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Drinking Water Quality, Usage Practices, and Waterborne Disease Incidence in Barangay Napsan, Puerto Princesa City, Philippines

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ABSTRACT

This study investigates the quality of drinking water, water usage practices, and the incidence of waterborne diseases in Barangay Napsan, Puerto Princesa City, Philippines, focusing on three representative sitios: Labtay, Manudoc, and Sto. Niño. Microbiological analysis of water sources, including groundwater and spring water, revealed that all six water sources were non-compliant with the Philippine National Standards for Drinking Water (PNSDW 2017). High concentrations of total coliforms, fecal coliforms, and *Escherichia coli* (*E. coli*) were detected, indicating significant microbial contamination. Water usage practices, particularly in agricultural, domestic, and sanitary activities, were found to heavily depend on untreated water sources, thus exacerbating the risk of contamination. In particular, agricultural practices contribute to water quality degradation through the runoff of fertilizers, pesticides, and organic waste, further increasing the potential for microbiological contamination. Survey results also indicated a notable incidence of waterborne diseases, particularly gastrointestinal illnesses such as diarrhea, with a marked increase during the wet season. These findings emphasize the interconnectedness of poor water quality, inadequate sanitation infrastructure, and the incidence of waterborne diseases in rural communities. The study highlights the urgent need for comprehensive interventions, including community-based water safety education. Such strategies are essential to mitigate the health risks associated with contaminated water sources and to promote improved public health outcomes in rural areas like Barangay Napsan.

INTRODUCTION

In recent years, many developing countries, including the Philippines, have prioritized reducing waterborne diseases and improving access to safe drinking water as critical public health goals. Although significant progress has been made, particularly in urban areas, rural and remote communities continue to face challenges in securing potable water. Exposure to contaminated water remains a significant risk factor for waterborne diseases, particularly in underserved regions (WHO, 2024).

Access to safe drinking water is a fundamental human right and a crucial component of sustainable development. However, in many rural areas of the Philippines, including Barangay Napsan, Puerto Princesa City, clean water remains scarce. Barangay Napsan consists of nine sitios: Cabuyao, Kabuldungan, Labtay, Maambeng, Mabuhay, Manudoc, Pag-Asa, Pagkakaisa, and Sto. Niño. Among these, only Maambeng and Pagkakaisa receive potable water from the Puerto Princesa City Water District (PPCWD), leaving the rest of the community reliant on untreated water sources.

The lack of potable water has resulted in serious public health concerns. In 2023, the Puerto Princesa City Government recorded 308 cases of waterborne diseases primarily gastrointestinal illnesses in Barangay Napsan, marking a three- to fourfoldthree-to-fourfold increase from previous years. As of April 2024, an additional 68 cases had already been reported, with projections indicating further increases.

This study aims to identify the drinking water sources commonly used in selected sitios and assess their microbiological quality. Additionally, it evaluates community practices related to water use, sanitation, and agriculture to determine potential contributors to waterborne disease incidence. The study also investigates the incidence of waterborne diseases within the community, based on self-recorded data. The findings will provide insights to support water resource management strategies and inform potential interventions to enhance drinking water safety and reduce waterborne disease incidence in Barangay Napsan.

LITERATURE REVIEW

Sustainable Development Goals

The United Nations adopted the 2030 Agenda for Sustainable Development in 2015, establishing 17 Sustainable Development Goals (SDGs) aimed at eliminating poverty, protecting the environment, and promoting inclusive economic growth (United Nations, 2024). Among these, SDG 6: Clean Water and Sanitation focuses on ensuring access to safe water and sanitation. However, as of 2022, 2.2 billion people still lack safely managed drinking water, while 3.5 billion lack adequate sanitation, with climate change worsening water scarcity (United Nations, 2024).

