The Water Quality Index of Springs in Bauro Village, Timor-Leste

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ABSTRACT

The spring in Bauro Village, Timor-Leste, is used to meet the community's daily needs; therefore, an evaluation is needed to determine the quality of the groundwater from this spring. This research aims to assess groundwater quality, particularly using the Water Quality Index (WQI). Evaluation was carried out on 12 springs that emerged from limestone and sandstone. The research results show that not all springs meet the quality standards for drinking water or clean water. The WQI assessment shows that the majority of the 12 sampled sites (S1–S10 and S12) fall into the unsuitable category, indicating high levels of contamination from both natural and anthropogenic sources. Only Bauro spring S11 exhibited excellent water quality, while Luarai spring S12 showed poor drinking water quality and was unsuitable for clean water, reflecting localized contamination and possible mineral enrichment.

Kata kunci: Water Quality Index (WQI), groundwater, spring, drinking water, clean water

ABSTRAK

Mata air di Desa Bauro, Timor Leste digunakan untuk memenuhi kebutuhan sehari-hari bagi masyarakat, oleh karena itu, diperlukan evaluasi untuk menentukan kualitas airtanah dari mata air ini. Penelitian ini ingin mengetahui kualitas airtanah, khususnya melalui parameter Indeks Kualitas Air (IKA). Evaluasi dilakukan terhadap 12 mata air yang muncul dari batugamping dan batupasir. Hasil penelitian menunjukkan bahwa tidak semua mata air memenuhi standar kualitas untuk air minum atau air bersih. Penilaian IKA menunjukkan bahwa mayoritas dari dua belas lokasi sampel (S1–S10 dan S12) termasuk dalam kategori tidak sesuai, yang menunjukkan tingkat kontaminasi yang tinggi dari faktor alam dan antropogenik. Hanya mataair Bauro S11 yang menunjukkan kualitas air yang sangat baik, sementara mataair Luarai S12 menunjukkan air yang buruk untuk penggunaan minum dan tidak sesuai untuk air bersih, yang mencerminkan kontaminasi lokal dan kemungkinan pengayaan mineral.

***Keyword**: Indeks Kualitas Air (IKA), airtanah, mataair, air minum, air bersih*

INTRODUCTION

Groundwater is a vital water resource that has recently been used as a primary source to meet the community's water needs, including in Bauro Village, Timor-Leste. The springs in this village serve the community's water needs; therefore, good groundwater quality is essential. Therefore, water quality studies are necessary to improve the local community
's quality of life.

Water quality is essential for its use as a water source [1]. The availability of water is increasingly unbalanced as the population grows. An increasing population on an unchanged land area will increase pressure on the environment [2].

Water quality evaluations have been conducted in various ways. One such method is determining the WQI. The WQI assessment can be carried out using a range of parameters, including physical, chemical, and biological ones.

Studies on groundwater quality have been extensively conducted [3-5], as these studies support human life needs. In many places, groundwater (including springs) is a vital water resource [6], used to meet clean water and drinking water needs. This is also the case in Bauro village, Timor Leste. Good quality groundwater is crucial for supporting public health [7].

Studies on groundwater quality using the WQI method have also been widely conducted [8-10]. Groundwater quality analysis studies using the WQI can help us understand the quality of the water we are testing. The WQI value is easy to use to determine the suitability of water for drinking, clean water, or other uses.

WQI analysis is a water-quality assessment method used to determine the suitability of water for drinking or other uses. The purpose of this study is to evaluate the suitability of groundwater from springs in the study area for clean water and drinking water purposes. The results of the WQI determination of groundwater in the Bauro area, Timor-Leste, are expected to provide important information to the community living there. The community in Timor-Leste requires accurate information on groundwater quality, which makes this study necessary. Information on groundwater quality, mainly quantitatively determined indicators such as the WQI, is essential to the people of Timor-Leste.

