JRSSEM 2025, Vol. 05, No. 03
E-ISSN: 2807 - 6311, P-ISSN: 2807 - 6494

Evaluation of Groundwater Quality in Spring Sources of Bauro Village, Lospalos Administrative Post, Lautém Municipality, Timor-Leste

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Abstract. The research examines the physical, chemical, and microbiological factors affecting water safety for human consumption and ecological health. Local communities rely on spring sources for agriculture and household use. Field investigations involved collecting and analyzing water samples from several springs, measuring indicators such as pH, turbidity, dissolved oxygen, heavy metals, and microbiological pollutants like *E. coli* and total coliform. Results show that while many springs met acceptable drinking water standards, some contained pollutant levels above the norm, mainly due to human activities such as improper waste disposal and agricultural runoff. Water quality was assessed using the Water Quality Index (WQI), which includes physical, chemical, and biological parameters. Physical parameters—color, taste, odor, temperature, turbidity, solids, and electrical conductivity—rated most samples as "good" for consumption. However, springs in high human activity areas had poorer pH, TDS, EC, ion content, and BOD values compared to less disturbed locations. The study reveals the importance of these parameters to community health in Bauro Village and underlines the need for regular monitoring and effective management practices. By providing insights into the dynamics of water quality in spring sources, it emphasizes the critical role of sustainable water resource management in ensuring clean, reliable supplies for communities dependent on these ecosystems.
Keywords: Quality Water, Parameter and Geology

INTRODUCTION

Groundwater constitutes an integral component of the global hydrological cycle. When precipitation reaches the ground surface, a portion infiltrates into subsurface layers. Water within the saturated groundwater system moves gradually through aquifer materials and may eventually discharge into streams, lakes, and oceans (Ntona et al., 2022; Nyakundi et al., 2022; Pino-Vargas et al., 2023; Thomas et al., 2017). Groundwater quality is influenced by multiple factors, including geological formations, climatic conditions, and land use patterns. Many naturally occurring chemical constituents in groundwater originate from the dissolution of rocks and minerals, weathering of soil materials, and decomposition of organic matter (Abanyie et al., 2023; Jha et al., 2020; Lapworth et al., 2022; Misstear et al., 2023; Xie et al., 2023).

In Timor-Leste, particularly in the Lospalos–Bauro region of Lautém Municipality, groundwater serves as a vital resource for local communities, supporting domestic water needs, agricultural activities, and ecosystem functions. According to the 2021 Bureau of Statistics Timor-Leste report, approximately 68% of the rural population in Lautém Municipality relies primarily on spring water and shallow wells for daily water consumption. However, recent observational data from the National Directorate of Water Services (2023) indicates increasing concerns regarding water quality degradation in several coastal and highland areas of Lospalos Administrative Post, with preliminary assessments suggesting potential contamination from agricultural runoff and inadequate sanitation facilities.

This study provides a comprehensive *Evaluation of Groundwater Quality in Spring Sources of Bauro Village, Lospalos Administrative Post, Lautém Municipality, Timor-Leste*, focusing on the systematic assessment of chemical, physical, and biological parameters. Such quality assessment is essential for ensuring public health safety and environmental sustainability. The geological substrate of the region, predominantly composed of Pleistocene–Holocene carbonate formations (Baucau Limestone), plays a crucial role in determining aquifer characteristics and groundwater quality. Understanding how geological factors, climatic variables, and human activities interact to influence water chemistry is fundamental for developing effective water resource management strategies.

According to Kumalasari and Satoto (2011), groundwater can be classified based on its position within soil profiles: shallow groundwater, which is retained by vegetation root systems and found close to the surface above impermeable layers, and deep groundwater, which originates from rainfall that percolates through deeper soil horizons via infiltration and filtration processes through rock and mineral strata. This distinction is significant because deep groundwater typically exhibits superior quality due to natural filtration through geological materials.

Groundwater quality is intrinsically linked to groundwater facies and hydrochemical composition. According to Kumar (2013), groundwater facies reflect the complex effects of subsurface hydrochemical processes occurring between aquifer lithology minerals and circulating groundwater. Furthermore, facies analysis can be employed to investigate the spatial distribution of groundwater chemistry and trace hydrochemical evolution pathways. Regional variations in groundwater quality arise from several interconnected factors. Priyana (2008) identified four primary influences on groundwater quality: climate and precipitation patterns, lithological characteristics, temporal factors, and human activities. Among these, anthropogenic activities generally exert the most significant impact on groundwater degradation. Population density correlates strongly with groundwater quality deterioration, as increased settlement density elevates the probability of pollution sources including domestic wastewater, agricultural chemicals, and inadequate waste management systems.

Recent studies have documented similar groundwater quality challenges in comparable geological settings. Ranjan and Singh (2019) conducted water quality assessments of springs in the Himalayan region, identifying agricultural contamination and microbial pollution as primary concerns. Prasasti et al. (2017) examined spring water contamination in West Java's mountainous regions, reporting significant health implications from elevated nitrate and coliform levels. Setiawan et al. (2018) demonstrated clear correlations between fertilizer and pesticide application and deteriorating water quality in Indonesian spring sources. However, comprehensive assessments integrating geological, hydrochemical, and microbiological analyses remain scarce for Timor-Leste, particularly for the eastern coastal regions. This research addresses this critical knowledge gap by providing detailed characterization of spring water quality in Bauro Village and identifying specific contamination sources and mechanisms.

The urgency of this research stems from several critical concerns. First, rapid population growth and agricultural intensification in the Lospalos–Bauro area have increased pressure on limited groundwater resources. Second, preliminary field observations revealed visible signs of water quality degradation at several spring locations, including turbidity increases during rainy seasons and proximity of springs to potential contamination sources such as livestock areas and agricultural fields. Third, public health data from the Ministry of Health Timor-Leste (2022) indicates elevated incidence of waterborne diseases in Lautém Municipality, suggesting possible linkages to compromised water quality. Finally, climate change projections for Timor-Leste predict altered rainfall patterns and increased drought frequency, potentially exacerbating water quality and availability challenges.

The research aims to assess spring water quality based on comprehensive physical, chemical, and biological parameters; identify geological factors affecting water quality; and evaluate water suitability for domestic, agricultural, and other purposes according to national and international standards (WHO, Timor-Leste Decree-Law No. 31/2020). This investigation is expected to provide critical baseline information on water quality conditions, supply essential data for governmental and institutional water resource management and protection initiatives, and establish a scientific foundation for policy development related to clean water provision and public health protection in Bauro Village and similar settings across Timor-Leste.

Hypothesis

1. The Physical, chemical, and biological parameters of water in springs, water quality as well as pH, TDS, EC, Ion Content, BOD, in springs located in areas with high human activity will have worse quality parameters compared to springs located in more natural areas or areas with minimal human activity.
2. The geology of Bauro Village a crucial role in determining the quality of spring water through various factors, including rock types, aquifer characteristics, tectonic influences, and land use practices. Understanding these geological factors is essential for effective water management and protection in the area.
3. Contaminant levels such as heavy metals, BOD (Biochemical Oxygen Demand), and total dissolved solids (TDS) in springs will exceed the safe limits set by water quality standards for domestic and agricultural use. The contaminad come from different recourses, like natural sources, agriculuture sources, industrial sources and urban sources.

MATERIALS AND METHODS

Geology Survey

Mapping the geology research will be conducted in Bauro Village, Lautem Regency, Timor-Leste and Water samples will be taken from several springs used by the community for daily needs in Bauro Village is essential for understanding the region's geological features, mineral resources, and groundwater dynamics. The correct sampling method is in accordance with laboratory procedures (using sterilized sample bottles).

