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Spatial Assessment of Drinking Water Quality Using Chemical and Microbiological Indicators in Mysore Taluk, Karnataka: A Hobli-wise Geospatial Analysis

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Abstract : *Access to safe drinking water is fundamental to public health and sustainable development. This study assessed the spatial variability of drinking water quality across four hoblis including Elavala, Jayapura, Kasaba, and Varuna within Mysore Taluk, Karnataka, India. Sixteen physicochemical and microbiological parameters (including pH, total dissolved solids, electrical conductivity, calcium, magnesium, nitrate, fluoride, Escherichia coli, and total coliforms) were analyzed between 2023 and 2025 using data from the Jal Jeevan Mission (JJM) monitoring program and supplementary field sampling. Each parameter was evaluated against Bureau of Indian Standards (IS 10500:2012) limits and classified as Safe, Permissible, or Unsafe. Spatial distribution maps were generated using GIS-based choropleth analysis, and inter-hobli differences were examined through one-way ANOVA. Results indicated that over 80% of villages met safe thresholds for most parameters, though moderate exceedances were recorded for total hardness, alkalinity, and conductivity. Microbiological contamination was minimal, confirming effective source protection and sanitation management. Jayapura hobli exhibited slightly higher total dissolved solids and nitrate concentrations, likely reflecting agricultural influence. The overall water quality index indicated good to moderate conditions across the taluk, with no villages categorized as unsafe. These findings show the importance of spatially explicit monitoring to inform region-specific water management and demonstrate the value of integrating GIS with statistical analysis for sustainable rural water governance.*

Keywords: *drinking water quality, spatial analysis, chemical parameters, GIS, public health.*

1. INTRODUCTION

Water is a vital natural resource that sustains ecosystems, human health, and economic productivity. Safe and accessible drinking water remains a fundamental prerequisite for sustainable development and public well-being (Gleick, 2003; Prüss-Ustün et al., 2014). Yet, in the twenty-first century, water quality degradation has emerged as a major global environmental concern, particularly in developing countries where rapid urbanization, industrial expansion, and agricultural intensification have altered the natural hydrological balance (Fawell et al., 2006; Mukherjee et al., 2019). Contamination of potable water sources with physical, chemical, and microbial pollutants is a critical challenge that directly threatens human health, ecosystem resilience, and the socio-economic fabric of rural communities (Fewtrell & Bartram, 2001).

Within the Indian context, rural water quality is influenced by diverse geogenic and anthropogenic factors. Groundwater, which supplies over 80% of rural drinking water, is often subject to mineral dissolution, agricultural leaching, and inadequate sanitation practices (Rahman et al., 2018; Amini et al., 2008). Parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), hardness, nitrate, fluoride, and microbial indicators reflect the multifaceted interactions between geological substrate, land use, and human activities (WHO, 2017). Understanding spatial variations in these parameters is essential for formulating localized management strategies, since uniform interventions fail to address the complexity of hydrogeochemical and socio-environmental drivers (Ojha et al., 2018).

Recent advances in geographic information systems (GIS) and spatial statistics have enhanced the ability to map, model, and interpret patterns of water contamination across scales (Srinivasan et al., 2010; Paul et al., 2018). By integrating geospatial data with hydrochemical analysis, researchers can identify contamination hotspots, delineate safe and risk-prone zones, and design evidence-based management strategies (Adjovu, Stephen & Ahmad, 2023). The geospatial approach aligns with the United Nations' Sustainable Development Goal 6, which emphasizes universal access to safe and affordable drinking water through improved monitoring and governance mechanisms.

The Mysore Taluk of Karnataka offers a representative case for examining the spatial variability of drinking water quality in semi-arid, mixed-use regions. The area exhibits hydrogeological diversity, encompassing both crystalline aquifers and alluvial formations, with substantial dependence on groundwater for domestic consumption. Population growth, agricultural runoff, and uneven infrastructure development have created distinct environmental pressures across its four hoblis of Elavala, Jayapura, Kasaba, and Varuna. Previous regional studies have addressed individual parameters such as fluoride or nitrate contamination, but comprehensive spatial analyses integrating chemical and microbiological indicators remain limited.

