittent water supply and inadequate chlorination (Jadeja & Shrimali, 2020).

A comparative study across talukas in north Gujarat by Parmar and Patel (2019) reported a wide variation in pH, electrical conductivity (EC), and turbidity, indicating spatial heterogeneity in aquifer characteristics. The high EC values in certain blocks suggest salinity intrusion, particularly in over-exploited groundwater zones (Thakor et al., 2017).

The Bureau of Indian Standards (BIS 10500:2012) provides benchmarks for permissible limits of key parameters like pH (6.5–8.5), TDS (500 mg/L), and nitrate (45 mg/L), yet many samples from Banaskantha exceed these limits, pointing to urgent quality control needs (BIS, 2012; Trivedi et al., 2023). Seasonal variation also plays a role; monsoon recharge affects dilution and microbial presence, with higher coliform counts often reported post-monsoon (Gandhi & Chauhan, 2015; Patel et al., 2022).

Emerging technologies such as GIS mapping and multivariate statistical analysis are increasingly employed for spatial analysis and source identification of pollution (Verma & Panchal, 2023; Rathod et al., 2021). Cluster analysis and principal component analysis (PCA) have helped distinguish between natural and anthropogenic influences on water chemistry (Kansal & Singh, 2019; Gamit et al., 2023).

Recent metagenomic and 16S rRNA sequencing approaches have opened avenues to study microbial diversity and antimicrobial resistance in water bodies, especially useful in regions with livestock-dominated agriculture like Banaskantha (Desai et al., 2022; Modi & Bhalani, 2020). This supports a shift toward a more integrated approach to water safety that includes both chemical and microbial risks (UNICEF, 2020).

Studies focusing on health impacts have shown a direct correlation between long-term consumption of contaminated groundwater and gastrointestinal, skeletal, and reproductive issues among residents (Rathod & Patel, 2018; WHO, 2023). This highlights the urgent need for intervention programs such as decentralized water purification, improved waste management, and regular monitoring.

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3. Study Area

The present study was conducted in Banaskantha district, located in the northern part of Gujarat, India, which forms part of the arid and semi-arid climatic zones. Banaskantha spans an area of approximately 12,703 square kilometers and is bounded by Rajasthan to the north and northeast. It falls under the North Gujarat Agro-climatic Zone, characterized by low and erratic rainfall, high evaporation rates, and scarce surface water resources, making groundwater the predominant source for drinking and irrigation purposes.

This study specifically focused on seven talukas (sub-districts) within Banaskantha, namely Amirgadh, Bhabhar, Danta, Dantiwada, Deesa, Deodar, and Dhanera. These talukas represent a mix of rural, agrarian, and semi-urban settlements with a high dependency on bore wells and tube wells for drinking water. The selection of these talukas was based on geographical spread, groundwater usage patterns, and preliminary reports indicating potential concerns with water quality.

Geographical and Hydrogeological Context

Banaskantha lies on the edge of the Aravalli hill range to the northeast, while the rest of the region is relatively flat, comprising alluvial plains. The groundwater in this region is extracted from shallow to moderately deep aquifers, which are prone to contamination due to agricultural runoff, open defecation, and leaching of geogenic minerals such as fluoride and salts.

Sample Locations and Parameters

Water samples were collected from drinking water sources in each of the seven talukas. These were analyzed for a combination of physicochemical and microbial parameters to evaluate overall water quality. The specific parameters included:

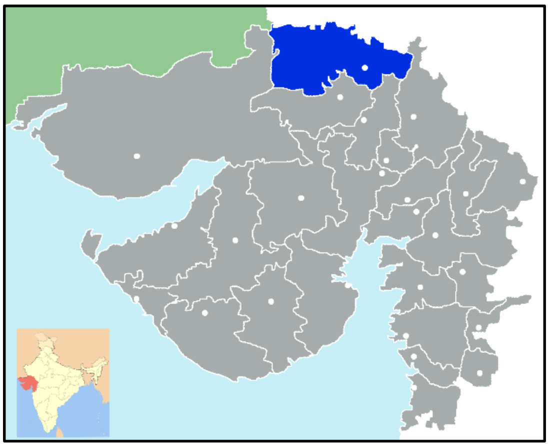

Figure 1. Map showing the location of Banaskantha district (highlighted in Blue) in the northern region of Gujarat, India. The district is the focus area for the present water quality assessment study.