Laboratory Testing

Chemical and Microbiological Tests:

Water samples will be analyzed in the laboratory to measure various water quality parameters, such as: pH; Turbidity; Total Dissolved Solids (TDS); BOD (Biochemical Oxygen Demand); COD (Chemical Oxygen Demand); Heavy metal content (eg, mercury, arsenic, cadmium); Pathogenic microorganisms (E. coli, total coliform); Dissolved oxygen (DO); Conduct chemical tests to determine the content of heavy metals and other hazardous substances.; Microbiological tests to determine the levels of pathogenic bacteria in water.
Physical Parameter Checks: Testing turbidity, temperature, and TDS to determine the physical condition of water.

Analysis Data

Based on the data obtained, the analysis will be carried out using descriptive statistics to describe water quality conditions, followed by comparing the test results against drinking water quality standards from WHO, the Indonesian Ministry of Health, as well as local regulations such as Decree-Low 31/2020 in Timor-Leste. The test results will be interpreted to assess the feasibility of the water as well as further analyzed by taking into account factors that affect water quality, such as human activities around water sources, geographical conditions, and weather. In particular, the quality of groundwater as a crucial resource for drinking water, agriculture, and industry is analyzed through chemical, physical, and microbiological parameters. The results show that groundwater quality is greatly influenced by natural processes and human activities, such as high levels of nitrates and phosphates due to agricultural runoff, heavy metals from industries or geological factors, and microbial contamination that is risky to health. The study also examines groundwater quality standards based on national and international guidelines, and identifies various contaminants such as pathogens, nutrients, heavy metals, and organic compounds along with their sources, mechanisms of displacement, and impacts on groundwater quality.

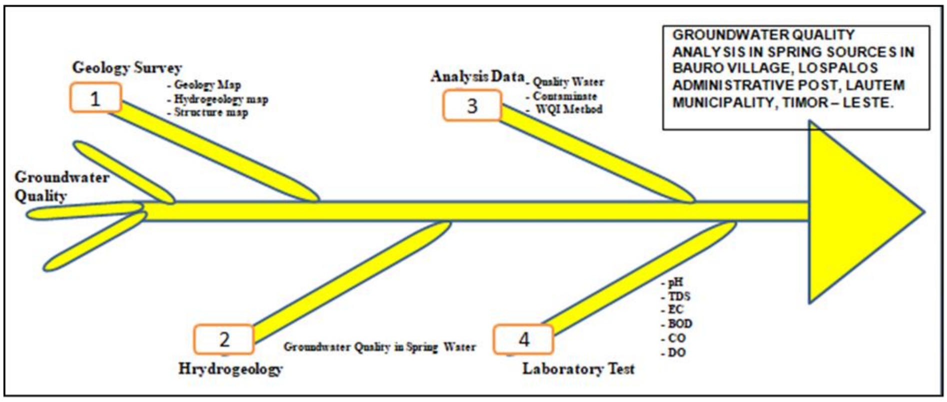

Figure 1. Groundwater Quality Analysis

Hydrogeology

The hydrogeological study of Bauro, located in the Lospalos administrative post of Lautem Municipality, Timor-Leste, aims to understand the groundwater systems and their interactions with the local environment. This region is characterized by a complex geological framework, predominantly consisting of sedimentary rocks from the Baucau Formation at period middle Miosenic until Pleistosenic, which significantly influences groundwater recharge and quality.

Research Device and Materials

Research method with its objective to do cartographic research (Mapping) and geological study, starting the first research secondary data or bibliography, field research, analysis and interpretation laboratory in the location of the study area and inductive method.
Inductive method is part of the enumeration of experiences or particular cases, to have a conclusion of universal order; includes four stages: Observation, Hypothesis, experimentation and verification that are raised from the hypothesis, to explain the facts that are observed in the area of study, to experiment and transform the theory that exists.
Adapted from the University of the West of Santa Catarina (UNOESC) 2006 In the book of scientific methodology of distance education. The equipment that is necessary to be used for field work, to collect geological data, hydrology and geological processing is as follows;

Table 1. Equipment collects geological data and water

No.	Equipment	Total	Function
1	Garmin GPS	1	Garmin GPS devices are versatile tools that cater to a wide range of navigation needs, from everyday driving to specialized outdoor activities.
2	Gloves	1	Gloves are protective hand coverings designed for various purposes, including safety, warmth, hygiene, and dexterity. They come in a wide range of materials, styles, and sizes to suit different applications.
3.	Cool Box	1	Cool boxes, also known as portable coolers are insulated containers designed to keep water.
4.	Camera	1	Cameras are devices used to capture images, either as photographs or videos.
5.	Clipboard/ Note Book	1	Clipboards and notebooks are essential tools for organizing notes, capturing ideas, and facilitating various tasks in both personal and professional settings.
6	Plastik Sample	1	Plastic samples refer to small, representative pieces of plastic materials used for various purposes, including testing, analysis, and demonstration.
7	Espidol and pencil	1	Markers and pencils are essential writing and drawing

No.	Equipment	Total	Function
			instruments used in various settings
8	Topography map	12	Topography maps are detailed representations of the Earth's surface that illustrate the terrain's physical features. They provide important information about elevation, landforms, and geographical features.
9	Bottle	1	Bottles are containers typically used for storing liquids, such as water

Source: Field research equipment inventory compiled for this study, 2024-2025

Locations Research

Location research was conducted in Bauro Village, Lospalos Administrative Post, Lautem Municipality, Goundwater quality analisis are analyzed in this study. For the local community, groundwater is a vital resource that supports economic activity, agriculture, and drinking water. The study is to map the distribution of important hydrogeology systems in the area, evaluate the quality of groundwater sources, and detect any contamined. In order to comprehend the physical attributes and landscape aspects of a particular area, this research focuses on the analysis of topographical maps. In-depth depictions of the terrain are provided by topography maps, which show landforms, elevation variations, and natural features like mountains, valleys, rivers, and lakes. These maps will be used in the study to evaluate land use, geographic trends, and possible environmental effects. In order to generate a thorough topographic profile, the study uses Geographic Information System (GIS) technology to assess elevation data, slope gradients, and contour lines. Important discoveries show notable differences in the distribution of landforms and elevation, which have an impact on local ecosystems, hydrology, and human activity. Areas vulnerable to erosion, flooding, and other natural hazards are also highlighted in the report.

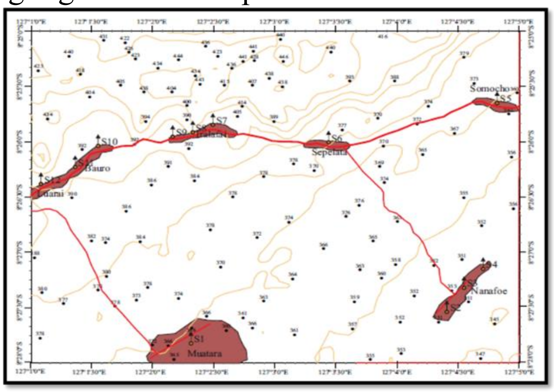

Figure 2. Topographic map of Bauro Village study area showing elevation contours, spring locations, and major geographical features

Source: Topographic map digitized using GIS technology from National Mapping Agency of Timor-Leste, scale 1:50,000, 2024

Survey

Mapping the geology research will be conducted in Bauro Village, Lautem Regency, Timor-Leste and Water samples will be taken from several springs used by the community for daily needs in Bauro Village is essential for understanding the region's geological features, mineral resources, and groundwater dynamics, research site located in Bauro, five villages took twelve (12) springs water to represent research area to analyze in the laboratory. The correct sampling method is in accordance with laboratory procedures (using sterilized sample bottles).

