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Analysis of Physical Parameters of Borehole Water in Anugerah Regensi Housing, Holtekamp

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Abstract

Holtekamp, a coastal area in Jayapura City, has long faced challenges in accessing clean water. The development of Anugerah Regensi Housing, which relies on boreholes as its primary water source, may increase groundwater extraction and the risk of seawater intrusion. This study aims to measure total dissolved solids (TDS), total suspended solids (TSS), electrical conductivity (EC), and temperature in borehole water; compare the results with applicable water quality standards; examine spatial and seasonal variations; and assess potential indications of seawater intrusion. This quantitative descriptive study employed purposive sampling at four borehole locations, with measurements conducted during the rainy and dry seasons. The results showed that TDS concentrations at all sampling points exceeded the 300 mg/L water quality standard in both seasons, ranging from 525 to 2,932 mg/L, whereas TSS concentrations (7–37 mg/L) and temperatures (28–30 °C) remained within the applicable standards. TDS concentrations and EC values were higher during the dry season, potentially due to reduced dilution, whereas TSS concentrations were higher during the rainy season, likely because of suspended particles transported through infiltration. The strongest indication of seawater intrusion was observed at Sampling Point 4, as evidenced by elevated TDS, EC, chloride concentrations, and salinity. In conclusion, the borehole water does not meet the specified quality requirements for hygiene and sanitation without appropriate treatment. Residents are therefore advised to treat the water before use and minimize excessive groundwater extraction to reduce the risk of further seawater intrusion.

INTRODUCTION

Water is a basic human necessity for drinking, cooking, bathing, washing, and sanitation (Maria, 2023). Therefore, water used by communities must meet physical, chemical, and biological quality requirements to prevent adverse health effects (World Health Organization [WHO], 2022). In areas with limited access to piped water supplies, reliance on groundwater extracted through drilled wells continues to increase (Ministry of Public Works and Public Housing [PUPR], 2023). Drilled wells are often preferred because they access deeper aquifers, which are generally better protected from surface contamination (Todd & Mays, 2005). However, groundwater quality is not always satisfactory, as it is influenced by geological conditions, rock formations, anthropogenic activities, and the geographical location of the wells.

In coastal areas, groundwater faces an additional risk of seawater intrusion, which occurs when seawater infiltrates freshwater aquifers, often as a result of excessive groundwater extraction that lowers groundwater levels and alters hydraulic gradients, allowing seawater to migrate inland (Todd & Mays, 2005; Benaafi et al., 2023; Kassem et al., 2024; Shalev, 2021).

Groundwater affected by seawater intrusion is typically characterized by a saline or brackish taste and elevated total dissolved solids (TDS), electrical conductivity (EC), and salinity (Alaydrus et al., 2024; Landia & Setiawan, 2024; Putriany & Sejati, 2023). Landia and Setiawan (2024) found that these three parameters were elevated in areas with extensive built-up land cover along the coast of Manna Market, Bengkulu. Similarly, Sijabat and Situmorang (2021) used EC and TDS measurements to identify potential seawater intrusion in drilled wells along the Deli Serdang coast.

Holtekamp is a coastal area located in Muara Tami District, Jayapura City. Residents have long experienced difficulties accessing clean water, prompting some households to rely on rainwater for cooking and drinking (Saturi, 2017). Previous research also reported that water from wells dug by residents of Holtekamp Village was classified as heavily polluted, with most physical, chemical, and biological parameters failing to meet Class I water quality standards (Balabuana et al., 2023). As new residential developments, such as Anugerah Regensi Housing in Holtekamp, continue to expand and rely primarily on drilled wells for their water supply, increasing groundwater extraction may intensify the risk of seawater intrusion. However, data on the physical quality of borehole water within this residential development remain limited, despite its direct use by residents for hygiene and sanitation purposes.

