

# Water quality assessment: Basis for the water quality management plan for Barangay San Cirilo, Pasacao, Camarines Sur

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## ***Abstract***

This study assessed the groundwater quality and socio-demographic profile of Barangay San Cirilo, Pasacao, Camarines Sur, as a basis for developing a community-based water quality management plan. A descriptive-correlational research design was employed involving 76 household respondents selected through stratified random sampling. Data were collected using survey questionnaires and laboratory analysis of water samples from eight sites. Results showed that physical and chemical parameters were generally within acceptable standards; however, bacteriological contamination was detected in several zones. Statistical analysis revealed significant relationships between civil status, educational attainment, and water quality perception. The findings highlight the need for targeted interventions, including regular monitoring, sanitation improvement, and community education. The study provides practical implications for educators, students, and local institutions in promoting water safety and environmental awareness.

***Keywords:*** groundwater quality, coliform contamination, rural water supply, water safety, community-based management

## **Water quality assessment: Basis for the water quality management plan for Barangay San Cirilo, Pasacao, Camarines Sur**

### **1. Introduction**

Access to safe and potable water remains a critical concern in rural communities. In Barangay San Cirilo, Pasacao, Camarines Sur, groundwater serves as the primary source of water for domestic use. However, its quality has not been comprehensively evaluated, particularly in terms of physical, chemical, and bacteriological characteristics. Contaminated water is associated with various health risks, including waterborne diseases, making regular monitoring essential. Water is an essential resource for all life on Earth. If a water source becomes contaminated due to pollution, it can lead to health issues in humans, such as cancer or cardiovascular conditions. (Haghighi, 2024). Water is an essential resource for human survival. According to the 2021 World Water Development Report released by UNESCO, the global use of freshwater has increased six-fold in the past 100 years and has been growing by about 1% per year since the 1980s. With the increase of water consumption,

Water quality is facing severe challenges. Industrialization, agricultural production, and urban life have resulted in the degradation and pollution of the environment, adversely affecting the water bodies (rivers and oceans) necessary for life, ultimately affecting human health and sustainable social development (Xu et al., 2022). Water is crucial for the survival of all living organisms on Earth. Nearly 71 % of the Earth's surface is covered by surface water, of which 97 % is ocean water. The World Health Organization (WHO) shaped international norms to set standards and guidelines for water quality. However, 36 % of people worldwide regularly consume low-quality water and 26 % lack access to safe water. (Nshimiyimana et al., 2025). Access to safe drinking water is directly linked to public health. According to the World Health Organization (WHO, 2020), contaminated water remains a leading cause of diarrheal diseases, particularly in developing countries. In the Philippines, studies such as those by David et al. (2018) Reported that groundwater sources in rural communities often exceed the acceptable limits for coliform bacteria, posing health risks to residents. Similar findings by Rola and Francisco (2019) emphasized that water quality in many localities deteriorates due to inadequate sanitation practices, agricultural runoff, and insufficient monitoring.

Socio-demographic factors also play a role in determining community vulnerability to unsafe water. A study by Cruz et al. (2020) revealed that households with limited income and lower educational attainment are more likely to use untreated water sources, increasing health risks. Furthermore, Villanueva and Garcia (2021) noted that demographic characteristics such as age, household size, and livelihood influence water consumption patterns and sanitation practices. The significance of this research lies in its capacity to provide a scientific basis for a Water Quality Management Plan tailored for Barangay San Cirilo. By examining both the socio-demographic profile of the community and the condition of its underground water, the study aims to highlight the importance of water quality as a foundation for health, sustainable livelihoods, and environmental protection. This research aligns with local government priorities and national goals of ensuring safe water access while contributing to global calls for sustainable water management.

This study aligns with Sustainable Development Goal 6, which promotes access to clean and safe drinking water. Despite global efforts, rural communities continue to face challenges in ensuring water safety. Thus, this research aims to assess groundwater quality and its relationship with socio-demographic characteristics to support a localized water management plan. (United Nations, 2019). However, many rural areas in the Philippines, such as Barangay Villarey in Pasacao, Camarines Sur, continue to face challenges regarding water safety and management. The underground water in the community serves as the primary source for domestic use, but its quality has not been fully assessed in terms of physical, chemical, and bacteriological parameters.

**Objectives of the Study** - This study aimed to assess the socio-demographic profile and groundwater quality

of Barangay San Cirilo as a basis for formulating a water quality management plan. Specifically, it aimed to determine the socio-demographic profile of the community in Barangay San Cirilo, evaluate the groundwater quality of Barangay San Cirilo in terms of physical characteristics, chemical properties, and bacteriological quality, analyze the significant relationship between the socio-demographic profile and groundwater quality and lastly proposed a strategies and interventions to improve water quality management in the community.

**Significance of the Study** - This study provides an evidence-based assessment of groundwater quality in Barangay San Cirilo, Pasacao, Camarines Sur, revealing the presence of bacteriological contamination despite acceptable physical and chemical parameters, and thereby offering a scientific basis for a community-based water quality management plan. The findings support local government units and policymakers in implementing data-driven water monitoring, sanitation programs, and public health interventions, while also increasing community awareness of safe water practices and disease prevention. In the educational context, the study provides relevant localized content that teachers and schools can integrate into environmental and health education, promoting student engagement through community-based and experiential learning approaches. Furthermore, it serves as a reference for future researchers in the fields of water quality, public health, and sustainable resource management. Overall, the study contributes to improved public health outcomes, environmental sustainability, and educational development through practical and evidence-based strategies.

