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Chemical Quality of Drinking Water from Community Wells

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Abstract

Water is a primary necessity for human life, and its quality directly affects public health and community welfare. In Wayame Village, Ambon City, shallow wells are still used by the community as a source of water for daily needs, including drinking water. This study aimed to evaluate the chemical quality of shallow well water by comparing laboratory test results with the drinking water quality standards established by the Ministry of Health of the Republic of Indonesia. This study employed a descriptive quantitative method. A total of eight shallow well water samples were collected from community wells in Wayame Village using purposive sampling. The chemical parameters analyzed included pH, fluoride, total chromium, cadmium, nitrite, nitrate, iron, hardness, chloride, manganese, lead, and free chlorine. Laboratory analysis was conducted at the Provincial Health Laboratory of Maluku, and the results were compared with the Regulation of the Minister of Health of the Republic of Indonesia Number 492/Menkes/Per/IV/2010. The results showed that most chemical parameters were below the permissible limits for drinking water. Fluoride, total chromium, cadmium, nitrite, nitrate, iron, hardness, chloride, manganese, and lead were within the required standards. However, several samples showed pH values below the minimum standard, indicating slightly acidic water conditions. In addition, free chlorine levels in all samples were below the recommended range, indicating limited residual disinfection capacity.

Introduction

Water is a primary necessity in life. The availability of water in a region, both in terms of quality and quantity, significantly impacts life. Ferede et al. (2022) and Irene et al. (2025), Uncontrolled and unbalanced use of water resources, which skews the balance between availability and demand, will impact availability. Water and soil are natural resources that play a vital role in the lives of living things. Water resources, particularly groundwater, are the primary alternative for daily needs compared to surface water because their quality is relatively better and they are free from pollution (Priyan, 2021; Sabale et al., 2023; Verlicchi & Grillini, 2020).

Water is a natural resource that plays a vital role in supporting human life, both for consumption and other domestic activities. The availability of safe and suitable drinking water is an important indicator in determining the level of public welfare and health. However, not all water sources used by the community meet established quality standards, potentially causing various health problems (Gleick, 2002; Charrois, 2010).

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According to the World Health Organization (WHO), safe drinking water is water that is free from contamination by pathogenic microorganisms, hazardous chemicals, and physical parameters that can harm human health. In its 2017 drinking water quality guidelines, the WHO emphasized that the presence of indicator bacteria such as Escherichia coli is not permitted in a 100 ml drinking water sample (Charrois, 2010).

The presence of Escherichia coli bacteria as an indicator of fecal contamination has very serious implications for public health (Ishii & Sadowsky, 2008; Soller et al., 2014; Szmolka & Nagy, 2013). This-bacteria generally originates from human and warm-blooded animal feces, so its presence in water indicates contamination that can carry various pathogens that cause diseases such as diarrhea, dysentery, and other gastrointestinal infections (Ashbolt et al., 2001). In addition to E. coli, the total coliform bacteria group is also used as a general indicator of water sanitation quality because it reflects the possibility of environmental contamination (Paruch & Mæhlum, 2012; Jin et al., 2004; Edberg et al., 2000; Gruber et al., 2014; Lin & Ganesh, 2013).

In Indonesia, particularly in coastal areas and settlements such as Wayame Village, Teluk Ambon District, Ambon City, groundwater utilization through dug and drilled wells remains the primary source of drinking water for the community. This well use is influenced by limited access to a centralized clean water supply system (Peter-Varbanets et al., 2009; Cole et al., 2018; Adamov et al., 2025; Arora et al., 2015). However, this condition also creates vulnerability to pollution, especially if the well construction does not meet technical standards and environmental sanitation is not properly addressed (King & King, 2013; Zanotti et al., 2022; Falae et al., 2024). Physical environmental factors such as soil type, groundwater depth, rainfall, and topography also influence well water quality.

Furthermore, anthropogenic factors such as the proximity of wells to septic tanks, domestic waste disposal sites, and community activities around water sources are also major causes of microbiological contamination (Freeze & Cherry, 1979; Todd & Mays, 2004). This condition is often exacerbated by a lack of public awareness of the importance of protecting drinking water sources (Howard et al., 2003).