Physical water quality parameters provide readily measurable preliminary indicators of water conditions. TDS represents the total concentration of dissolved substances, including inorganic ions and dissolved organic compounds (Effendi, 2003). Total suspended solids (TSS) represent particulate matter suspended in water that may contribute to turbidity (Sukmono, 2018). Electrical conductivity (EC) indicates the ability of water to conduct electricity, which is primarily influenced by the concentration and mobility of dissolved ions, while temperature affects the solubility of substances and the rates of chemical reactions in water. Because TDS and EC are both influenced by dissolved ionic constituents, their combined assessment can provide preliminary indications of potential seawater intrusion into groundwater (Ferdy et al., 2025; Gemilang et al., 2022; Jeen et al., 2021). The maximum permissible TDS concentration for water intended for hygiene and sanitation purposes is 300 mg/L under Regulation of the Minister of Health Number 2 of 2023 (Ministry of Health of the Republic of Indonesia, 2023). Meanwhile, the reference value for TSS is 40 mg/L, based on the Class I water quality standard established under Government Regulation Number 22 of 2021 (Government of the Republic of Indonesia, 2021). In addition to spatial variations, seasonal conditions may influence groundwater quality. During the rainy season, groundwater recharge can dilute dissolved substances, whereas during the dry season, reduced recharge and declining groundwater levels may increase dissolved constituent concentrations. Therefore, measurements conducted during both seasons are necessary to provide a more comprehensive understanding of groundwater quality variations.

Previous studies examining the physical parameters of well water have predominantly focused on densely populated or industrial areas, whereas investigations of groundwater quality in developing residential settlements along the Jayapura coast remain limited. The novelty of this study lies in its focus on a developing coastal residential area, its comparative assessment across rainy and dry seasons, and its integrated examination of four key physical water quality parameters to evaluate the suitability of borehole water for hygiene and sanitation purposes. Specifically, this study aims to determine TDS concentrations, TSS concentrations, EC values, and water temperatures in drilled wells within Anugerah Regensi Housing, Holtekamp; compare the measured values with applicable water quality standards; assess spatial and seasonal variations; and identify preliminary indications of seawater intrusion based on TDS and EC measurements.

METHOD

Research Location and Time

The study was conducted at Anugerah Regensi Housing in Holtekamp Village, Muara Tami District, Jayapura City, Papua Province, Indonesia (Figure 1). Water samples were collected during the rainy season (April 24, 2026) and dry season (July 10, 2026). Laboratory analyses were performed at the Chemistry Education Laboratory, Faculty of Teacher Training and Education, Cenderawasih University, on April 27 and July 13, 2026, respectively.



Figure 1. Map of the research location at Anugerah Regensi Holtekamp Housing, Muara Tami District, Jayapura City (base map: © OpenStreetMap).

Design and Sampling

This study is a quantitative descriptive research with an observational approach. The sampling point was determined through location observation using *the purposive sampling technique*, which is the selection of points that are considered to represent the condition of the drilled well in the research area, so that four drilled well points (Point 1 to Point 4) were obtained. Sampling followed SNI 6989.58:2008 (National Standardization Agency [BSN], 2008). The well mouth was cleaned and water was drained for about 5–10 minutes before the sample was taken using a sterile bottle. Each bottle was labeled with a location code, date, and time of collection, then stored in a *cool box* at a temperature of about 4 °C.

Tools, Materials, and Measurements

The equipment used included a 100 mL beaker, a funnel, a sample bottle, a dropper pipette, a 10 mL pipette, a spray bottle, a TDS meter, a thermometer, and a set of turbidity test equipment, while the materials used were drilled well water, aqueducts, and standard solutions for tool calibration. The parameters measured were TDS (mg/L), TSS (mg/L), DHL (µS/cm), and °C temperature. The measurement results were compared with the TDS quality standard of 300 mg/L (Ministry of Health of the Republic of Indonesia, 2023) and the TSS quality standard of 40 mg/L (Government of the Republic of Indonesia, 2021). DHL is not regulated in both regulations so it is used as supporting data. The temperature quality standard in the Minister of Health Regulation Number 2 of 2023 is considered relative to the air temperature that was not recorded in this study, so that the water temperature is compared to the laboratory reference range of 20–30 °C.

Data Analysis

The data were analyzed descriptively by calculating an average of four points in each season as well as the change in the value in summer to the rainy season, i.e. the difference between summer and rainy season values divided by the rainy season value, multiplied by 100%. The consistency between TDS and DHL was checked by the TDS/DHL ratio, which in natural water generally ranges from 0.55–0.75 (Hem, 1985). Support for the indication of seawater intrusion was obtained from chloride and salinity data measured at the same point in the companion study (Jenmau et al., 2026).