**Scope and Limitations** - This study assessed the groundwater quality and socio-demographic profile of selected households in Barangay San Cirilo, Pasacao, Camarines Sur, focusing on physical, chemical (pH), and bacteriological parameters from eight sampling sites. Using a descriptive-correlational design, it examined relationships between variables based on data from 76 respondents. However, the study was limited to groundwater sources and selected parameters, excluding other contaminants and water sources. Results were based on data collected within a specific period and are limited to the study area, thus may not be generalizable to other communities.

**Theoretical Framework** - This study is anchored on the Environmental Determinism Theory, which explains that environmental conditions influence human behavior, health, and overall well-being. In this study, groundwater quality is considered a key environmental factor affecting the health and living conditions of the community. The study is further supported by the Germ Theory of Disease, developed by Louis Pasteur and Robert Koch, which establishes that microorganisms are the primary cause of infectious diseases. This provides a scientific basis for examining bacteriological contamination, particularly the presence of coliform bacteria, as an indicator of water safety. Moreover, the study is guided by the Philippine Clean Water Act of 2004 (Republic Act No. 9275), which serves as the legal framework for the protection and management of water resources in the Philippines. This law emphasizes the importance of maintaining water quality standards and ensuring access to safe and potable water.

## 2. Methodology

This section presents the overall framework and methodology used in the conduct of this study. It includes the research design, area of the study, respondents, population and sampling design, data gathering procedures, instrumentation, and statistical tools used in data analysis.

**Research design** – This study employed a descriptive–correlational research design to examine the relationship between the socio-demographic characteristics of households and the quality of underground water in Barangay San Cirilo, Pasacao, Camarines Sur. The descriptive component focused on identifying the socio-demographic profile of respondents and the existing condition of groundwater quality, while the correlational component determined the significant relationship between selected socio-demographic variables and water quality conditions. Both quantitative survey and experimental laboratory analysis were utilized to ensure comprehensive and reliable data interpretation.

**Study Area** – The study was conducted in Barangay San Cirilo, Pasacao, Camarines Sur, a low-lying coastal community located at approximately 13.5146° N latitude and 123.0447° E longitude. The barangay has an estimated population of 5,503 based on the 2015 census and an average elevation of 5.4 meters above sea level. The area is characterized by coastal exposure, periodic flooding, and proximity to neighboring barangays such as Balogo, Odicon, Santa Rosa del Norte, and Santa Rosa del Sur. These geographic and environmental conditions may influence groundwater quality through natural hydrological processes and human activities. Eight (8) representative underground water sources (deep wells) were selected as sampling points across the barangay for water quality assessment (Figure 1).

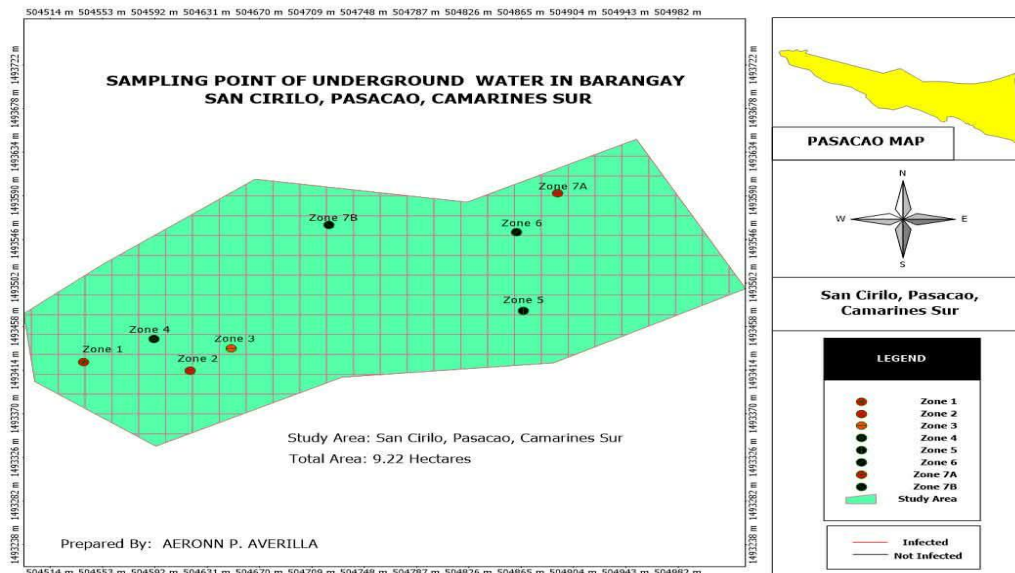


Figure 1. Sampling Points of Underground Water Sources in Barangay San Cirilo, Pasacao, Camarines Sur

**Respondent of the Study** – The respondents of the study consisted of 1,116 households in Barangay San Cirilo. The household head or any adult member knowledgeable about household water use served as the respondent. For the water quality component, 53 underground water sources were identified, serving approximately 430 households (38.5% of the total population). These water sources were distributed across eight (8) zones of the barangay and were primarily used for drinking, cooking, bathing, laundry, and other domestic purposes.

**Sampling Design** – A stratified random sampling technique was employed to ensure proportional representation of all zones in the barangay. The population was divided into eight (8) geographical strata based on zoning classification. The number of respondents per zone was determined using proportional allocation. An official list of households was obtained from the barangay office, and respondents were randomly selected using a lottery method or random number generator to ensure unbiased selection. For the water quality assessment, one (1) representative underground water source per zone was selected based on accessibility and usage, resulting in a total of eight (8) sampling sites.

**Data Gathering Procedure** – The data gathering process was conducted in three phases:

Phase 1: Socio-Demographic Survey, A structured questionnaire was administered to selected respondents to gather socio-demographic information such as age, sex, civil status, educational attainment, occupation, monthly income, and household size. Prior to data collection, informed consent was obtained from all participants.