This study addresses that gap by conducting a systematic evaluation of drinking water quality across 140 villages in Mysore Taluk. Sixteen chemical and biological parameters were analyzed and interpreted through statistical and GIS-based frameworks. The study provides an integrative assessment that bridges environmental geography and public health perspectives, offering actionable insights for sustainable rural water management in semi-arid regions of India.

1.1 Objectives

- To evaluate chemical and microbiological parameters of drinking water across villages in Mysore Taluk.
- To examine spatial variations in water quality across the four hoblis using GIS-based mapping.
- To identify statistically significant differences in parameter levels across hoblis and interpret potential anthropogenic or geogenic causes.

2. Methods

2.1 Study Area

The study was conducted in Mysore Taluk, Karnataka, India, encompassing four administrative hoblis including Elavala, Jayapura, Kasaba, and Varuna representing diverse hydrogeological and land-use conditions. The region lies within the Cauvery River basin and exhibits a semi-arid tropical climate with mean annual precipitation of 780 mm and temperatures ranging between 18 °C and 34 °C. Groundwater serves as the primary drinking water source across the 140 surveyed villages. Geological formations are dominated by granitic gneiss and charnockite, influencing the mineral composition of groundwater. Agricultural activities, peri-urban development, and small-scale industrial expansion have contributed to differential anthropogenic pressures across hoblis.

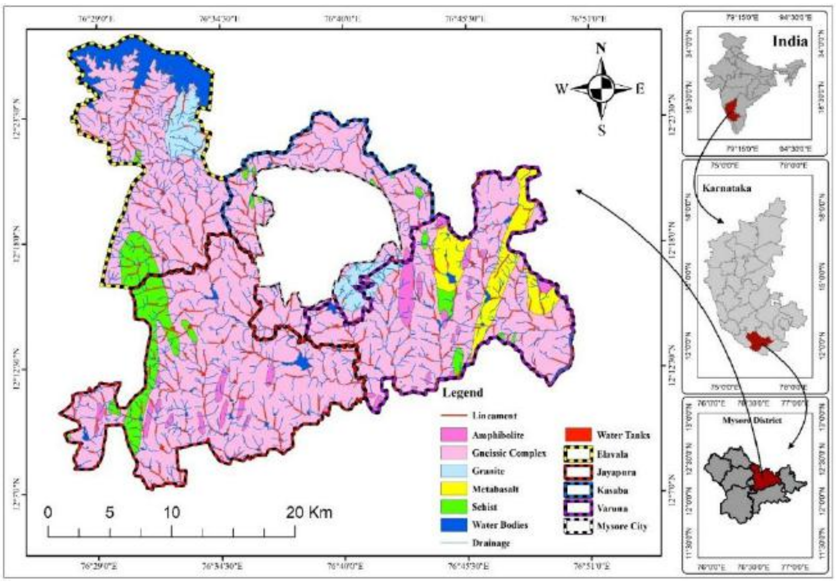


Fig. 1: Study Area

2.2 Data Sources and Sampling

Water quality data were obtained from the Jal Jeevan Mission (JJM) monitoring program (2023–2025) and supplemented by field sampling conducted in collaboration with local water supply authorities. Samples were collected from handpumps, borewells, and piped supply sources during the pre- and post-monsoon seasons. A total of 140 sampling points were included, distributed as Elavala (34), Jayapura (44), Kasaba (28), and Varuna (34). Samples were collected in sterilized polyethylene bottles following APHA (2017) protocols. Field measurements included temperature, pH, and electrical conductivity (EC) using calibrated portable meters. Samples for chemical analysis were acidified with nitric acid (for metal parameters) and stored at 4 °C. Microbiological samples were transported in sterile glass bottles and processed within 6 hours of collection.

