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Assessment of Drinking Water Quality through Physicochemical Analysis of Bore Well Samples in Mokokchung, Nagaland

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ABSTRACT

This study investigates the water quality of bore wells in Mokokchung Municipality, Nagaland, India. Eleven wards were selected for sampling, and various physicochemical parameters were analyzed, including pH, turbidity, total dissolved solids (TDS), total hardness, calcium, magnesium, total alkalinity, chloride, iron, nitrate, fluoride, and dissolved oxygen (DO). The results were compared with guidelines from the World Health Organization (WHO) and the Bureau of Indian Standards (BIS). The findings indicate that all measured parameters fall within acceptable limits, suggesting that the bore well water in Mokokchung, Nagaland is suitable for domestic and drinking purposes. This study highlights the importance of regular water quality monitoring to ensure the safety and health of local populations.

INTRODUCTION

Water is vital for all living organisms' survival and development (Greenhalgh, 2007). Access to clean and drinkable water is essential for human beings, especially in urban areas. Groundwater is commonly considered the most dependable and trustworthy drinking water source in urban and rural areas. Water is the predominant and abundant constituent of an ecosystem. Earth is a celestial body, with approximately 70% of its surface consisting of water. Approximately 80% of the Earth's surface is covered with water, yet only a small fraction is appropriate for human use. The ocean comprises seawater, polar ice caps, glaciers, and subterranean reserves (Dara, 1995). Groundwater refers to water that is located beneath the Earth's surface, specifically in crevices and voids within the soil, sand, and rocks. This source serves two separate purposes. Firstly, it is a crucial source of water supply for both urban and rural populations. Secondly, it supports numerous wetland ecosystems (Adeyemo *et al.*, 2002). The primary determinant of groundwater supply is predominantly the precipitation and subsequent water infiltration into the ground. The composition and characteristics of the soil are another significant factor (Adoni & Joshi, 1987). Potable water should be devoid of pathogenic agents and chemical elements, pleasing to taste, usable for domestic uses, and safe for humans (Gupta *et al.*, 2004; Ramakrishnaiah *et al.*, 2009). However, the growing human population, widespread use of fertilizers in agriculture, and various anthropogenic activities have heavily polluted the environment with various dangerous contaminants. Regular monitoring of drinking water quality is essential to prevent the spread of diseases caused by consuming contaminated water (Sharma & Bhattacharya, 2016).

Wells and bore wells utilize groundwater. Bore-well water is generally used for drinking and other domestic purposes in this area. Groundwater is a reliable source of water supply because it remains unpolluted, and pollutants cannot penetrate through the soil profile (Lamb & Woodard 1987). When water percolates through the ground, it dissolves various soil components, resulting in complex chemical compositions. This groundwater often contains elevated levels of salts and metals, such as iron and manganese. Annually, approximately 3.4 million people die from causes directly related to inadequate water sanitation and hygiene. The World Health Organization (WHO, 2023) reports that most of these deaths occur in developing countries due to the consumption of contaminated water. The United Nations (United Nations, 2006) further highlights that water and sanitation issues cause more disease-related deaths than armed conflicts. Consequently, ensuring the provision of high-quality and abundant clean water is essential for human health and well-being.

To evaluate the water quality of a specific location or source, it is necessary to examine its physical, chemical, and biological parameters. When these parameters exceed the established safety limits set by organizations such as WHO and the Bureau of Indian Standards (BIS, 2003), the water is deemed hazardous and unsuitable for human consumption, agricultural use, and other applications. Numerous researchers have investigated groundwater quality across various states in India, including Uphade et al. (2008), Suresh and Kottureshwara (2009), Tripathi & Tripathi (2016), Shivaprasad et al. (2014), Kamboj & Kamboj (2019), Rawat and Siddiqui (2019), Rao et al. (2020), Patil et al. (2022), Nuri and Adammu (2023), and Veerappadevaru et al. (2024). However, this study represents the first comprehensive assessment of the water quality of bore wells specifically in Nagaland.

1. Materials and method

2.1 Study Area

Mokokchung is a municipality in the Mokokchung district of the Indian state of Nagaland. Mokokchung town functions as the district's administrative center and is the region's most populous urban area. According to the Census of India (2011), Mokokchung has a population of 1,94,622, with 1,01,092 males and 93,530 females. The majority ethnic group in the district is the Ao Naga tribe, which makes up the majority of the population. The town has 18 wards, with Sangtemla, Alempang, Yimyu, and Kumlong being the most populous. Mokokchung is located in the northeastern section of Nagaland state, with latitude ranging from 26.12°N to 26.45°N and longitude ranging from 94.18°E to 94.50°E. The location is 1325 metres above sea level and experiences an average yearly precipitation of approximately 200 centimetres.