Phase 2: Water Sampling and Laboratory Analysis, Water samples were collected from selected underground sources following Department of Health (DOH) standard procedures. Each sample consisted of 120 mL of water collected in sterilized containers. The following parameters were analyzed the Physical: color, odor, temperature, turbidity, Chemical: pH level measured on-site using a calibrated pH meter and Bacteriological: detection of Escherichia coli (E. coli). Samples were properly labeled, stored in iceboxes, and transported within six (6) hours

to the Metropolitan Naga Water District Laboratory for bacteriological examination.

Phase 3: Data Validation, all collected data were checked for completeness, consistency, and accuracy. Survey responses and laboratory results were validated through barangay records and field verification prior to statistical analysis.

**Validity and Reliability of the Instrument** – The research instrument (survey questionnaire) underwent content validation by experts in research methodology and environmental science to ensure that all items were clear, relevant, and aligned with the objectives of the study. Revisions were made based on expert feedback to improve clarity and appropriateness. And the reliability of the questionnaire was assessed through a pilot test conducted on a small sample population similar to the study respondents. The internal consistency of the instrument was measured using Cronbach's alpha coefficient, with a threshold value of 0.70 or higher considered acceptable, indicating that the instrument was reliable for data collection.

**Statistical Treatment of Data** - To facilitate the analysis and interpretation of the collected data, this study utilizes several statistical tools to ensure accuracy and clarity. Slovin's Formula was initially employed with a 5% margin of error to determine the appropriate sample size and ensure a proportionate distribution of respondents from the total population. The Frequency and percentage used to describe the socio-demographic profile of respondents and lastly the Chi-Square Test of Independence used to determine the significant relationship between socio-demographic variables and water quality perceptions a 0.05 level of significance was applied for all inferential statistical tests.

### 3. Results and Discussion

This section presents, analyzes, and interprets the data gathered from the field survey and laboratory analysis conducted in Barangay San Cirilo, Pasacao, Camarines Sur. The results are organized in accordance with the specific objectives of the study, focusing on the socio-demographic profile of the respondents, the physicochemical and bacteriological characteristics of underground water sources, and the relationship between socio-demographic variables and water quality and the management plan suggestions. The findings are supported with statistical analysis and are interpreted in relation to relevant literature, theories, and existing studies to provide a comprehensive understanding of groundwater conditions in the study area we're discussed.

#### 3.1 Distribution of Demographic profile of the respondents such as Gender, Age, Civil Status, Educational attainment, Monthly income, Occupation, and Household size

**Distribution of Demographic profile for Gender** - The study examined gender participation in Barangay San Cirilo, Pasacao, Camarines Sur, to understand differences in involvement with household and community water management. Among the seventy-seven (77) respondents, fifty-one (51) were female, representing 66.23% of the total, while twenty-six (26) were male, accounting for 33.77%, indicating a higher presence of women in the survey. This predominance of female respondents may be attributed to their more active engagement and responsibility in managing household water. Women often play a central role in household water use, including tasks such as cooking, cleaning, and sanitation, which gives them direct insight into water quality and usage patterns. This aligns with Cañete and Capilitan (2023), who noted that women commonly oversee domestic water sources which emphasizes that women are key managers of household water, highlighting their perspectives as vital for planning inclusive water management strategies.

**Distribution of Demographic profile for Age** - The study examined respondents' age in Barangay San Cirilo, Pasacao, Camarines Sur, to evaluate its influence on participation in water management activities. The majority of respondents were aged 36–45 years (33.77%), followed by 26–35 years (24.68%) and 46–55 years (20.78%). Respondents aged 18–25 years accounted for 15.58%, while those 56 years and above comprised 5.19%. The predominance of middle-aged respondents suggests that individuals in this age range are more actively involved in addressing household and community water issues. Younger respondents may participate less due to lower

responsibilities, while older respondents may have reduced involvement because of physical limitations. Middle-aged adults likely play a central role in ensuring water quality and household management, reflecting their responsibility and awareness of environmental and health concerns. This is consistent with Adejumo et al. (2019), who reported that middle-aged individuals are often the most active in community and household management activities, due to greater responsibility, stability, and awareness of environmental and health issues compared to younger or older groups.

***Distribution of Demographic profile for Civil Status*** - The study assessed civil status in Barangay San Cirilo, Pasacao, Camarines Sur, to determine its relationship with household water management responsibilities. Most respondents were married (66.23%), followed by single individuals (22.08%), widowed (7.79%), and separated (3.90%). The majority being married indicates higher involvement in domestic water management, sanitation, and hygiene responsibilities. Single and separated respondents may have fewer household duties, while widowed individuals may contribute insights based on long-term experience. Married respondents often serve as decision-makers in family health and resource use, directly influencing water safety and quality at home. This aligns with Zaragoza-Magsayo (2023), who emphasized that civil status affects how individuals manage and conserve water resources, suggesting that household-centered initiatives should be prioritized in water quality management planning.

***Distribution of Demographic profile for Educational Attainment*** - The study examined the educational background of respondents in Barangay San Cirilo, Pasacao, Camarines Sur, to evaluate its influence on awareness and participation in water management. The majority attained a high school education (45%), followed by elementary level (35%), college level (17%), and only 3% reported no formal education. The predominance of respondents with elementary to high school education indicates that the community generally has a moderate educational background, sufficient to understand basic health, sanitation, and water quality issues. Residents' education level suggests that information campaigns, seminars, and conservation programs can be effectively implemented, as they are capable of comprehending and applying water management knowledge. This is consistent with Alimoradi et al. (2020), who reported that educational attainment influences awareness and behavior toward environmental health and safe water practices.