METHOD

The hydrogeological survey was conducted in Bauro Village (Fig. 1) and included groundwater sampling at 12 springs. Then, all samples have been tested in the laboratory to determine their properties.

The data obtained have been analyzed using the WQI to describe water quality conditions. All parameters have been compared with Water Quality Standards, regulatory guidelines that establish acceptable limits for various physical, chemical, and biological parameters in drinking water and clean water, set by Timor-Leste's Low Water Quality Control for Human Consumption Decree-Low 31/2020, August 26 [11]. Interpretation of the results was done by compiling test results, assessing whether the water meets the requirements, and analyzing factors that affect water quality, such as human activities around the spring.

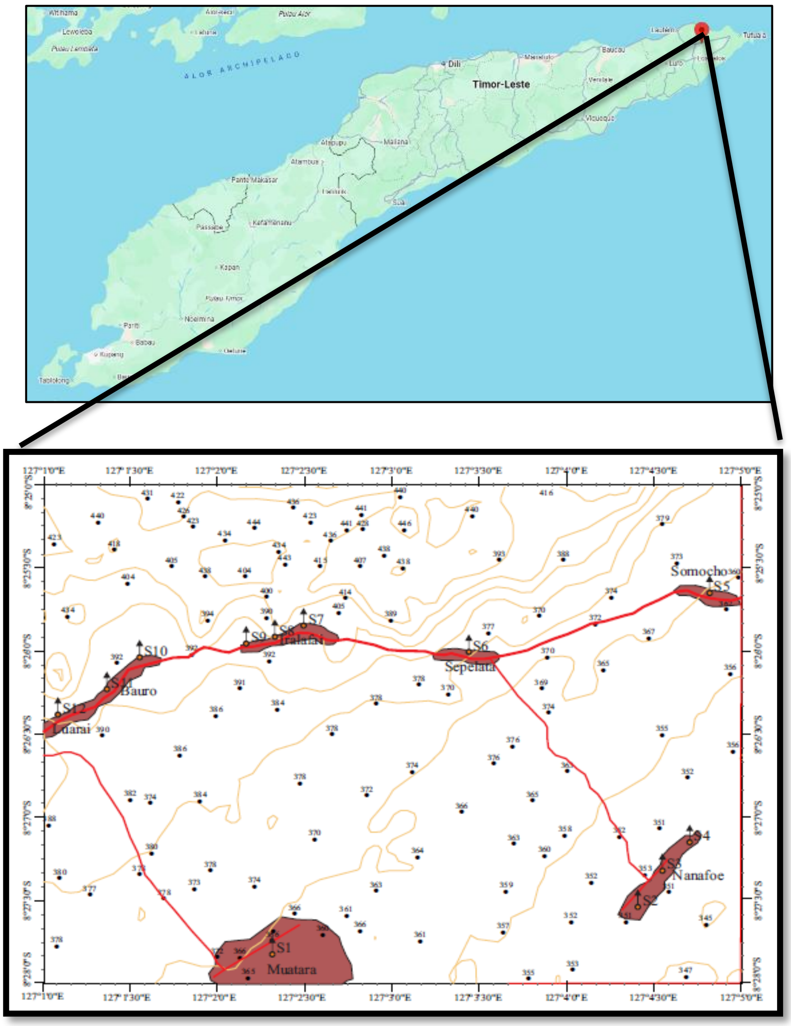

Figure 1. *Location of research area.*

The most widely applied approach is the WQI method [8]. In this method, each parameter is assigned a weight (Wi) based on its relative importance to water quality, determined by the inverse of its standard permissible value (Si). A quality rating (Qi) is then calculated for each parameter, representing the relative difference between the parameter value and the allowable standard (Si).