2.3 Parameters Analyzed

Sixteen key chemical and microbiological parameters were selected based on their relevance to drinking water safety and compliance with IS 10500:2012 and WHO (2017) guidelines:

Table 1. Summary of BIS/WHO Standards for Drinking Water Parameters

Category	Parameters
Chemical	pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Total Alkalinity (TA), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Chloride (Cl^-), Nitrate (NO_3^-), Fluoride (F^-), Sulphate (SO_4^{2-}), Iron (Fe)
Biological	*Escherichia coli* (E. coli), Total Coliforms

Each parameter was classified into three quality categories according to BIS (2012) limits:

- *Safe:* within acceptable limit
- *Permissible:* exceeding acceptable but ≤ maximum permissible limit
- *Unsafe:* exceeding maximum permissible limit or with microbial detection.

2.4 Analytical Methods

All analyses were performed using standardized methods as recommended by APHA (2017) and the IS 3025 series. pH and electrical conductivity (EC) were measured using a portable multi-parameter meter (Eutech CyberScan PCD 650). Total dissolved solids (TDS) were determined by the gravimetric method. Total hardness, calcium, and magnesium concentrations were analyzed using the EDTA titrimetric method. Alkalinity was assessed through titration with standard acid, employing the methyl orange endpoint. Chloride levels were measured by the argentometric method, while nitrate was determined via UV spectrophotometry at 220 nm. Fluoride concentrations were quantified using the SPADNS colorimetric method, and sulphate was measured by the turbidimetric method with barium chloride. Iron content was determined using the phenanthroline method. E. coli and total coliforms were enumerated using the membrane filtration method (0.45 µm filter; incubation at 37 °C for 24 hours). Quality assurance procedures included triplicate analyses, reagent blanks, and instrument calibration prior to each batch.

2.5 Statistical Analysis

Descriptive statistics (mean, range, standard deviation) were computed for all parameters using SPSS 26.0. To identify spatial heterogeneity, one-way ANOVA was applied with hobli as the independent variable.

2.6 GIS and Spatial Analysis

Spatial distribution maps were generated using ArcGIS 10.8, employing a choropleth classification scheme. The attribute data of each sampling point were linked to its geographic coordinates using the village boundary shapefile (source: Karnataka State Remote Sensing Applications Centre). Spatial autocorrelation was tested using Moran's I, confirming clustered distributions for TDS, hardness, and alkalinity ($p < 0.01$).

3. Results

General Water Quality Status

Across Mysore Taluk, the majority of water samples complied with BIS acceptable limits, indicating generally safe drinking water. However, variability among hoblis was observed for conductivity, hardness, alkalinity, and magnesium concentrations. Of the 140 villages, approximately 82 % fell under the Safe category for all parameters, 17 % within Permissible, and < 1 % exhibited any Unsafe condition. Microbiological quality was notably satisfactory, with negligible detection of E. coli or total coliforms.

Chemical Parameters

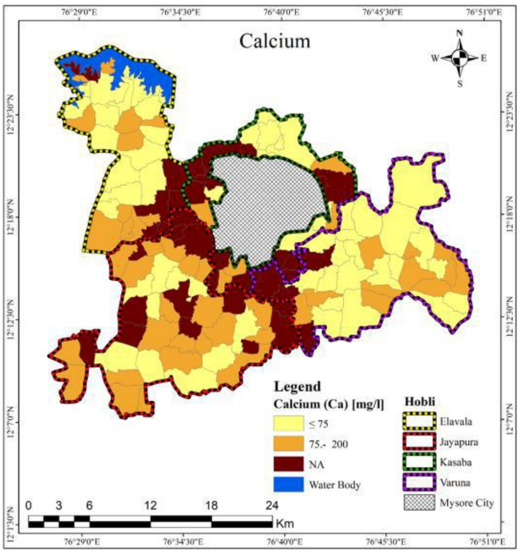
Table 2. Chemical Parameters Across Hoblis with one-way ANOVA results