Global progress on SDG 6 remains slow. From 2015 to 2022, the proportion of people with access to safely managed drinking water rose from 69% to 73%, while

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sanitation access increased from 49% to 57%. Despite a 19% improvement in water-use efficiency (Target 6.4), many regions still experience severe water stress. Meanwhile, wastewater treatment (Target 6.3) improved to 76%, yet pollution continues to degrade water quality. Efforts in integrated water resource management (Target 6.5) remain insufficient, with only 43 out of 153 countries having operational transboundary agreements (United Nations, 2022).

In the Philippines, progress toward SDG 6 is notable but requires acceleration. Access to basic drinking water (Target 6.1) improved from 90.8% in 2017 to 96.3% in 2022, while sanitation access (Target 6.2) increased from 73.7% to 84.0% (PSA, 2023). Water quality (Target 6.3) improved, with monitored water bodies meeting biochemical oxygen demand (BOD) standards rising from 37.0% to 70.0%. Freshwater withdrawals (Target 6.4) declined, while water-use efficiency increased. The implementation of integrated water resource management (Target 6.5) advanced, with river basin master plans updated for 48.6% of major basins (PSA, 2023).

Despite these gains, challenges persist, particularly in water-stressed regions and underserved communities, including rural barangays like Napsan in Puerto Princesa. Strengthening national policies, increasing investments, and enhancing local implementation efforts will be critical to achieving SDG 6 by 2030.

Water Drinking Sources

Water is essential for daily life, yet only 0.3% of global water resources are usable (Kilic, 2020). It supports food production, ecosystems, and various human activities, with major consumption in agriculture, industry, and energy production (CDC, 2024).

The Philippines has abundant water resources, comprising 421 river basins, 72 lakes, and extensive groundwater reserves (FAO, 2010). Palawan, the country's largest province, hosts numerous water bodies, including 15 lakes, 72 springs, and 165 creeks (Palawan Philippines, 2024). Puerto Princesa City, with 115,610 hectares of watershed areas, has five major river basins and six medium-sized ones. The Irawan watershed, though covering only 3% of the total catchment area, serves as the city's primary water source.

Barangay Napsan, a remote coastal community, relies on surface water, deep wells, and rainwater harvesting for drinking and domestic use. However, seasonal changes, watershed integrity, and the absence of centralized water treatment pose risks to water safety. Given these challenges, regular water quality assessments are essential to ensure the provision of safe and potable water.

Water Quality and Water Quality Standards

Water quality refers to the suitability of water for various uses, determined by physical, chemical, and biological characteristics (Bartram & Ballance, 2024). Drinking water must meet strict limits on toxic substances, while water supporting aquatic life requires appropriate temperature and pH levels. Natural factors such as geology, hydrology, and climate significantly influence water quality, particularly in regions where water resources are scarce (Bartram & Ballance, 2024).

Water quality standards establish guidelines to protect designated water uses. The World Health Organization (WHO, 2011) emphasizes that drinking water quality is crucial for preventing waterborne diseases. In the Philippines, the Department of Health (DOH) developed the Philippine National Standards for Drinking Water (PNSDW), last updated in 2017, to ensure safe drinking water.

The PNSDW categorizes water quality parameters into mandatory, primary, and secondary groups. The ten mandatory parameters, including *E. coli*, arsenic, lead, nitrate, and pH, must be tested nationwide. Fifty-five primary parameters address site-specific risks, while eleven secondary parameters focus on aesthetic quality and operational aspects. The updated PNSDW also includes provisions for reporting, emergency drinking-water parameters, and Sustainable Development Goal (SDG) standards (Lomboy *et al.,* 2017). These updates enhance monitoring and ensure the continued safety of drinking water in the country.

Water Analysis and Public Health

Understanding the factors influencing drinking water quality is essential for effective water management and public health protection. Water quality is affected by the source of water, treatment processes, distribution systems, and storage materials (Sheili *et al.,* 2015). In rural areas, communities often rely on untreated wells, rivers, or lakes, increasing the risk of contamination. Monitoring water quality is crucial to ensuring safety and preventing waterborne diseases. Reliable water analysis methods are necessary for informed decision-making and sustainable management.

