

Assessment of potable water quality in Sitio Sarimao, Pasacao, Camarines Sur: Physicochemical and microbiological analysis

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Abstract

This study employed a qualitative descriptive research design to assess the current water quality status of Sitio Sarimao, Pasacao, Camarines Sur, and to identify potential sources of contamination across three selected sampling sites. Water samples were analyzed for physical, chemical, and microbiological parameters, with emphasis on Fecal Coliform. The investigation followed the Environmental Management Bureau–Department of Environment and Natural Resources (EMB–DENR) Water Quality Monitoring Manual (Volume I and II), utilizing in situ measurements and analyses conducted by accredited government laboratories. Results were evaluated against the standards set by DAO2016-08. Findings revealed that two sampling sites complied with both physicochemical and microbiological standards, while one site passed only the physical and chemical criteria but failed the microbiological requirement. Moreover, observed potential contamination sources included saltwater intrusion, livestock discharge, and land use/urbanization, all occurring within the 25-meter minimum setback for water sources. The study concludes that although two sites were classified as potable, the presence of these contamination risks poses significant threats, particularly at Station 1, which is more vulnerable to saltwater intrusion and livestock discharge, and Station 2, which is susceptible to contamination from residential activities and livestock presence. Furthermore, these findings underscore the need for continuous monitoring and community-based management to safeguard

local water resources.

Keywords: EMB–DENR, DAO2016-08, fecal coliform, saltwater intrusion, contamination sources

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1. Introduction

Water is a vital natural resource essential for life, ecosystems, and socio-economic development; however, despite its abundance, only about 3% of Earth's water is freshwater, much of which is inaccessible due to being stored in glaciers and deep groundwater, highlighting the need for effective management (United Nations, 2023). Globally, water scarcity and declining water quality have become critical concerns driven by population growth, urbanization, industrialization, and climate change. Over two billion people still lack access to safe drinking water, and many urban systems struggle to meet demand, as seen in places like Manhattan, where aging infrastructure affects supply, and Cape Town, which experienced the "Day Zero" crisis due to severe drought (World Health Organization, 2022).

Water pollution and inadequate sanitation remain major issues in the Eastern Hemisphere, driven by rapid urbanization and poor wastewater management, which contribute to groundwater contamination and declining water quality. Many countries struggle to balance development with environmental protection, resulting in increased risks to both ecosystems and public health (Li et al., 2021). In the Philippines, freshwater resources are under growing pressure due to population growth, urbanization, and environmental degradation. Despite having abundant water sources, pollution from wastewater, agricultural runoff, and improper waste disposal continues to threaten water quality, particularly in densely populated areas where microbial contamination is prevalent (DENR, 2021; Castro & Obusan, 2024).

In rural areas such as the Bicol Region, many communities still depend on natural water sources, which are vulnerable to contamination and seasonal shortages. In Sitio Sarimao, Pasacao, the lack of water quality data highlights the need to assess physicochemical and microbiological conditions to ensure safety and identify potential health risks (DOH, 2024; Reyes et al., 2023).

Objectives of the Study

- To determine the physicochemical characteristics of the water sources, including Calcium, Chloride, Color, Magnesium, Nitrate, pH, Phosphate, Salinity, Temperature, and Total Suspended Solids (TSS)
- To evaluate the microbiological quality of water based on the presence of Fecal Coliform.
- To identify potential sources of water contamination through field observation and local investigation.
- To provide practical recommendations for improving water quality and ensuring the safety of water used by the local community, with the recommendations guided by the insights and expertise of professionals in the field.

2. Methodology

This section outlines the research design, methods, and data gathering procedures used to assess water quality in Sitio Sarimao, Pasacao. It ensures a clear, systematic, and reliable approach to achieving the study's objectives.

Area of the Study - The study was conducted in Pasacao, Camarines Sur, Philippines, a coastal municipality characterized by both upland and lowland areas and facing the Ragay Gulf. Pasacao is recognized as the summer capital of Camarines Sur and is an emerging center for economic and tourism activities (GOV PH, 2023). The specific study site, Sitio Sarimao, is located at 13°31'25.4" N and 123°00'04.9" E. It is a rural community consisting of approximately 297 households, many of which rely heavily on natural water sources for daily

activities. Due to its coastal setting, the sitio depends on local water systems, including groundwater and artesian wells, which serve as the primary sources of water for the community. Shown in (Figure 1).

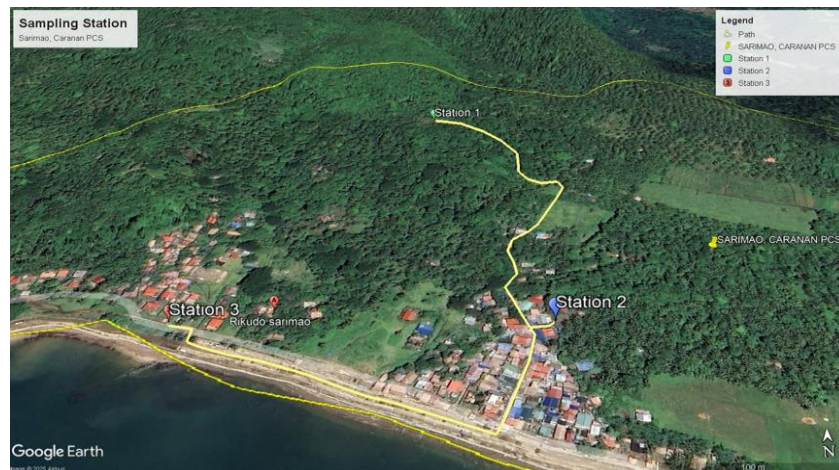


Figure 1. Sitio Sarimao, Sampling Station Map, Source Google Map, 2025.