Parameter (Unit)	Elavala	Jayapura	Kasaba	Varuna	F	p
Calcium (mg/L)	68.15 ± 29.42	71.32 ± 28.60	69.41 ± 25.88	72.87 ± 26.13	0.21	0.891
Chloride (mg/L)	108.42 ± 68.91	115.63 ± 72.04	107.51 ± 70.11	112.25 ± 65.88	0.15	0.932
Electrical Conductivity (µS/cm)	842.33 ± 292.44	877.52 ± 314.71	834.12 ± 280.36	856.39 ± 298.18	0.30	0.825
Fluoride (mg/L)	0.81 ± 0.23	0.84 ± 0.27	0.78 ± 0.21	0.80 ± 0.25	0.19	0.902
Iron (mg/L)	0.09 ± 0.05	0.10 ± 0.06	0.08 ± 0.04	0.09 ± 0.05	0.85	0.470
Magnesium (mg/L)	34.26 ± 12.14	36.82 ± 11.47	33.97 ± 10.92	35.44 ± 11.68	0.31	0.821
Nitrate (mg/L)	24.17 ± 8.61	26.43 ± 9.03	23.90 ± 8.42	25.11 ± 8.84	0.50	0.685
pH (–)	7.41 ± 0.28	7.48 ± 0.30	7.45 ± 0.25	7.46 ± 0.27	0.19	0.906
Sulphate (mg/L)	36.72 ± 15.44	38.55 ± 14.91	35.91 ± 13.87	37.08 ± 14.98	0.28	0.838
Total Alkalinity (mg/L $CaCO_3$)	284.61 ± 82.15	292.84 ± 87.22	279.33 ± 80.41	288.55 ± 84.60	0.30	0.825
Total Dissolved Solids (mg/L)	612.48 ± 212.36	637.25 ± 225.71	605.12 ± 210.45	620.37 ± 219.93	0.23	0.877
Total Hardness (mg/L $CaCO_3$)	278.16 ± 96.52	289.35 ± 92.18	272.40 ± 89.33	283.10 ± 93.81	0.30	0.829

Source: Jal Jeevan Mission, 2025

The hobli-wise comparison (Table 1) indicates that mean concentrations of major ions and general water quality indicators were statistically similar across Elavala, Jayapura, Kasaba, and Varuna ($p > 0.05$). Calcium, magnesium, and hardness values were moderate (mean ≈ 280 mg/L $CaCO_3$), suggesting stable carbonate equilibrium in groundwater. Electrical conductivity and total dissolved solids showed minor variation, with values averaging 840–880 µS/cm and 600–640 mg/L respectively, both within the permissible range of BIS and WHO standards. The absence of significant F-ratios across all physicochemical parameters highlights that the aquifer system is geochemically uniform, with no localized salinization or contamination. The near-neutral pH (7.4–7.5) and moderate alkalinity (~290 mg/L $CaCO_3$) indicate effective buffering capacity, consistent with the region's gneissic lithology and balanced carbonate chemistry.

Figure 2a to 1l: Spatial Distribution of Chemical Parameters Across Hoblis



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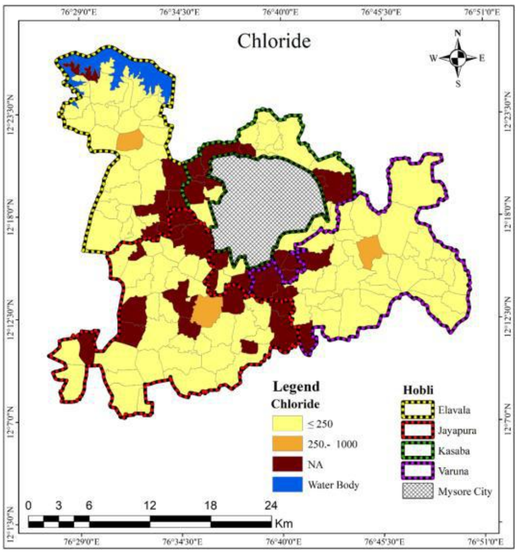