The problem of well water quality is becoming increasingly complex because microbiological contamination cannot be detected directly through visual observation (Jung et al., 2014; Lemarchand et al., 2004). Water that appears clear is not necessarily safe for consumption, so laboratory analysis is needed to ensure its quality. One factor that also influences groundwater quality is the characteristics of the land, such as slope and texture. The slope of the land surface affects the vertical and lateral movement of groundwater following the equilibrium shape due to the slope of the phreatic slope surface or hydraulic gradient. (Reid & Iverson, 1992; Rodhe & Seibert, 2011; Larkin & Sharp, 1992) Thus, the steeper the slope, the faster the groundwater will flow, the more easily dissolved materials are transported to the slope below, thus accelerating groundwater contamination. Similarly, the condition of soil texture. Sandy soils have a small surface area, making it difficult to retain water (Peng & Brusseau, 2005).

Pollution is more likely to occur in sandy soil. The high volume of activity results in varying amounts of waste, including solid and liquid chemicals, organic compounds that can decompose or be degraded by microorganisms, such as food, and inorganic compounds such as soap, detergent, shampoo, and other cleaning products, which generally originate from fatty acids (stearic, palmitic, or oleic) reacted with bases such as Na(OH) or K(OH). Furthermore, oily liquid waste containing benzene is released into the environment, potentially contributing

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to groundwater contamination. Therefore, both settlement level and land characteristics influence the chemical quality of groundwater in the study area.

Therefore, the use of indicator parameters such as E. coli and total coliform is crucial in evaluating the suitability of drinking water used by the community (Singh et al., 2019; Standridge, 2008; Payment et al., 2003; Edokpayi et al., 2018). Based on the description, research on the quality of drinking water in community wells in Wayame Village, Teluk Ambon District, Ambon City is very relevant to be conducted. This research is expected to provide a scientific picture of water quality conditions, especially from a microbiological aspect, and become a basis for efforts to manage and protect drinking water sources to improve public health. This study aims to determine whether the drinking water used by the community, especially that from shallow wells, has met the eligibility according to the Drinking Water Quality Standards issued by the government so as not to impact the health of the people who use it.

Methods

Research Design

This study employed a descriptive quantitative design to evaluate the chemical quality of shallow well water used by the community in Wayame Village, Teluk Ambon District, Ambon City. This design was selected because the study aimed to describe the measured chemical characteristics of well water and compare them with the applicable drinking water quality standards. The study did not involve experimental treatment or intervention. The analysis focused on laboratory based measurement of selected chemical parameters and interpretation of whether each parameter met the permissible limits for drinking water.

Research Location

The study was conducted in Wayame Village, Teluk Ambon District, Ambon City, Maluku Province, Indonesia. This location was selected because several community members still use shallow wells as a source of water for daily needs, including drinking water. The area has varied environmental characteristics, including residential areas, coastal influence, alluvial lowlands, hilly terrain, and different soil and geological conditions. These characteristics were considered relevant because they may influence the chemical quality of shallow groundwater.

Sampling Technique and Sampling Points

The sampling points were determined using purposive sampling. This technique was used because the selected wells had to meet specific criteria relevant to the purpose of the study. The criteria included wells used by the community as water sources, wells classified as shallow community wells, accessibility for sample collection, and representation of residential areas in Wayame Village. A total of eight shallow wells were selected as sampling points. The samples were coded as W 01, W 02, W 03, W 04, W 05, W 06, W 07, and W 08 to facilitate laboratory analysis, data tabulation, and comparison among sampling locations.

Water Sampling Procedure

Water samples were collected directly from each selected shallow well using clean sample bottles prepared for chemical analysis. Before sampling, the bottles were cleaned to minimize the risk of contamination. Water was collected from the well water column at approximately 20 to 30 cm below the water surface. After collection, each bottle was tightly closed, labeled

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

according to the sample code, and transported to the Provincial Health Laboratory of Maluku for analysis. Field notes were also taken during sampling to record general information on the sampling location and surrounding environmental conditions.

