Groundwater Quality Assessment in Kanakapura Town, Bengaluru South District Karnataka

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Abstract

Water is very important for sustainable life. It not only sustains life but also determines the quality of life. Assessing water quality is just as important as quantity in water resource planning and management. In recent years, rapid urbanization, population growth, and changing land use patterns have led to increasing stress on water resources, especially groundwater. Kanakapura, like many other towns in Karnataka, is experiencing rising water demand for agricultural, domestic, and developmental activities. These pressures have caused variations in groundwater quality, making continuous assessment crucial. The present study on the groundwater quality of Kanakapura town aimed to evaluate physico-chemical parameters to assess suitability for drinking and domestic use. A total of 20 samples were collected ward-wise and analyzed for parameters including pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), calcium, magnesium, chloride, fluoride, sulphate, phosphate, sodium, potassium, and nitrate, in accordance with BIS (IS 10500:2012) standards. Overall, the findings reveal that while pH, fluoride, phosphate, sodium, potassium, and nitrate remain largely within permissible limits, parameters such as EC, TDS, total hardness, calcium, chloride, and sulphate exceeded recommended limits in several locations. These results suggest that certain wards in Kanakapura face significant water quality challenges, likely due to combined effects of geology, agricultural practices, and urban activities.

Keywords: Groundwater, Quality, Extraction, Recharge, Pollution

INTRODUCTION

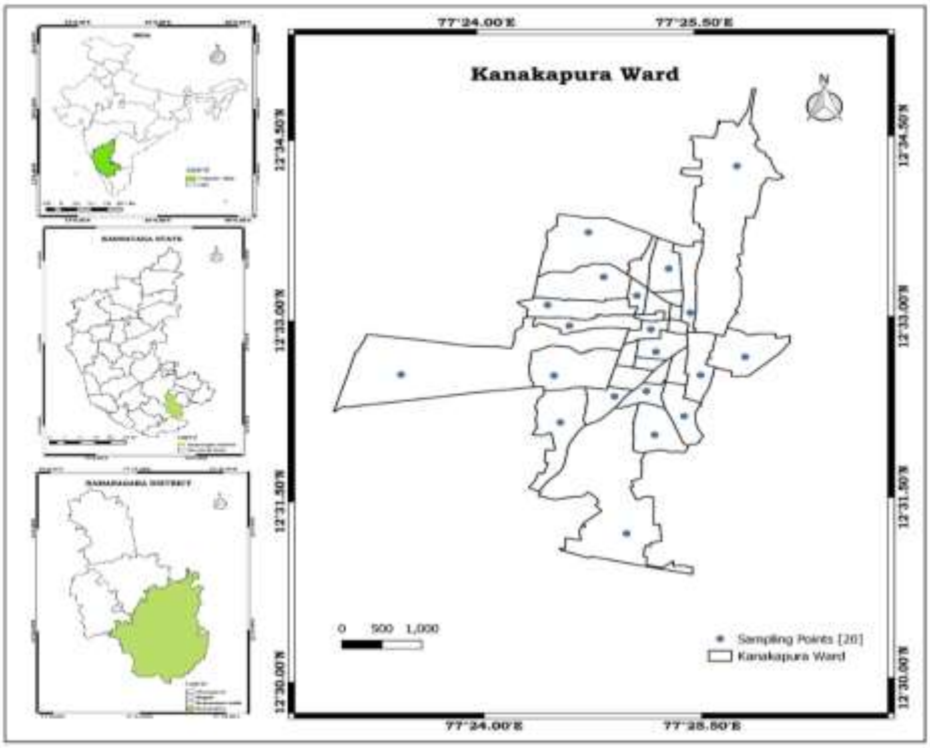
Groundwater comprises nearly 99% of Earth's liquid freshwater and offers substantial social, economic, and environmental benefits, including climate resilience. Groundwater is the largest source of unfrozen freshwater, accounting for approximately 30% of the world's freshwater resources. It provides about 50% of global drinking water and nearly 43% of the water used for irrigation, supporting food security and economic development (UNESCO, 2022). In India, the groundwater serves as the primary foundation of agricultural activity and drinking water supply, meeting nearly 62% of irrigation needs, 85% of rural consumption, and 50% of urban demand (CGWB 2025). The total annual groundwater recharge in the country has been assessed as 448.52 billion cubic meter (bcm). Keeping an allocation for natural discharge, the annual extractable ground water resource has been assessed as 407.75 bcm. The annual groundwater extraction (as in 2025) is 247.22 bcm (UNESCO 2026).

As per the results of Dynamic Ground Water Resource Assessment Report (GOK) 2025 of Karnataka, the Annual Ground Water Recharge has been assessed as 18.74 BCM and the Annual Extractable Ground Water Resource is 16.88 BCM. The Current Annual Ground Water Extraction is 11.55 BCM and the Stage of Ground Water Extraction is 68.44%. This indicates that, on an average, 68.4% of yearly replenishable groundwater is being used in the State. The assessment of 14,978 groundwater samples indicated that nearly 71.7% complied with the BIS (IS 10500) drinking water standards. In contrast, approximately 28.3% of the samples exceeded the permissible limits for one or more parameters, suggesting localized deterioration in groundwater quality in India (CGWB 2025).

Materials and methods

Description of study area: Kanakapura taluk is one of the taluk in Bengaluru south district, situated in southeastern part of the district. Kanakapura is located at 12° 33’ to 12° 55' North latitudes and 77° 25′ east 77° 42′ East longitudes. It has an average elevation of 638 meters from MSL. Kanakapura is situated 56 km south to Bangalore and 26 kms from Ramanagara on the Arkavathi river bank. Kanakapura city, a growing town in the Bengaluru south district, is officially divided into 27 municipal wards which administrated by Local Planning Authority (Figure.1).