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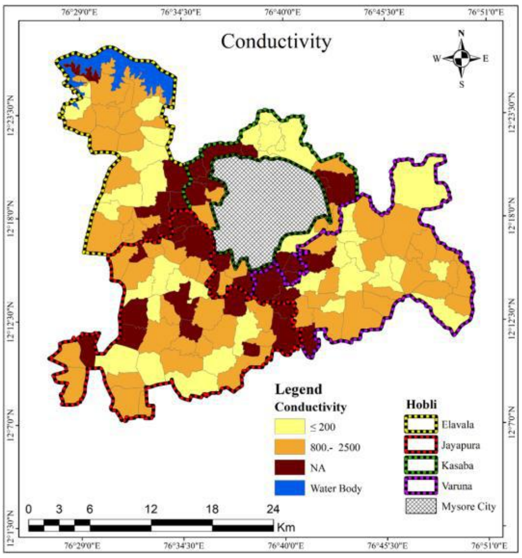

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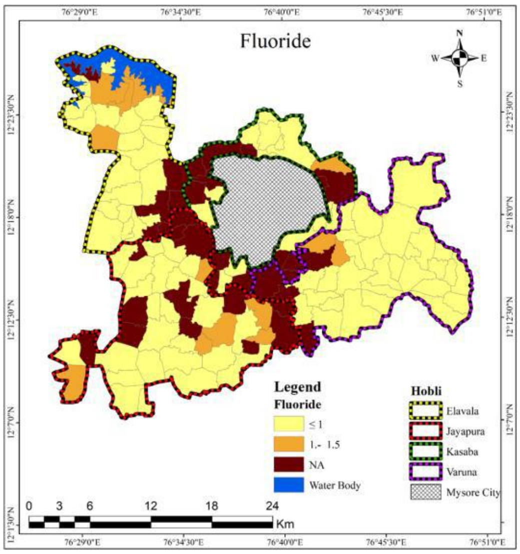

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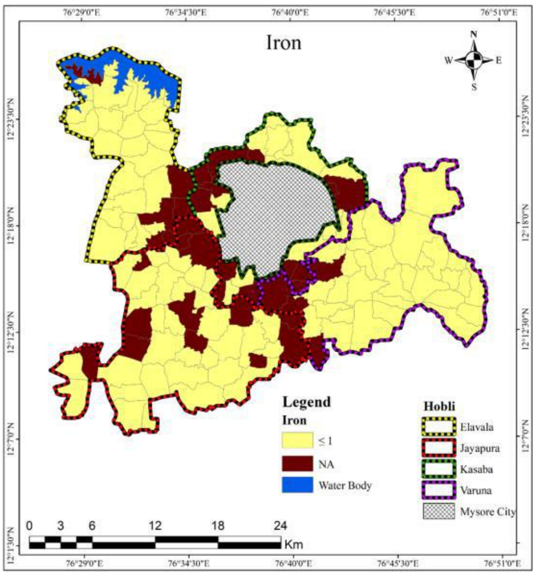

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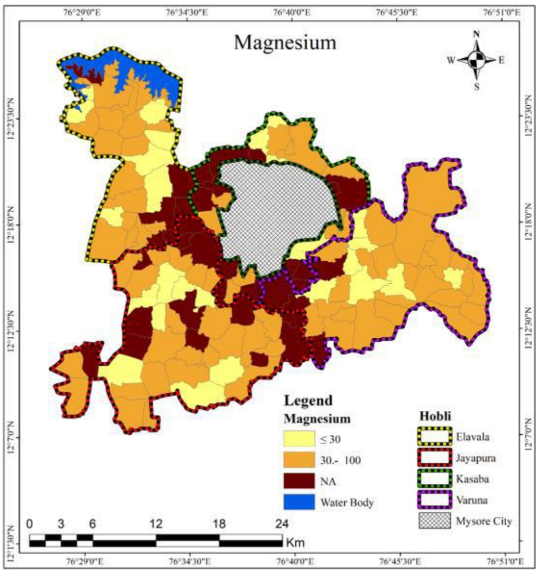