The hydrogeological study of Bauro, located in the Lospalos administrative post of Lautem Municipality, Timor-Leste, aims to understand the groundwater systems and their interactions with the local environment. This region is characterized by a complex geological framework, predominantly consisting of sedimentary rocks from the Baucau Formation at period middle Miosenic until Pleistosenic, which significantly influences groundwater recharge and quality.

Laboratory Testing

1. Chemical, physical and Microbiological Tests:

Water samples will be analyzed in the laboratory to measure various water quality parameters, such as:

Table 2. Chemical, physical and Microbiological Tests

Physical, Chemical, Biology Parameters	Analysis Method	Natural Range References DL No. 3/2020 Timor Leste	International Standards	References
pH	pH Meter	6,5 - 8,5	6,5 - 8,5	WHO, 1984
EC (μs)	Conductivity Meter	30 - 2000	100 μs - 1 ms	WHO, 2001
TDS (mg/L)	TDS Meter	1000	1000	WHO, 2001
Salinity (‰)	Conductivity Meter		< 1,0	AG NHMRC, 2017
Temperature (ºC)	Conductivity Meter		20 – 28	WHO, 2001
Clorida (Cl)	ICP-MS	0,1-25	250	WHO, 1993
Sodium (Na) - (mg/L)	ICP-MS		200	CDWQ, 2006
Sulphate (SO4) - (mg/L)	Spectrofotometer	2 – 70	250	**WHO,2004**
Fluoride (F) - (mg/L)	Spectrofotometer	0,02 – 2	1,5	**WHO, 1993**
Manganese (Mn) - (mg/L)	ICP-MS	0,2 – 20	0,5	**WHO, 1993**
Iron (Fe) - (mg/L)	ICP-MS	0,02 q– 3	0,3	**WHO, 2004**
Nitrite (NO2) - (mg/L)	Spectrofotometer	2 – 250	3	**WHO, 2004**
Nitrate (NO3) - (mg/L)	Spectrofotometer	0,3 – 30	50	**WHO, 2004**
Ammonia (NH3-N) - (mg/L)	Spectrofotometer	0,02 - 2,50	1,5	**WHO, 2004**
Magnesium (Mg) - (mg/L)	ICP-MS	0,07 - 4,00	50	CDWQ, 2006
Potassium (K) - (mg/L)	ICP-MS	< 25		**Ns**
Bicarbonate (HCO3) - (mg/L)	Titration	< 5 - 730		**Ns**
Chloride (Cl) - (mg/L)	Titration	0,1 – 25	250	**WHO,1993**
Arsenic (As) - (μg/L)	ICP-MS	0 – 100	10	**WHO, 2011**
Mercury (Hg) - (μg/L)	ICP-MS		2	**US EPA, 2006**
Lead (Pb) - (μg/L)	ICP-MS		10	**WHO, 2004**
Copper (Cu) - (μg/L)	ICP-MS	< 20	2000	**WHO, 2011**
Total Coliform - (MPN/100 ml)	MPN	0	0	**WHO, 1996**
Escherichia coli (E. coli) - (MPN/100 ml)	MPN	0	0	**WHO, 1996**

Source: Compiled from WHO drinking water quality guidelines (1984-2011)

Analysis Data

The data obtained will be analyzed using descriptive statistics to describe water quality conditions, then compared with drinking water quality standards from WHO and the Ministry of Health of Timor-Leste (Decree-Low 31/2020). The test results will be interpreted to determine the feasibility of the water and analyzed the factors that affect it such as human activities, geographical conditions, and weather. The quality of groundwater as a vital resource was analyzed through chemical, physical, and microbiological parameters, where the results showed significant influences from natural processes and human activities – including increased nitrates and phosphates from agricultural runoff, heavy metals from industrial pollution, and microbial contamination in areas with poor sanitation. The study also examines groundwater quality standards based on national and international guidelines, while identifying various contaminants such as pathogens, nutrients, heavy metals, and organic compounds along with their sources, transport mechanisms, and impacts on groundwater quality.

The general quality of water in different settings, such as rivers, lakes, and groundwater, is the Water Quality Index (WQI). Policymakers, environmentalists, and the general public may easily grasp water conditions thanks to its ability to incorporate several water quality metrics into a single numerical score.

The selection of criteria including pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), total dissolved solids (TDS), and nutrient levels (nitrates and phosphates) is highlighted in this paper's review of the methods used to compute WQI. The importance of each metric to water quality, aquatic life, and human health are taken into consideration while determining its weight.

Effective water management techniques and pollution control measures are made possible by the WQI, which is crucial for monitoring changes in water quality across time and space. Its use in evaluating the well-being of aquatic ecosystems and the efficiency of water treatment procedures is demonstrated by case studies.

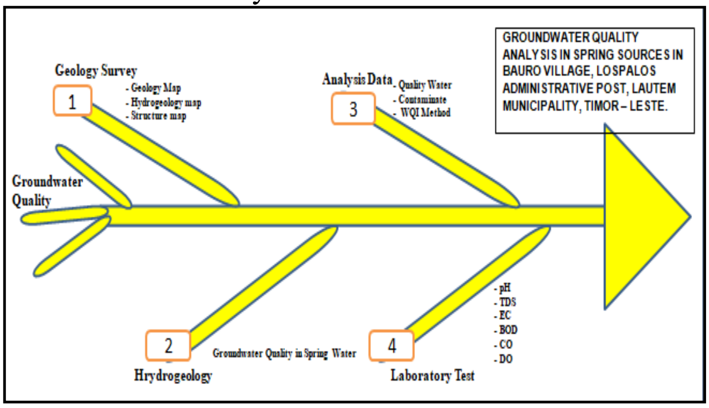

Figure 3. Guide of Research

Source: Research framework developed for this study

RESULTS AND DISCUSSION

Geology

The Baucau limestone reef, a plateau of dark coral rock dominating Bauro Village, forms part of the region's topography and consists mainly of limestone, calcarenite, and sandstone facies. Identified by Audley Charles (1968) as Pleistocene–Holocene in age, this formation features porous sandstone layers rich in gastropods and algae (UN, 2003). Its high permeability allows effective groundwater storage, with the dissolution process over time forming caverns and valleys, characteristic of karst aquifers. The Baucau Limestone, reaching up to 500 meters thick, serves as the primary aquifer system controlling groundwater flow in the Bauro area.