Figure 1: Ground water sampling points in Kanakapura ward



Climate: The climate in the region is hot, moist and semi-arid Ecological Sub Region with length of growing period of 150-180 days. The Kanakapura Local Planning Area belongs to the Eastern Dry Agro-Climatic Zone. The LPA experiences pleasant weather almost throughout the year. March, April and May are the predominant summer while December and January constitute winter.

Ground water sampling: The ground water sampling was carried out in the month of July 2025. Twenty (20) ground water samples were collected in clean plastic bottles of 2 liters capacity. The samples were brought to the laboratory and were subjected to physico-chemical analysis (APHA, 2022).

Table 1: Sampling Coordinates of Groundwater in Kanakapura ward

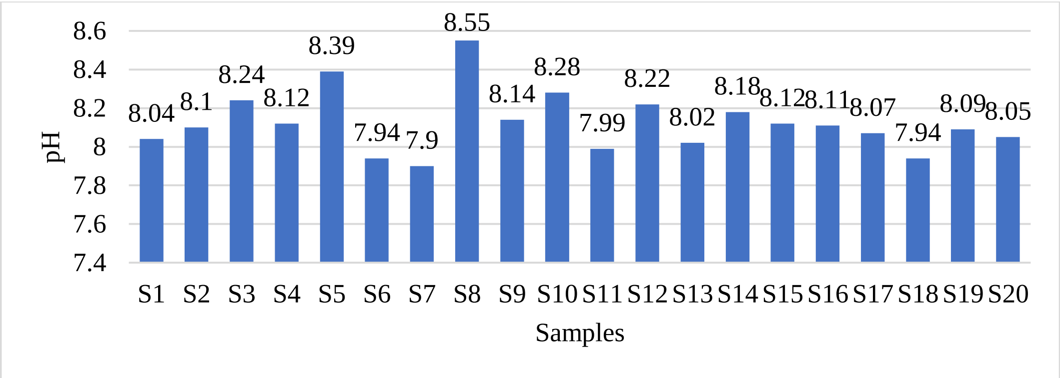
Sample no	Ward name	Latitude	Longitude
1	Boodikeri	12.546993°	77.411378°
2	Pete beedi	12.550377°	77.418277°
3	Muslim block	12.552037°	77.425132°
4	Ajad Nagar	12.548896°	77.423427°
5	Megala Beedi	12.551236°	77.421435°
6	Bananthamma extension	12.557208°	77.41957°
7	Nirvaneshwara Nagara	12.545837°	77.402938°
8	Melekote	12.543830°	77.425303°
9	Ajeej Nagara	12.554012°	77.423057°
10	Maharaja katte	12.559767°	77.409948°
11	Basaveshwara Nagara	12.543831°	77.413932°
12	Kurupete kere beedi	12.540541°	77.420545°
13	Malagalu	12.324123°	77.25216°
14	Mahadeshwara badavane	12.331342°	77. 25203°
15	Vivekananda Nagara	12.330381°	77250308°
16	Kote kelabhaga	12.323513°	77.253013°
17	Ambedkar Nagara	12.321780°	77.245587°
18	Bhuvaneshwari nagara	12.322526°	77.250281°
19	H.M. Doddi	12.322765°	77.251827°
20	Henchina Factory Extension	12.324269°	77.293743°

RESULTS AND DISCUSSION

Assessment of Ground Water Quality: The use of groundwater has increased significantly in the last decades due to its widespread occurrence and overall good quality. Physical and chemical constituents are useful in deciding water use strategies for various purposes. The present study deals with the ground water quality in Kanakapura ward.

pH: The pH of water is a critical parameter that indicates whether the groundwater is acidic, neutral, or alkaline. It influences the chemical and biological properties of water (APHA 2022).

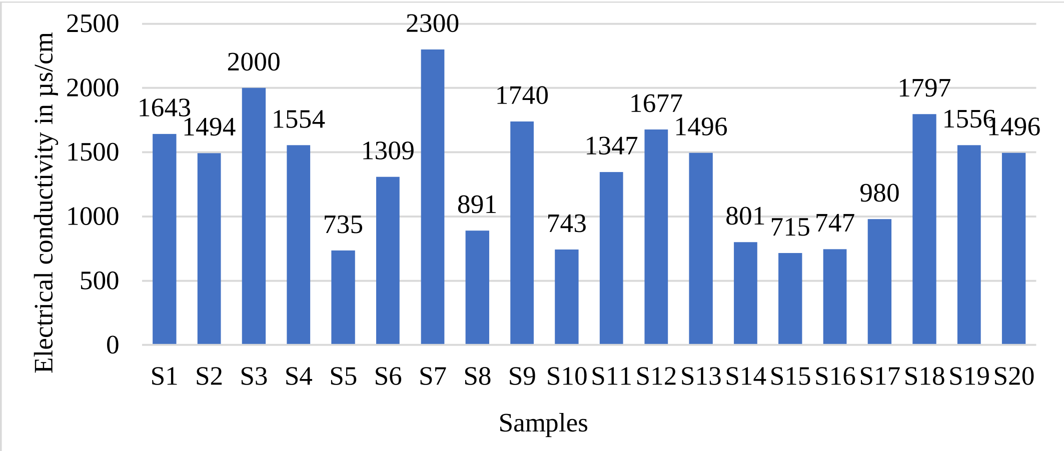
Figure 2: pH values in the Ground Water Samples



The pH values of the groundwater samples range from 7.94 to 8.55. According to the BIS (IS 10500:2012) standards, the acceptable pH limit for drinking water is 6.5 to 8.5. The results show that samples fall within the permissible range, suggesting that the groundwater is generally safe in terms of pH. The variations in pH may be due to factors such as geological formations, natural buffering capacity of the aquifer, and possible contamination from nearby anthropogenic sources. Overall, the groundwater in the study area is within acceptable pH limits.