2.2 Methodology

For this study, we randomly selected 11 wards out of 18 wards. The following wards are included: Aongza, Arkong Artang, Dilong, Kumlong, Lijabalijen, Majakong, Marepkong, Mongsengbai, Penli and Salangtem (Fig.1). The samples were collected in clean 1-litre polythene bottles without any air bubbles (Fig. 2). The bottles were rinsed before sampling and tightly sealed after collection and labelled in the field. There are several physiochemical parameters of drinking water quality. For this study, the parameters that were analyzed include colour, odour, taste, pH, turbidity, total dissolved solids (TDS), total hardness, calcium, magnesium, total alkalinity, chloride, iron, nitrate, fluoride, and dissolved oxygen (DO), were analyzed using standard testing procedures as shown in Table 1. Results were compared with WHO and BIS drinking water standards, as depicted in Table 2.

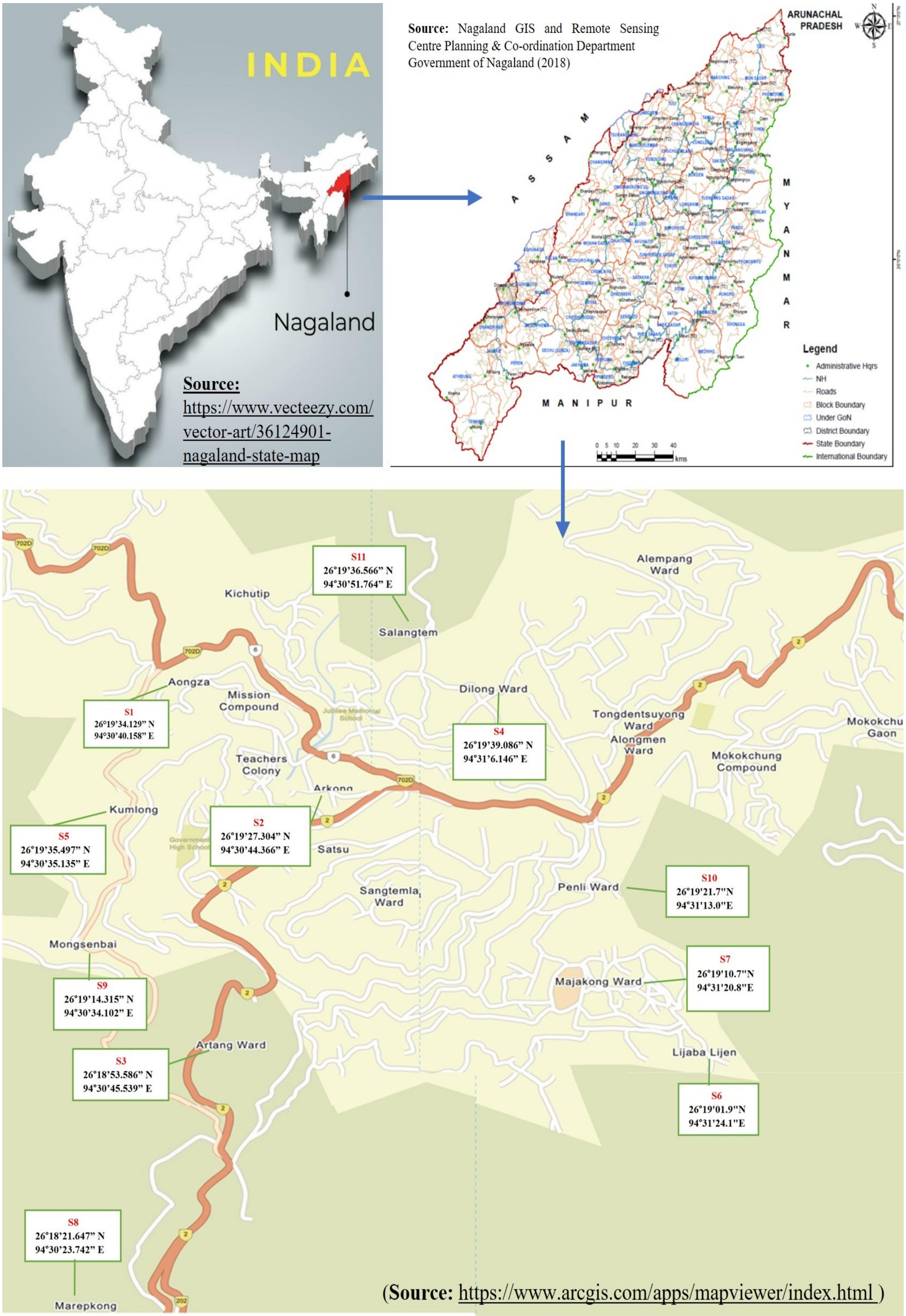


Fig. 1 The location map of the study area.