RESULTS AND DISCUSSION

The results of the measurement of physical parameters at the four drilled well points are presented in Table 1. Of the four parameters, only the TDS did not meet the quality standards at all points in both seasons. The TSS and temperature were within the reference range at all points, while DHL, which had no quality standards, showed very high values at Point 3 and Point 4. The TDS and DHL values were higher in the summer than in the rainy season at all points, while the TSS was higher in the rainy season.

Table 1. Results of measurement of physical parameters of drilled well water in Anugerah Regensi Holtekamp Housing

Parameters	Seasons	Point 1	Point 2	Point 3	Point 4	Average	Quality standards
TDS (mg/L)	Rain	525	789	867	1.674	963,8	≤ 300
	Hot	731	1.594	1.100	2.932	1.589,3	
TSS (mg/L)	Rain	12	31	37	23	25,8	≤ 40
	Hot	7	14	17	14	13,0	
DHL (µS/cm)	Rain	230	320	5.000	2.340	1.972,5	Unregulated
	Hot	450	450	9.000	4.581	3.620,3	
Temperature (°C)	Rain	28	28	29	29	28,5	20–30†
	Hot	30	29	30	29	29,5	

TDS quality standards: Permenkes Number 2 of 2023; TSS: PP Number 22 of 2021 Class I. †Laboratory reference range; temperature according to Permenkes Number 2 of 2023 is assessed relative to air temperature (not recorded).

Total Dissolved Solids (TDS)

TDS values at all points exceeded the 300 mg/L quality standard in both seasons (Figure 2). In the rainy season, TDS ranged from 525–1,674 mg/L or 1.8–5.6 times the quality standard, while in summer it rose to 731–2,932 mg/L or 2.4–9.8 times the quality standard. The average TDS increased from 963.8 mg/L to 1,589.3 mg/L (64.9%). Based on the classification of Freeze and Cherry (1979), which divides groundwater into freshwater (TDS 0–1,000 mg/L) and brackish water (1,000–10,000 mg/L), Point 1 is classified as freshwater in both seasons, Point 2 and Point 3 change from freshwater in the rainy season to brackish water in summer, and Point 4 is classified as brackish water in both seasons. Thus, Point 1 does not meet the standards of hygiene and sanitation quality even though it is still classified as freshwater.

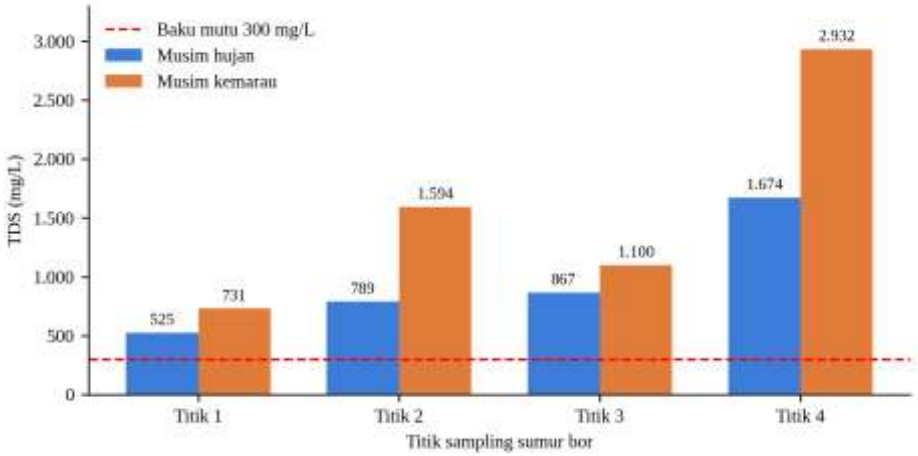


Figure 2. The TDS value of drilled well water at four sampling points in the rainy season and summer was compared to the quality standard of 300 mg/L.