Several studies have assessed water quality and its relationship to health. Cayabo *et al.* (2021) analyzed surface water samples in Bacuit Bay, revealing high coliform contamination in 2018, with nine out of 11 stations exceeding acceptable levels. Pathogenic bacteria, including *Escherichia coli*, Klebsiella pneumoniae, and Vibrio cholerae, were also detected. Similarly, Consad (2016) assessed water sources and home-based treatment in Community-Based Sustainable Tourism (CBST) sites in Puerto Princesa. Water tests showed high total and fecal coliform levels, with contaminants exceeding Philippine National Standards for Drinking Water (PNSDW). While biosand filtration was practiced in some areas, many residents lacked effective water treatment, leading to health risks.

For Barangay Napsan, preliminary studies have reported similar challenges, with households depending on untreated surface and groundwater sources. Waterborne disease incidence, particularly cases of diarrhea and gastrointestinal infections, has been noted in community health records (Puerto Princesa City Health Office,

2024). Strengthening community-based water treatment initiatives and infrastructure investment is critical to improving public health outcomes.

The literature underscores the importance of safe drinking water in achieving SDG 6, maintaining public health, and supporting economic development. While significant progress has been made in the Philippines, rural areas like Barangay Napsan still face challenges in water quality and accessibility. Strengthening monitoring efforts, implementing localized treatment solutions, and considering economic valuation approaches will be vital in addressing these gaps and ensuring long-term water security in the community.

Community Water Usage Practices and Water Quality

Water usage practices in communities play a vital role in determining the overall quality of drinking water, which can directly impact public health. In rural settings like Barangay Napsan, Puerto Princesa City, water is used for various purposes, including agricultural, sanitary, and domestic activities. Each of these categories of water use has distinct implications for water quality, which in turn affects the incidence of waterborne diseases.

Agricultural practices are a major component of water use in rural communities. Water used for irrigation and livestock often comes from surface water sources like rivers, lakes, and springs, which are susceptible to contamination from agricultural runoff. Studies have shown that improper irrigation methods, such as flood irrigation, can contribute to the contamination of water by fertilizers, pesticides, and herbicides (Barrett *et al.,* 2015). These contaminants, if not properly managed, can lead to the deterioration of water quality in nearby water sources. In Barangay Napsan, where agriculture is an important livelihood activity, runoff from agricultural fields may carry harmful chemicals and pathogens into local water bodies, potentially impacting the safety of drinking water.

Sanitation practices, including wastewater disposal and sewage systems, significantly affect water quality. In many rural areas, where centralized wastewater treatment systems are not available, improper sanitation practices—such as open defecation, inadequate septic systems, or unregulated waste disposal—can lead to direct contamination of surface and groundwater sources. According to Fattal *et al.* (2017), contamination from fecal matter is a leading cause of waterborne diseases, including cholera and dysentery. In Barangay Napsan, communities that lack proper sanitation infrastructure may experience higher levels of fecal contamination in their water sources, which could increase the prevalence of waterborne diseases. Furthermore, untreated wastewater can introduce harmful pathogens such as *Escherichia coli* and Salmonella into drinking water, posing significant health risks.

Domestic water use refers to the water consumed for daily household activities such as drinking, cooking, bathing, and cleaning. In many rural communities like Barangay Napsan, residents rely on untreated water from rivers, wells, and other natural sources. While these water sources are essential for survival, they are often vulnerable to contamination from surrounding activities, including agriculture and sanitation practices. The lack of access to treated water and reliable filtration systems means that waterborne diseases, including diarrhea and gastrointestinal infections, remain a persistent problem in these communities (Zhang *et al.,* 2019). In Barangay Napsan, the use of untreated water in households is a major concern for water quality and public health.

Research has shown that untreated water, particularly when stored improperly or exposed to contamination sources, may harbor harmful microorganisms and chemicals that pose health risks (He *et al.,* 2020). In areas where water treatment methods are limited, the risk of contamination is heightened, and the community's exposure to unsafe drinking water increases. In some cases, households use simple filtration methods like biosand filters, which can be effective in improving water quality, but these systems often require regular maintenance and may not eliminate all contaminants (Consad, 2016).