***Distribution of Demographic profile for Monthly Income*** - The study examined the monthly income of households in Barangay San Cirilo, Pasacao, Camarines Sur, to assess its influence on access to and management of water resources. The data revealed that the majority of households (87%) earn below ₱5,000 per month, 12% reported an income between ₱5,000–₱10,000, and only 1% earn ₱15,000–₱20,000, with no households earning above ₱20,000. These results indicate that most residents belong to the low-income sector, which may limit their ability to maintain safe water quality, invest in purification systems, or access reliable sanitation facilities. Low-income households are more likely to rely on untreated or less safe water sources, highlighting the importance of economic considerations in water management. This aligns with the Department of Environment and Natural Resources (DENR, 2022), which emphasizes that socio-economic conditions affect a community's capacity to ensure safe water.

***Distribution of Demographic profile for Occupation*** - The study investigated the occupation of residents in Barangay San Cirilo to evaluate how employment types influence household water management practices. The data revealed that most residents are self-employed (44%), followed closely by unemployed individuals (42%). Only a small portion work as fisherfolk (5%), government employees (5%), or laborers (4%). These results indicate that most households depend on small-scale, informal livelihoods, while many residents face unemployment or unstable work, which may affect their ability to access and manage water resources effectively. Occupation shapes water management behaviors, as those with unstable income may struggle to implement safe water practices or invest in water treatment and storage solutions. Similarly, van der Merwe et al. (2025) found that lower employment status frequently leads households to rely on less safe or more distant water sources, emphasizing the need for affordable and practical interventions in community water management plans.

**Distribution of Demographic profile for Household size** - The study examined household size in Barangay San Cirilo to understand its impact on water consumption and management practices. Nearly half of the respondents (48%) belong to medium-sized households of 4–6 members, 31% are part of large households with seven or more members, and 21% live in small households of 1–3 members. This indicates that the community is largely composed of medium to large families, often reflecting extended or multigenerational living arrangements. Larger households naturally place greater demands on water resources, as more individuals rely on the same source for drinking, cooking, cleaning, and livelihood activities. Household size affects water consumption and management, with larger households facing higher daily demand and potential challenges in maintaining safe water, making it important to tailor water management strategies according to family size. Valerio and Mallari (2019) reported that household size significantly influences water use patterns and resource management. In the context of Barangay San Cirilo, medium and large households may benefit from interventions such as community water storage systems, household-level treatment options, and educational programs on efficient water use to ensure equitable access to safe and clean water for all members.

### 3.2 Groundwater Quality Assessment of Barangay San Cirilo

This section presents the results of the physical, chemical, and bacteriological analysis of groundwater samples collected from eight (8) sampling zones in Barangay San Cirilo, Pasacao, Camarines Sur. The assessment was conducted in accordance with the Philippine National Standards for Drinking Water (PNSDW). The results were analyzed to determine whether groundwater quality in each zone meets national drinking water standards

**Physical Characteristics of Groundwater** - Physical parameters such as color, odor, turbidity, and temperature were evaluated through on-site observation and standard field measurements. These indicators provide an initial assessment of groundwater quality and its acceptability for domestic use.

**Color of Groundwater** - The color of groundwater was evaluated using the PNSDW True Color Unit (TCU) standard ( $\leq 15$  TCU). As shown in Table 1.a, most sampling zones complied with the standard, with values ranging from clear to slightly yellow (3–10 TCU). However, Zone 7B recorded 20 TCU, exceeding the allowable limit, indicating possible contamination or high organic/mineral content. The overall mean color value of 6.9 TCU with a standard deviation of 6.03 indicates moderate variability across zones. While most samples fall within acceptable limits, the discoloration observed in certain areas may be attributed to dissolved organic matter, iron, manganese, or pipe corrosion. Similar findings were reported by Prasanthrajan et al. (2020), where groundwater discoloration was linked to natural geochemical processes and infrastructure conditions. These results suggest generally acceptable water color conditions, with localized quality concerns in Zone 7B.

**Table 1.a**  
*Color Assessment Results of Groundwater Samples in Barangay San Cirilo*

Zones	Observe Color	Intensity (TCU)	Standard (<15 TCU)	Interpretation
1	Slight yellow	10	Within standard	Acceptable
2	Clear	3	Within standard	Acceptable
3	Clear	3	Within standard	Acceptable
4	Slight yellow	9	Within standard	Acceptable
5	Clear	3	Within standard	Acceptable
6	Clear	3	Within standard	Acceptable
7a	Clear	4	Within standard	Acceptable
7b	Brown	20	Within standard	Acceptable
Mean:		6.9 TCU		
Standard Deviation:		6.03 TCU		

Note. Acceptability is based on Philippine National Standards for Drinking Water (PNSDW  $\leq 15$  TCU).

**Odor of Groundwater** - Odor was assessed using the PNSDW scale (0 = no odor, 5 = very strong odor). Results indicate that most zones exhibited no detectable odor as shown in table 1.b, suggesting good groundwater quality. Zones 1 and 4 showed slight earthy odor, which remains acceptable under natural groundwater conditions. However, Zone 7B exhibited a strong rotten-egg odor, indicative of hydrogen sulfide (H<sub>2</sub>S) formation, commonly

associated with anaerobic decomposition or contaminated well systems. According to Pal et al. (2020), such conditions may result from organic decay or microbial activity in oxygen-depleted environments. This finding suggests localized contamination requiring further investigation.

**Table 1.b**

*Color Assessment Results of Groundwater Samples in Barangay San Cirilo*

Zones	Odor scale(0-5)	Observe odor	Interpretation
1	1	None	Acceptable
2	0	None	Acceptable
3	0	None	Acceptable
4	1	Slight earthy	Acceptable
5	0	None	Acceptable
6	0	None	Acceptable
7a	0	None	Acceptable
7b	5	Rotten egg	Not Acceptable

Note. PNSDW requires drinking water to be free from objectionable odor.