Sample Stations - Three (3) sampling stations were established within Sitio Sarimao to collect water samples from the primary sources utilized by the local community. These stations were strategically selected to represent variations in elevation, surrounding land use, and potential exposure to environmental and anthropogenic influences. Station 1 is located at a higher elevation and consists of a Small Water Impounding System (SWIS) surrounded by trees and diverse vegetation (Figure 2). The presence of dense flora provides natural protection to the water source, potentially reducing direct contamination while also influencing physicochemical characteristics through organic matter input.



Figure 2. Sampling Station 1, Small Water Impoundment System



Figure 3. Sampling Station 2, Artesian Well



Figure 4. Sampling Station 3, Artesian Well

Stations 2 and 3 are situated in the lower portions of the sitio and are classified as water pump sources (artesian well). Station 2 is located within a densely populated area and is heavily utilized for domestic purposes, livestock activities, and recreational use (Figure 3). Due to the intensity of human and animal activities in the vicinity, this station is more susceptible to contamination from surface runoff and improper waste disposal. Station 3, positioned at the lowest elevation, is located near a roadway and a newly constructed seawall (Figure 4). Its proximity to infrastructure development and coastal modifications increases the potential for environmental stressors, including urban runoff and saltwater intrusion, which may affect water quality.

Research Design - This study employed a qualitative descriptive research design to thoroughly assess the water quality in Sitio Sarimao, Pasacao. The design ensures both the quantification and in-depth discussion of key physicochemical parameters, including; calcium, chloride, color, magnesium, nitrate, pH, phosphate, salinity, temperature, and total suspended solids (TSS). Additionally, the study analyzed the microbiological quality of the water, focusing on the detection of Fecal Coliform. The descriptive approach provides a clear and detailed understanding of the current condition of the water, enabling the identification of potential health and environmental concerns. The results gathered serve as a basis for future recommendations and community action to improve water safety and sustainability.

Research Method - This study employed a systematic approach to assess the water quality in Sitio Sarimao, Pasacao, focusing on three identified water sampling sites. These sources are primarily used by the local community for essential activities such as drinking, cooking, and hygiene practices. Two of the sampling points are situated in the lower part of the barangay, while the main water source is located at a higher elevation, where the primary water supply originates. Conducting field reconnaissance before selecting sampling sites. It highlights how such reconnaissance helps note conditions that may affect sampling, like access issues, seasonal changes, or potential sources of contamination, ensuring representative, accurate and safe sample collection (Wilde. F., 2005). Water sample collection and analysis followed standard procedures from EMB–DENR and MNWD to ensure accuracy and reliability. Laboratory analyses were conducted in accredited facilities, including the Regional Soil Laboratory (RSL) in Pili, Environmental Health Laboratory Services Cooperative in Naga City, and Bicolandia Environmental Testing & Consultancy Services in Legazpi City.

Additionally, bacteriological testing was conducted based on the established protocols of the Metropolitan Naga Water District (MNWD) to ensure precise evaluation of microbiological parameters. This methodological framework ensures that the data gathered are scientifically accurate and suitable for drawing meaningful conclusions regarding the safety and quality of the local water supply. Each site was closely monitored to identify any existing environmental or human-related factors that may contribute to water contamination. In-situ observation is crucial for assessing water quality as it enables the immediate detection of environmental conditions and potential contamination sources that may not be apparent through laboratory analysis alone (Carrington, 2024).

The parameters pH, salinity, and temperature were measured in-situ to obtain accurate, real-time data on water conditions. On-site testing minimizes changes during transport and ensures reliable results for water quality assessment (Carrington, 2024). Water samples were promptly transported to accredited laboratories for microbiological analysis and for determining nitrate and phosphate levels. Immediate processing is essential, as delays can alter water quality and affect accuracy. According to WHO guidelines, samples should be analyzed within 6 hours or within 24 hours if properly stored at 4–10°C (Aquaya, 2025). Water sampling followed standardized EMB–DENR protocols, including proper sampling procedures and use of personal protective equipment (PPE), to ensure accuracy, safety, and sample integrity. These standardized methods promote consistency in collection, preservation, and analysis, reducing errors and ensuring reliable and comparable water quality results (WHO, 2022).