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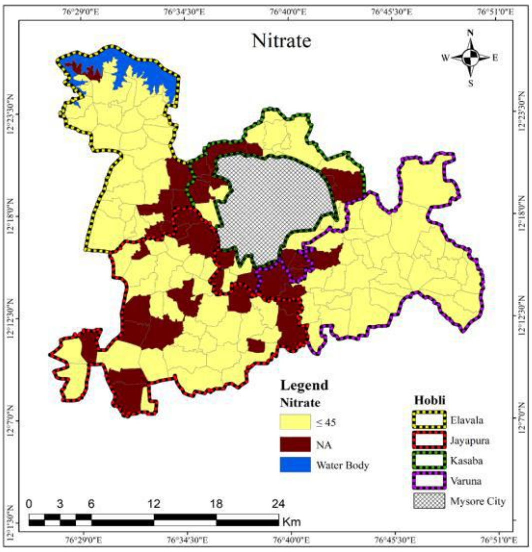

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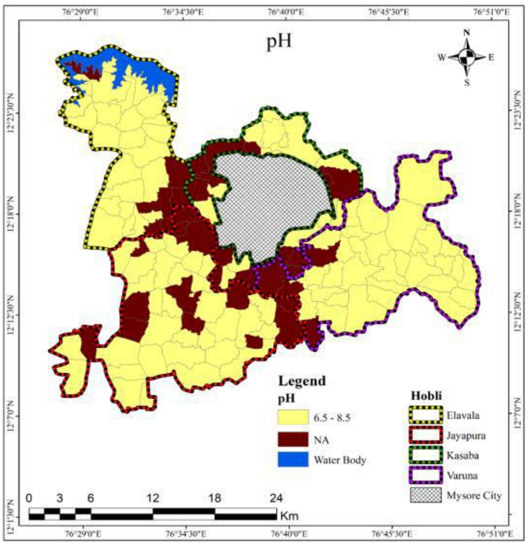

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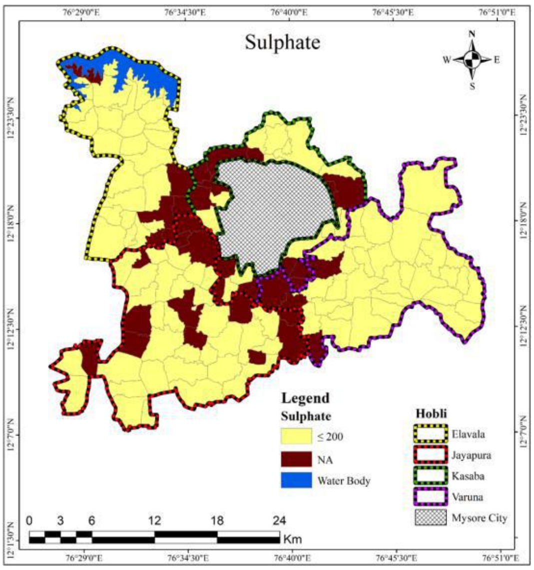

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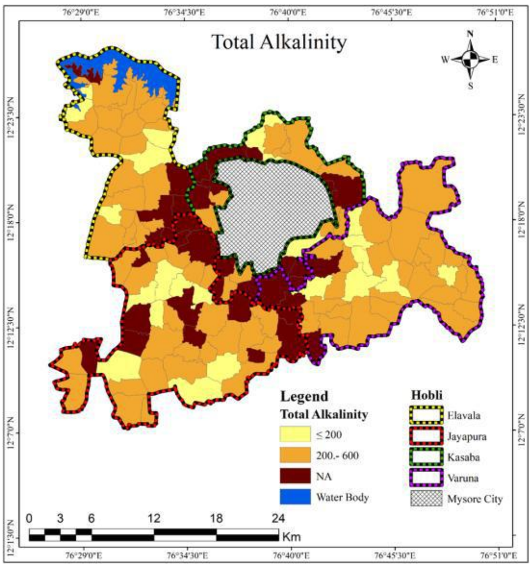