The overall WQI is derived from the weighted average of all Qi values, according to the formula:

$$WQI = \frac{\sum(Q_i \times W_i)}{\sum W_i} \tag{1}$$

Where:
Qi = Quality rating of parameter *i*
Wi = Unit weight of parameter *i*

The WQI value is determined based on the weight (wi) for each groundwater, the relative weight (Wi), and the quality rating scale (qi). The Wi value is determined using the Wi formula [8]. The following formula determines the value of Wi.

$$Wi = wi / (\Sigma wi) \tag{2}$$

The value of qi is calculated based on the concentration of groundwater (ci) and the standard value of groundwater (si), as defined in the Timor-Leste Minister of Health Regulation Degree Law 31/2020 for drinking and clean water.

$$qi = ci / si \times 100 \qquad (2)$$

The WQI value is the sum of SI, where SI is calculated based on the WI and qi values as presented in the following formula.

$$SI = Wi \times qi \tag{3}$$

$$WQI = \Sigma SI \tag{4}$$

The Water Quality Index (WQI) is a composite indicator that summarizes the overall water quality by combining multiple physical, chemical, and biological parameters into a single numerical value. It provides an effective tool for comparing water quality among sites and over time. The WQI was calculated using the classification [8] and a weighted arithmetic approach, adapted to comply with the Timor-Leste Standard (Decree-Law No. 31/2020) for drinking water quality [12].

Each measured parameter (such as pH, turbidity, conductivity, residual chlorine, total coliforms, and E. coli) is converted to a sub-index according to its deviation from ideal and permissible limits, and then combined with appropriate weights reflecting its importance to human health and water aesthetics. The resulting WQI ranges from 0 to 100, with higher values indicating poorer water quality (Table 1).

Table 1. WQI ranges and classification for drinking water and clean water [8].

WQI Range	Water Quality Class	Interpretation (Drinking Water)	Interpretation (Clean Water / Environmental Use)
0 – 25	Excellent	Water meets all Timor-Leste 31/2020 limits; safe for direct consumption	Very high quality; suitable for all aquatic uses
26 – 50	Good	Generally acceptable; minor deviation from ideal; safe for drinking after simple disinfection	Suitable for domestic and aquatic life
51 – 75	Poor / Fair	Several parameters approach limits; may require treatment before drinking	Moderately polluted; limited clean-water use
76 – 100	Very Poor / Unacceptable	Exceeds national standards; not safe for drinking without treatment	Polluted water; unsuitable for most uses
> **100**	Unsuitable	Severely contaminated; requires urgent remediation	Highly polluted; not suitable for any use

RESULT AND DISCUSSION

Water Quality Index (WQI) analysis at 12 spring locations in Bauro Village revealed variations in groundwater quality based on physical and chemical parameters (WQI_PhysChem), which were then compared with microbiological test results (Total Coliform and E. coli). The WQI calculation refers to the formula used by previous researchers [8,9].

The Water Quality Index (WQI) was calculated to assess groundwater suitability for drinking water and clean water purposes. The evaluation used key physicochemical. Each parameter was assigned a relative weight (Wi) based on its significance for water quality, according to the Timor-Leste Standard (31/2020) [12] and WHO guidelines [13]. Calculations of each parameter at locations of spring S1-S12 have been done.

The analysis of groundwater quality was conducted using the Water Quality Index (WQI) method developed by previous researchers [8] and adapted to the Timor-Leste Standard (Decree-Law No. 31/2020) for drinking water [12]. A total of 20 physicochemical and microbiological parameters were evaluated, including Total Coliform, Escherichia coli, pH, Turbidity, Total Dissolved Solids, Chlorides, Iron, and Nitrates.

Each parameter was compared with its standard limit and assigned a relative weight based on its importance to human health. Sub-index values were calculated and aggregated to produce overall WQI scores for both drinking water and clean water conditions.