The increase in TDS in summer is suspected to occur due to a decrease in rainwater replenishment that usually dilutes groundwater, as well as a decrease in groundwater level and increased evaporation so that solutes become more concentrated. The largest increase occurred at Point 2 (789 to 1,594 mg/L, or 102.0%), followed by Point 4 (75.1%), Point 1 (39.2%), and Point 3 (26.9%). Point 4 had the highest TDS in both seasons. This is in line with supporting data on chloride (1,651.97–1,761.87 mg/L) and salinity (2.40–3.18‰) at the same point, which is classified as brackish (Jenmau et al., 2026), so the solutes at this point are suspected to come from seawater intrusion, considering that Holtekamp is located in a coastal area. In contrast, Point 1 has the lowest TDS and chloride (86.85–125.85 mg/L) below the taste threshold of 250 mg/L (World Health Organization [WHO], 2022), so the influence of seawater at this point is relatively minimal. TDS above 1,000 mg/L is unpleasant (World Health Organization [WHO], 2022) and can scale household appliances and reduce the effectiveness of soap, so that the water from the borewell at the study site is not yet qualified for hygiene and sanitation purposes without treatment.

Total Suspended Solids (TSS)

The TSS value at all points met the quality standard of 40 mg/L in both seasons (Figure 3). In contrast to TDS, TSS was actually higher in the rainy season (12–37 mg/L) than in the summer season (7–17 mg/L), and the average TSS decreased from 25.8 mg/L to 13.0 mg/L (49.5%), or about half.

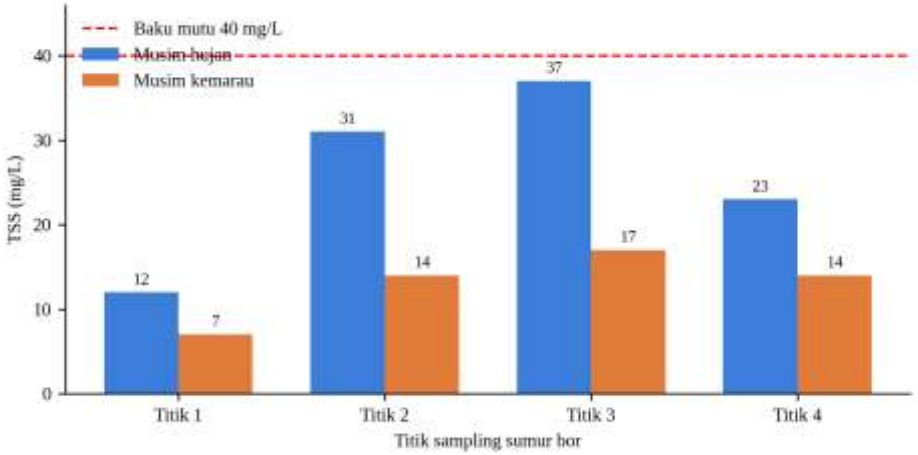


Figure 3. The TSS value of drilled well water at four sampling points in the rainy season and summer was compared to the quality standard of 40 mg/L.

High TSS during the rainy season is thought to occur because seeping rainwater carries fine particles such as clay, silt, and organic matter into the aquifer, in line with the tendency of TSS to increase when rainwater carries soil particles due to erosion (Sukmono, 2018). In addition, rising groundwater levels can stir up sediments around pipes and well bottoms, while in summer infiltration flows are reduced, so more particles settle. The TSS value of Point 3 in the rainy season (37 mg/L) has reached 92.5% of the quality standard. In addition, laboratory reports noted that Point 2 and Point 4 water are brownish-yellow, which can indicate the presence of iron (Fe) or manganese (Mn), but the two metals have not been measured. Although TSS meets quality standards, simple filtration is still recommended before water is used.

Electrical Transmission (DHL)

DHL does not have quality standards in the Regulation of the Minister of Health Number 2 of 2023 or Government Regulation Number 22 of 2021, so it is used as supporting data describing the content of dissolved ions (Figure 4). In the rainy season, DHL ranges from 230–5,000 µS/cm, while in summer it rises to 450–9,000 µS/cm, with an average increase from 1,972.5 to 3,620.3 µS/cm (83.5%). Point 1 and Point 2 have low DHL (230–450 µS/cm), while Point 3 (5,000–9,000 µS/cm) and Point 4 (2,340–4,581 µS/cm) are very high. The decrease in DHL during the rainy season at all points indicates the occurrence of dilution by seeping rainwater.