**Turbidity of Groundwater** - Turbidity was measured using a visual scale (0–3). Most zones recorded low turbidity values (0), indicating clear water conditions. Zones 1 and 4 showed slight turbidity (1), while Zone 7B recorded the highest value (3), indicating localized water quality concern. The mean turbidity score of 0.625 and standard deviation of 1.06 reflect generally low turbidity levels with some variability across zones that shown in table 1.c. Although the method provides only relative estimates, it is useful for preliminary water quality screening in resource-limited settings. Similar approaches have been applied in studies assessing river water quality in Camarines Sur (Sale, 2025).

**Table 1.c**

*Color Assessment Results of Groundwater Samples in Barangay San Cirilo*

Zones	Observe condition	Turbidity scale (0-3)	Standard (≤5 NTU)	Interpretation
1	Slight brown	1	Within standard	Acceptable
2	Clear	0	Within standard	Acceptable
3	Clear	0	Within standard	Acceptable
4	Slight brown	1	Within standard	Acceptable
5	Clear	0	Within standard	Acceptable
6	Clear	0	Within standard	Acceptable
7a	Clear	0	Within standard	Acceptable
7b	Brown	3	Within standard	Acceptable

Note. Visual scaling used in this assessment

**Temperature of Groundwater** - Groundwater temperature ranged from 30.0°C to 32.5°C across all zones shown in table 1.d. Although PNSDW does not specify a numerical standard, drinking water is generally considered more acceptable at 10°C–22°C (Xiamen Smart Water Technology Co., 2025). The observed temperatures are typical for tropical groundwater systems. Variations may be attributed to shallow well depth, environmental exposure, and reduced groundwater recharge. Rivera and Flores (2020) reported similar temperature ranges in rural Philippine wells, while Chen and Wu (2024) noted that tropical aquifers naturally exhibit elevated temperatures due to climatic conditions.

**Table 1.d**

*Temperature Assessment Results of Groundwater Samples in Barangay San Cirilo*

Zones	Temperature (°C)	PNSDW standard	Interpretation
1	30.0	No limit	Acceptable
2	30.0	No limit	Acceptable
3	31.0	No limit	Acceptable
4	31.0	No limit	Acceptable
5	31.5	No limit	Acceptable
6	32.5	No limit	Acceptable
7a	31.5	No limit	Acceptable
7b	31.0	No limit	Acceptable

**Chemical Characteristics of Groundwater** - pH is a key indicator of water quality affecting mineral solubility

and disinfection efficiency. According to PNSDW (2017), acceptable drinking water pH ranges from 6.5 to 8.5.

**pH level of Groundwater** - The pH values ranged from 7.23 to 7.75, with a mean of 7.49 and a standard deviation of 0.18 are shown in table 1.e. All samples fall within the acceptable range, indicating that the groundwater is neutral to slightly alkaline. The low variation suggests uniform groundwater chemistry across zones. Similar findings were reported by Sumaria (2024) in Bohol groundwater systems, indicating stable geochemical conditions in rural aquifers.

**Table 1.e**  
*pH level Assessment Results of Groundwater Samples in Barangay San Cirilo*

Zones	pH value	PNSDW Range (6.5–8.5)	Interpretation
1	7.60	Within standard	Acceptable
2	7.56	Within standard	Acceptable
3	7.40	Within standard	Acceptable
4	7.43	Within standard	Acceptable
5	7.64	Within standard	Acceptable
6	7.75	Within standard	Acceptable
7a	7.31	Within standard	Acceptable
7b	7.23	Within standard	Acceptable
Mean	7.49		
Standard deviation	0.18		

**Bacteriological Quality: Total and Fecal Coliform** - Bacteriological quality is a critical determinant of drinking water safety. According to PNSDW (2017), both total and fecal coliform must be absent (0 MPN/100 mL) for potable water.

**Coliform Contamination of Groundwater** - The Results shown in table 1.f the total coliform ranging from <1.1 to 4.6 MPN/100 mL (mean = 2.08), while fecal coliform was detected in Zones 3 and 7A (4.6 MPN/100 mL). Although most zones showed low contamination, the presence of coliform bacteria indicates possible environmental or fecal contamination, likely due to sanitation issues or proximity to septic systems. Zones 3 and 7A failed to meet PNSDW standards, indicating that groundwater in these areas is unsafe for direct consumption without treatment. The findings highlight localized contamination despite generally acceptable chemical and physical quality.

**Table 1.f**  
*Total and Fecal Coliform Results of Groundwater Samples in Barangay San Cirilo*

Zones	Total Coliform (MPN/100 mL)	Fecal Coliform (MPN/100 mL)	PNSDW Standard	Remarks
1	2.6	<1.1	0 / <1.1	Failed
2	2.6	<1.1	0 / <1.1	Failed
3	4.6	4.6	0 / <1.1	Failed
4	<1.1	<1.1	0 / <1.1	Passed
5	<1.1	<1.1	0 / <1.1	Passed
6	<1.1	<1.1	0 / <1.1	Passed
7a	4.6	4.6	0 / <1.1	Failed
7b	<1.1	<1.1	0 / <1.1	Passed
Mean	2.08	1.56		
Standard deviation	1.80	1.84		

### 3.3 Relationship between Socio-demographic profile (Gender, Age, Civil status, Educational attainment, Monthly income, Occupation and Household size) and Water Quality

This section presents the discussion of the relationship between socio-demographic characteristics of respondents and groundwater quality indicators in Barangay San Cirilo, Pasacao, Camarines Sur. The analysis focused on color, odor, turbidity, temperature, pH level, and bacteriological quality using Chi-Square Test of Independence for categorical variables. Socio-demographic variables included sex, age, civil status, educational attainment, monthly income, occupation, and household size. The results are interpreted in relation to existing literature and water quality standards.