- **pH** (measure of acidity/alkalinity)
- **Fluoride** (a key geogenic contaminant in Gujarat)
- **Total Dissolved Solids (TDS)**
- **Electrical Conductivity (EC)**
- **Turbidity** (optical clarity)
- **Chloride** (indicator of salinity or contamination)
- **Total Hardness (TH)**
- **Coliform Bacteria Count** (indicator of microbial contamination)

4. Sampling Locations

The talukas were selected based on their geographical spread, dependency on groundwater for drinking purposes, and preliminary signs of potential water quality concerns. The selected talukas are: Amirgadh, Bhabhar, Danta, Dantiwada, Deesa, Deodar, and Dhanera. From each taluka, four representative groundwater samples were collected—covering diverse locations such as village borewells, hand pumps, agricultural wells, and semi-urban domestic water points—resulting in a total of 28 samples (4 samples × 7 talukas). This sampling design ensured spatial representation and captured variability in groundwater quality across different hydrogeological and anthropogenic settings in the region.

Details of Sampling Points

Location	Code	Description
Amirgadh	SA1	Village water source primarily dependent on borewell system.
Bhabhar	SB1	Semi-urban area with mixed domestic and agricultural water use.
Danta	SC1	Hilly taluka with springs and shallow aquifer extraction.
Dantiwada	SD1	Proximity to agricultural land; water from deep borewells.
Deesa	SE1	Densely populated with high groundwater extraction rate.
Deodar	SF1	Semi-rural taluka relying on both handpumps and wells.
Dhanera	SG1	Northern taluka with a mix of domestic and irrigation usage.

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JCHR (2025) 15(4), 2911-2919 | ISSN:2251-6727

Each of these sites was selected to provide representative data on groundwater quality across diverse hydrogeological and anthropogenic contexts within the district. The sampling was conducted during the pre-monsoon season of 2024, when water quality stress is typically most pronounced due to lower recharge and higher concentration of dissolved constituents.

All samples were collected in sterile polyethylene bottles following standard procedures recommended by the Indian Standards (IS: 10500) and were immediately transported to the laboratory under controlled conditions for analysis. The selection of parameters—pH, fluoride, total dissolved solids (TDS), electrical conductivity, turbidity, chloride, total hardness, and coliform—was based on both public health relevance and regional hadrochemical characteristics.

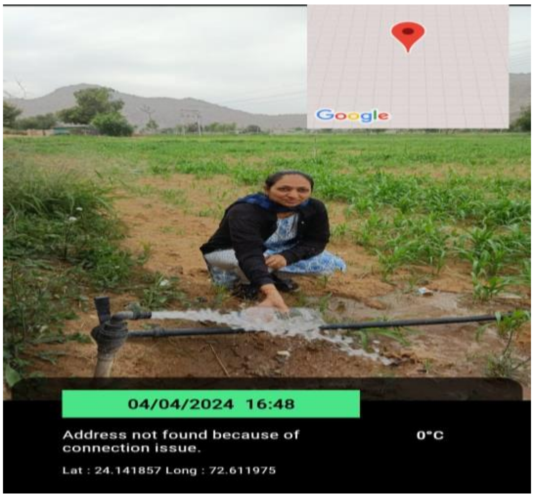

Figure 3. Field photographs showing groundwater sampling activities in Banaskantha district, Gujarat Collection of water sample from Groundwater extraction and sampling from a borewell in an agricultural field near Danta taluka (Lat: 24.141857, Long: 72.611975).

5. Parameter Selection

The selection of water quality parameters in this study was guided by their environmental and health relevance, as well as their inclusion in the Indian Standard IS 10500:2012 for drinking water, published by the Bureau of Indian Standards (BIS). This standard provides the regulatory framework for acceptable and permissible limits for various physicochemical and microbiological constituents in drinking water across India. Considering the groundwater dependency of Banaskantha district in Gujarat, the selected parameters are aimed at comprehensively evaluating water quality for safe human consumption in both rural and semi-urban areas.

The desirable pH range in drinking water is 6.5–8.5, which ensures chemical stability and supports biological processes without causing corrosion or scaling. Fluoride, naturally occurring in groundwater, is limited to a desirable level of 1.0 mg/L, with a permissible limit of 1.5 mg/L due to its links with dental and skeletal fluorosis, which is prevalent in parts of Banaskantha.