Data Gathering Procedure - This study followed EMB–DENR Water Quality Monitoring Manual Volume I and MNWD bacteriological testing protocols to ensure proper water sample collection and accurate analysis. Three sampling sites in Sitio Sarimao were identified, and sterilized containers were used to prevent contamination

(Figure 5). Prior to sampling, water pipes were disinfected using sodium hypochlorite and flame-sterilized with 70% isopropyl alcohol (flFigure 6). Water was then collected after allowing it to flow briefly, ensuring proper handling and avoiding air bubbles to maintain sample integrity and reliable results.



Figure 5. Container Sterilization



Figure 6. Flaming The Nozzle of Water Source for 30 Seconds

To assess the physicochemical parameters on-site at the three (3) sampling stations, the researchers utilized specialized instruments to ensure accurate and reliable measurements, following established guidelines and detailed step-by-step procedures to ensure the accuracy and consistency of results. The sample collection process conducted using proper techniques and protective equipment, strictly adhering to the protocols outlined in the Environmental Management Bureau – Department of Environment and Natural Resources (EMB–DENR) Water Quality Monitoring Manual.

- pH meter used to determine the hydrogen ion concentration, indicating the acidity or alkalinity of the water. Water is on a scale from 0 to 14. A pH of 7 is neutral, below 7 is acidic, and above 7 is basic. It is important because extreme pH levels can affect water safety and the health of organisms. The pH test performed three times per sample, and the average taken for more accurate data presentation (Figure 7).
- Salinometer measure the salinity, or the amount of dissolved salts present. The salinity of each sample tested three times, and the average result will be used for accuracy (Figure 8).
- To measure the temperature, thermometer used on-site to determine the current temperature of the water sources, the test performed three times, and average for accurate data collection (Figure 9).



Figure 7. Measuring of pH, Using pH Meter



Figure 8. Salinity Measurement, Using Salinometer



Figure 9. Measuring of Temperature, Using pH Meter in Temperature Reading

The biological quality of water, particularly fecal coliform, was analyzed at the Metropolitan Naga Water District (MNWD) laboratory. Physicochemical parameters such as calcium, chloride, color, and magnesium were examined at the Environmental Health Laboratory Services Cooperative in Naga City, Camarines Sur, while total suspended solids (TSS) were tested at Bicolandia Environmental Testing & Consultancy Services in Legazpi City, Albay. Nitrate and phosphate analyses were conducted at the Regional Soil Laboratory (RSL) in Pili, Camarines Sur.

After collection, water samples were properly stored, placed in ice boxes, and promptly transported to the respective laboratories to preserve sample integrity and minimize changes in microbial content (Figure 10). The results were then evaluated and compared with the standards set by DENR Administrative Order (DAO) 2016-08 and the Philippine National Standards for Drinking Water (PNSDW) to determine the suitability of the water for human consumption.



Figure 10. Sample Preservation

3. Results and Discussion

The following section presents the consolidated results from the four participating laboratories, covering all measured water quality parameters across the study area. These include the applicable standards for evaluation

and the final remarks for each of the three sampling stations, providing a basis for assessing the overall condition and compliance of the water sources with water quality guidelines.

The (Table 1) shows a clear contrast in water quality among the three sampling stations, highlighting the influence of geological conditions and surrounding land use. Stations 1 and 2 generally complied with DAO 2016–08 standards, indicating relatively stable conditions, while Station 3 showed notable deviations, particularly in microbiological parameters, suggesting the influence of nearby human activities and coastal exposure. These results serve as a basis for understanding water safety, ecological conditions, and implications for future water resource management in the area.

Table 1
Physical and Chemical Analysis in Comparison with DAO2016-08 Water Quality Standard in Class AA, 2025

Physical Parameters	DAO – 2016 Standard	Station 1	Remarks
Color	5 TCU	3 TCU	PASSED
Salinity	<0,05%	0%	PASSED
Temperature	26 °c – 30 °c	27.8 °c	PASSED
Total Suspended Solids (TSS)	25 mg/L	1.0 mg/L	PASSED
Chemical Parameters			
Calcium	300 mg/L	71.6 mg/L	PASSED
Chloride	250 mg/L	17.7 mg/L	PASSED
Magnesium	300 mg/L	9.26 mg/L	PASSED
Nitrate	7 mg/L	3 mg/L	PASSED
Hydrogen Ion Concentration (pH)	6.5 – 8.5	7.44	PASSED
Phosphate	<0.003 mg/L	<0.003 mg/L	PASSED

Physical Parameters	Station 2	Remarks	Station 3	Remarks
Color	3 TCU	PASSED	3 TCU	PASSED
Salinity	0%	PASSED	0%	PASSED
Temperature	29.9 °c	PASSED	29.4 °c	PASSED
Total Suspended Solids (TSS)	1.0 mg/L	PASSED	1.0 mg/L	PASSED
Chemical Parameters				
	77.6 mg/L	PASSED	77.0 mg/L	PASSED
Calcium				
Chloride	31.1 mg/L	PASSED	36.3 mg/L	PASSED
Magnesium	13.4 mg/L	PASSED	29.0 mg/L	PASSED
Nitrate	3 mg/L	PASSED	3 mg/L	PASSED
Hydrogen Ion Concentration (pH)	7.44	PASSED	7.54	PASSED
Phosphate	<0.003 mg/L	PASSED	<0.003 mg/L	PASSED