Figure. 4. Limestone and sandstone

Source: Field documentation, Bauro Village geological survey

According to petrographic analysis is a carbonate rock (limestone) with a micrite dominance, fine texture, intergranular porosity and intercrystalline permeability, it's included in the Mudstone according to Dunham's classification. Based on the petrographic analysis of a fine-grained limestone sample with the sample code Ju I, the following results were obtained: Mineralogical Composition Micrite (microcrystalline calcite): 92%, Sparry Calcite: 8%, Textural Characteristics Color: Grayish white, Grain size: Very fine-grained (calcified), Grading: Well calibrated, Porosity: Intergranular, Rock Classification, According to Dunham (1962), it is a mudstone,

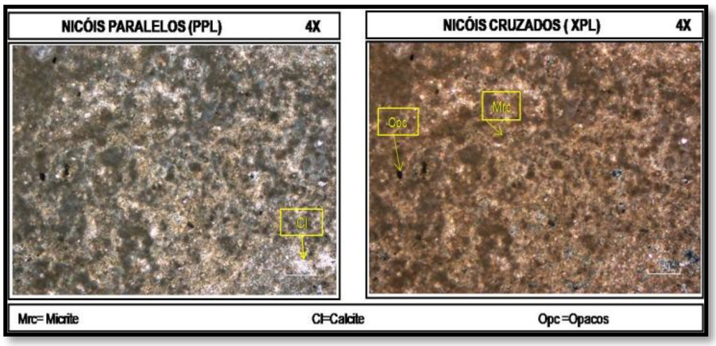

Figure 5. Petrographic analysis

Source: Petrographic analysis conducted at National Directorate of Water Services Laboratory, Timor-Leste, May 2024

Based on petrographic analysis of thin sections using a polarizing microscope, the following results were obtained, Mineralogical Composition, Sparry Calcite = 45%, Micrite = 33%, Bioclasts (fossil/organic fragments) = 22%, Texture & Structure, Color: Grayish brown, Grain size: Coarse (grossier), Grading: Poor (mal calibrada) Porosity: Intergranular and intraparticle, Classification. According to Dunham (1962) Packstone (granular carbonate rock with micrite matrix). The sample (Ju II) is a carbonate rock (limestone) with a dominant sparry calcite content and micrite, as well as significant bioclasts. Dunham classifies it as a packstone, while Folk classifies it as an unsorted biosparite. This rock exhibits a coarse texture with an uneven grain distribution, rich in bioclastic fragments.

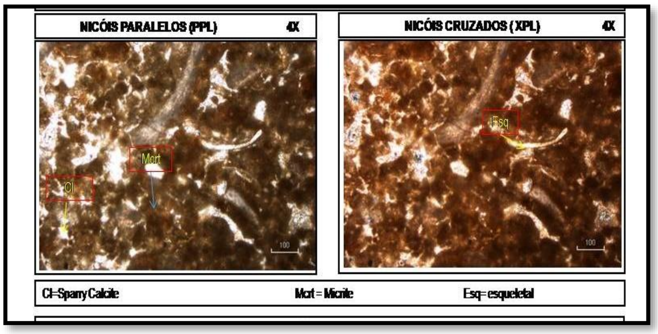

Figure 6. Petrographic analysis.

Groundwater quality of Spring Water

Groundwater quality in Bauro Village, assessed under Decree-Law No. 31/2020 by the Ministry of Health of Timor-Leste and verified by the National Water Services Laboratory, meets national and WHO standards for physical, chemical, and microbiological parameters. The study covered twelve perennial springs Muatara (S1), Nananfoe (S2–S4), Somocho (S5), Sepelata (S6), Iralafai (S7–S9), and Bauro-Luarai (S10–S12) which remain active even during climate variations, indicating stable hydrogeological conditions and reliable groundwater sources for the region.

Figure 7. Recearch of spring water location photo

The spring water is located in the area of Muatara, Bauro village which is long on the SE coast in the research area with its coordinate point, 08^{0}27'15"S, 127^{0}4'24"E, its elevation 366 meters from sea level. Water observed to come from calcilothic limestone with water physical characteristics of Ph 7.20, showed good final results according to international standards of conductivity 6.5-8.5 μs/cm, TDS with final results of 295, salinity 0.29, turbidity 0.15. This water is used to supply all communities in the Muatara community and surrounding areas. For those who consume the nascent residences, schools, and various uses of water for cultivation of yards, tos, varsea, as well as fob a animals and for construction. Based of result national laboraty by Decree-Law No. 31/2020 of August 26 Control of the Quality of Water for Human Consumption, by the Ministry of Health Timor Leste and analyses carried out by the National laboratory of the current National Direction of Water Services Timor-Leste.

The spring water is located in the area of Nanafoe, Bauro village which is long on the SE coast in the research area with its coordinate point, 08^{0}4'26"S, 127^{0}4'24"E, its elevation 353 meters from sea level. Water observed to come from calcilothic limestone with water physical characteristics of pH 7.02, showed good final results according to international standards of conductivity 6.5-8.5 μs/cm, TDS with final results of 320, salinity 0.32, turbidity 0.53. Laboratory result indicated that the microbiolocical contamination is present as total coliforms 82 and Escherichia Coli 33.

This water is used to supply all communities in the Nanafoe and surrounding areas. The solutions for community before consume water need to boiling water, Instruct the community to boil water before consumption to kill harmful bacteria. Use of water filters to promote the use of household water filters that are capable of removing bacteria. Addressing microbiological contamination in groundwater requires a multifaceted approach that includes immediate actions, community education, infrastructure improvements, and long-term sustainable practices. Through these solutions, the health risks associated with contaminated water can be significantly reduced, ensuring safer drinking water for the residents of Nanafoe, Bauro Village.

The spring water is located in the area of Nanafoe, Bauro village which is long on the SE coast in the research area with its coordinate point, 08^{0}27'42"S, 127^{0}4'33"E, its elevation 353 meters from sea level. Water observed to come from calcilothic limestone with water physical characteristics of pH 7.20, showed good final results according to international standards of conductivity 6.5-8.5 μs/cm, TDS with final results of 279, salinity 0.28, turbidity 0.61.

Laboratory result indicated that the microbiolocical contamination is present as total coliforms 27 and Escherichia Coli 13. This water is used to supply all communities in the Nanafoe and surrounding areas. The solutions for community before consume water need to boiling water, Instruct the community to boil water before consumption to kill harmful bacteria.

Use of water filters to promote the use of household water filters that are capable of removing bacteria. Addressing microbiological contamination in groundwater requires a multifaceted approach that includes immediate actions, community education, infrastructure improvements, and long-term sustainable practices. Through these solutions, the health risks associated with contaminated water can be significantly reduced, ensuring safer drinking water for the residents of Nanafoe, Bauro Village.

The spring water is located in the area of Nanafoe, Bauro village which is long on the SE coast in the research area with its coordinate point, $08^0$27'54"S, $127^0$4'48"E, its elevation 353 meters from sea level. Water observed to come from calcilothic limestone with water physical characteristics of pH 7,12, showed good final results according to international standards of conductivity 6.5-8.5 µs/cm, TDS with final results of 308, salinity 0.31, turbidity 0.41. Laboratory result indicated that the microbiolocical contamination is present as total coliforms 12 and Escherichia Coli 5.

This water is used to supply all communities in the Nanafoe and surrounding areas. The solutions for community before consume water need to boiling water, Instruct the community to boil water before consumption to kill harmful bacteria. Use of water filters to promote the use of household water filters that are capable of removing bacteria. Addressing microbiological contamination in groundwater requires a multifaceted approach that includes immediate actions, community education, infrastructure improvements, and long-term sustainable practices.

Through these solutions, the health risks associated with contaminated water can be significantly reduced, ensuring safer drinking water for the residents of Nanafoe area. Based of result national laboraty by Decree-Law No. 31/2020 of August 26 Control of the Quality of Water for Human Consumption, by the Ministry of Health Timor Leste and analyses carried out by the National laboratory of the current National Direction of Water Services Timor-Leste, the next anexe table.

The spring water is located in the area of Somocho, Bauro village which is long on the SE coast in the research area with its coordinate point, $08^0$26'37"S, $127^0$4'45"E, its elevation 362 meters from sea level. Water observed to come from calcilothic limestone with water physical characteristics of pH 7,43, showed good final results according to international standards of conductivity 6.5-8.5 µs/cm, TDS with final results of 271, salinity 0.27, turbidity 0.62. Laboratory result indicated that the microbiolocical contamination is present as total coliforms 13 and Escherichia Coli 0. This water is used to supply all communities in the Nanafoe and surrounding areas. The solutions for community before consume water need to boiling water, Instruct the community to boil water before consumption to kill harmful bacteria.