TDS represents the total concentration of dissolved substances. As per IS 10500:2012, the acceptable limit is 500 mg/L, with a maximum permissible limit of 2000 mg/L. High TDS can negatively affect water taste and contribute to scaling in pipelines. Electrical conductivity (EC), although not directly specified in IS 10500, is a critical parameter for assessing salinity and correlates closely with TDS. Turbidity, indicating the presence of suspended solids and potential microbial content, has a desirable limit of 1 NTU and a permissible limit of 5 NTU, as high turbidity may protect pathogens from disinfection.

Chloride, an important indicator of salinity and potential contamination from anthropogenic activities such as sewage and agricultural runoff, has a desirable limit of 250 mg/L and a permissible limit of 1000 mg/L in IS 10500:2012. Total hardness, caused primarily by calcium and magnesium ions, is limited to 200 mg/L (desirable) and 600 mg/L (permissible), as excessive hardness causes scaling and reduces the efficiency of soaps and detergents. Lastly, coliform bacteria serve as microbiological indicators of fecal contamination. IS 10500:2012 mandates that drinking water should not contain any coliform organisms in 100 mL of the sample, as their presence signals potential pathogenic contamination and poses severe health risks.

Overall, the selected parameters represent a blend of geogenic pollutants (e.g., fluoride, chloride, TDS) and anthropogenic influences (e.g., turbidity, microbial contamination), ensuring a well-rounded water quality assessment. Given the variability in environmental conditions, water infrastructure, and sanitation across Banaskantha, this combination provides critical insight into current groundwater quality and helps support evidence-based water management and policy planning.

6. Methodology

This study was conducted across seven talukas of Banaskantha district in Gujarat, India to evaluate the physicochemical and microbial quality of groundwater used for drinking. A total of 28 water samples were collected, four from each taluka, during the pre-monsoon season of 2024. Sampling sites were selected based on their geographic diversity, population density, and dependency on groundwater sources such as borewells, handpumps, and tube wells. Samples were collected

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following Indian Standards (IS:10500) guidelines using sterile polyethylene bottles and transported under controlled conditions for laboratory analysis.

Eight critical water quality parameters were examined. These parameters were chosen based on their public health relevance and inclusion in the IS 10500:2012 standards for safe drinking water. Physicochemical parameters were analyzed using standard protocols, and microbial quality was assessed using Most Probable Number (MPN) methods to estimate coliform concentrations. The results were compared against the Bureau of Indian Standards (BIS) limits to assess potability and health risks, while spatial variability across talukas was documented to identify localized contamination.

7. Key Findings

The study revealed significant spatial variability in water quality across the seven talukas of Banaskantha. While pH levels were largely within BIS acceptable limits (6.5–8.5), slightly acidic tendencies were observed in Deesa and Dhanera, and alkaline conditions in Amirgadh. Fluoride levels remained within the permissible range (0.5–1.0 mg/L), but Amirgadh and Deodar approached the upper safety threshold, indicating potential future risk. Total dissolved solids (TDS) and electrical conductivity were markedly high in Bhabhar, with TDS reaching 1580 mg/L and EC rising to 3522 µS/cm, pointing to elevated salinity and dissolved mineral content. Chloride concentrations also peaked in Bhabhar (624.8 mg/L), surpassing the BIS limit and suggesting possible geogenic and anthropogenic contamination. Total hardness exceeded the desirable limit (200 mg/L) in all locations, with Deodar nearing the maximum permissible limit of 600 mg/L.

Microbiologically, all samples across all talukas tested positive for coliform bacteria (ranging from 22 to 50 MPN/100 mL), violating BIS norms that require zero coliform presence in potable water. This widespread contamination indicates systemic sanitation failures and potential fecal pollution, particularly acute in Bhabhar, Deesa, and Deodar. Although turbidity levels were within acceptable limits, the presence of coliforms highlighted that clear water does not equate to safe water. In summary, while some physicochemical parameters were within acceptable limits, none of the sampled locations met microbiological safety standards, making all samples unsuitable for direct human consumption without treatment. These findings call for urgent intervention through regular monitoring, improved sanitation, and targeted groundwater management policies.