Chemical Parameters Analyzed

The chemical parameters analyzed in this study included fluoride, total chromium, cadmium, nitrite, nitrate, iron, hardness, chloride, manganese, pH, lead, and free chlorine. These parameters were selected because they represent important chemical indicators related to drinking water quality, including acidity, dissolved ions, nitrogen compounds, metal elements, and residual disinfectant capacity. Although arsenic and aluminum were included in the table of drinking water quality standards, the results for these parameters were not presented as numerical values. Therefore, their status should be reported clearly as not detected, not analyzed, or below the laboratory detection limit, depending on the actual laboratory report.

Laboratory Analysis

Laboratory analysis was conducted at the Provincial Health Laboratory of Maluku using standard procedures for drinking water quality testing. The analytical methods included appropriate chemical testing techniques based on the characteristics of each parameter. The laboratory results were recorded according to sample code and parameter type. The measured values were then used to determine whether the chemical quality of each well water sample complied with the applicable drinking water quality standards.

Drinking Water Quality Standard

The laboratory results were compared with the drinking water quality standards stipulated in the Regulation of the Minister of Health of the Republic of Indonesia Number 492/Menkes/Per/IV/2010. This regulation was used as the main reference to assess the suitability of each chemical parameter for drinking water. Each measured value was compared with the permissible limit or recommended range. Parameters that were below the maximum permissible limit or within the recommended range were categorized as meeting the standard. Parameters that were below the minimum required value or outside the recommended range were identified as requiring further attention.

Data Analysis

The data were analyzed descriptively and comparatively. Descriptive analysis was used to present the chemical characteristics of the eight shallow well water samples. Comparative analysis was used to compare the measured values with the drinking water quality standards. The interpretation focused on identifying parameters that met the standard and parameters that did not fully comply with the standard. Particular attention was given to pH and free chlorine because these parameters showed deviations from the required or recommended range in the laboratory results.

Data Presentation

The results were presented in table form to allow comparison among the eight sampling points and between the measured values and the drinking water quality standards. The table included sample codes, chemical parameters, units, measured values, permissible limits, and interpretation of compliance status. This format was used to make it easier to identify which parameters met the standard and which parameters required further attention.

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

Results and Discussion

Territorial Form, Geology, Land Use and Cover, Soil, and Climate

Wayame Village's landscape ranges from lowlands to hills. Within the hilly areas, there are plateaus, which are flat to somewhat flat. The geology of Wayame Village is characterized by alluvium in the lowlands, hills of loose material and sandstone, while the plateau is composed of coral. Alluvium in the lowlands results from erosion in the hilly areas, accumulation of sea sand, and flooding from the Waiame River. Land use in Wayame Village includes residential areas, agriculture, industry, security and economic development, and education. Land cover includes housing, open land, agriculture, secondary forest, and others. The soil types in Wayame Village include alluvial and regosol in the lowlands, regosol and cambisol in the hilly areas, and lithosol, rensina, and cambisol in the highlands. The climate conditions of Wayame Village, based on data from the Meteorology, Climatology, and Geophysics Agency (BMKG) at the Laha recording station, show the distribution of temperature, rainfall, rainy days, and relative humidity over a 10-year period (2011–2020), as shown in Table 2.

Table 2. Data on Air Temperature, Rainfall, Rainy Days, and Relative Humidity in the Study Area for the 10-Year Observation Period (2011–2020)

Month	Temperature (°C) Avg.	Max.	Min.	Rainfall (mm)	Rainy Days (days)	Relative Humidity (%)
January	27.3	31.7	24.1	199.5	19.7	82.0
February	27.2	31.9	23.9	131.6	18.2	81.7
March	27.3	31.8	24.1	139.1	17.2	82.1
April	27.0	31.2	24.1	194.1	20.8	85.0
May	26.6	30.2	24.2	557.0	25.0	87.9
June	25.7	28.9	23.7	694.7	25.4	88.3
July	25.4	28.2	23.5	769.7	26.9	88.8
August	25.3	28.3	23.1	413.5	24.6	87.1
September	25.9	29.3	23.2	264.0	16.2	86.1
October	26.8	30.6	23.7	129.0	13.0	83.9
November	28.0	31.0	24.1	68.0	11.5	81.7
December	27.6	31.7	25.1	152.4	19.1	81.2
Total	–	–	–	3733.9	237.9	–
Monthly Average	26.7	30.4	22.0	373.4	19.8	84.7