Electrical Conductivity (EC): Electrical conductance is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts (Dahiya et.al., 1999)

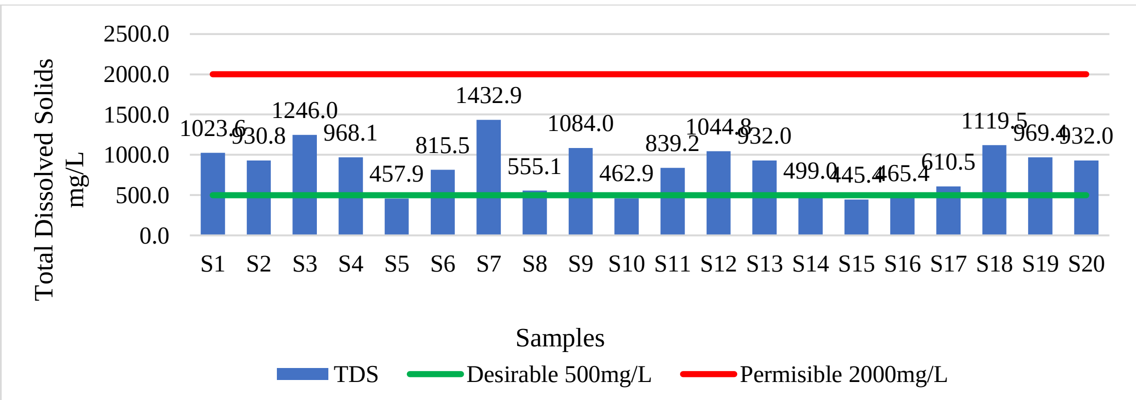
Figure 3: Electrical conductance values in the ground water samples



The EC values in the 20 samples ranges from 715 µS/cm (Sample 15) to a peak of 2300 µS/cm (Sample 7), indicating moderate to high salt content. Elevated EC levels suggest significant presence of dissolved ions such as calcium, magnesium, chloride, and sulphates, which increase water's ability to conduct electric current. Samples 1, 4, 7, 9, 11, 13, and 18 show notably high EC values (above 1500 µS/cm), pointing toward higher mineralization and possible salinity concerns. Although there is no strict permissible limit for EC in drinking water, values above 1500–2000 µS/cm are typically considered an indication of poor water quality. These findings emphasize the need for further evaluation of ionic composition and potential treatment before domestic use.

Total Dissolved Solids: Total dissolved solid is the term used to describe the inorganic salts and small amounts of organic matter present in water. The presence of dissolved solids in water may affect its taste (Bruvold and Ongerth 1969).

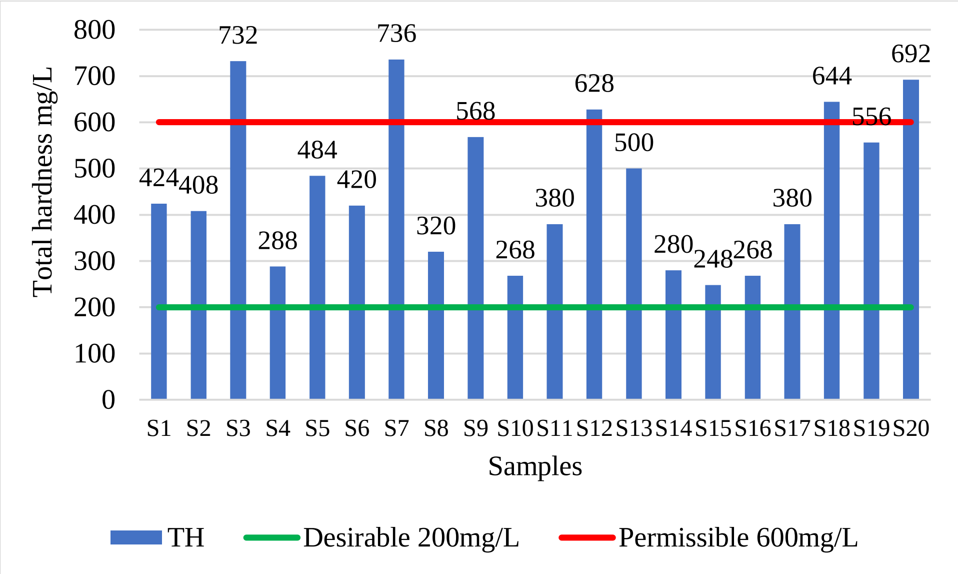
Figure 4: TDS values in the ground water samples



The Total Dissolved Solids (TDS) analysis of 20 groundwater samples shows that most samples exceed the acceptable limit of 500 mg/L set by IS 10500:2012, although all remain below the permissible limit of 2000 mg/L. The highest TDS levels were recorded in Sample 7 (1432.9 mg/L), Sample 3 (1246.0 mg/L), and Sample 1 (1023.0 mg/L), indicating significant mineral and salt content. TDS measures the concentration of inorganic salts and minor organic substances in water, which can affect the water's taste and overall quality. While moderate levels may not pose direct health risks, high TDS concentrations can lead to undesirable taste and may indicate contamination. The findings suggest a need for monitoring and possible treatment, especially for samples with values far above the acceptable threshold.

Total Hardness: According to U.S. Geological Survey (USGS, 2009), Total hardness is primarily caused by the presence of multivalent metallic cations like calcium and magnesium in the water.