Fig. 2 Water samples in one-liter polyethylene bottles for analysis.

Table 1. Parameters and testing methods for collected water samples

Sr. No.	Parameters	Test method
1	Colour	APHA 23rd Edition-2120-Platinium cobalt visual comparison
2	Odour	IS 3025(part 5)
3	Tastes	IS 3025 (part 8)
4	pH at 25°c	APHA 23rd edition- 4500- Method B
5	Turbidity	APHA 23rd Edition-2130-Method B
6	Total dissolved solids (mg/lit)	APHA 23rd Edition- 2540- Dried at180°celsius
7	Total hardness (mg/lit)	APHA 23rd Edition- 2340 – EDTA method
8	Calcium (mg/lit)	APHA 23rd Edition- 3500- EDDTA method
9	Magnesium (mg/lit)	APHA 23rd Edition-3500 – by calculation
10	Total Alkalinity (mg/lit)	IS 3025 (PART 23)
11	Chloride (mg/lit)	APHA 23rd Edition – 4500 – Argentometric method
12	Iron (mg/lit)	Photometer
13	Nitrate (mg/lit)	Photometer
14	Fluoride (mg/lit)	Photometer
15	Dissolved oxygen (DO) (mg/lit)	DO meter

Table 2. Drinking Water Quality Standards (Comparison of WHO and BIS Standards)

Sr. No.	Parameters	WHO Standard	BIS Standard
1	pH	6.5 – 9.2	6.5 – 8.5
2	Turbidity	5 NTU	5 NTU
3	Total dissolved solids	500 mg /lit	500 mg /lit
4	Total alkalinity	300 mg /lit	200 mg/ lit
5	Dissolved oxygen	----	5 mg/ lit
6	Total hardness	150 - 500 mg /lit	200 mg/ lit
7	Calcium	100-200 mg /lit	75 mg/ lit

8	Magnesium	50-150 mg /lit	30 mg/ lit
9	Chloride	200-300 mg /lit	250 mg/ lit
10	Iron	0.3 mg/ lit	0.3 mg/ lit
11	Nitrate	10 mg/ lit	45 mg/ lit
12	Fluoride	1.0 mg/ lit	1.0 mg/ lit

2. RESULTS AND DISCUSSION

The result of the physiochemical assessment of the bore wells water samples of the selected wards from Mokokchung Municipal Town has been summarized in Table 3. The bore well water was determined to be translucent, tasteless and agreeable in odour.

2.1 pH

The pH level of water significantly impacts its corrosiveness. The pH of pure water usually ranges from 6.5 to 8.5. A decrease in pH levels results in water becoming acidic, consequently enhancing its corrosive properties. The pH level is positively correlated with both electrical conductivity and total alkalinity (Gupta *et al.*, 2009). The pH of sampling stations (S1 – S12) varied from 5.73 to 6.78 with a mean of 6.5. The pH values of the present study were found to be within the WHO and BIS standards whereas S8 is below permissible limit as shown in Fig. 3.

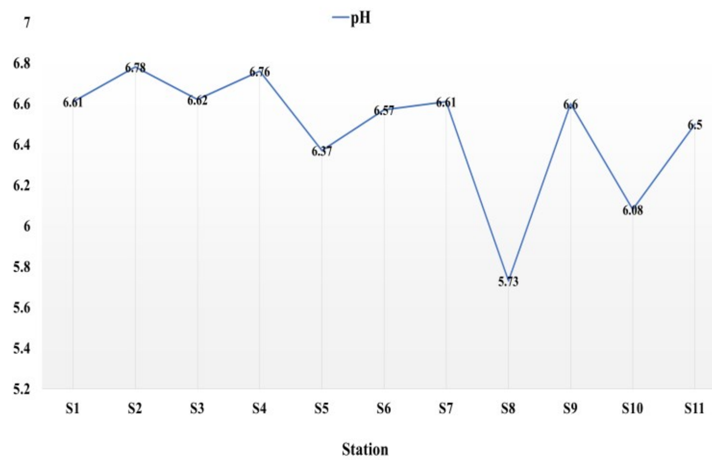


Fig. 3 pH vs samples collected.

2.2 Dissolved Oxygen (DO)

Dissolved oxygen (DO) is an intrinsic parameter in water quality assessment and biological processes prevailing in the water. The DO values indicate the degree of pollution in the water bodies. The presence of DO enhances the quality of water. The water sample's dissolved water ranged from 5 mg/lit to 8 mg/lit. The dissolved oxygen values of samples collected at S2, S3, S5, S6, S7, S8, S9, S10 and S11 are above the BIS standard limits as shown in Fig. 4.