**Relationship Between Water Color and Socio-Demographic Profile** - The Chi-Square analysis revealed that there is no significant relationship between water color perception and all socio-demographic variables, including gender, age, civil status, educational attainment, monthly income, occupation, and household size ( $p > 0.05$  for all variables) that shown in table 2. This indicates that perceptions of groundwater color are independent of demographic characteristics. This finding suggests that all respondents, regardless of background, were exposed to similar water conditions within the barangay's communal groundwater system. The uniformity of responses implies that environmental and infrastructural conditions, rather than personal socio-economic attributes, are the primary determinants of perceived water color. These results are consistent with Gómez-Llanos et al. (2024), who found that water-related perceptions are not significantly influenced by gender differences, and with WHO and UNICEF (2021), which emphasized that shared water systems produce similar user perceptions regardless of educational or economic background.

**Table 2**  
*Relationship Between Water Color and Socio-Demographic Profile*

Socio-demographic profile variables	Computed X <sup>2</sup>	Tabular value	Interpretation
Gender	0.029	3.841	Not significant
Age	0.543	9.488	Not significant
Civil status	0.557	7.815	Not significant
Educational attainment	0.482	7.815	Not significant
Monthly income	0.317	5.991	Not significant
Occupation	0.603	9.488	Not significant
Household size	0.053	5.991	Not significant

**Relationship Between Water Odor and Socio-Demographic Profile** - The results have a similar to water color, no significant relationships were found between socio-demographic variables in odor perceptions ( $p > 0.05$ ) that shown in table 3. This suggests that household characteristics do not influence the sensory perception of groundwater quality. The results indicate that odor and turbidity conditions are generally experienced uniformly across the population. While most zones exhibited acceptable conditions, localized variations were observed, but these were not associated with demographic differences. This supports Abdullah et al. (2021), who reported that water quality perceptions are more strongly influenced by environmental conditions and water source characteristics than by socio-demographic factors.

**Table 3**  
*Relationship Between Water Odor and Socio-Demographic Profile*

Socio-demographic profile variables	Computed X <sup>2</sup>	Tabular value	Interpretation
Gender	0.029	3.841	Not significant
Age	0.235	9.488	Not significant
Civil status	4.771	7.815	Not significant
Educational attainment	0.678	7.815	Not significant
Monthly income	0.32	5.991	Not significant
Occupation	0.938	9.488	Not significant
Household size	5.991	5.991	Not significant

**Relationship Between Water Turbidity and Socio-Demographic Profile** - The Chi-Square analysis revealed that turbidity showed no significant relationship with all socio-demographic variables ( $p > 0.05$ ), including gender, age, civil status, educational attainment, monthly income, occupation, and household size shown in table 3. This indicates that respondents' perception and exposure to turbidity are independent of socio-demographic characteristics. Regardless of background, households experienced similar turbidity conditions, with most zones exhibiting low turbidity levels and only localized variation observed in specific areas. The findings suggest that turbidity in groundwater is primarily influenced by environmental factors, such as soil composition, well structure, and surface runoff, rather than by household characteristics. This supports previous studies indicating that turbidity variations in groundwater are associated with physical disturbances and natural conditions rather than socio-economic differences. Sorlini et al. (2020) emphasized that turbidity variations are commonly linked to environmental factors such as rainfall infiltration and well maintenance rather than demographic influences.

**Table 3***Relationship Between Water Turbidity and Socio-Demographic Profile*

Socio-demographic profile variables	Computed X <sup>2</sup>	Tabular value	Interpretation
Gender	0.45	3.841	Not significant
Age	0.163	3.841	Not significant
Civil status	0.167	3.841	Not significant
Educational attainment	0.482	3.841	Not significant
Monthly income	0.178	3.841	Not significant
Occupation	0.181	3.841	Not significant
Household size	0.083	3.841	Not significant

**Relationship Between Water Temperature and Socio-Demographic Profile** - The results showed that temperature has no significant relationship with socio-demographic variables ( $p > 0.05$ ) shown in table 4, indicating that groundwater temperature is uniformly experienced across all respondents regardless of their demographic background. The observed temperature variations are likely influenced by environmental and climatic conditions, including solar exposure, shallow well depth, and ambient temperature. These factors are inherent to the physical environment and are not affected by human characteristics. This finding is consistent with previous research showing that groundwater temperature is primarily controlled by geographical and climatic conditions. Rivera and Flores (2020) reported that groundwater temperatures in rural Philippine communities remain relatively stable and are influenced by environmental exposure rather than user characteristics.

**Table 4***Relationship Between Water Temperature and Socio-Demographic Profile*

Socio-demographic profile variables	Computed X <sup>2</sup>	Tabular value	Interpretation
Gender	0.261	3.841	Not significant
Age	0.114	3.841	Not significant
Civil status	0.261	3.841	Not significant
Educational attainment	0.16	3.841	Not significant
Monthly income	0.534	3.841	Not significant
Occupation	0.141	3.841	Not significant
Household size	0.16	3.841	Not significant

**Relationship Between pH level and Socio-Demographic Profile** - The Chi-Square analysis revealed that pH level has no significant relationship with socio-demographic variables ( $p > 0.05$ ) shown in table 5, indicating that groundwater chemical properties are independent of respondents' socio-demographic profile. All measured pH values were within the acceptable range, suggesting that groundwater in Barangay San Cirilo is chemically stable. The consistency of pH levels across zones reflects the uniform geochemical characteristics of the aquifer system. These findings align with studies indicating that groundwater pH is largely influenced by natural geochemical processes, such as mineral dissolution and soil-water interaction. According to WHO (2021), pH levels in groundwater are primarily controlled by geological formations rather than human demographic factors.