The Water Quality Index (WQI) for all samples was calculated using physicochemical and microbiological parameters according to the method of the classification [12], and the Water Quality Index (WQI) for some samples was computed using physicochemical and microbial parameters according to the method and the classification of WQI [8]. The computed WQI values for S1, for example, were 955.9 for drinking water and 1641.5 for clean water. Both values fall within the "Unsuitable" category (WQI > 100), indicating that the water quality at this site is not safe for human consumption or domestic use without proper treatment. High WQI values are mainly influenced by elevated levels of conductivity, total hardness, pH, and salinity, which greatly exceed the permissible limits for drinking and clean water standards. It may be that the "Unsuitable" water indicates high levels of contamination from natural and anthropogenic factors.

This study evaluates groundwater quality from twelve sampling sites (S1–S12) across the Bauro, Iralafai, Sepelata, Somoco, Nanafoe, and Luarai areas using the Water Quality Index (WQI) method. The WQI values were calculated for both drinking water and clean water purposes to determine the suitability of groundwater for domestic consumption. The appearance of one of the springs is shown in Figure 2.

Figure 1. *Example of spring in Bauro Village* [14].

The results show that most sampling sites (S1–S10 and S12) have WQI values exceeding acceptable limits, classifying them as "Unsuitable" for both drinking and household use. Only Bauro S11 exhibited an "Excellent Water" classification, indicating high-quality groundwater suitable for human consumption and domestic use. In contrast, Luarai S12 recorded a "Poor Water" type for drinking water and an "Unsuitable" type for clean water, reflecting elevated contamination and mineral concentrations. The Poor Water" of S12 for drinking use and "Unsuitable" for clean water, may reflect localized contamination and possible mineral enrichment.

The determination of WQI for groundwater from 12 springs in Timor-Leste is expected to broaden insight into local groundwater conditions, supported by quantitative calculations that should be more reliable. Overall, the groundwater quality across the study area is generally poor, influenced by geological composition, surface runoff, and possible anthropogenic activities. Continuous monitoring, proper sanitation, and groundwater protection measures are recommended to improve and preserve water quality for future use (Table 2).

Table 2. WQI calculation from all data in the research area [14].

Sample	Location	Drinking Water		Clean Water	
		WQI	Water Type	WQI	Water Type
S1	Mautara	955,900974	Unsuitable	1641,491425	Unsuitable
S2	Nanafoe	661134,7771	Unsuitable	661137,5299	Unsuitable
S3	Nanafoe	223632,7504	Unsuitable	198527,0172	Unsuitable
S4	Nanafoe	126300,2	Unsuitable	72227,31702	Unsuitable
S5	Somocho	90303,96998	Unsuitable	92458,74757	Unsuitable
S6	Sepelata	954048,3991	Unsuitable	252,8811169	Unsuitable
S7	Iralafai	287519,9937	Unsuitable	268862,4341	Unsuitable
S8	Iralafai	33358,8846	Unsuitable	31193,83166	Unsuitable
S9	Iralafai	273632,7523	Unsuitable	255867,6531	Unsuitable
S10	Bauro	97243,59847	Unsuitable	92378,86652	Unsuitable
S11	Bauro	22,46100751	Excellent Water	24,34795508	Excellent Water
S12	Luarai	1272,068709	Poor Water	1970,558698	Unsuitable

CONCLUSION

A Water Quality Index (WQI) assessment has been conducted for groundwater from springs in Bauro Village, Timor-Leste. The results show that the majority of the 12 sampled sites (S1–S10 and S12) fall into the "Unsuitable" category, indicating high levels of contamination from both natural and anthropogenic sources. Only Bauro S11 exhibited "Excellent Water" quality, while Luarai S12 showed "Poor Water" for drinking use and "Unsuitable" for clean water, reflecting localized contamination and possible mineral enrichment. The results of the WQI calculations are expected to provide more measurable information about groundwater quality.

ACKNOWLEDGMENT

This research is part of the thesis of the first author, and the author would like to express their gratitude to the institution, in particular, the leaders of the University of Orient Timor Lorosa'e and Unital Timor-Leste, who have facilitated the first author's pursuit of further study. The author also thanks ITNY for funding this seminar.

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