3.1 Physicochemical Analysis

Color (TCU) - Data shows the consistently low color value of 3 True Color Units (TCU) observed across all sample stations indicates that the water possesses minimal apparent coloration and remains within the acceptable limits set for potable water. Despite this low measurement, it is important to recognize that several environmental and geochemical factors can influence water color even at low concentrations. One of the most common contributors is dissolved organic matter (DOM), particularly humic and fulvic substances derived from the decomposition of vegetation and soil organic materials. These compounds can impart a yellow to brown tint to water and are widely recognized as natural colorants in groundwater and surface water (Water Quality Training Canada, 2025). In addition to organic matter, metals and minerals—particularly iron (Fe) and manganese (Mn)—are known to influence water color. When exposed to oxygen, dissolved iron can oxidize and form reddish or brown precipitates, while manganese may produce darker discoloration. Studies confirm that these metals are among the primary contributors to color formation in drinking water systems (Kim et al., 2023).

Water clarity (or transparency) is an indicator of how far light can penetrate through the water column and is important for aquatic ecosystems, drinking water, aesthetics and recreational values (Department of Environment, Science and Innovation, Queensland, 2023). The United States Environmental Protection Agency (EPA) (2022) classifies color under secondary drinking water standards, meaning it affects taste, odor, and consumer acceptance rather than health. Water with low color levels encourages higher usage and trust in water sources, which is particularly important in communities that rely on natural wells and springs. Nevertheless, despite the presence of

these potential color-altering factors, the measured color value of 3 TCU indicates that the water across all stations meets the potable standard of DAO2016-08, and is considered aesthetically acceptable for drinking. This suggests that the levels of dissolved organics, metals, and particulates remain either naturally low or sufficiently filtered within the aquifer system to maintain high water clarity.

Salinity (%) - Data revealed that the three stations exhibit (0%) salinity level, salinity in groundwater systems can nonetheless be influenced by key natural processes. In particular, geology and mineral dissolution, saltwater intrusion, and groundwater depth and residence time are three critical factors that could potentially increase salinity under certain conditions. In the study area, geological dissolution of evaporite minerals may supply dissolved salts over time. In their study, Callistus et al (2024) identify evaporite deposits (halite, gypsum, and anhydrite) as major geogenic sources of salinity in coastal groundwater systems. These minerals dissolve when groundwater flows through them, thereby contributing ions like Na^+ , Cl^- , Ca^{2+} , and SO_4^{2-} , which elevate salinity. They also note that anthropogenic influences (e.g., sewage, industrial effluents) can exacerbate salinization, but even without those, mineral-water interactions alone can significantly raise groundwater salinity over time. Moreover, Station 3, being near the shore, remains vulnerable to seawater intrusion, which can introduce marine-derived ions (e.g., Cl^- , Na^+) into the aquifer. Stations 2 and 3, which are relatively close to residential zones and possibly have slower recharge or longer groundwater residence times, may experience salt accumulation because water spends more time in contact with mineral surfaces, enhancing ion exchange and salt buildup.

DAO 2016–08 and PNSDW 2017 do not set a direct salinity limit for drinking water but instead use total dissolved solids (TDS) as the standard indicator. The allowable limit is 500 mg/L TDS, which is approximately equivalent to 0.05% salinity, representing the acceptable level of dissolved salts in potable water. This shows that even small increases in dissolved solids can affect water quality, making TDS an important measure for monitoring salinity (DOH, 2017). A salinity level of (0%) Indicates that the water contains no measurable dissolved salts, meaning it is freshwater and passed the considerable amount for drinking water. This is an important indicator of good drinking water quality. According to the World Health Organization (WHO, 2022), potable water should have very low salinity to avoid undesirable taste, dehydration effects, and corrosion issues that may occur with elevated salt concentrations.

Temperature (°C) - The data shows moderate variation in water temperature among the three sampling stations in Sitio Sarimao. Station 1 recorded the lowest temperature at 27.8 °C, while Station 2 exhibited the highest temperature at 29.9 °C, followed closely by Station 3 at 29.4 °C. These differences suggest that elevation, surrounding land use, and the type of water source play a significant role in influencing water temperature across the study area. The relatively lower temperature observed at Station 1 can be attributed to its higher elevation, dense vegetation cover, and classification as a groundwater source within a Small Water Impounding System. Vegetation surrounding the site likely provides shading, which reduces direct solar radiation and helps regulate water temperature. Studies have shown that shaded and vegetated areas tend to maintain cooler water temperatures due to reduced heat absorption and enhanced microclimatic regulation (Rahman et al., 2022).

In contrast, Station 2, which recorded the highest temperature, is located in a lower-elevation, densely populated residential area and is an artesian well with a water pump. Increased human activity, reduced vegetation cover, and exposure to open surroundings can contribute to higher ambient temperatures, which may influence water temperature during pumping and storage. Although artesian wells generally exhibit stable thermal conditions due to confined aquifers, surface conditions and frequent water extraction can still cause slight temperature elevation (Nguyen et al., 2021). Water temperatures within the 26°C to 30°C range are classified as AA Class under DAO 2016 and are considered suitable for potable use due to minimal impact on taste, low risk of promoting microbial growth, and suitability for household consumption. This range also supports healthy aquatic ecosystems by maintaining optimal conditions for the metabolism and reproduction of aquatic organisms, contributing to ecological balance (European Environment Agency, 2021).