Source: Pattimumra Air Force Station, Laha, Ambon (in Ely. S. S. 2023)

This BMKG data shows that annual rainfall is 3,733.9 mm, with an annual average of 373.4 mm. The lowest average rainfall occurs in November (68.0 mm) and the highest in July (769.7 mm). The average annual temperature is 26.7°C. The highest temperature is 31.9°C in February and the lowest is 23.1°C in August. The average monthly temperature is 26.7°C, the average maximum temperature is 30.4°C, and the minimum is 22.0°C. The annual number of rainy days is 237.9 days, or 19.8 rainy days per month. The average monthly relative humidity is 84.7%.

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

Figure 1. Well Water Sampling Locations in Wayame Village

Source: Google Earth, March 19, 2024)

Description:

W-1: V. Sapulette Village

W-2: Junaidi Bin Taher Village

W-3: Mrs. Durenge Village

W-4: A. Relebulan Village

W-5: State Elementary School 45/76 Ambon

W-6: Mrs. N. Hunihua Village

W-7: Mrs. N. Sahurila Village

W-8: Mrs. O. Talaperu Village

Based on the results of laboratory analysis and comparison with the Drinking Water Quality Standard Criteria (Table 3), the following explanation can be obtained:

Table 3. Comparison of Element Content in Well Water with Drinking Water Quality Standards

No	**Parameter**	**Unit**	**W-01**	**W-02**	**W-03**	**W-04**	**W-05**	**W-06**	**W-07**	**W-08**	**Permissible Limit**
Chemical											
1	Arsenic	–	–	–	–	–	–	–	–	–	0.01
2	Fluoride	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
3	Total Chromium	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05
4	Cadmium	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.003

ISSN 2721-1304 (Print), ISSN 2721-1207 (online)

5	Nitrite (as NO_2)	mg/L	0.01	0.0	0.01	0.01	0.0	0.03	0.02	0.0	3
6	Nitrate (as NO_3)	mg/L	0.01	0.0	0.01	0.01	0.0	0.04	0.01	0.0	50
7	Aluminum	mg/L	–	–	–	–	–	–	–	–	0.2
8	Iron	mg/L	0.0805	0.0823	0.0888	0.0731	0.0721	0.0851	0.0897	0.0805	0.3
9	Hardness	mg/L	53.1	52.2	137.7	128.7	170.1	157.5	129.6	116.1	500
10	Chloride	mg/L	19.7	9.39	24.1	16.2	12.5	18.9	12.5	22.6	250
11	Manganese	mg/L	0.0215	0.1745	0.0277	0.0277	0.0236	0.0905	0.0241	0.0868	0.4
12	pH	–	6.40	6.12	6.18	6.38	6.62	6.75	6.73	6.75	6.5–8.5
13	Lead	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
14	Free Chlorine	mg/L	0.04	0.06	0.04	0.04	0.04	0.06	0.04	0.04	0.2–0.5

The analysis results show that most chemical parameters in the eight shallow well water samples were within the permissible limits based on the Regulation of the Minister of Health Number 492/Menkes/Per/IV/2010. However, several parameters did not fully meet the required standards. The pH values in samples W 01, W 02, W 03, and W 04 were below the minimum standard, while free chlorine levels in all samples were below the recommended range. Therefore, the well water quality can be considered generally acceptable for most chemical parameters, but it cannot be concluded as fully meeting drinking water quality standards without qualification.