6. Results and Discussion

The analysis of water samples collected from seven different talukas of Banaskantha district revealed significant spatial variations in key physicochemical and microbiological parameters. The results were compared against the permissible and desirable limits specified in IS 10500:2012 to assess potability and safety concerns.

pH

The pH values ranged from 6.45 (Deesa) to 8.22 (Amirgadh). All samples fell within the IS 10500:2012 acceptable range (6.5–8.5), except Deesa and Dhanera, which slightly dipped below the lower threshold. Amirgadh showed alkaline characteristics, which may influence the solubility and bioavailability of certain chemical constituents.

Fluoride

Fluoride concentrations varied between 0.5 to 1.0 mg/L. Amirgadh and Deodar recorded the maximum permissible value (1.0 mg/L) set by IS 10500, suggesting potential fluoride risk in the future if concentrations increase. Fluoride levels in other locations were within safe limits, but continuous monitoring is recommended due to Banaskantha's known vulnerability to fluoride contamination.

Total Dissolved Solids (TDS)

TDS values ranged from 420 mg/L (Dantiwada) to 1580 mg/L (Bhabhar). While Dantiwada, Danta, and Deesa were within the acceptable limit of 500 mg/L, most samples exceeded it but remained below the permissible limit of 2000 mg/L. The highest TDS in Bhabhar may be due to geogenic contributions or possible anthropogenic inputs such as agricultural runoff or wastewater intrusion.

Electrical Conductivity (EC)

Electrical conductivity followed a trend similar to TDS, with values ranging from 802 µS/cm (Dantiwada) to 3522 µS/cm (Bhabhar). High conductivity in Bhabhar again points to the elevated ionic load, suggesting the presence of dissolved salts and minerals. EC strongly correlated with TDS in all locations, validating the ion concentration levels.

Turbidity

Turbidity values across all samples were within the BIS acceptable limit of 1 NTU, with Dantiwada (0.2 NTU) having the lowest and Amirgadh (0.7 NTU) the highest. Low turbidity indicates good physical clarity of water; however, this does not necessarily imply microbial safety, which is evident from coliform levels.

Chloride

Chloride concentrations ranged from 99.96 mg/L (Dhanera) to 624.80 mg/L (Bhabhar). While only Bhabhar exceeded the permissible limit of 250 mg/L, this highlights potential saltwater intrusion or contamination through anthropogenic activities like fertilizer use. Deesa and Amirgadh also showed moderately elevated chloride levels.

Total Hardness (TH)

All locations showed elevated hardness, with values ranging from 180 mg/L (Dhanera) to 500 mg/L (Deodar). All samples exceeded the desirable limit of 200 mg/L, and Deodar approached the maximum permissible limit of 600 mg/L. High hardness can affect domestic usability and contribute to pipe scaling.

Coliform Bacteria

Microbial analysis revealed coliform presence in all samples, ranging from 22 MPN/100 mL (Danta) to 50 MPN/100 mL (Bhabhar, Deesa, and Deodar). According to IS 10500:2012, drinking water must be free of coliforms, hence none of the samples meet the standard for microbial safety. This strongly indicates possible fecal contamination and inadequate sanitation or water infrastructure in the surveyed areas.

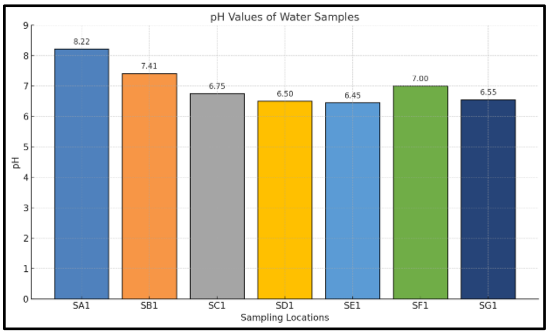

Figure 4. Bar graph showing variation in pH levels across the seven sampling locations in Banaskantha district.