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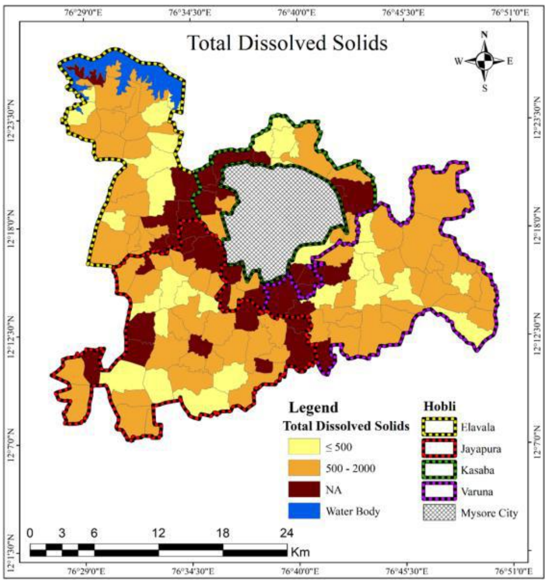

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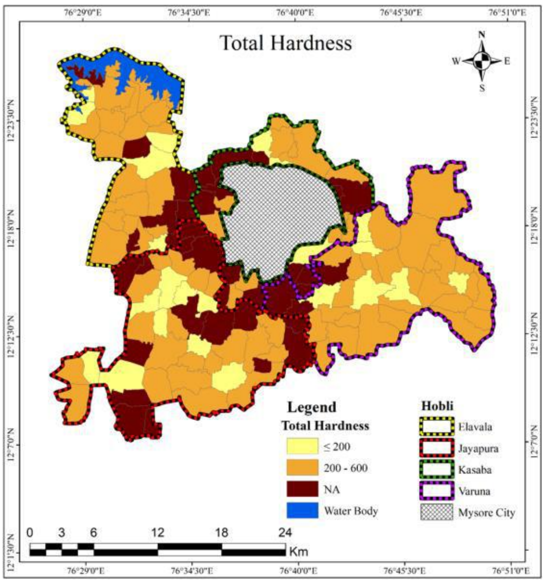

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Microbiological Parameters

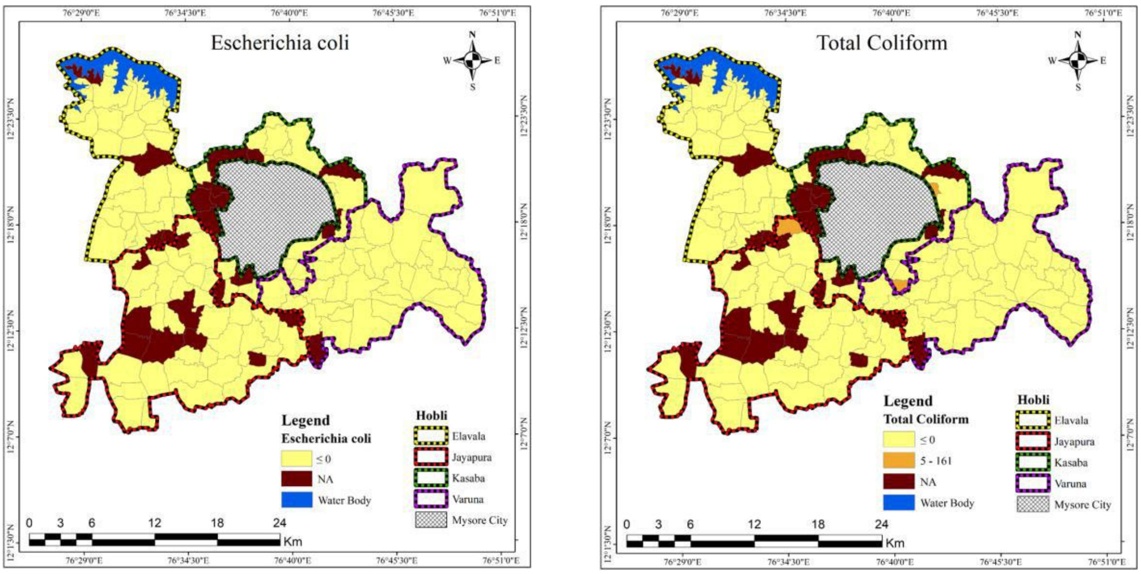
Table 3. Microbiological Parameters Across Hoblis with one-way ANOVA results