**Table 5***Relationship Between pH level and Socio-Demographic Profile*

Socio-demographic profile variables	Computed X <sup>2</sup>	Tabular value	Interpretation
Gender	0	3.841	Not significant
Age	0	3.841	Not significant
Civil status	0	3.841	Not significant
Educational attainment	0	3.841	Not significant
Monthly income	0	3.841	Not significant
Occupation	0	3.841	Not significant
Household size	0	3.841	Not significant

*Note.* The absence of a significant relationship ( $p > 0.05$ ) indicates that pH levels are consistent across all groups and are not affected by socio-demographic factors, but rather by natural environmental conditions such as soil composition and mineral content.

**Relationship Between Bacteriological Quality and Socio-Demographic Profile** - The Chi-Square analysis revealed that bacteriological quality has a significant relationship with selected socio-demographic variables such as a civil status and educational attainment ( $p < 0.05$ ) shown in table 6. This indicates that the presence of total coliform and fecal coliform in groundwater is associated with certain characteristics of the respondents. This finding suggests that bacteriological contamination is not solely influenced by environmental factors but may also

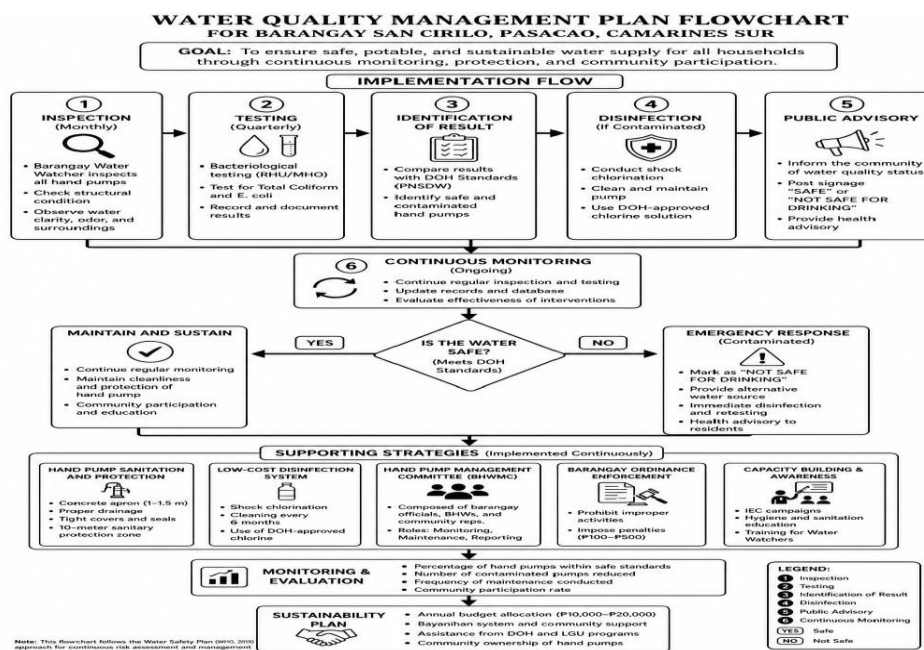
be linked to household conditions and practices, such as sanitation behavior, waste disposal methods, water handling, and level of awareness regarding water safety. Variations in educational attainment and civil status levels may influence knowledge and access to proper sanitation facilities, while household size may affect water usage and storage practices. These factors can contribute to differences in exposure to microbial contamination. The result implies that socio-demographic conditions play a role in groundwater contamination risk, particularly in areas where sanitation infrastructure is limited or improperly managed. This finding is supported by Bain et al. (2021), who emphasized that fecal contamination in water sources is strongly associated with household sanitation practices and hygiene behavior. Similarly, Armah et al. (2020) found that socio-economic conditions significantly influence exposure to contaminated water due to differences in sanitation access and environmental management.

**Table 5**  
*Relationship Between Bacteriological Quality and Socio-Demographic Profile*

Socio-demographic profile variables	Computed X <sup>2</sup>	Tabular value	Interpretation
Gender	1.119	3.841	Not significant
Age	6.586	9.488	Not significant
Civil status	9.77	7.815	Significant
Educational attainment	8.62	7.815	Significant
Monthly income	4.73	7.815	Not significant
Occupation	4.29	9.488	Not significant
Household size	5.16	5.991	Not significant

**3.4 Recommendations for Improving Water Quality Management in Barangay San Cirilo.**

**Management plan for Barangay San Cirilo, Pasacao Camarines Sur** - The study recommended the implementation of a comprehensive Water Quality Management Plan to address microbial contamination identified in selected hand pump water sources in Barangay San Cirilo. Although most physicochemical parameters were within acceptable standards, the presence of total coliform and E. coli indicates the need for preventive and corrective interventions. Furthermore, emergency response measures were included to ensure immediate action in cases of water contamination, alongside community awareness programs and capacity-building initiatives. The plan emphasizes sustainability through community participation, low-cost interventions, and alignment with national policies such as RA 9275, RA 7160, and DOH PNSDW guidelines. The recommended Water Quality Management Plan adopts a preventive and community-based approach aimed at ensuring the long-term safety and sustainability of drinking water sources. The diagram showed the process of the management plan for Barangay San Cirilo, Pasacao Camarines Sur (Figure 2).