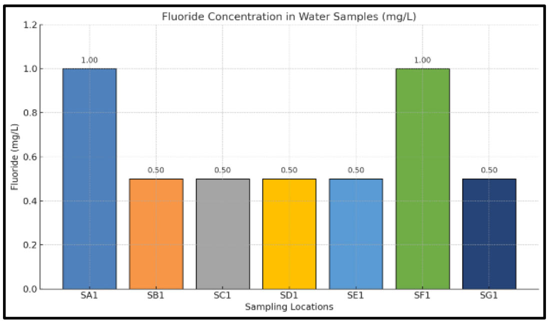

Figure 5. Comparison of fluoride concentrations with IS 10500 permissible limits in drinking water.

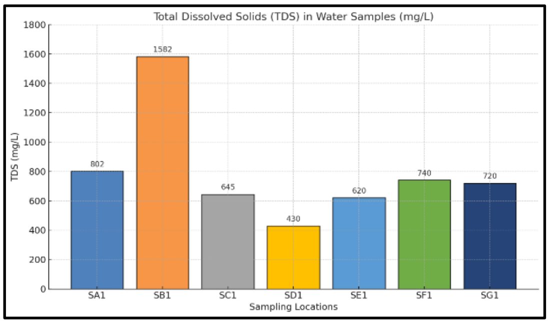

Figure 6. TDS values recorded across sampling sites compared against IS 10500 permissible limits.

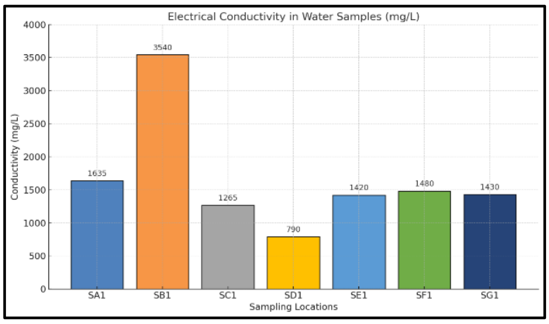

Figure 7. Electrical conductivity variation indicating ionic concentration in groundwater samples.

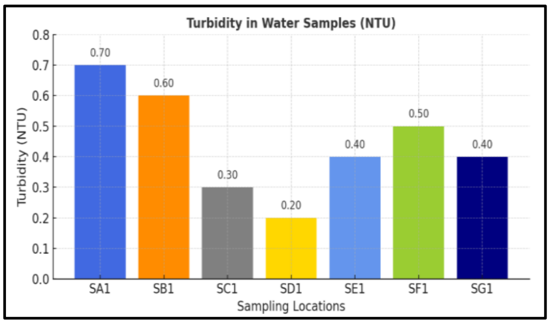

Figure 8. Turbidity levels (NTU) in groundwater samples from seven talukas of Banaskantha district. All values are within BIS acceptable limits, indicating relatively clear water, though not necessarily free of microbial contamination.

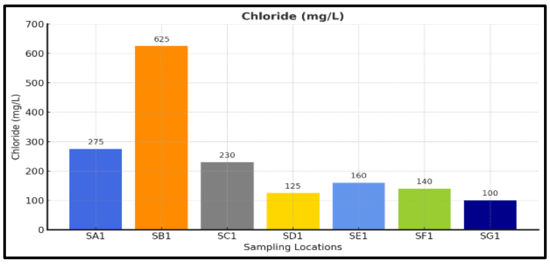

Figure 9. Chloride concentrations (mg/L) observed in groundwater samples. Elevated levels in Bhabhar

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and Amirgadh suggest possible anthropogenic or geogenic salt intrusions.

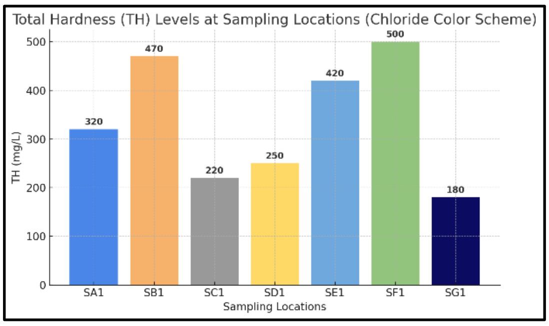

Figure 10. Total Hardness (TH) values across sampling locations. All sites exceed the BIS desirable limit of 200 mg/L, with Deodar approaching the maximum permissible limit of 600 mg/L.