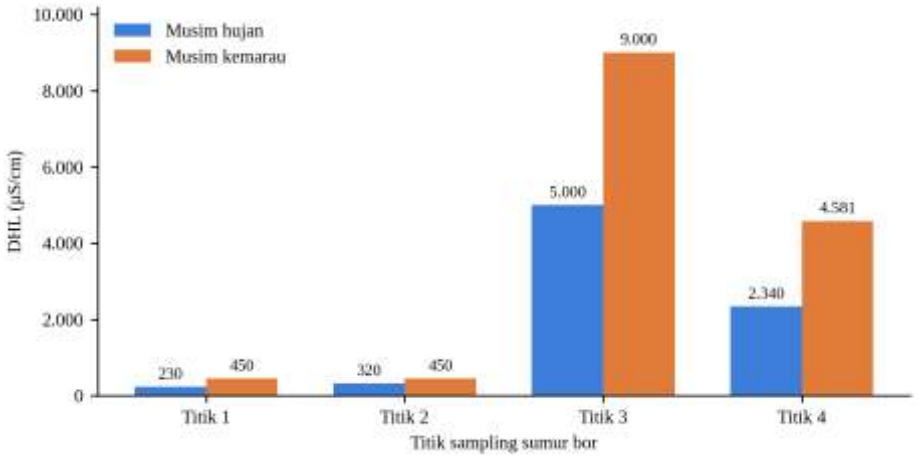


Figure 4. DHL value of drilled well water at four sampling points in the rainy season and summer

Because they are both dependent on dissolved ions, the TDS (mg/L) in natural water is generally 0.55–0.75 times DHL (µS/cm) (Hem, 1985). The TDS/DHL ratio in this study was only appropriate at Point 4 (0.72 in the rainy season and 0.64 in summer), while at Point 1 and Point 2 the ratios were much greater than one (1.62–3.54) and at Point 3 it was much smaller (0.12–0.17) (Table 2). This discrepancy was also apparent when DHL was compared with supporting data. Point 3 has a chloride of only 264.10–338.55 mg/L and a salinity of 0.36–0.61‰ which is not in line with DHL 5,000–9,000 µS/cm, while Point 2 has a chloride of 616.83–689.50 mg/L which is not in line with DHL of 320–450 µS/cm. In contrast, TDS, chloride, and salinity are both lowest at Point 1 and highest at Point 4 in both seasons.

Table 2. TDS/DHL ratio of borewell water and its suitability to the general range of natural water

Dot	Rainy season	Summer	Compatibility with 0.55–0.75
Point 1	2,28	1,62	Not suitable (too high)
Point 2	2,47	3,54	Not suitable (too high)
Point 3	0,17	0,12	Not suitable (too low)
Point 4	0,72	0,64	Conform

Ratio = TDS (mg/L) divided by DHL (µS/cm); general range of natural water 0.55–0.75 (Hem, 1985). Source: research data (2026).

Temperature

Drilled well water temperatures across points ranged from 28–30 °C and were within the laboratory reference range of 20–30 °C (Figure 5). Temperatures ranged from 28–29 °C in the rainy season and 29–30 °C in season, with an average increase of 1 °C, from 28.5 to 29.5 °C. This small difference suggests that groundwater temperatures are relatively stable because aquifers are protected from daily changes in air temperature and, in the tropics, are generally close to the local annual average air temperature (Todd & Mays, 2005). Small increases in summer are thought to be related to higher air temperatures and stronger solar irradiation.

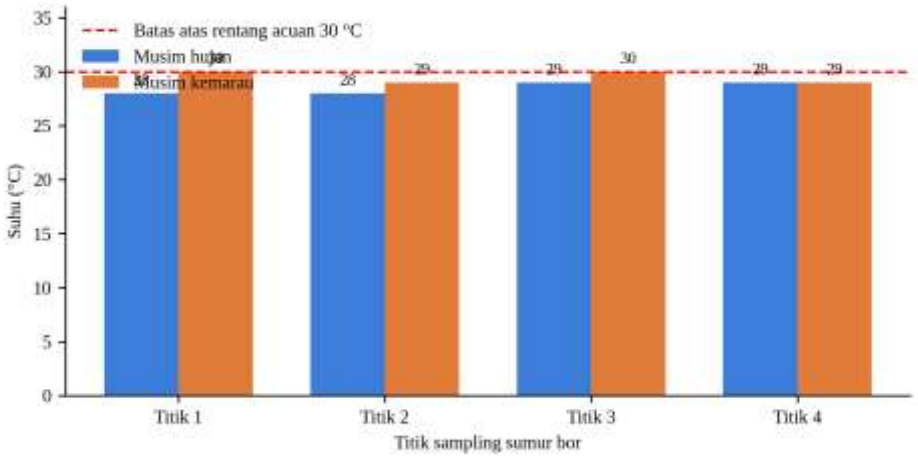


Figure 5. Drilled well water temperature at four sampling points in the rainy season and summer (source: research data, 2026).