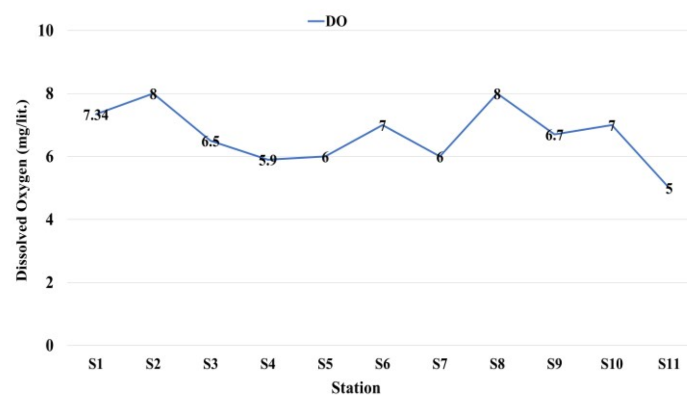


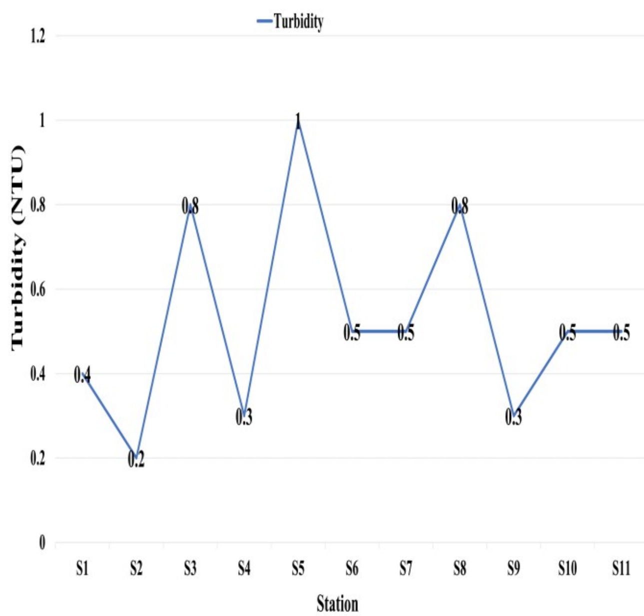
Fig. 4. Dissolved oxygen levels in collected samples

2.3 TURBIDITY (NTU)

The turbidity levels of the bore well water samples ranged from 0.2 to 37 NTU. Colloidal and highly dispersed particles cause the presence of turbidity in water samples. The turbidity levels of the 11 water samples were determined to be within the acceptable range, as illustrated in Fig. 5.

2.4 TOTAL DISSOLVED SOLIDS (TDS)

Total dissolved solids (TDS) values of the studied bore wells water sample ranged from 81.7 to 247 mg/lit, as shown in Fig. 6. As per the World Health Organisation (WHO), the safe level for Total Dissolved Solids (TDS) in drinking water is 500mg/lit. All the samples tested were found to be within this acceptable limit. A high total dissolved solids (TDS) concentration negatively impacts the quality of water for drinking, irrigation, and agricultural purposes, as stated by the World Health Organisation in 2002. Increased Total Dissolved Solids (TDS) levels in drinking water can cause various non-waterborne ailments due to excessive salt content. The concentration of dissolved solids tends to rise when water pollution levels increase (Sabata *et al.*, 1995; Parihar *et al.*, 2012).



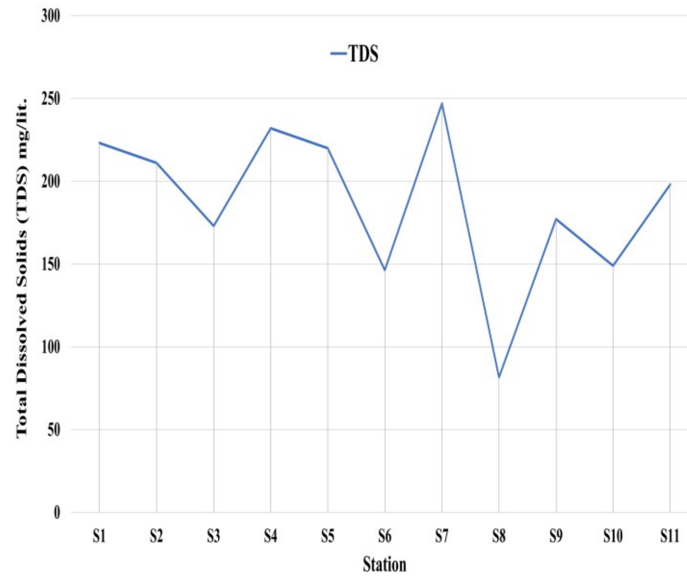


Fig. 6. Total Dissolved Solids levels in collected samples

3.5 TOTAL ALKALINITY

The alkalinity value of water indicates the presence of naturally occurring salts in the water. Alkalinity is mainly caused by dissolving minerals from the soil into water. The salts of weak acids typically distribute it. The water samples exhibited alkalinity levels ranging from 20 mg/lit to 52 mg/lit at all sampling sites, as depicted in Fig. 7.