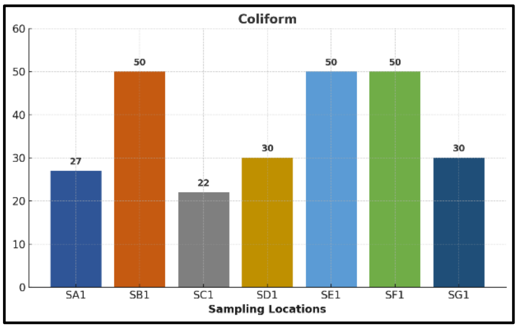

Figure 11. Coliform bacteria counts (MPN/100 mL) across all sites. All samples exceed BIS standards (0 MPN/100 mL), indicating microbiological unsuitability for direct human consumption.

7. Implication

The widespread presence of microbial and chemical contaminants in groundwater has direct implications for public health and regional water management. The detection of coliforms in all samples signals an urgent need for enhanced microbial testing in routine surveillance and improved sanitation infrastructure. Elevated salinity indicators—such as TDS, chloride, and conductivity—in Bhabhar and Deodar suggest geogenic risks worsened by unregulated agricultural runoff and groundwater overuse. Policymakers must implement decentralized treatment systems (e.g., chlorination, filtration), initiate groundwater recharge efforts, and strengthen community awareness campaigns on safe water use and hygiene. Establishing a long-term monitoring framework with updated regional databases will be essential to mitigate future health risks and ensure water security in Banaskantha and other semi-arid rural districts.

8. Conclusion

This study assessed the physicochemical and microbial quality of drinking water across seven talukas of Banaskantha district, Gujarat, using eight key parameters and comparing them against the Bureau of Indian Standards (IS 10500:2012). The findings, represented through both tabular and graphical formats, provide a detailed insight into the spatial variability and safety status of groundwater sources in the region. The figure-wise analysis highlighted significant observations. The pH values (Figure 4) across all samples remained within the BIS acceptable range of 6.5–8.5, with Amirgadh exhibiting slightly alkaline conditions and Deesa and Dhanera showing slightly acidic tendencies. Fluoride levels (Figure 5) were within permissible limits, although Amirgadh and Deodar reached the upper limit of 1.0 mg/L, indicating potential future risk of fluorosis if levels increase. Total dissolved solids (Figure 6) were notably high in Bhabhar, exceeding 1500 mg/L, suggesting salinity-related concerns, while other sites remained within acceptable or moderate ranges. Electrical conductivity (Figure 7) followed a similar trend, with Bhabhar showing the highest values, reflective of elevated ion concentrations and potential geogenic influence.

Turbidity (Figure 8) remained low across all locations, indicating physically clear water; however, this parameter alone does not reflect biological safety. Chloride concentrations (Figure 9) were highest in Bhabhar, surpassing the permissible limit of 250 mg/L, followed by moderate values in Amirgadh and Deesa, likely influenced by agricultural or sewage contamination. Total hardness (Figure 10) exceeded the desirable limit (200 mg/L) in all samples, with Deodar approaching the maximum permissible limit of 600 mg/L, which may impact water usability and infrastructure through scaling. Coliform contamination (Figure 11) was present in all samples, with the highest counts recorded in Bhabhar, Deesa, and Deodar. As per IS 10500:2012, potable water must be completely free of coliform bacteria; hence, the detection of coliforms in all samples indicates widespread microbial contamination and the potential presence of pathogenic organisms.

The tabular summary (Table 1) reinforced these findings by consolidating all parameter values across the sampled talukas. It revealed that Bhabhar had the highest overall contamination, exceeding limits in TDS, conductivity, chloride, hardness, and coliform count. Deodar also presented multiple exceedances, including microbial load, hardness, and borderline fluoride concentration. Dhanera, though moderate in physicochemical parameters, was still unsafe for direct consumption due to microbial contamination. Importantly, all samples across the district failed the microbiological criteria set by BIS, rendering them unsafe without adequate treatment.

In conclusion, both table-wise and figure-wise interpretations confirm that the drinking water in Banaskantha district is at risk from both geogenic (e.g., fluoride, salinity, hardness) and anthropogenic (e.g., microbial) contamination. The results strongly advocate for immediate attention to water treatment, regular surveillance, and improved sanitation practices, particularly in talukas like Bhabhar, Deesa, and Deodar. This study offers essential baseline data to guide public health policies and resource planning for ensuring safe and sustainable drinking water in the region.

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