Total Suspended Solids (TSS) (mg/L) - Data shows a low Total Suspended Solids (TSS) concentration (1.0

mg/L) to all sampling stations, indicating “acceptable” levels for drinking water, several key processes could drive TSS higher over time — particularly natural marine influence, soil erosion and runoff, and wastewater / land-use change. Station 3, due to its coastal position, is vulnerable to marine resuspension of sediments via waves, currents, and tides, which can transport and suspend particles from the seabed into the water column. Station 1, despite currently showing low total suspended solids (TSS), may still be vulnerable to soil erosion and runoff due to its higher elevation, where rainfall can transport sediments into water sources. Studies show that slope-related erosion is a major contributor to increased suspended solids in nearby water bodies, meaning current results may not fully reflect long-term sediment risks.

When TSS levels increase, water quality can deteriorate significantly, as suspended particles can carry pathogens, heavy metals, and other contaminants. High TSS can also shield microorganisms from disinfection processes, allowing them to survive longer and increasing the risk of waterborne diseases such as diarrhea and gastrointestinal infections. Overall, while the present TSS values at all stations meet drinking-water standards, the interaction of natural coastal dynamics, geomorphological characteristics, and future human activities forms a complex set of pressures that may influence TSS levels over time.

Calcium (mg/L) - The data shows calcium concentration in stations 1 (71.6 mg/L) while station 2 has 77.6 mg/L, and Station 3 resulted in 77.0 mg/L, the results can be attributed to the geographic location of the sample stations and soil characteristic possibly affect the level of calcium gathered in 3 sample sites. A calcium content ranging from 77.0 to 77.6 mg/L indicates that the water possesses a moderate level of hardness, which is generally acceptable for drinking purposes. Calcium is an essential mineral for human health, contributing to bone development and various physiological functions. The low calcium concentration observed at Station 1 may be attributed to its higher elevation, dense vegetation cover, and its classification as a groundwater source associated with a Small Water Impounding System (SWIS). Water sources located in elevated and vegetated areas often have reduced contact time with calcium-rich minerals, limiting mineral dissolution. In addition, organic-rich environments can promote slightly acidic conditions, which may reduce the mobilization of calcium ions into the water (WHO, 2022).

Station 3’s sandy-clay soil texture contributes to higher calcium levels due to clay’s high cation exchange capacity (CEC), which allows it to retain and adsorb positively charged ions such as Ca^{2+} . As water moves through these soils, it can dissolve and accumulate calcium from clay particles, affecting the chemical composition of groundwater. Studies show that higher clay content enhances cation retention in soils, influencing groundwater chemistry (Soil Quality Knowledge Base, 2024). Overall, the measured calcium levels across all stations, ranging from 77.0 mg/L to 77.6 mg/L, fall under Class AA of DAO 2016, meaning all sources meet the standards for drinking water. Despite slight variations influenced by soil and groundwater conditions, the calcium concentrations remain within safe limits, indicating that all stations are suitable for potable use based on calcium content.

Chloride (mg/L) - The analysis of chloride concentration revealed a gradual increase across the three sampling stations. Station 1 recorded the lowest chloride level at 17.7 mg/L, followed by Station 2 at 31.1 mg/L, while Station 3 exhibited the highest concentration at 36.3 mg/L. This pattern indicates that chloride levels in the water sources of Sitio Sarimao are influenced by elevation, proximity to coastal environments, and surrounding land use. The increased chloride concentrations at Stations 2 and 3 can be associated with their lower elevation and closer proximity to human activities and coastal influences. Station 2, situated in a densely populated residential area, may be affected by domestic wastewater, surface runoff, and land-use practices that contribute to chloride enrichment. Station 3, located near the roadside and close to the shoreline, is more likely to experience marine aerosol deposition and early signs of saltwater intrusion, which are common sources of chloride in coastal groundwater systems (Rahman et al., 2023).

High chloride levels can negatively affect freshwater ecosystems by increasing water corrosiveness and producing a salty taste in drinking water, though Pu (2021) notes these impacts are mainly environmental and aesthetic. In this study, chloride concentrations (17.7–36.3 mg/L) remain well below the DAO 2016 limit of 250

mg/L, indicating that the water is still potable in terms of taste and quality standards. The WHO (2022) further confirms that chloride at typical environmental levels does not pose direct health risks to humans.