2.5 TOTAL HARDNESS

The total hardness of the bore well water sample was found between the range of 52 mg/lit to 188 mg/lit, as shown in Fig. 8. Hardness is a characteristic of water that inhibits the creation of lather when soap is used and increases the boiling point of water. The concentration of calcium, magnesium, or both minerals mainly determines water's hardness. The total hardness of eleven bore well water samples had been found to be within the acceptable range. The calcium hardness of eleven sampling stations was found to be between 16 mg/lit and 72 mg/lit, as illustrated in Fig. 9. Magnesium hardness ranges between 4.86 mg/lit to 28.2 mg/lit, as shown in Fig. 10. An abundance of calcium and magnesium in water results in water hardness, which is unsuitable for drinking.

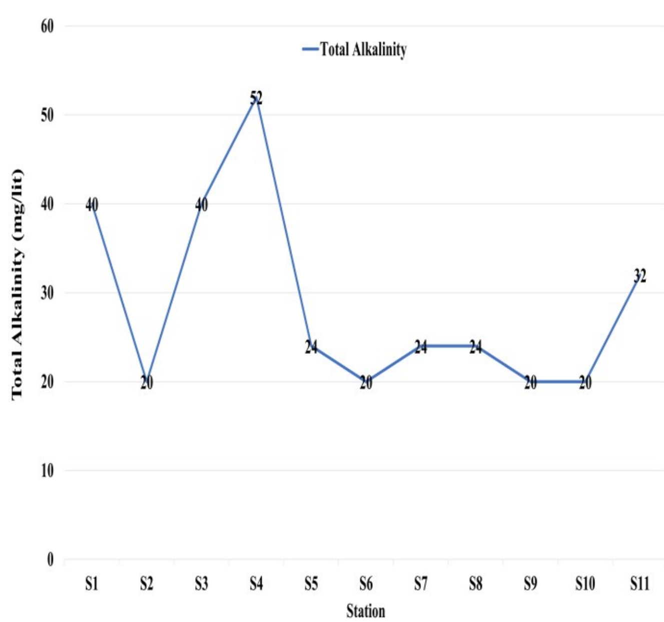


Fig. 7. Total alkalinity levels in collected samples