Figure 5: Total Hardness values in the ground water samples

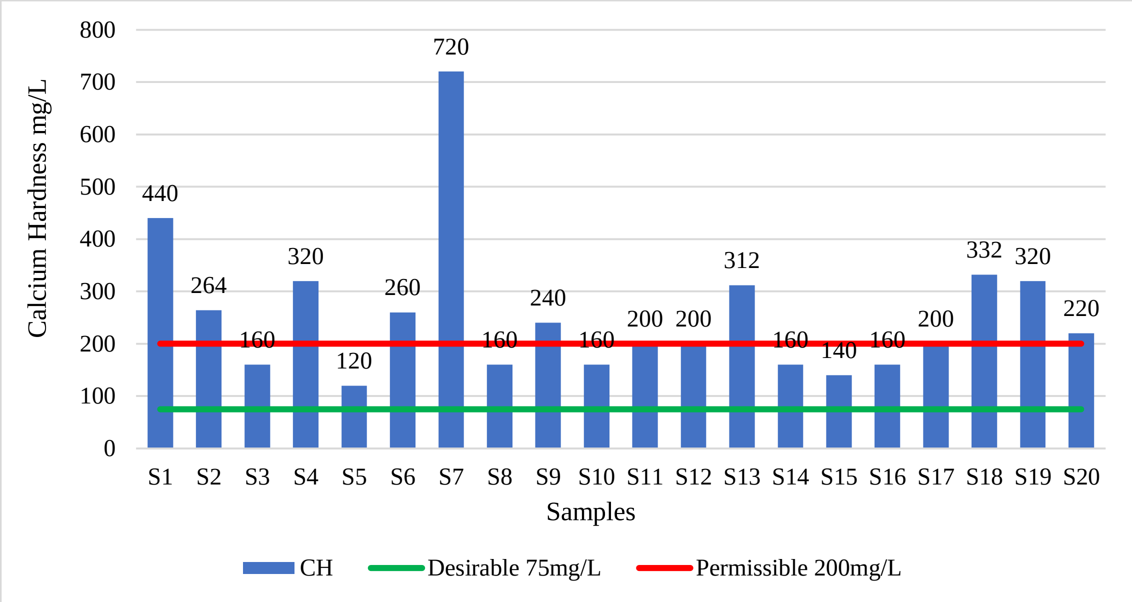


The total hardness (T.H.) of water, as shown in the analysis, varies significantly across the 20 groundwater samples, with several exceeding the permissible limit of 600 mg/L as per IS 10500:2012 standards. While the acceptable limit is 200 mg/L, many samples, such as Sample 5 (732 mg/L), Sample 7 (736 mg/L), Sample 13 (628 mg/L), and Sample 20 (692 mg/L), show considerably higher concentrations.

According to the U.S. Geological Survey (USGS, 2009), excessive hardness in drinking water may contribute to health issues such as urolithiasis (kidney stones) and also affects household water systems. The results highlight a need for appropriate water treatment measures to ensure the water is safe for consumption and domestic use.

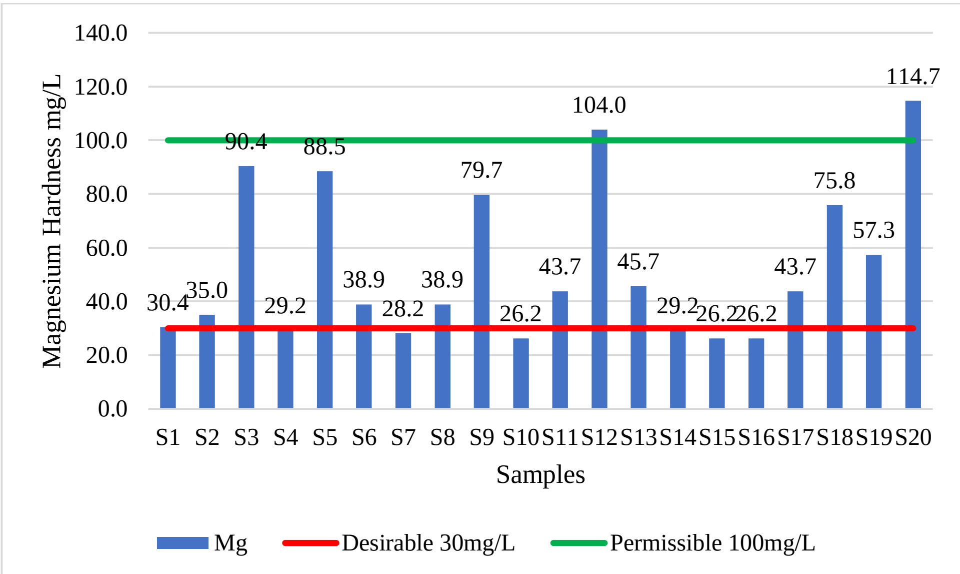
Calcium Hardness: Calcium is an important element to develop proper bone growth. It is found alkaline in nature. The presence of calcium in the groundwater is from silicate mineral group, such as pyroxene and amphibole in the igneous rocks. In addition, the shales, sandstone also contain calcium in the form of carbonate.

Figure 6: Calcium Hardness values in the ground water samples



The analysis of calcium hardness in groundwater samples reveals that calcium levels in all 20 samples exceeds the acceptable limit of 75 mg/L as per IS 10500:2012 standards. Several samples also surpass the permissible limit of 200 mg/L, with the highest concentration observed in Sample 7 at 720 mg/L.
This indicates a significant presence of calcium in the groundwater, which is likely due to the weathering of silicate minerals such as pyroxene and amphibole found in igneous rocks. While calcium is essential for bone development and contributes to the alkalinity of water, excessive concentrations may lead to hardness-related issues such as scaling in pipes and appliances. The findings suggest a need for treatment or mitigation measures to ensure water quality remains within safe and usable limits.
Magnesium (as Mg^{2+}): Magnesium usually occurs in lesser concentration than calcium due to the fact that the dissolution of magnesium rich minerals is slow process and that of calcium is more abundant in the earth's crust. If the concentration of magnesium in drinking water is more than the permissible limit, it causes unpleasant taste to the water (BIS, 2018).