Use of water filters to promote the use of household water filters that are capable of removing bacteria. Addressing microbiological contamination in groundwater requires a multifaceted approach that includes immediate actions, community education, infrastructure improvements, and long-term sustainable practices. Through these solutions, the health risks associated with contaminated water can be significantly reduced, ensuring safer drinking water for the residents of Somocho area. Based of result national laboraty by Decree-Law No. 31/2020 of August 26 Control of the Quality of Water for Human Consumption, by the Ministry of Health Timor Leste and analyses carried out by the National laboratory of the current National Direction of Water Services Timor-Leste, the next anexe table.

The spring water is located in the area of Sepelata, Bauro village which is long on the SE coast in the research area with its coordinate point, $08^0$26'57"S, $127^0$3'30"E, its elevation 377 meters from sea level. Water observed to come from calcilothic limestone with water physical characteristics of pH 7,45, showed good final results according to international standards of conductivity 6,5-8,5 µs/cm, TDS with final results of 298, salinity 0,30, turbidity

0,47. Laboratory result indicated that the microbiolocical contamination is present as total coliforms 122 and Escherichia Coli 38.

This water is used to supply all communities in the Sepelata and surrounding areas. The solutions for community before consume water need to boiling water, Instruct the community to boil water before consumption to kill harmful bacteria. Use of water filters to promote the use of household water filters that are capable of removing bacteria. Addressing microbiological contamination in groundwater requires a multifaceted approach that includes immediate actions, community education, infrastructure improvements, and long-term sustainable practices.

Through these solutions, the health risks associated with contaminated water can be significantly reduced, ensuring safer drinking water for the residents of Sepelata area.

Based of result national laboraty by Decree-Law No. 31/2020 of August 26 Control of the Quality of Water for Human Consumption, by the Ministry of Health Timor Leste and analyses carried out by the National laboratory of the current National Direction of Water Services Timor-Leste, the next anexe table. The spring water is located in the area of Iralafai S7, Bauro village which is long on the SE coast in the research area with its coordinate point, 08^{0}26'6"S, 127^{0}2'35"E, its elevation 390 meters from sea level. Water observed to come from calcilothic limestone with water physical characteristics of pH 7,23, showed good final results according to international standards of conductivity 6,5-8,5 μs/cm, TDS with final results of 284, salinity 0,28, turbidity 0,35.

Laboratory result indicated that the microbiolocical contamination is present as total coliforms 35 and Escherichia Coli 16. This water is used to supply all communities in the Iralafai and surrounding areas. The solutions for community before consume water need to boiling water, Instruct the community to boil water before consumption to kill harmful bacteria. Use of water filters to promote the use of household water filters that are capable of removing bacteria. Addressing microbiological contamination in groundwater requires a multifaceted approach that includes immediate actions, community education, infrastructure improvements, and long-term sustainable practices. Through these solutions, the health risks associated with contaminated water can be significantly reduced, ensuring safer drinking water for the residents of Iralafai, area.

The spring water is in the area of Iralafai S8, Bauro village which is long on the SE coast in the research area with its coordinate point, 08^{0}26'03"S, 127^{0}2'31"E, its elevation 390 meters from sea level. Water observed to come from calcilothic limestone with water physical characteristics of pH 7,07, showed good final results according to international standards of conductivity 6,5-8,5 μs/cm, TDS with final results of 284, salinity 0,28, turbidity 0,51. Laboratory result indicated that the microbiolocical contamination is present as total coliforms 4 and Escherichia Coli 2. This water is used to supply all communities in the Iralafai and surrounding areas. The solutions for community before consume water need to boiling water, Instruct the community to boil water before consumption to kill harmful bacteria. Use of water filters to promote the use of household water filters that are capable of removing bacteria. Addressing microbiological contamination in groundwater requires a multifaceted approach that includes immediate actions, community education, infrastructure improvements, and long-term sustainable practices. Through these solutions, the health risks associated with contaminated water can be significantly reduced, ensuring safer drinking water for the residents of Iralafai, area.

The spring water is located in the area of Iralafai S9, Bauro village which is long on the SE coast in the research area with its coordinate point, 08^{0}26'0"S, 127^{0}2'08"E, its elevation 390 meters from sea level. Water observed to come from calcilothic limestone with water physical characteristics of pH 7,19, showed good final results according to international standards of conductivity 6,5-8,5 μs/cm, TDS with final results of 244, salinity 0,24, turbidity

0,92. Laboratory result indicated that the microbiolocical contamination is present as total coliforms 35 and Escherichia Coli 11.

This water is used to supply all communities in the Iralafai and surrounding areas. The solutions for community before consume water need to boiling water, Instruct the community to boil water before consumption to kill harmful bacteria. Use of water filters to promote the use of household water filters that can remove bacteria. Addressing microbiological contamination in groundwater requires a multifaceted approach that includes immediate actions, community education, infrastructure improvements, and long-term sustainable practices.

Through these solutions, the health risks associated with contaminated water can be significantly reduced, ensuring safer drinking water for the residents of Iralafai, area. Based of result national laboraty by Decree-Law No. 31/2020 of August 26 Control of the Quality of Water for Human Consumption, by the Ministry of Health Timor Leste and analyses carried out by the National laboratory of the current National Direction of Water Services Timor-Leste. The spring water is located in the area of Bauro S10, Bauro village which is long on the NE coast in the research area with its coordinate point, 08^{0}26'50"S, 127^{0}1'33"E, its elevation 392 meters from sea level. Water observed to come from calcilothic limestone with water physical characteristics of pH 7,20, showed good final results according to international standards of conductivity 6,5-8,5 μs/cm, TDS with final results of 308, salinity 0,31, turbidity 0,41. Laboratory result indicated that the microbiolocical contamination is present as total coliforms 12 and Escherichia Coli 5.

This water is used to supply all communities in the Bauro area. The solutions for community before consume water need to boiling water, Instruct the community to boil water before consumption to kill harmful bacteria. Use of water filters to promote the use of household water filters that are capable of removing bacteria. Addressing microbiological contamination in groundwater requires a multifaceted approach that includes immediate actions, community education, infrastructure improvements, and long-term sustainable practices. Through these solutions, the health risks associated with contaminated water can be significantly reduced, ensuring safer drinking water for the residents of Bauro area. Based of result national laboraty by Decree-Law No. 31/2020 of August 26 Control of the Quality of Water for Human Consumption, by the Ministry of Health Timor Leste and analyses carried out by the National laboratory of the current National Direction of Water Services Timor-Leste.

The spring water is located in the area of Bauro S11, Bauro village which is long on the NE coast in the research area with its coordinate point, 08^{0}26'43"S, 127^{0}0'26"E, its elevation 390 meters from sea level. Water observed to come from calcilothic limestone with water physical characteristics of pH 6,96, showed good final results according to international standards of conductivity 6,5-8,5 μs/cm, TDS with final results of 296, salinity 0,29, turbidity 0,36. Laboratory result indicated that the microbiolocical contamination is present as total coliforms 12 and Escherichia Coli 5. This water is used to supply all communities in the Bauro area. The solutions for community before consume water need to boiling water, Instruct the community to boil water before consumption to kill harmful bacteria. Use of water filters to promote the use of household water filters that can remove bacteria. Addressing microbiological contamination in groundwater requires a multifaceted approach that includes immediate actions, community education, infrastructure improvements, and long-term sustainable practices.