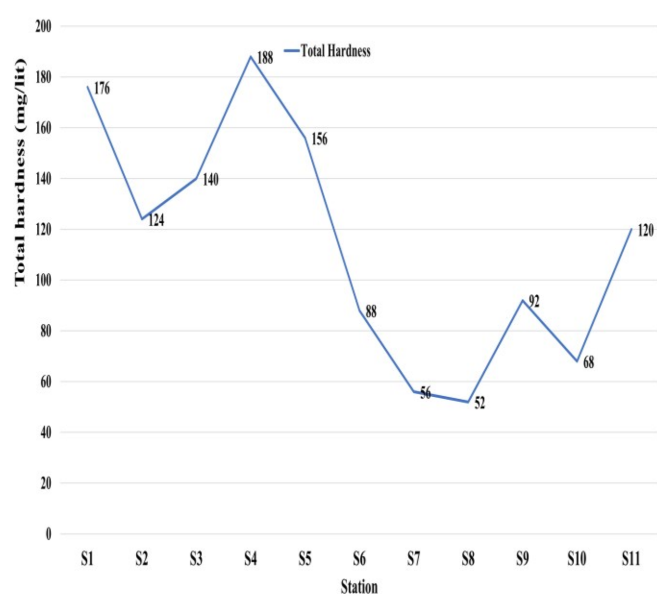


Fig. 8. Total hardness levels in collected samples

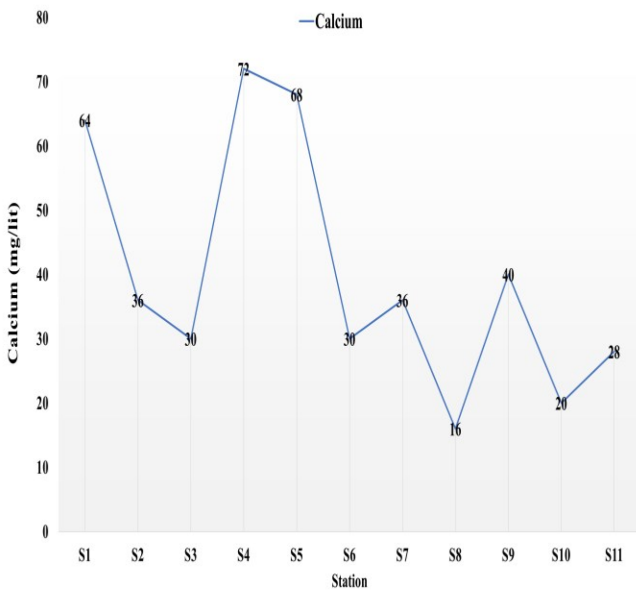


Fig. 9. Calcium levels in collected samples

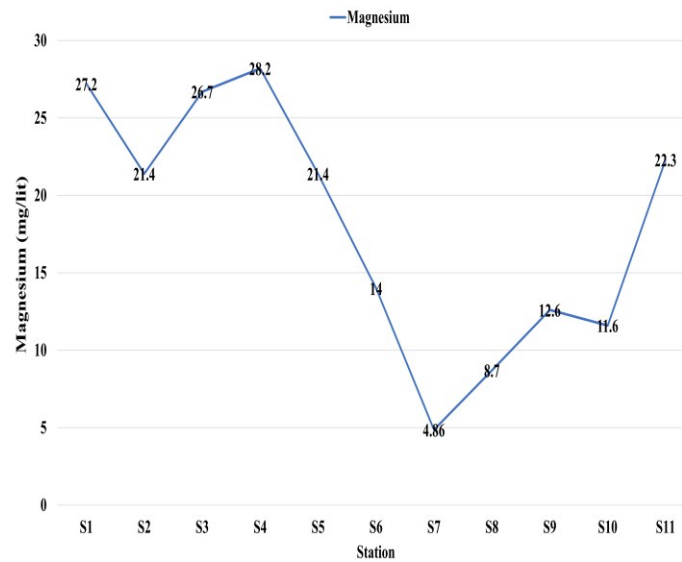


Fig.10. Magnesium levels in collected samples

3.6 CHLORIDE

The chloride concentrations of eleven well water samples ranged from 7.9 mg/lit to 32 mg/lit, as shown in Fig.11. Chlorides play a crucial role in identifying the presence of wastewater contamination in groundwater. The maximum allowable concentration of chloride in drinking water is 250 mg/L. The chlorine levels measured in eleven well water samples were well below the acceptable threshold. The presence of chloride ions gave the water a saline flavour. Individuals unaccustomed to high chloride levels may experience a laxative effect (Agarwala *et al.*, 2012).