Figure 7: Magnesium Hardness Values in the Ground Water Samples

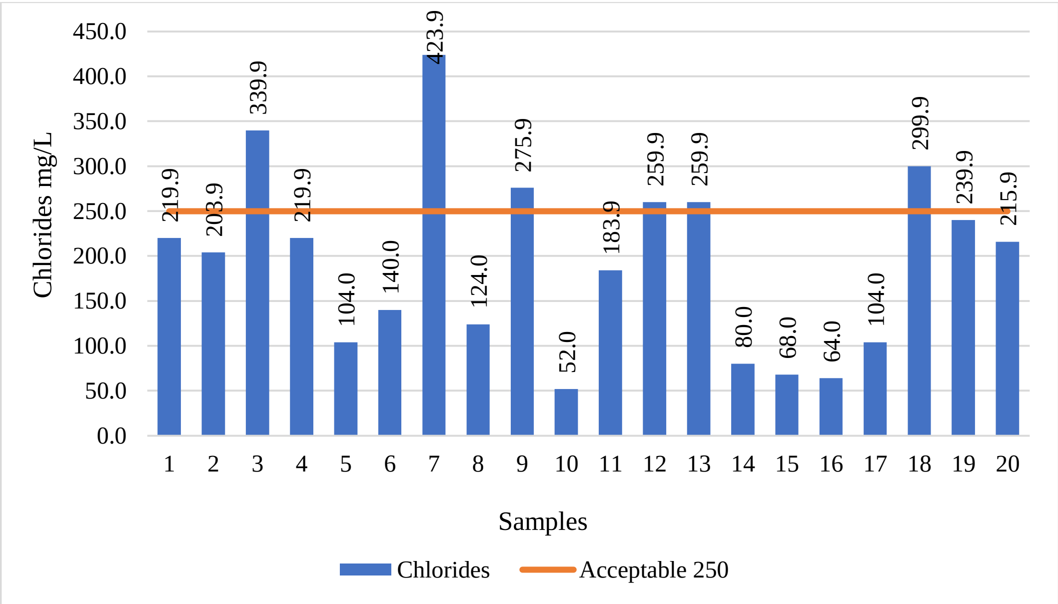


The analysis of Magnesium in groundwater samples reveals that magnesium levels recorded from 26.2mg/L to 104mg/L. Six ground water samples are within and fourteen ground water samples have exceeded the acceptable limit of 30 mg/L as per IS 10500:2012 standards Sample no 14 and sample no 20 have exceeded the permissible limit of 200 mg/L.

Hardness of water mainly depends upon the amount of calcium or magnesium salts or both. The concentration of magnesium may be due to the dissolution of magnesium calcite, gypsum and dolomite. The similar research findings of increased level of Magnesium hardness in groundwater was also noticed by Ravindra and Sharada (2015).

Chloride: Chlorides are widely distributed in nature as salts of sodium (NaCl), potassium (KCl), and calcium ($CaCl_2$). It occurs naturally and is also a relatively minor contaminant Kelly *et al.*, (2012). Chloride concentrations in excess of about 250 mg/litre can give rise to detectable taste in water, but the threshold depends upon the associated cations.

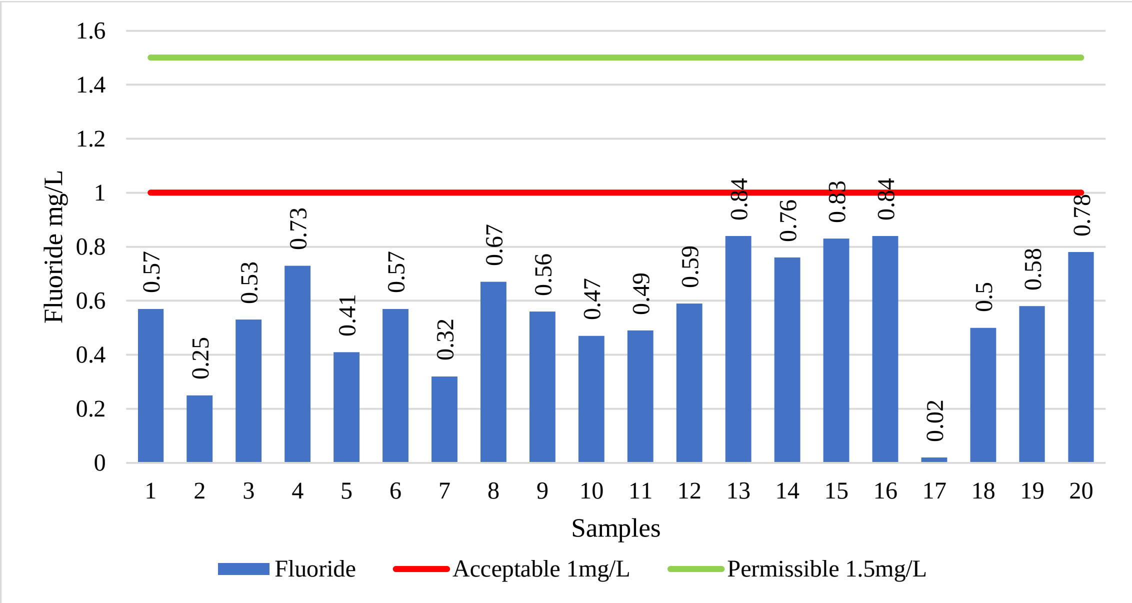
Figure 8: Chlorides concentrations in the Ground Water Samples



The analysis of chloride concentrations in 20 groundwater samples reveals that several samples exceed the acceptable limit of 250 mg/L as per IS 10500:2012 standards, although all remain well below the permissible limit of 1000 mg/L. Notably, Sample 6 (423.9 mg/L), Sample 4 (339.9 mg/L), Sample 13 (275.9 mg/L), Sample 18 (299.9 mg/L), and Sample 12 (259.9 mg/L) shows elevated chloride levels, which may cause a detectable salty taste in the water. Chloride levels in water often depend on the type of cations present, and excessive concentrations can contribute to corrosion in plumbing systems and affect water palatability. While some samples fall within acceptable limits, the elevated readings in multiple locations indicate the need for regular monitoring and possibly treatment to maintain water quality.