(Figure 2. Flowchart diagram of the management plan for Barangay San Cirilo, Pasacao, Camarines Sur)

#### 4. Summary, findings, conclusion and recommendations

**Summary** - This study assessed the underground water quality of Barangay San Cirilo, Pasacao, Camarines Sur in terms of physical, chemical, and bacteriological characteristics. Specifically, it evaluated water color, odor, turbidity, temperature, pH level, and the presence of total coliform and fecal coliform (*E. coli*). It also examined whether socio-demographic factors such as gender, age, civil status, educational attainment, monthly income, occupation, and household size are significantly related to water quality perceptions and bacteriological contamination. Data were gathered through field observations, laboratory testing conducted by the Metropolitan Naga Water District, and survey questionnaires. Statistical analysis using the Chi-Square Test of Independence was used to determine relationships between variables. Overall, the study was designed not only to assess water quality conditions but also to serve as a basis for a proposed Water Quality Management Plan focusing on prevention of contamination, regular monitoring, and community-based water safety interventions.

**Findings** - The Physical Water Quality Most underground water sources in Barangay San Cirilo were found to be physically acceptable. Water color was generally clear to slightly yellow, odor was mostly absent except in one affected zone, turbidity levels were low, and water temperature ranged from 30°C to 32.5°C, which is typical for tropical groundwater conditions. Chemical Water Quality (pH Level), all sampling zones recorded pH levels between 7.23 and 7.75, which fall within the PNSDW acceptable range (6.5–8.5). This indicates that the groundwater is chemically stable, neutral to slightly alkaline, and safe in terms of acidity and alkalinity. Bacteriological Quality (Critical Finding), while most zones complied with standards, Zones 3 and 7A tested positive for total coliform and fecal coliform (*E. coli*), exceeding the PNSDW requirement of 0 MPN/100 mL. This indicates localized microbial contamination and potential health risks if consumed without treatment. And finally the Socio-Demographic Relationship the results showed that the most socio-demographic variables (gender, age, income, occupation, and household size) showed no significant relationship with water quality perception. However, civil status and educational attainment showed a significant relationship in bacteriological perception, suggesting that awareness and household structure may influence how contamination is perceived.

**Conclusion** - The study concludes that the underground water in Barangay San Cirilo is generally acceptable in terms of physical and chemical quality. The water is clear, stable, and chemically balanced, indicating suitability for domestic use under normal conditions. However, the detection of total coliform and fecal coliform in specific zones reveals that certain water sources are microbiologically unsafe for direct consumption. This poses a potential public health risk that requires urgent attention. Furthermore, socio-demographic characteristics generally do not influence water quality perceptions, except in bacteriological aspects where civil status and educational attainment showed some influence. This suggests that awareness and household structure may affect how residents interpret contamination risks. Overall, the study concludes that while the groundwater system in Barangay San Cirilo is mostly safe in physical and chemical terms, a structured Water Quality Management Plan is necessary to address microbial contamination, prevent future risks, and ensure sustainable safe drinking water supply for the community.

**Recommendations** - The findings of this study, maintaining the quality of groundwater is essential to safeguard the health and well-being of the community. In view of these findings, the researcher formulated several recommendations aimed at addressing water quality concerns and promoting safe and sustainable water practices among residents.

- An infographic based on the laboratory results was provided to the residents of Barangay San Cirilo to enhance their awareness and understanding of the water quality conditions in the area.
- The Water Quality Management Plan was presented to the Local Government Unit (LGU) of Pasacao and the Barangay Council of San Cirilo for review, approval, and possible implementation to strengthen community-based water safety management.
- Regular bacteriological monitoring of all hand pump water sources was strictly implemented, with priority testing in Zones 3 and 7A, to ensure early detection of contamination and immediate application

of corrective measures such as disinfection and temporary water source restriction.

**Implications for Practitioners/Teachers** – The findings provide a basis for integrating contextualized environmental and health education into the curriculum. Since groundwater quality issues are shared across households regardless of socio-demographic background, educators are encouraged to shift from purely theoretical instruction to applied, community-based learning approaches. Teachers can incorporate lessons on water safety, sanitation practices, and microbial contamination into science and environmental education subjects. More importantly, they can adopt experiential learning strategies, such as water quality monitoring activities, community surveys, and sanitation awareness campaigns, allowing students to directly engage with real-world issues in their locality. The presence of bacteriological contamination in selected zones also implies that teachers should emphasize preventive health practices, including safe water handling, boiling, filtration, and proper sanitation. By modeling these behaviors, educators serve as key agents in translating knowledge into practice, reinforcing the connection between environmental conditions and public health outcomes.

**Implications for Students** – The findings highlight the need to transition from awareness to responsible environmental and health practices. While groundwater conditions are largely shared across the community, the detection of microbial contamination in specific areas places responsibility on students to adopt safe water practices within their households. Students are encouraged to actively participate in community-based environmental initiatives, such as water sanitation campaigns, proper waste disposal practices, and household-level water treatment methods. Through participation in school-led projects and research activities, students can develop a deeper understanding of water quality issues and their impact on community health.

**Implications for Schools** – The findings emphasize the need to strengthen institutional efforts in Water, Sanitation, and Hygiene (WASH) programs. Given that groundwater quality issues are environmentally driven and affect the entire community, schools are in a strategic position to lead community extension and outreach initiatives. School administrations can develop programs focused on water safety education, including regular awareness campaigns, integration of water quality topics into the curriculum, and partnerships with local government units for water monitoring and sanitation improvement projects. Furthermore, schools can transform into centers of community learning by promoting sustainable practices such as proper waste management, water conservation, and hygiene promotion. By doing so, schools not only educate students but also extend their impact to the broader community, contributing to improved groundwater quality and public health.

**AI Declaration** – The authors declare that artificial intelligence tools (e.g., ChatGPT) were used solely for language refinement, formatting assistance, and improvement of academic writing structure. All data analysis, interpretation, and final responsibility for the content remain with the authors. The authors confirm that all references were cross-checked and verified for accuracy.

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