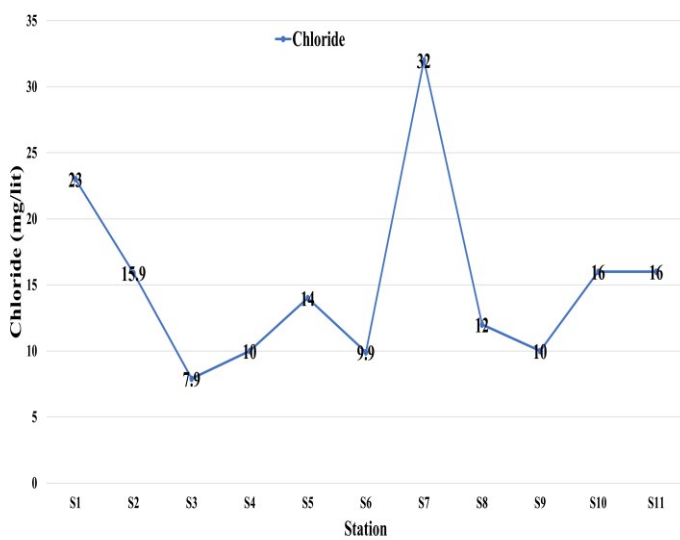


Fig. 11. Chloride in collected samples

3.7 NITRATE

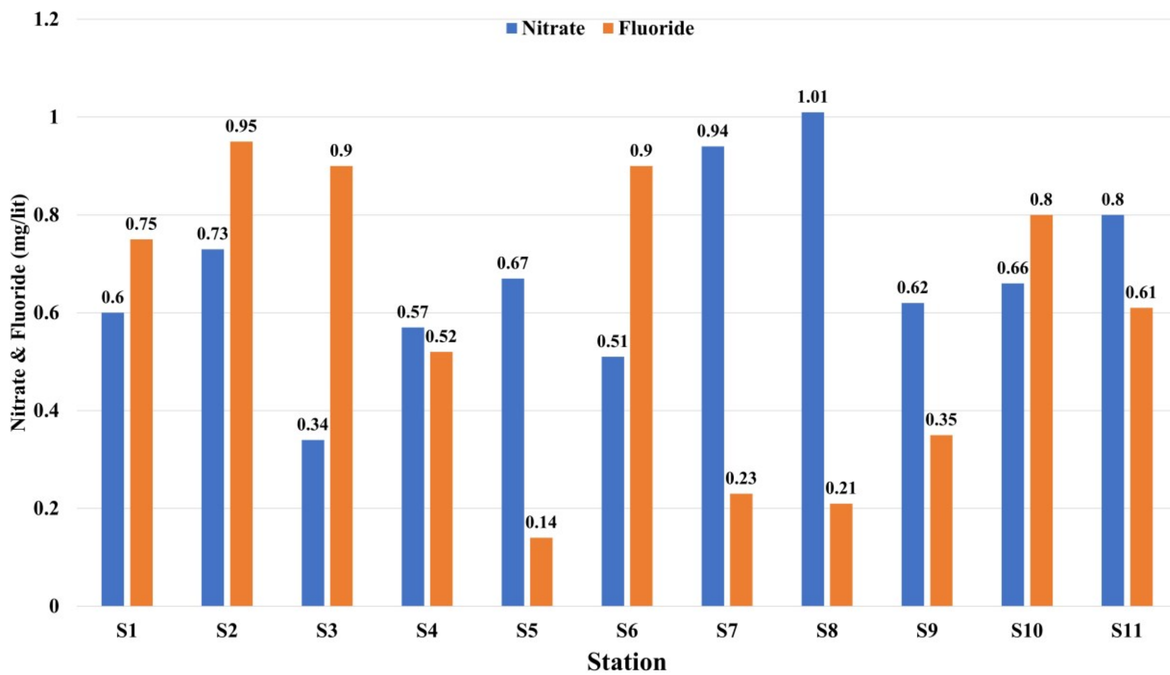
Nitrate is one of the important nutrients in an ecosystem. Generally, water bodies polluted by organic matter exhibit higher values of nitrate. In the present study, water samples from the stations (S1 to S11) showed low nitrate concentrations, 0.34 mg/lit to 1.01 mg/lit, which is well below permissible levels per the standards shown in Fig. 12.

3.8 FLUORIDE

Fluoride is a prevalent element in groundwater. The optimal level of fluoride in groundwater can have positive effects, while elevated concentrations might result in various health problems and other emergencies. The erosion of fluoride-containing minerals like apatite, fluorite, biotite, and hornblende is the origin of fluoride in nature. The sources of fluoride in groundwater caused by human activity are agricultural fertilizers and coal burning (Brindha & Elango, 2011). The bore healthy samples exhibit a fluoride concentration ranging from 0.14 mg/lit to 0.95 mg/l, with an average concentration of 0.56 mg/lit, as depicted in Fig. 12. Therefore, the overall fluoride content in the research area is considered low. All samples are under the acceptable thresholds set by the Bureau of Indian Standards (BIS) and the World Health Organisation (WHO) at 1 mg/l.

3.9 IRON

Iron is the second most plentiful metallic element in Earth's crust. The presence of iron in water can vary based on the geological characteristics of the region and other chemical constituents of the river. The chemical reactivity of iron and its ability to dissolve in water is greatly influenced by the level of oxidation present in the system, with pH also playing a significant role. Industrial wastes, mine drainage water, and iron-bearing groundwater are the primary sources of iron in water resources and are frequently found in rocks. The analysis of bore well samples revealed a negligible iron level ranging from 0.01 mg/lit and 0.07 mg/l, as illustrated in Fig. 13. The iron content of the bore wells falls below the acceptable limits set by the World Health Organisation (WHO) and the Bureau of Indian Standards (BIS), which is 0.3 mg/l.



CONCLUSION

The examination of water quality parameters in groundwater from eleven stations in Mokokchung Municipality reveals that the colour, odour, taste, pH, turbidity, total dissolved solids (TDS), total hardness, calcium, magnesium, total alkalinity, chloride, iron, nitrate, fluoride, and dissolved oxygen (DO) values are all within the acceptable thresholds set by the World Health Organisation (WHO) and the Bureau of Indian Standards (BIS,2003). The current study concludes that Mokokchung Municipality's groundwater is suitable for both household and drinking purposes.