Chemical Parameters

The results of the chemical parameter analysis showed that most parameters were below the permissible threshold. Heavy metals such as arsenic, cadmium, and lead were not detected in any of the samples, thus not posing a toxic risk to health. The nitrite and nitrate content in all samples was also very low and well below the maximum limit (3 mg/L and 50 mg/L, respectively). This indicates that pollution from organic waste or agricultural activities is still relatively low. Iron (Fe) content ranged from 0.0721–0.0897 mg/L, still below the threshold of 0.3 mg/L, so it did not cause color, taste, or sediment problems. Water hardness ranged from 52.2–170.1 mg/L, which is classified as soft to moderate water and still well below the maximum limit of 500 mg/L. Chloride and manganese levels were also within safe limits. However, there were several samples that had pH values below the minimum standard (6.5), namely in W-01, W-02, W-03, and W-04 with a pH range of 6.12–6.40. This indicates that the water tends to be slightly acidic, which has the potential to cause corrosion in pipes and affect the taste of the water. In general, the chemical parameters indicate that the quality of the well water still meets drinking water standards, although there are slight deviations in the pH parameters.

The findings show that the chemical quality of shallow well water in Wayame Village was generally acceptable for most tested parameters, although the water cannot yet be classified as fully compliant with drinking water standards because several wells had pH values below the minimum standard and all samples had free chlorine below the recommended range. This

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pattern indicates that the main concern is not severe contamination by heavy metals or nitrogen compounds, but rather water stability, corrosiveness, and limited residual protection against possible microbial contamination during household use. The low concentrations of fluoride, chromium, cadmium, nitrate, nitrite, iron, hardness, chloride, manganese, and lead suggest that the sampled wells were not strongly affected by toxic metals, salinity, or nitrogen based pollution at the time of analysis. However, the deviation in pH and free chlorine means that the safety of the water should be interpreted cautiously, especially because chemical compliance alone is not sufficient to confirm drinking water safety without microbiological testing.

The slightly acidic pH recorded in W 01, W 02, W 03, and W 04 is an important finding because pH influences the chemical stability of groundwater and its tendency to corrode pipes or dissolve metals from storage and distribution materials. Recent groundwater studies emphasize that pH must be interpreted as part of the wider hydrogeochemical system, because acidity can be shaped by rainfall infiltration, aquifer minerals, dissolved carbon dioxide, organic matter decomposition, and land use around wells (Priyan, 2021; Sabale et al., 2023; Zohud et al., 2023). In the context of Wayame Village, where the landscape includes coastal areas, alluvial deposits, residential zones, and different soil formations, the pH variation among wells may reflect local differences in recharge pathways and mineral buffering capacity. Therefore, the acidic tendency should not be dismissed as a small numerical deviation, because it may affect long term water stability even when heavy metals are currently undetected.

The very low nitrate and nitrite concentrations indicate that the sampled wells were not strongly influenced by recent organic waste, septic leakage, or agricultural nitrogen input. This finding is encouraging because nitrate is widely used as a sensitive indicator of groundwater contamination from domestic wastewater, fertilizers, and sanitation systems (Ferede et al., 2022; Piekut, 2022; Nawaz et al., 2023). Nevertheless, the result should be interpreted as a current condition rather than a permanent guarantee. Groundwater nitrate levels can change seasonally, particularly in areas with high rainfall, shallow aquifers, and dense settlement activity (Valizadeh et al., 2026). Since Wayame receives high rainfall and the wells are used directly by the community, periodic monitoring is still necessary to detect any future increase in nitrogen compounds.

The low chloride concentration is also significant because Wayame is located in a coastal environment where chloride may indicate seawater intrusion, marine aerosol input, domestic wastewater, or mixing with saline water. Studies on groundwater quality have shown that chloride is a useful indicator of salinization and water source mixing because it is chemically stable and easily transported in groundwater systems (Verlicchi & Grillini, 2020; Al Mahasneh et al., 2023; Arıman et al., 2024). In this study, chloride remained far below the permissible limit, suggesting that the sampled wells were not experiencing serious seawater intrusion during the sampling period. However, coastal groundwater systems are vulnerable to changes in recharge, extraction, and land use, so low chloride values should be maintained through controlled groundwater use and protection of recharge areas.