Fluoride: Fluoride is a chemical that occurs naturally within many types of rock. Bedrock containing fluoride minerals is generally responsible for high concentration of this ion in groundwater.

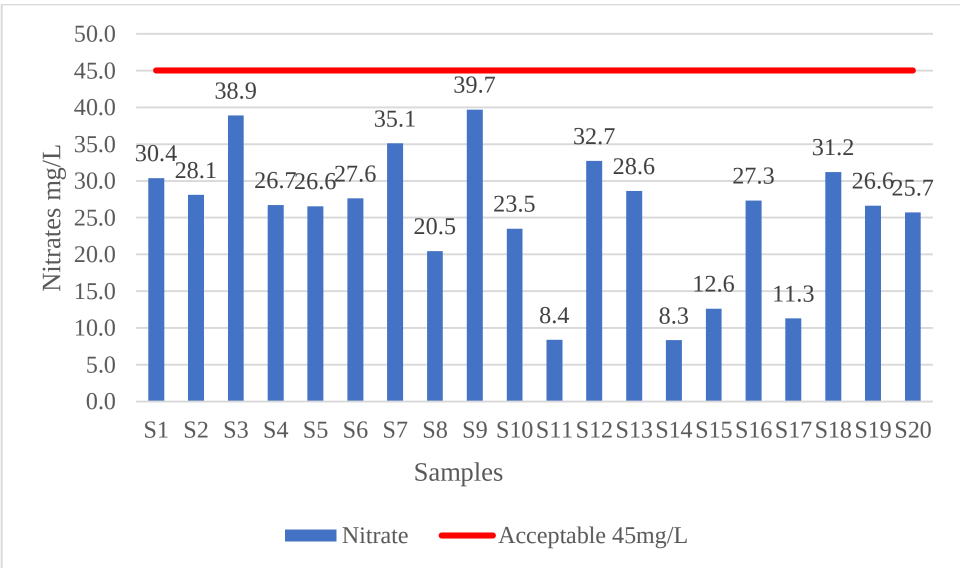
Figure 9: Fluorides concentration in the ground water samples



The fluoride analysis of 20 groundwater samples indicates that all values fall within the acceptable limit of 1.0 mg/L, and well below the permissible limit of 1.5 mg/L as per IS 10500:2012 standards. Fluoride occurs naturally in water, and in India, typical concentrations range between 0.1–0.2 mg/L. However, most of the analyzed samples shows fluoride levels higher than this natural range, with the highest concentrations recorded in Sample 15 (0.84 mg/L), Sample 16 (0.83 mg/L), and Sample 14 (0.84 mg/L). On the lower end, Sample 17 shows notably low concentration of just 0.02 mg/L. while fluoride at optimal levels is beneficial for dental health, concentrations that are too low may not provide this benefit, and excessive levels can cause fluorosis. Overall, the fluoride levels in these samples are considered safe and do not pose any immediate health concern (EFSA, 2005).

Nitrates (NO_3^-): Nitrate is a chemical compound of one-part nitrogen and three parts oxygen that is designated the symbol “NO_3”. It is the most common form of nitrogen found in water. Other forms of nitrogen include nitrite (NO_2) and ammonia (NH_3).

Figure 10: Nitrate value in the ground water samples

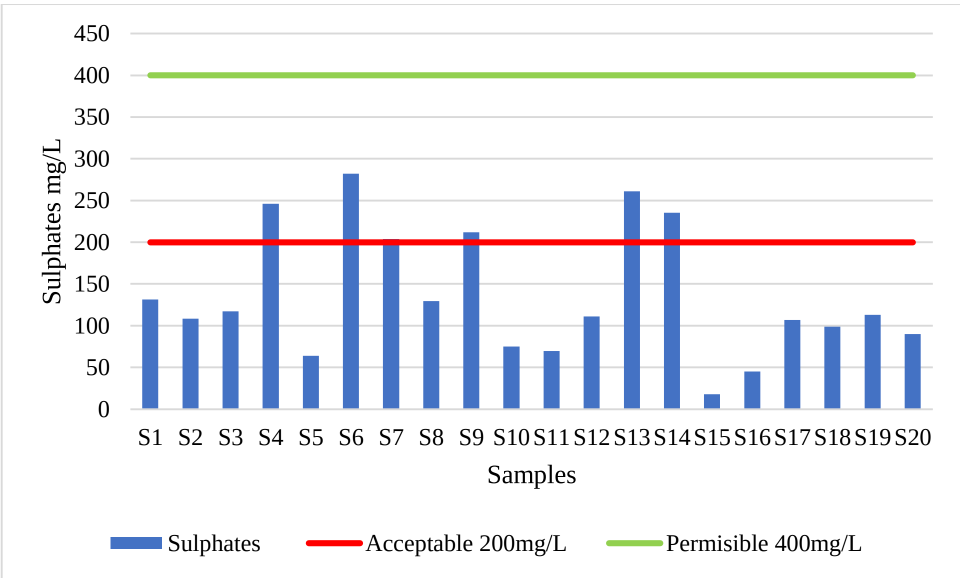


Nitrate concentrations in groundwater samples ranged from 8.3 mg/L (S13) to 39.7 mg/L (S9). All values were within the permissible limit of 45 mg/L as per BIS standards. The highest nitrate levels were observed in S3 (38.9 mg/L), S9 (39.7 mg/L), and S12 (32.7 mg/L). Elevated nitrate concentrations are often associated with leaching from agricultural fields due to excessive fertilizer use. Septic tank leakage and wastewater infiltration are also common contributors in urban and peri-urban areas (Raghavendra et al., 2018).