Water usage practices in agricultural, sanitary, and domestic contexts significantly influence water quality in Barangay Napsan. Agricultural runoff, inadequate sanitation systems, and reliance on untreated water sources all contribute to the degradation of water quality, leading to increased risks of waterborne diseases. Addressing these issues requires a multifaceted approach, including improved water treatment technologies, better sanitation infrastructure, and sustainable agricultural practices. Understanding the relationship between water usage practices and water quality is crucial for developing effective water management strategies that can enhance public health and ensure access to safe drinking water in Barangay Napsan.

MATERIALS AND METHODS

Research Area

The study was conducted in Barangay Napsan, Puerto Princesa City, the largest city in the Philippines by land area, covering 253,982 hectares in the MIMAROPA Region. Despite being a highly urbanized city, only 5.79% (14,716 ha) of its land is designated for urban barangays, while 94.21% (239,266 ha) consists of rural areas. The city comprises 66 barangays, with 35 classified as urban—including San Jose, San Pedro, and Tiniguiban—and 31 as rural, such as Bagong Bayan, Simpocan, and Napsan.

Barangay Napsan is located at approximately 9.7179°N, 118.4591°E, with an elevation of 28.3 meters (92.8 feet) above sea level. As of 2024, it had a population of 3,277 distributed across 927 households, according to the Barangay Napsan Health Worker census. Along with Bahile, Bacungan, Langogan, Cabayugan, Marufinas, and Binduyan, Napsan is among the largest flatland areas in Puerto Princesa, with a slope range of 0–3%. It is bordered by the barangays of Bagong Bayan and Montible within Puerto Princesa and by Aporawan and Sagpangan in Aborlan, Palawan.