The values of hardness, iron, and manganese further indicate that the sampled well water was chemically acceptable and unlikely to create major aesthetic or technical problems. The hardness values suggest soft to moderate water, meaning that calcium and magnesium dissolution from local geological materials was not excessive. This condition differs from groundwater systems dominated by carbonate rocks where hardness may become a major

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limitation for drinking and domestic use (Zohud et al., 2023; Farzana et al., 2025). Iron and manganese were also below the permissible limits, suggesting that the aquifer conditions did not strongly favor metal mobilization under reducing conditions. This is important because high iron and manganese can cause discoloration, metallic taste, pipe deposits, and lower consumer acceptability of water (Islam et al., 2024). Even so, the presence of slightly acidic pH in several wells means that metal parameters should continue to be monitored because pH changes can influence metal solubility over time.

The absence of detectable cadmium, lead, chromium, and arsenic is one of the strongest positive results of the study. These metals are associated with long term toxicological risks when present in drinking water, especially through chronic exposure. Recent studies have shown that groundwater contamination by heavy metals can originate from geogenic processes, industrial activities, poor well construction, and nearby pollution sources (Zanotti et al., 2022; Islam et al., 2024). In Wayame, the non detected values suggest that the tested wells were not measurably affected by these contaminants at the time of sampling. However, the discussion should avoid claiming that the wells are permanently free from heavy metal risk, because the study used only eight samples and did not include seasonal comparison. The safer interpretation is that the samples met the drinking water standard for heavy metals during the observed period, but regular testing remains necessary.

The most critical issue is the low free chlorine level in all samples. Free chlorine is important because it indicates residual disinfection capacity, which protects water from microbial contamination after collection, storage, or distribution. Although this study focused on chemical parameters, the low free chlorine result indirectly raises concern about microbiological safety. Recent studies on small water supplies and groundwater wells emphasize that water appearing chemically acceptable may still be unsafe if it lacks residual disinfection and has not been tested for microbial indicators such as total coliform and Escherichia coli (Edokpayi et al., 2018; Falae et al., 2024). Therefore, the article should not conclude that the water is fully safe for drinking based only on chemical results. Further microbiological testing is needed, especially because shallow wells are vulnerable to contamination from septic tanks, runoff, household waste, and poor well protection.

The findings suggest that shallow well water in Wayame Village has a favorable chemical profile, but its drinking water safety still requires qualification. The low levels of nitrate, nitrite, chloride, hardness, iron, manganese, and heavy metals indicate limited chemical pollution, while the acidic pH in several wells and insufficient free chlorine show that water treatment and monitoring remain necessary. The study's contribution is therefore strongest when framed as a baseline chemical assessment rather than a complete drinking water safety evaluation. Future monitoring should include seasonal sampling, microbiological parameters, well construction assessment, distance from septic tanks, household storage practices, and possible treatment interventions. This would allow the study to move beyond compliance reporting and provide a stronger basis for community water safety management in Wayame Village.

Conclusion

Based on the laboratory analysis of eight shallow well water samples in Wayame Village and comparison with the drinking water quality standards stipulated in the Regulation of the Minister of Health of the Republic of Indonesia Number 492/Menkes/Per/IV/2010, the chemical quality of the well water generally showed acceptable conditions for most tested

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parameters. The results indicated that fluoride, total chromium, cadmium, nitrite, nitrate, iron, hardness, chloride, manganese, and lead were below the maximum permissible limits. These findings suggest that the well water was not significantly affected by heavy metal contamination, excessive dissolved ions, or nitrogen based chemical pollution. However, not all parameters fully met the required standard. Several samples, namely W 01, W 02, W 03, and W 04, showed pH values below the minimum standard of 6.5, indicating slightly acidic water conditions. In addition, the free chlorine values in all samples were below the recommended range of 0.2 to 0.5 mg/L. These findings indicate that although most chemical parameters were within acceptable limits, pH and free chlorine require further attention, especially in relation to water stability, corrosiveness, and protection against possible microbial contamination during storage or distribution. Overall, the shallow well water in Wayame Village can be considered chemically acceptable based on most of the tested parameters. Nevertheless, the water quality cannot be concluded as fully meeting drinking water requirements without qualification because several samples did not meet the standard for pH and all samples showed low free chlorine levels. Regular monitoring, improvement of water treatment practices, and further testing of microbiological parameters are recommended to ensure that the well water remains safe for community consumption.

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