Through these solutions, the health risks associated with contaminated water can be significantly reduced, ensuring safer drinking water for the residents of Bauro area. Based of result national laboraty by Decree-Law No. 31/2020 of August 26 Control of the Quality of Water for Human Consumption, by the Ministry of Health Timor Leste and analyses carried out by the National laboratory of the current National Direction of Water Services Timor-Leste.

The spring water is located in the area of Bauro S12, Bauro village which is long on the NE coast in the research area with its coordinate point, $08^0$26'43"S, $127^0$0'26"E, its elevation 390 meters from sea level. Water observed to come from calcilothic limestone with water physical characteristics of pH 7,01, showed good final results according to international standards of conductivity 6,5-8,5 µs/cm, TDS with final results of 304, salinity 0,30, turbidity 0,41. Laboratory result indicated that the complies with standar parameter as total coliforms 0 and Escherichia Coli 0. This water is used to supply all communities in the Bauro area. Based of result national laboraty by Decree-Law No. 31/2020 of August 26 Control of the Quality of Water for Human Consumption, by the Ministry of Health Timor Leste and analyses carried out by the National laboratory of the current National Direction of Water Services Timor-Leste.

This data is the most important depth of spring water at ground until supsurface, start from minimal height 12 m – 28 m and masimal 56 m – 87 m betwin S1-S12 location of spring water in Bauro village. Clarified the result obtain in the area research are showing the next table 3.

Table 3. Spring water at ground until subsurface

Coordinate		Elevation	Height	Location
X	Y	(m)	(m)	Research
$127^0$2'24"E	$08^0$27'15"S	366	28	S1
$127^0$4'24"E	$08^0$27'02"S	353	18	S2
$127^0$4'33"E	$08^0$27'42"S	353	16	S3
$127^0$4'48"E	$8^0$27'54"S	353	12	S4
$127^0$4'45"E	$08^0$26'37"S	362	56	S5
$127^0$3'30"E	$08^0$26'57"S	377	60	S6
$127^0$2'35"E	$08^0$26'6"S	390	80	S7
$127^0$2'31"E	$08^0$26'03"S	390	82	S8
$127^0$2'08"E	$08^0$26'0"S	390	87	S9
$127^0$1'33"E	$08^0$26'50"S	392	69	S10
$127^0$0'26"E	$08^0$26'43"S	390	76	S11
$127^0$0'26"E	$08^0$26'43"S	390	56	S12

Hydrophysical of groundwater quality spring in area recearh

This study analyzes the hydrophysical characteristics of groundwater in the spring areas of Bauro Village. Turbidity levels ranged from 0.15–0.92 NTU, well below the national standard of 5 NTU, indicating generally clear water. pH values between 7.0–7.45 show neutral to slightly alkaline conditions suitable for aquatic life, while conductivity values of 503–657 µS/cm and TDS levels of 244–320 mg/L reflect moderate mineral content. Salinity ranged from 0.24–0.32 g/L, indicating good water quality. Overall, the results confirm that groundwater in Bauro meets national and WHO standards, emphasizing the need for ongoing monitoring to support sustainable water management and protect community health.

Table 4. Water Quality Data

Location Research	Color	pH	Total Dissolved Solid (TDS, mg/l)	Conductivity	Test and Odor	Salinity	Turbidity
S1	0	7.20	295	606	0	0.29	0.15
S2	0	7.02	320	657	0	0.32	0.53
S3	0	7.20	279	574	0	0.28	0.61
S4	0	7.12	318	653	0	0.32	0.43
S5	0	7.43	271	559	0	0.27	0.65
S6	0	7.45	298	613	0	0.30	0.47
S7	0	7.23	284	585	0	0.28	0.35
S8	0	7.07	284	586	0	0.28	0.51
S9	0	7.19	244	503	0	0.30	0.92
S10	0	7.20	308	633	0	0.30	0.41
S11	0	6.96	296	610	0	0.29	0.36

S12	0	7.01	304	626	0	0.30	0.41
Degree of Law Timor Leste, 31/2020 Standard	**20**	**6.5–8.5**	**1000**	**2500**	**0**	**0**	**5**

Hydrochemistry of groundwater quality spring in area recearh

Magnesium concentrations were found to be relatively low, ranging from 19.44 to 47.14 mg/L is considered low to moderate. These levels are important for assessing water quality, as magnesium plays a vital role in aquatic ecosystems and human health, because Nasional standartd Timor Leste Degree of Low No. 31/2020, the total is 50 mg/L. **Aluminum Levels** a range of 0.0011 to 0.035 mg/L is typically considered low. Calcium (Ca) levels in water, which can vary significantly based on the source, a range of 0.32 to 77.6 mg/L is quite broad normal, because nasional standartd is 100, a Langelier Index (LI) value of 0.15 is elevaded to indicate that the water is slightly supersaturated with calcium carbonate.

This suggests a tendency for the water to form scale, which can lead to mineral deposits in plumbing systems and appliances. While a positive LI value generally signifies lower corrosivity, ongoing monitoring is recommended to manage potential scaling and maintain water quality effectively, the next is table 5.

Table 5. Hydrophysical result of nasional laboratory

Location Research	Mg	Al	Calcium	Chlorides	Nitrates	Nitrites	LI
S1	47.14	0.007	77.6	1.2	1.03	0.04	0.53
S2	35.48	0.026	58.4	2.4	2.07	0.00	-0.05
S3	36.45	0.016	38.4	0.9	2.07	0.02	0.13
S4	27.22	0.012	44.8	0.9	1.12	0.06	0.04
S5	26.24	0.006	43.2	1.1	1.46	0.05	-0.25
S6	22.48	0.011	37.6	1.0	3.37	0.09	0.22
S7	23.33	0.007	38.5	1.5	6.60	0.06	-0.04
S8	41.31	0.035	68.1	1.1	2.98	0.05	-0.05
S9	36.45	0.010	60.0	0.6	0.91	0.03	0.13
S10	29.16	0.011	48.0	2.5	6.19	0.19	0.05
S11	23.8	0.012	39.2	1.0	2.52	0.08	-0.34
S12	19.44	0.011	32.0	0.8	3.12	0.08	-0.19
Degree of Law Timor Leste, 31/2020 Standard	50	0.2	100	250	11	0.15	-0.5 – +0.5

Hydrobiology of groundwater quality spring in area research

This study investigates the hydrobiology of groundwater quality in a selected area, focusing on the biological parameters that influence water health. Groundwater samples were collected from various springs in Bauro start from S1 Location until S12 in research area, The recorded levels were 82, 27, 71, 13, 122, 4, 35, and 12 CFU/100 mL. Notably, the highest concentration of 122 CFU/100 mL raises concerns regarding potential contamination at that site. The variability among samples indicates differing levels of microbial safety, with some sites requiring immediate attention to mitigate health risks. These findings emphasize the necessity for regular monitoring of coliform levels in groundwater to ensure safe drinking water and to inform public health strategies aimed at reducing contamination sources.

This study presents laboratory results for the concentrations of Escherichia coli in groundwater samples, with total values recorded as follows: 33, 13, 27, 38, 16, 2, 11, and 5 CFU/100 mL. The highest concentration, 38 CFU/100 mL, indicates significant potential contamination at that site, while the lowest value was 2 CFU/100 mL. The variability in E. coli levels across samples underscores the need for regular monitoring to ensure water safety for local communities. These findings highlight the importance of identifying contamination sources and implementing effective management strategies to protect public health and groundwater quality.