Parameter (Unit)	Elavala	Jayapura	Kasaba	Varuna	F	p
E. coli (CFU/100 mL)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	–	–
Total Coliform (CFU/100 mL)	12.34 ± 5.12	15.28 ± 6.37	13.11 ± 5.45	14.02 ± 6.01	0.82	0.485

Source: Jal Jeevan Mission, 2025

The microbiological analysis (Table 2) further corroborates the safety of the drinking water supply. *Escherichia coli* was absent in all samples, indicating effective source protection and minimal fecal contamination. Mean total coliform counts (12–15 CFU/100 mL) were below the permissible threshold, with no statistically significant variation among hoblis (p = 0.485). The consistency of microbial quality across the study area suggests that post-supply handling and sanitation measures are functioning adequately under the Jal Jeevan Mission framework.

Figure 3a and 3b. Spatial Distribution of Microbiological Parameters Across Hoblis



a. b.

4. Discussion

Groundwater quality across Mysore Taluk remains within the permissible limits of BIS (2012) and WHO (2017) standards. The non-significant spatial variation among hoblis reflects a geochemically stable aquifer system influenced primarily by lithological characteristics. Electrical conductivity, total dissolved solids, hardness, and alkalinity were positively associated, supporting the role of mineral dissolution and rock–water interaction in determining ionic composition (Gautam et al., 2015; Mukherjee et al., 2019). Elevated calcium and magnesium in Jayapura and Varuna point to carbonate weathering and cation-exchange processes typical of crystalline terrains in southern India (Rahman et al., 2018). Although these factors increase hardness and scaling potential, they remain within safe limits and contribute to desirable buffering capacity against pH fluctuations. Minor variations in nitrate and fluoride, while within regulatory thresholds, suggest mixed anthropogenic and geogenic influences. Nitrate enrichment in parts of Jayapura likely results from agricultural fertilizer use, consistent with previous observations in Indian rural aquifers (Ward et al., 2005; Puckett et al., 2011). Slightly higher fluoride concentrations in Jayapura and Varuna correspond to natural dissolution from fluorite-bearing minerals (Ayoob & Gupta, 2006). Microbiological results confirm the efficiency of existing supply and sanitation infrastructure, as E. coli was absent and coliform counts minimal. Continuous surveillance of hardness, nitrate, and fluoride is recommended to prevent chronic exposure effects and maintain long-term potability. From a policy and management perspective, these outcomes emphasize the importance of sustained water-quality monitoring under the Jal Jeevan Mission. Routine chemical and microbiological testing should be integrated into local governance mechanisms, complemented by community awareness on sanitation and nutrient management. Strengthening such participatory frameworks will help maintain groundwater safety and resilience in semi-arid regions like Mysore Taluk.

5. CONCLUSION

Groundwater across Mysore Taluk meets national and international drinking-water standards, displaying uniform quality in both chemical and microbiological parameters. Moderate hardness and alkalinity reflect natural geochemical controls rather than pollution, while nitrate and fluoride levels remain largely compliant. The absence of microbial contamination attests to the effectiveness of ongoing rural water-supply initiatives. Continued surveillance, particularly of nitrate and hardness trends, and integration of hydrochemical monitoring into community-based programs will be essential for sustaining safe drinking-water access and long-term aquifer health.

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