Magnesium (mg/L) - The analysis of magnesium concentration revealed a distinct increasing trend across the three sampling stations. Station 1 recorded the lowest magnesium level at 9.26 mg/L, followed by Station 2 at 13.4 mg/L, while Station 3 exhibited the highest concentration at 29.0 mg/L. This pattern suggests that magnesium levels in the water sources of Sitio Sarimao are influenced by geological conditions, water source type, and proximity to coastal environments. The relatively low magnesium concentration at Station 1 can be attributed to its higher elevation, dense vegetation cover, and location away from direct coastal influence. Groundwater in elevated inland areas typically has reduced interaction with magnesium-rich minerals and is less affected by marine-derived inputs, resulting in lower magnesium concentrations (WHO, 2022). Lastly, According to Ecosoft (2025), the recommended daily intake is 360–420 mg, depending on age and gender. Drinking 2 liters of water containing 30 mg/L of magnesium can supply about 14–17% of a person's daily magnesium needs. The magnesium result ranging from (13.4 mg/L) to (29.0 mg/L) indicating that the water contains low to moderate levels of magnesium, which is considered safe and acceptable for drinking after comparing to the DAO 2016-08.

Nitrate (mg/L) - All sampling stations recorded nitrate levels of 3 mg/L (3 ppm), which remains within the DAO 2016-08 permissible limit for drinking water, indicating current safety in terms of nitrate exposure. However, potential contamination sources near the area, particularly livestock waste and septic discharge from nearby residential communities, may threaten long-term water quality stability, especially at Station 2. These activities are known to contribute significantly to nitrate pollution, as nitrogen compounds from animal manure and untreated wastewater can leach into soil and groundwater or be transported via runoff, gradually increasing nitrate levels over time (Álvarez-Cámara et al., 2021). The measured nitrate concentration of 3 mg/L across the sampling stations remains well below the Class AA water quality standard set by DAO2016-08, indicating that the water currently meets the national guideline for potable water sources. This result suggests that, at present, nitrate contamination does not pose a direct health risk to the community and that the study sites remain compliant with regulatory requirements for drinking-water quality.

Hydrogen Ion Concentration (pH) - The measured pH values (7.44) in Stations 1 and 2, and (7.54) in Station 3 indicate that the water is slightly alkaline, a condition that is acceptable for drinking. These slight differences in pH may be influenced by the elevation, location, and type of the water sources: Station 1, being at a higher elevation in the sitio, may receive more fresher recharge with greater buffering capacity, whereas Station 3 and 2, is a deep well located in a lower part of the Sitio. Station 1's slightly alkaline pH (7.44), measured at a higher elevation, may be influenced by enhanced carbonate mineral dissolution during recharge: as meteoric water infiltrates at higher terrain, deeper root penetration and soil CO₂ drive the dissolution of carbonates, adding bicarbonate and carbonate ions to the water. This process increases the system's buffering capacity, thereby raising the pH. Empirical and modeling studies show that deepening roots promote CO₂-rich recharge in the subsurface, which enhances carbonate weathering and elevates dissolved inorganic carbon (DIC) and alkalinity in groundwater (Wen et al, 2021). The data shows pH range of station 1 and 2 resulted 7.44 while the outcome for station 3 is 7.54 these pH range indicates that the water is slightly alkaline, which is within the optimal range for drinking water. According to the World Health Organization (WHO, 2022), the acceptable pH range for potable water is 6.5 to 8.5. Water within this range is considered chemically stable, non-corrosive, and safe for human consumption.

Phosphate (mg/L) - Data indicate that all sampling stations recorded phosphate concentrations of < 0.003 mg/L (<0.003 ppm), a level considered acceptable for potable water and well below water quality guideline limits. Such low phosphate concentrations generally signify minimal nutrient pollution and suggest that the water sources are currently not impacted by excessive organic inputs or fertilizer contamination. Maintaining phosphate levels within safe thresholds is essential, as elevated concentrations may contribute to eutrophication, degradation of aquatic ecosystems, and deterioration of water quality for human consumption (WHO, 2022). Despite the present suitability of the water for drinking purposes, phosphate levels remain vulnerable to fluctuations caused by environmental and anthropogenic factors. Agricultural runoff, particularly from the use of phosphate-based

fertilizers and livestock operations, is widely recognized as a major contributor to increased phosphate loading in surface water and groundwater systems. Rainfall events can transport these nutrients from farmlands into adjacent water bodies, gradually raising phosphate concentrations (Ringler et al., 2022). Similarly, domestic wastewater and septic system discharges release phosphorus-rich effluents that can infiltrate groundwater or flow directly into nearby streams when treatment systems are inadequate or poorly maintained (UNEP, 2021). Therefore, while the current phosphate concentrations across all stations remain within potable standards after comparing to DAO2016-08 standard, continuous monitoring and watershed protection strategies are required to prevent possible contamination.

3.2 Bacteriological Analysis

Fecal Coliform (MPN/100mL) - Table 2 shows the result of microbiological parameter for three stations in comparison to DAO2016-08 and PNSDW class AA standard. The results of the microbiological analysis revealed that Stations 1 and 2 recorded <1.1 MPN/100 mL of Fecal Coliform, which is within the allowable limit for Class AA waters under the Department of Environment and Natural Resources Administrative Order (DAO) No. 2016-08. This classification denotes that the water is safe for drinking, confirming its high microbiological quality. In contrast, Station 3 showed a Fecal Coliform count of 2.6 MPN/100 mL, which exceeds the Class AA standard, indicating microbial contamination that warrants further evaluation. The presence or absence of Fecal Coliform bacteria is a crucial indicator of sanitary quality and the potential presence of pathogenic microorganisms. Drinking water with disease-causing bacteria, viruses, or parasites (collectively called pathogens) can make you sick. It is not practical to test drinking water for every type of pathogen, but it is simple to test drinking water for coliform bacteria. The presence of coliform bacteria can indicate there may be harmful pathogens in the water (MN Department of Health, 2024).