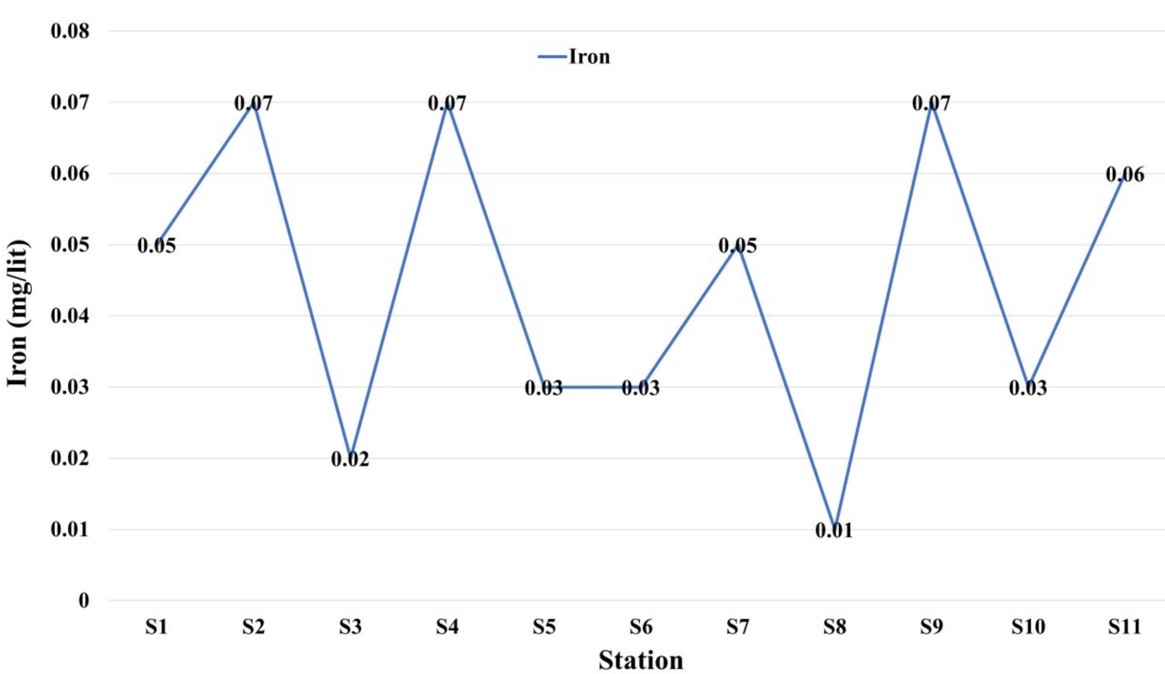


Fig. 13. Iron in collected samples

Table 3. Physicochemical Properties of Bore Well Water in Mokokchung Municipal Town

Wards (Samples)	Colour Hazen Unit (HU)	Odour	Tastes	pH at 25 °C	Turbidity NTU	Total Dissolved	Total Hardness	Calcium	Magnesium	Total Alkalinity	Chloride	Iron	Nitrate	Fluoride	Dissolved Oxygen
Aongza (S1)	10	Agreeable	Tasteless	6.61	0.4	223	176	64	27.2	40	23	0.05	0.6	0.75	7.34
Arkong (S2)	10	Agreeable	Tasteless	6.78	0.2	211	124	36	21.4	20	15.9	0.07	0.73	0.95	8.0
Artang (S3)	10	Agreeable	Tasteless	6.62	0.8	173	140	30	26.7	40	7.9	0.02	0.34	0.90	6.5
Dilong(S4)	10	Agreeable	Tasteless	6.76	0.3	232	188	72	28.2	52	10	0.07	0.57	0.52	5.90
Kumlong(S5)	10	Agreeable	Tasteless	6.37	1.0	220	156	68	21.4	24	14	0.03	0.67	0.14	6.0
Lijabalijen(S6)	10	Agreeable	Tasteless	6.57	0.5	146.3	88	30	14	20	9.9	0.03	0.51	0.90	7.0
Majakong(S7)	10	Agreeable	Tasteless	6.61	0.5	247	56	36	4.86	24	32	0.05	0.94	0.23	6.0
Marepkong(S8)	10	Agreeable	Tasteless	5.73	0.8	81.7	52	16	8.7	24	12	0.01	1.01	0.21	8.0
Mongsenbai(S9)	10	Agreeable	Tasteless	6.60	0.3	177.1	92	40	12.6	20	10	0.07	0.62	0.35	6.7
Penli (S10)	10	Agreeable	Tasteless	6.08	0.5	149	68	20	11.6	20	16	0.03	0.66	0.80	7.0
Salangtem (S11)	10	Agreeable	Tasteless	6.5	0.5	198	120	28	22.3	32	16	0.06	0.8	0.61	5.0

Note: All the parameters expressed in mg/lit. Except pH, colour, taste and turbidity (NTU)

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