Elevated levels of fecal coliforms were observed at several sites, indicating potential contamination and posing health risks to local communities relying on these water sources. These findings highlight the need for regular monitoring and assessment of microbial quality in groundwater to ensure public health safety and inform water management strategies.

Effective interventions are crucial for mitigating contamination risks and safeguarding water quality, by standard quality water of Degree Low No. 31/2020 of Minister Healt of Timor Leste is 0 (zero). the next is table 6.

Table 6. Hydrobiological result of national laboratory

Location Research	Total Coli Forms	Escherichia coli
S1	0	0
S2	82	33
S3	27	13
S4	71	27
S5	13	0
S6	122	38
S7	35	16
S8	4	2
S9	35	11
S10	12	5
S11	0	0
S12	0	0
Degree of Law Timor Leste, 31/2020 Standard	**0**	**0**

Rainfall on groundwater

The rainfall map compiled in this study provides an overview of the distribution of rainfall intensity in Bauro Village, Lospalos Administrative Post, Lautem Municipality, Timor-Leste. Based on climatological data, this area falls within a tropical climate zone with distinct rainy and dry seasons. Average annual rainfall is relatively high, but its distribution is uneven throughout the year.

Rainfall plays a crucial role in aquifer recharge. In the study area, the aquifer is dominated by carbonate rocks in the form of mudstone, micrite, and packstone. Carbonate rocks vary in porosity and permeability, with packstone zones tending to be more porous and allowing greater rainfall infiltration than relatively dense mudstone. Therefore, rainfall maps combined with geological data can identify the best potential recharge zones.

The interpretation of the results shows that areas with high rainfall intensity are positively correlated with increased spring discharge during the rainy season. Conversely, during the dry season, spring discharge decreases drastically, indicating that groundwater availability is highly dependent on seasonal rainfall patterns. This demonstrates the importance of rainfall maps in understanding aquifer dynamics in the Bauro region.

The region experiences significant annual rainfall, which replenishes groundwater supplies, particularly during the wet season from December to May. However, heavy rainfall events can lead to flooding, washing pollutants into groundwater sources and increasing the risk of contamination, including the presence of coliform bacteria such as *E. coli*.

Seasonal variations in groundwater levels and flow are evident, with reduced flows during the dry season, highlighting the reliance on rainfall for sustaining groundwater resources. Additionally, climate change poses risks to these systems, with altered rainfall patterns potentially affecting groundwater recharge and availability. This research emphasizes the need for effective water management strategies to mitigate the impacts of rainfall on groundwater quality, ensuring the sustainability of water resources for the community. The findings aim to inform local conservation efforts and enhance the protection of groundwater sources in Bauro Village, the table of rainfall the research area.

PARAMETER	Yaer	J	F	M	A	M	J	J	O	S	O	N	D	ANN
PRECTOTCORR_SUM	2024	305.9	316.4	94.92	256.5	16.7	18.39	0	8.57	24.5	30.21	95.54	196.8	1364.4
PRECTOTCORR_SUM	2025	265.7	223.7	126.92	32.05	30.93	93.6	2.7						

Figure 8. Monthly rainfall distribution graph for Bauro Village showing seasonal variation between wet season (December-May) and dry season (June-November)

Aquifer of groundwater

The aquifer map generated from this study illustrates the distribution and potential groundwater storage in Bauro Village, Lospalos Administrative Post, Lautem Municipality, Timor-Leste. The aquifer in this area is dominated by carbonate limestone with petrographic classifications of mudstone, micrite, and packstone, characterized by intergranular and intraparticle porosity. These conditions allow for significant groundwater storage and movement.

Based on map interpretation, there is a close relationship between the lithology of the aquifer and its groundwater storage capacity. Areas composed of mudstone have relatively low porosity, thus limiting their storage capacity, while areas dominated by packstone and biosparite exhibit better porosity, thus functioning as productive aquifers.

Besides lithology, rainfall plays a crucial role in aquifer recharge. Combined with aquifer maps, rainfall maps show that areas with high rainfall intensity have greater recharge potential. This has implications for the sustainability of groundwater availability, particularly during the dry season.

Furthermore, rainfall maps also help explain variations in groundwater quality. Locations with high recharge tend to have better physical and chemical quality due to natural dilution processes. However, from a microbiological perspective, several locations still showed Total Coliform and E. coli contamination, indicating that human activities around the springs also influence water quality, beyond rainfall alone.

Hydrochemistry of Groundwater

The groundwater samples taken directly from spring wells were then tested for their physical and chemical properties in the laboratory. The parameters tested included turbidity, TDS, and pH. The table shows that the groundwater looks clear to cloudy, relatively acidic, with a low TDS (fresh) to quite high (brackish). The high standard deviation is indicated by the values of TDS, Mg2+, and SO42- due to anomalies in the shallow well groundwater sample in Bauro. The other samples generally showed acceptable groundwater quality. The results of the field survey showed that in general the groundwater from springs is odorless, tasteless, colorless/clear, while there are some areas with low groundwater quality.

Discussion of WQI Results, 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 WQI value formula that has been used by previous researchers (Bowen, 1986; Kawo & Karuppannan, 2018; RamyaPriya & Elango, 2018).

The WQI value is determined based on weight (wi) for each groundwater, relative weight (Wi) and quality rating scale (qi). The wi value is determined by referring to (Kawo & Karuppannan, 2018). The value of Wi is determined by the following formula. $Wi = wi / (\Sigma wi)$ (1) The value of qi is calculated based on the concentration of groundwater (ci) and standard value of groundwater (si) which refers to the standard of the Timor-Leste Minister of Health Regulation Degree Low (Permenkes) 31/2020 for drinking and for clean water. $qi = ci / si \times 100$

(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 x qi (3) WQI = ΣSI (4) Furthermore, the water class is determined based on the classification of Sahu & Sikdar (2008)

1. Physiochemical Category

a. Most samples (S1, S2, S3, S4, S5, S6, S7, S9, S11) were categorized as Excellent, with WQI_PhysChem values ranging from 8.43 to 24.35.
b. Samples S8 and S12 were categorized as Good, indicating quality that was still suitable for use.
c. Sample S10 was the only sample categorized as Unsuitable, with a very high WQI value (1821.13), likely influenced by high levels of one of the chemical parameters (e.g., nitrite/nitrate or conductivity).

2. Microbiology Results

Although most of the water was categorized as Excellent physically and chemically, many locations showed microbiologically substandard results.

a. Seven locations (S2, S3, S4, S5, S6, S7, S8, S9) were contaminated with coliform and/or E. coli. This indicates the influence of human or animal activity around the water source.
b. b. Only three locations (S1, S11, S12) were completely safe from a microbiological perspective.

Table 8.