The variation in Fecal Coliform levels among stations can be attributed to several environmental and anthropogenic factors. Stations such as Stations 1 and 2 have a lower level of coliform, although station 2 observed with a presence of domestic animals, yet has a lower human activity. On the other hand, the elevated level observed in Station 3 may result from runoff contamination, proximity to residential or domestic livestock and construction projects observed near the site, a direct infiltration of untreated waste can possibly elevate the bacteriological activities in the station. Water that has detectable levels of fecal coliform is considered unsafe for drinking. According to the World Health Organization (WHO) guidelines: “All water directly intended for drinking, E. coli or thermotolerant coliform bacteria must not be detectable in any 100 mL sample”

Table 2
Microbiological Analysis, Fecal Coliform, in Comparison with DAO 2016-08 and PNSDW Water Quality Standard, 2025.

Parameter	Station	Results	DAO2016-08 Standard	Remarks
Fecal Coliform	1	<1.1	<1.1	PASSED
Fecal Coliform	2	<1.1	<1.1	PASSED
Fecal Coliform	3	2.6	<1.1	FAILED

In spite of the fact that Stations 1 and 2 met both the physicochemical and microbiological drinking water quality criteria, indicating they passed the established potability standards. However, Station 3, despite passing all physicochemical tests, failed the microbiological analysis, which means its water cannot be considered potable. This conclusion aligns with research of Adesakin et al. (2020) showing that meeting only chemical-physical limits is insufficient; if microbiological parameters exceed safe thresholds, the water poses a potential health risk and is disqualified as safe for consumption. The need for microbiological testing has been highlighted in numerous instances where water contamination has caused widespread illness. For example, inadequate testing or delayed results can leave communities vulnerable to outbreaks, as contaminated water can spread quickly through municipal systems (Water Online, 2024). Drinking water of unreliable microbiological quality can result in gastrointestinal diseases and is also responsible for deaths (Kaynar et al., 2022).

3.3 Potential Source of Water Contamination

The conducted field observations and local investigation in Sitio Sarimao, monitored an identified potential source of water contamination across the three monitoring stations, focusing on factors that could affect both physicochemical and microbiological water quality. Station 1 appeared relatively protected. The small water impoundment is surrounded by dense vegetation, including trees and other flora, which likely acts as a natural buffer and filter against surface runoff contamination. The nearest residence is located approximately 20 meters downhill from the water source. According to the implementing rules of Chapter XVII — Sewage Collection and Disposal, Excreta Disposal and Drainage of the Code on Sanitation of the Philippines (P.D. 856), a minimum septic-to-well distance is required to prevent fecal contamination. Since Station 1's surroundings meet or exceed this buffer, the risk of microbial contamination from nearby households is minimal (Supreme Court E-Library, 1995.). This indicates that Station 1 is likely to maintain safe microbiological quality under current conditions.

Urbanization process is associated with population growth and industrial and agricultural development and, consequently, the chemical composition of water is possibly influenced by human activities (Rivera et al., 2022). Higher human population density also increases the potential for waterborne contamination, because more residents mean more waste generation and increased pressure on sanitation infrastructure (Pangestuti et al., 2020). Station 3 showed the highest risk due to nearby human activities such as road widening and sea-wall construction, which can disturb soil and increase sediment, chemical, and microbial contamination through runoff. These activities are known to degrade water quality by introducing pollutants like suspended solids, oils, heavy metals, and construction-related chemicals into nearby water bodies (Scanlon et al., 2020). Additionally, construction and urbanization can cause long-term water quality deterioration by increasing erosion and polluted runoff entering aquatic systems, ultimately harming ecosystem stability (Pang & Guan, 2024).

Additionally, livestock were located about 10 meters from the water source, and nearby residences increase the potential for microbial intrusion. Although the physicochemical characteristics of Station 3 may still meet acceptable limits, the observed conditions suggest a high likelihood of microbial contamination, which renders the water unsuitable for drinking. Saltwater intrusion in coastal areas like Sitio Sarimao occurs when seawater enters freshwater aquifers due to groundwater over-extraction or rising sea levels, reducing freshwater quality and usability. This process increases salinity, which disrupts aquatic ecosystems by harming freshwater species and reducing biodiversity, linking it to SDG 14 (Life Below Water).

The investigation indicates a clear gradation in contamination risk among the three stations. Station 1 remains the safest for consumption, Station 2 requires monitoring and preventive measures due to animal presence and residential density, and Station 3 is at high risk of microbial contamination primarily from construction activities, nearby livestock and saline intrusion. These findings highlight the importance of not only maintaining physicochemical water quality but also addressing environmental and anthropogenic factors that influence microbiological safety. Finally, the validity of water quality conditions is time-bound and may vary due to seasonal changes, environmental disturbances, and increasing anthropogenic pressures around water sources. Thus, quarterly water quality monitoring is necessary to ensure the continuous safety and reliability of potable water by enabling the early detection of changes in physicochemical and microbiological parameters. Community (Environmental Protection Agency, 2023).