High nitrate levels in drinking water can lead to health issues such as methemoglobinemia ("blue baby syndrome") in infants. Though values are within limits, samples close to the threshold require attention to prevent future exceedances. Continuous monitoring and promotion of organic farming practices could reduce nitrate leaching. Proper sewage disposal systems can also help maintain safe nitrate concentrations (WHO 2022).

Sulphates: Sulphates are an amalgamation of sulfur and oxygen and are a part of naturally occurring minerals in some soil and rock formations that contain groundwater. The mineral dissolves over time and is released into groundwater.

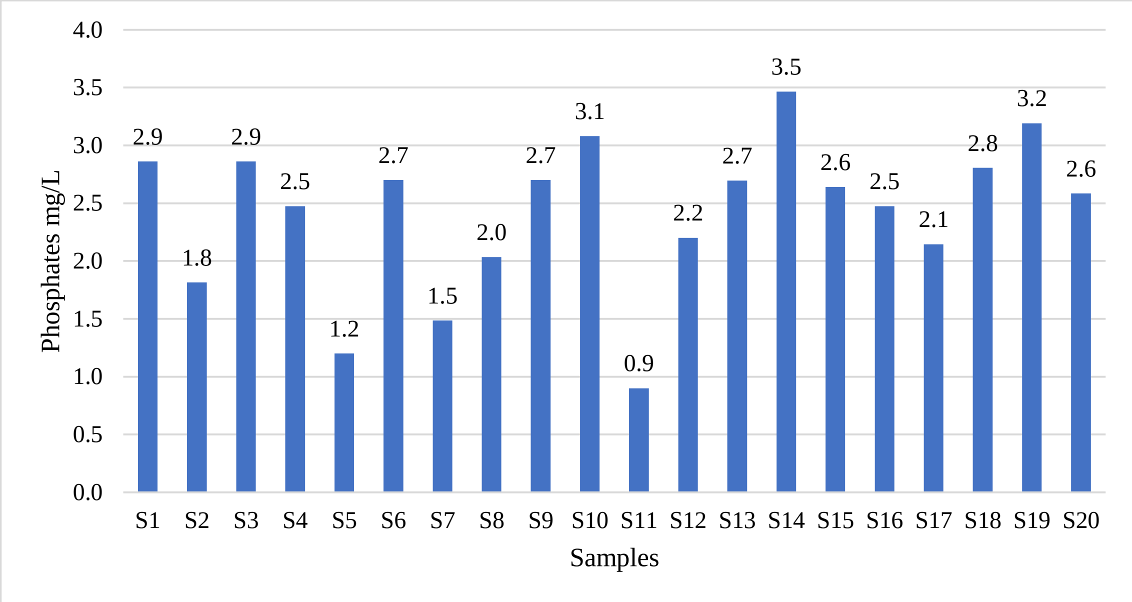
Figure 11: Sulphate concentration in the ground water samples



Sulphate values are recorded from 17.75mg/L to 288mg/L. The highest concentrations are found in Sample 6 (282 mg/L) and lowest in sample no 15 is 17.7mg/L. The sulphate analysis of 15 groundwater samples shows relatively low concentrations, well within the acceptable limit of 200 mg/L and 5 samples below the permissible limit of 400 mg/L, as per IS 10500:2012 standards.

Phosphates: During the natural process of weathering, the rocks gradually release the phosphorus as phosphate ions which are soluble in water and the mineralize phosphate compounds breakdown. Phosphates exist in three forms i.e. orthophosphate, metaphosphate (or polyphosphate) and organically bound phosphate. Concentrations of dissolved phosphorus (DP) in groundwater typically are low because phosphorus tends to absorb to soil and aquifer sediments and is not readily transported in groundwater (Holman et al. 2008).