Although within the reference range, temperatures at Point 1 and Point 3 in summer (30 °C) reach the upper limit. Higher temperatures can increase mineral solubility, accelerate chemical reactions, and lower dissolved oxygen levels (Effendi, 2003). Minister of Health Regulation Number 2 of 2023 assesses temperature relative to air temperature during sampling,

so temperature compliance with these regulations cannot be ensured and recording of air temperature in the field is required in subsequent studies.

Indications of Seawater Influence and Water Feasibility

The combined data show that the strongest indication of seawater influence is found at Point 4, as the highest TDS in both seasons (1,674–2,932 mg/L), high DHL (2,340–4,581 µS/cm) with a reasonable TDS/DHL ratio, 1,651.97–1,761.87 mg/L chloride, and salinity 2.40–3.18‰ are mutually supportive indicators. The TDS value of Point 4 remains high during the rainy season so that its influence is not lost by rainwater replenishment. Point 1 shows the smallest influence, while Point 2 and Point 3 are among those with increased TDS, chloride, and salinity in summer.

Based on the TDS quality standard, the drilled well water at the four points is not yet suitable for hygiene and sanitation purposes without treatment. This assessment is only based on physical parameters, while other parameters required for water for hygiene and sanitation purposes, such as iron, manganese, and microbiological parameters, have not been measured.

Research Limitations

This study has several limitations. The number of sampling points is only four and each season is represented by one sampling (April 24 and July 10, 2026) so that the differences between seasons are indicative and presented descriptively without statistical tests.

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CONFLICT OF INTEREST

The author states that this research was conducted without any commercial or financial relationship that can be interpreted as a potential conflict of interest.

AUTHOR CONTRIBUTION

If relevant, statements regarding the contributions of each author may be included in this section.

GENERATIVE ARTIFICIAL INTELLIGENCE USAGE STATEMENT

The authors state that generative artificial intelligence (AI) was used in the preparation of this manuscript. The authors acknowledge the use of generative AI to help improve language clarity and improve the grammatical structure of manuscripts. The use is carried out in compliance with applicable ethical guidelines regarding the use and disclosure of generative AI in scientific research. Each author has made substantial intellectual contributions to this work. The entire content of the manuscript has been carefully reviewed to ensure its accuracy, and the author is solely responsible for the integrity and final content of the manuscript

CONCLUSION

Borehole water at Anugerah Regensi Housing, Holtekamp, did not meet the applicable water quality standards for hygiene and sanitation purposes, as total dissolved solids (TDS) concentrations exceeded 300 mg/L at all four sampling points during both seasons, ranging from 525 to 2,932 mg/L. Meanwhile, total suspended solids (TSS) concentrations (7–37 mg/L) and water temperatures (28–30 °C) remained within the applicable standards. Seasonal variations were observed, with higher TDS concentrations and electrical conductivity (EC) values during the dry season, potentially due to reduced dilution, while TSS concentrations were higher during the rainy season, likely because of suspended particles transported by infiltrating water. Water temperatures remained relatively stable across both seasons. The strongest indication of potential seawater intrusion was identified at Sampling Point 4, as evidenced by elevated TDS, EC, chloride concentrations, and salinity.

Residents are advised to avoid consuming untreated borehole water and to implement appropriate water treatment methods, such as multistage filtration combined with reverse

osmosis to reduce elevated TDS concentrations. Residents near Sampling Points 3 and 4 should consider alternative drinking and cooking water sources, including treated municipal water supplies or properly collected and treated rainwater, while minimizing excessive groundwater extraction, particularly during the dry season. The relevant health and environmental authorities in Jayapura City are encouraged to conduct regular groundwater quality monitoring and consider expanding access to safe water supplies in coastal residential areas. Future research should incorporate additional sampling locations, well depths, and distances from the coastline, alongside comprehensive chemical and microbiological analyses, including iron, manganese, salinity, and Escherichia coli (E. coli), to better assess groundwater quality and potential seawater intrusion.

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