4. Summary, Findings, Conclusion, and Recommendations

This chapter presents the summary of the study, followed by the findings, conclusions, and recommendations organized according to each Statement of the Problem (SOP), ensuring a clear and direct presentation of the results.

Summary - This study employed a qualitative descriptive research design to assess the current condition of water sources in Sitio Sarimao, focusing on both physicochemical and microbiological water quality characteristics. Three strategically selected sampling sites were established to represent the major water sources utilized by the

community. Field observations indicated the presence of potential contamination factors surrounding all sampling stations, emphasizing the need to document environmental risks and develop practical recommendations aimed at improving local awareness, safeguarding public health, and promoting community well-being. Water quality assessment followed the Environmental Management Bureau–Department of Environment and Natural Resources (EMB–DENR) Water Quality Monitoring Manual (Volumes I and II) to ensure standardized sampling and analytical procedures. Selected parameters were measured through in situ field monitoring, complemented by laboratory analyses conducted in accredited government laboratories to ensure data accuracy and reliability. The analytical results were evaluated against the DENR Administrative Order (DAO) 2016 Water Quality Guidelines, which served as the national benchmark for determining water safety and compliance.

SOP 1 - The analysis of physicochemical parameters—including calcium, chloride, color, magnesium, nitrate, pH, phosphate, salinity, temperature, and total suspended solids (TSS)—revealed that all three sampling stations complied with the DAO 2016-08 standards for potable water. These findings indicate that the water sources in Sitio Sarimao currently maintain acceptable physical and chemical quality suitable for human consumption. Overall, the results suggest that the existing environmental conditions in the study area support relatively stable water chemistry across the stations. However, potential influences such as coastal proximity and land-use activities may affect these parameters over time, highlighting the need for continuous monitoring to ensure sustained water quality. Among the stations, Station 1 exhibited the most favorable conditions, with both physicochemical and microbiological parameters meeting potable water standards. To preserve this status, regular monitoring should be conducted, alongside the protection of surrounding vegetation and the regulation of human activities to prevent future contamination.

SOP 2 - Bacteriological analysis revealed differences in fecal coliform levels among the sampling stations. Stations 1 and 2 complied with potable water standards, indicating that these sources are microbiologically safe for consumption. In contrast, Station 3 exceeded the allowable limit, suggesting fecal contamination and making the water unsuitable for direct use without treatment. Despite all stations meeting physicochemical standards, microbiological safety was not consistent. The elevated fecal coliform level in Station 3 highlights the risk of contamination, while Stations 1 and 2 remain relatively safe for domestic use based on current conditions. Although Station 2 still meets potable standards, its proximity to residential areas and potential livestock discharge poses a risk of future contamination. Continuous monitoring, improved sanitation practices, proper waste management, and coordination with local authorities are recommended to prevent possible deterioration of water quality.

SOP 3 - Field observations showed that Station 3 is the most vulnerable to contamination due to its coastal location, construction activities, and nearby livestock, while Station 2 also faces potential risks from residential and livestock influences. In contrast, Station 1 remains the most protected because of its elevation, vegetation cover, and minimal human disturbance. The findings highlight that both environmental and human activities affect water quality across the stations. Station 3 is the most at risk, followed by Station 2, whereas Station 1 is currently the most reliable source. This emphasizes the need for proper sanitation, waste management, and continuous monitoring. Since Station 3 failed the bacteriological standard, immediate action is required. Water from this station should only be used after proper treatment, and efforts such as improved sanitation, monitoring, and possible water treatment facilities are necessary to protect public health.

Implications for Learners. The findings of this study highlight the importance of developing learners' awareness and understanding of environmental issues, particularly water quality and safety. Students are encouraged to apply scientific knowledge in real-life contexts, fostering critical thinking and responsible decision-making regarding water use and conservation. This study also promotes experiential learning by emphasizing the value of field-based observation, data analysis, and environmental stewardship, which can enhance students' engagement and appreciation of science.

Implication for Teachers and Academe. For teachers and academic institutions, this study underscores the

need to integrate environmental education and water quality awareness into the curriculum. Educators are encouraged to incorporate practical and research-based activities that develop students' analytical and investigative skills. Furthermore, the academe can use this study as a basis for community extension programs, collaborative research, and policy advocacy, contributing to sustainable water resource management and public health awareness.

I/We used ChatGPT (OpenAI, GPT-4-class and GPT-5.3 models) for grammar checking, fact-checking, APA 7th edition formatting, and general reference validation. All outputs generated by the AI tool were carefully reviewed, cross-checked, and edited by the author. This includes verification of citation accuracy, DOI validation, formatting corrections, and refinement of language in accordance with APA 7th edition guidelines. No confidential or personally identifiable information was entered into the AI system. The author assumes full responsibility for the accuracy, integrity, and final content of the thesis.

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