Location	WQI_PhysChem	Category	Total Coliform	E. coli	Microbial Status
S1	24.35701474	Excellent	0	0	Safe
S2	13.14797249	Excellent	82	33	Contaminated
S3	15.91634218	Excellent	27	13	Contaminated
S4	10.72476484	Excellent	71	27	Contaminated
S5	23.17473719	Excellent	13	0	Contaminated
S6	10.1466611	Excellent	122	38	Contaminated
S7	9.104131393	Excellent	35	16	Contaminated
S8	28.33453723	Good	4	2	Contaminated
S9	8.430574395	Excellent	35	11	Contaminated
S10	1821.135478	Unsuitable	12	5	Contaminated
S11	9.976498809	Excellent	0	0	Safe
S12	33.61119761	Good	0	0	Safe

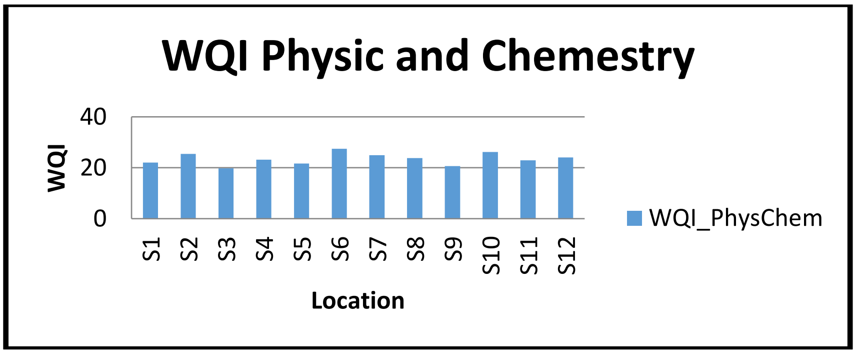

Figure 9. WQI Phisic and Chemestry

This situation emphasizes that water quality assessments are not solely based on physical and chemical parameters; microbiological aspects must also be considered. A high WQI value (Excellent category) can be misleading without biological analysis, as the water may be visually clear but still contain harmful bacteria. Sample S10 requires special attention due to its WQI value. Very high levels indicate serious chemical contamination. Groundwater

Management Implicationso Water from locations with a Contaminated status must undergo a treatment process (e.g., filtration, disinfection/chlorination, or boiling) before it is suitable for consumption. Locations with a Safe status (S1, S11, S12) can be prioritized as a source of clean water for the community, although regular monitoring is still required. These results also demonstrate the importance of protecting recharge areas and spring zones from potentially polluting activities (waste disposal, livestock, and domestic activities).

Based on the physical-chemical WQI calculations, most samples (S1–S7, S9, S11) are categorized as Excellent, two samples (S8, S12) are categorized as Good, and one sample (S10) is categorized as Unsuitable due to its very high WQI value. Microbiological results indicate that only three locations (S1, S11, S12) are completely free from coliform and E. coli contamination, while the majority of other locations remain contaminated. This indicates that the groundwater quality in Bauro Village is relatively good physically and chemically, but still faces serious microbiological problems.

Table 9.

Location	pH	TDS	Conductivity	Salinity	Turbidity	Mg	Al	Ca	Chlorides	Nitrates	Nitrites	LI
S1	7.20	295	606	0.29	0.15	47.14	0.007	77.6	1.2	1.03	0.04	0.53
S2	7.02	320	657	0.32	0.53	35.48	0.026	58.4	2.4	2.07	0.00	-0.05
S3	7.20	279	574	0.28	0.61	36.45	0.014	60	0.6	1.04	0.02	0.13
S4	7.12	318	653	0.32	0.43	27.22	0.012	44.8	0.9	1.12	0.05	-0.03
S5	7.43	271	559	0.27	0.65	26.24	0.006	43.2	1.1	1.46	0.05	0.25
S6	7.45	298	613	0.30	0.47	22.48	0.011	37.6	1.0	3.37	0.00	0.22
S7	7.23	284	585	0.28	0.35	23.33	0.007	38.4	1.5	6.60	0.00	-0.04
S8	7.07	284	586	0.28	0.51	41.31	0.035	68	1.1	2.98	0.05	-0.05
S9	7.19	244	503	0.24	0.92	36.45	0.010	60	0.6	0.91	0.00	0.16
S10	7.20	308	633	0.00	0.41	29.16	0.011	48	2.5	6.19	0.19	0.03
S11	6.96	296	610	0.29	0.36	23.8	0.012	39.2	1.2	2.52	0.00	-0.23
S12	7.01	304	626	0.30	0.41	19.44	0.011	32	0.8	3.12	0.08	-0.19

Recommendations

1. Water from microbiologically contaminated locations should not be consumed directly, but should be treated with simple treatments such as boiling or chlorine disinfection.
2. Locations with a Safe status (S1, S11, S12) can be prioritized as primary drinking water sources, but regular monitoring is still required.
3. Local governments and communities need to protect catchment areas and spring zones from activities that could pollute them, such as domestic waste disposal, livestock pens, or intensive agricultural activities.
4. Regular water quality monitoring is necessary to ensure changes in quality over time, especially during the rainy season when the risk of microbiological contamination increases.

Table 10.

Location	WQI_PhysChem	Category	TotalColiform	Ecoli	Microbial_Status
S1	24.35701474	Excellent	0	0	Safe
S2	13.14797249	Excellent	82	33	Contaminated
S3	15.91634218	Excellent	27	13	Contaminated
S4	10.72476484	Excellent	71	27	Contaminated
S5	23.17473719	Excellent	13	0	Contaminated
S6	10.1466611	Excellent	122	38	Contaminated
S7	9.104131393	Excellent	35	16	Contaminated
S8	28.33453723	Good	4	2	Contaminated
S9	8.430574395	Excellent	35	11	Contaminated
S10	1821.135478	Unsuitable	12	5	Contaminated
S11	9.976498809	Excellent	0	0	Safe
S12	33.61119761	Good	0	0	Safe

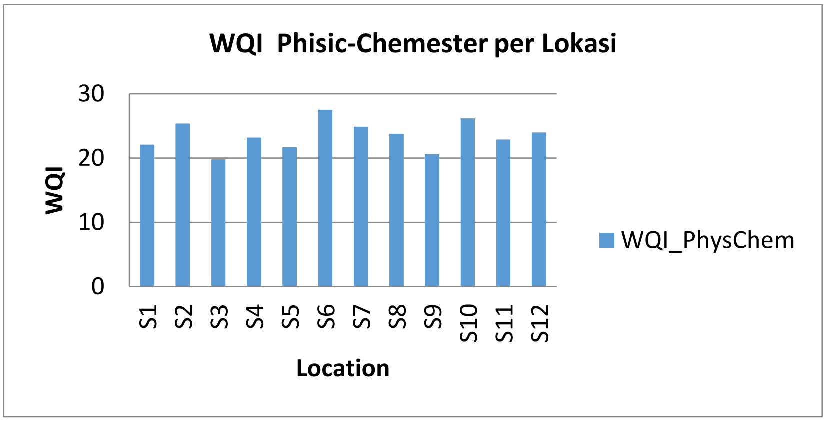

Figure 10. WQI Phisic-Chemester per Lokasi

Geology of research area

The geology of the study area is dominated by carbonate sedimentary rocks with strong tectonic influences resulting in fold and fault structures. The presence of carbonate and alluvial aquifers makes this area important for groundwater studies, although vulnerability to contamination remains high due to secondary porosity and human activity in both the highlands and lowlands. Hydro geological Implications, Carbonate aquifers (limestone–calcarenite) have secondary porosity (fractures, certification), thus serving as the primary groundwater reservoir. Alluvial aquifers (sand and gravel) are shallow, easily accessible, but susceptible to contamination. Clay/marl layers serve as a barrier (aquitard).

CONCLUSION

The analysis of groundwater quality in Bauro Village, Lospalos, Timor-Leste, indicates variations in key parameters, with certain sites showing risks of contamination that may threaten public health. While concentrations of magnesium, aluminum, and calcium generally comply with national standards, elevated levels of total coliform and *E. coli* in some areas suggest microbial pollution requiring urgent mitigation. To ensure long-term water safety, continuous monitoring, improved sanitation, and sustainable agricultural practices should be prioritized, alongside community engagement in water quality awareness and testing initiatives. Future research should focus on seasonal variations, hydrogeological influences, and the development of predictive models to better understand contamination pathways and guide preventive water management strategies.

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