Figure 12: Phosphate Concentrations in the ground water samples

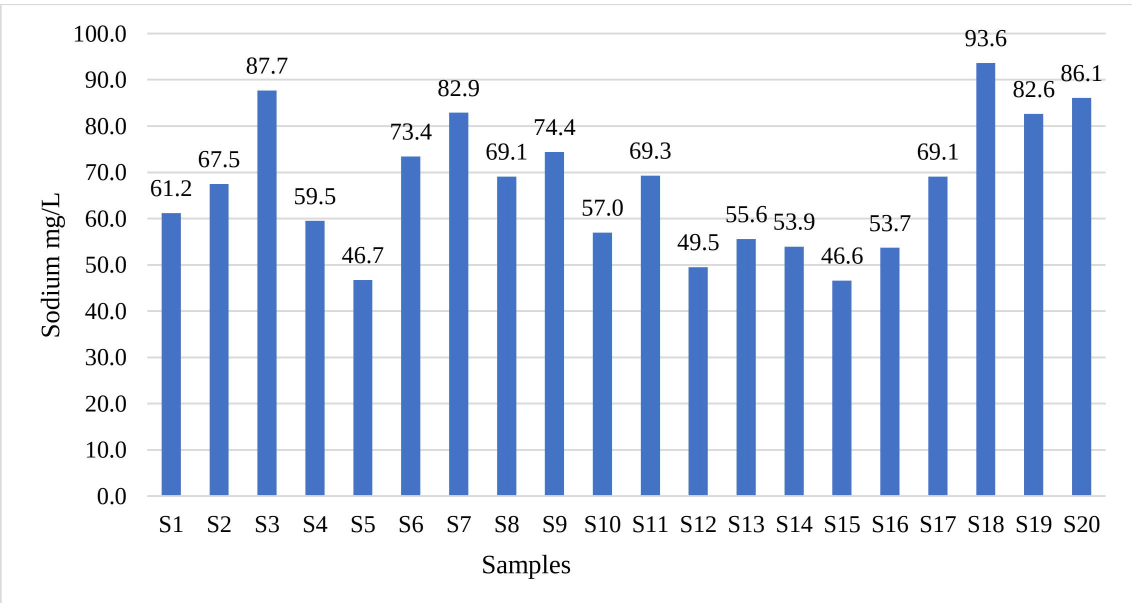


The analysis of phosphates in groundwater samples indicates generally low concentrations across all the 20 samples, which aligns with the natural behavior of phosphorus in the environment. Dissolved phosphorus (DP) typically shows low mobility in groundwater because it tends to bind with soil particles and aquifer sediments, reducing its transport.

Although phosphate levels in groundwater are usually not a major concern for human health, elevated concentrations can contribute to eutrophication if the water enters surface bodies. The results confirm that phosphorus contamination in this case is minimal and within environmentally safe limits.

Sodium (Na^+): Sodium is the sixth most abundant element on Earth and is widely distributed in soils, plants, water and foods. Sodium is a highly soluble chemical element and often naturally found in groundwater.

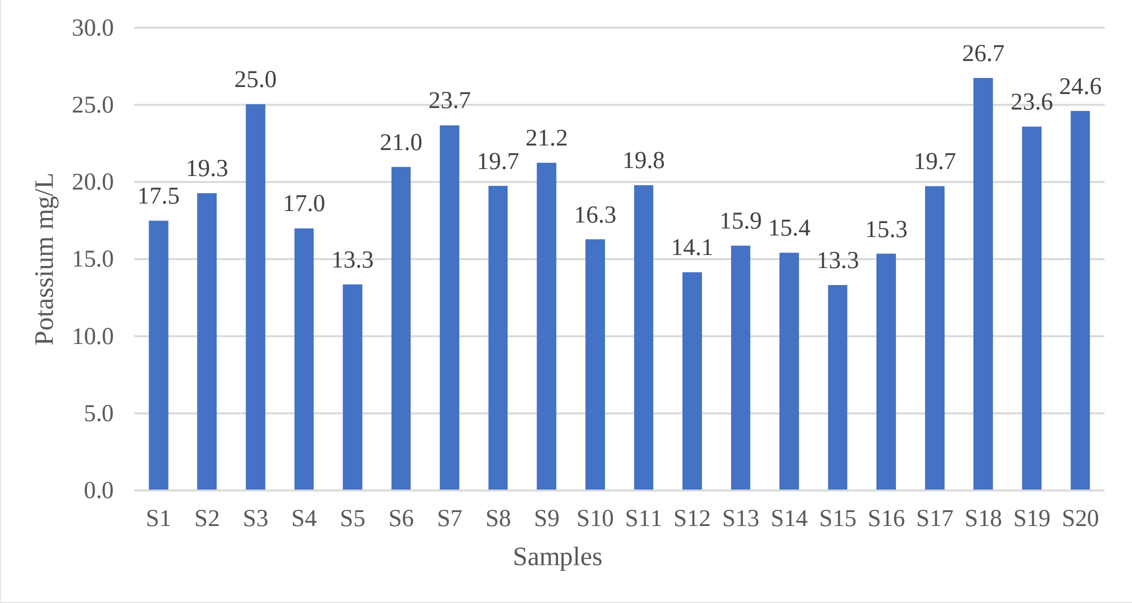
Figure 13: Sodium Concentration in the Ground water samples



Sodium concentrations in the samples ranged from 46.6 mg/L (S15) to 93.6 mg/L (S18). Higher sodium values were recorded in S4 (87.7 mg/L), S7 (82.9 mg/L), S19 (86.1 mg/L), and S20 (82.6 mg/L). While BIS standards do not specify a strict limit for sodium, the WHO recommends a maximum of 200 mg/L for drinking water. Sodium in groundwater originates from natural processes such as weathering of sodium-bearing minerals and from anthropogenic sources like domestic wastewater. Elevated sodium can have health implications, especially for individuals with hypertension or those on sodium-restricted diets.

Potassium (K^+): Potassium is common in many rocks. Many of these rocks are relatively soluble and potassium concentrations in ground water increase with time and it is an important fertilizer, is strongly held by clay particles in soil. Therefore, leaching of potassium through the soil profile and into ground water is important only on coarse-textured soils.

Figure 14: Potassium Concentration in the Ground water samples



Potassium concentrations varied between 13.3 mg/L (S6, S14, S15) and 26.7 mg/L (S18). Higher potassium levels were noted in S4 (25.0 mg/L), S7 (23.7 mg/L), and S20 (24.6 mg/L). Potassium generally occurs in lower concentrations in groundwater compared to sodium, as it is strongly retained in soils and less mobile. Its presence in higher amounts may be linked to fertilizer application in agricultural lands. Natural sources include weathering of potassium-rich minerals such as feldspar and mica. Although potassium is essential for human health, excessive intake can be harmful for individuals with kidney disorders. Agricultural runoff is likely a significant source in wards with elevated potassium. Regular monitoring and judicious fertilizer application are essential to prevent further increases. Public awareness on balanced fertilizer use can help maintain safe levels.

Conclusion:

Overall, the findings reveal that while pH, fluoride, phosphate, sodium, potassium, and nitrate remain largely within permissible limits, parameters such as EC, TDS, total hardness, calcium, chloride, and sulphate exceed recommended limits in several locations. These results suggest that certain wards in Kanakapura face significant water quality challenges, likely due to combined effects of geology, agricultural practices, and urban activities.

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