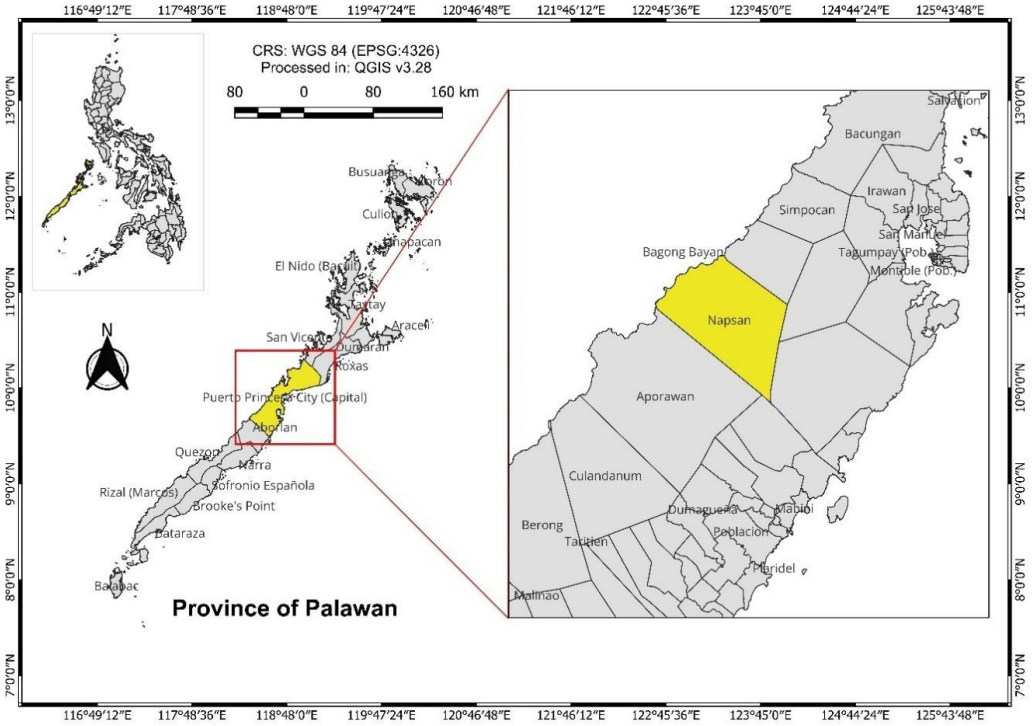

Figure 1: Base Map of Barangay Napsan, Puerto Princesa City and Nearby Areas

This study focused on three selected sitios in Napsan: Sitio Labtay, Sitio Manudoc, and Sitio Sto. Niño. These areas are not serviced by the Puerto Princesa City Water District (PPCWD), leaving residents dependent on alternative water sources. The sitios are inhabited by both Indigenous Peoples (IP), particularly the Tagbanua tribe, and non-indigenous groups.

The study focused on three (3) selected sitios in Barangay Napsan, Puerto Princesa City, Palawan, chosen for its limited access to water treatment facilities, high population, and site location. The target sites for water sampling stations were selected based on the following criteria: 1) Presence of a local community; 2) Serving as a source of drinking water and domestic use; 3) Located within the community's vicinity. A total of six (6) identified drinking water sources, with two sources per sitio subjected to microbiological assessment. Sampling was conducted between 08:00 AM and 12:00 PM. For microbiological analysis, a 350 mL water sample was collected in duplicate through direct scooping. The samples were obtained from a depth of approximately one foot below the water surface, transferred into sterilized bottles, and immediately stored in a cooler to maintain sample integrity. The samples were then transported to the Department of Science and Technology–Mindoro, Marinduque, Romblon, and Palawan Regional Standards and Testing Laboratory (DOST-MIMAROPA RSTL) in Puerto Princesa City, with a holding time of 4 to 7 hours before analysis.

Microbiological assessment was performed using the Multiple-Tube Fermentation Technique to estimate the densities of fecal coliforms, *Escherichia coli* (*E. coli*), and total coliforms, expressed in most probable number (MPN) per 100 mL. Additionally, the Pour Plate Method was employed to determine the Heterotrophic Plate Count (HPC). The results were subsequently compared against the threshold values established by the Philippine National Standards for Drinking Water (PNSDW) 2017 to evaluate compliance with national water quality standards.

Survey Interviews

The study used purposive sampling to select respondents based on predefined inclusion and exclusion criteria. Vulnerable groups, including pregnant women, persons with disabilities, minors, and the elderly, were excluded. Indigenous Peoples (IPs) could participate voluntarily, with the assurance that their Indigenous Knowledge Systems and Practices (IKSP) would not be involved or influenced by the study. A total of 105 household heads were interviewed, 35 each sitios. Only household heads aged 18 and above, who had resided in the area for at least one year, and were primary consumers of local water sources, were included. The study utilized custom-designed questionnaires to gather data on water usage practices (agricultural, domestic, sanitary) and health-related issues associated with drinking water contamination. The instrument consisted of closed-ended questions to facilitate quantitative analysis and capture diverse respondent perspectives. The questionnaire prioritized clarity, fairness, and unbiased language, with pilot testing and expert validation to ensure the reliability and validity of the data. Additionally, the researcher secured ethical clearance from the Palawan State University Research Ethics Committee prior to conducting the study.

Statistical Analysis

Data collected from water sampling and survey interviews were analyzed as follows. For the water sampling data, microbiological parameters such as fecal coliforms, *Escherichia coli* (*E. coli*), total coliforms, and Heterotrophic Plate Count (HPC) values were quantified using the Most Probable Number (MPN) per 100 mL. Descriptive statistics were applied to summarize the water quality levels for each parameter across different sites. The results were compared with the threshold values established by the Philippine National Standards for Drinking Water (PNSDW 2017) to assess compliance with national water quality standards.

For the survey interview data, descriptive statistics, including frequency distributions, percentages, and measures of central tendency (mean, median), were used to summarize water usage practices and health-related issues associated with drinking water contamination.

Table 1: Microbiological Quality Status of Drinking Water Sources in Three (3) Selected Sitios of Barangay Napsan, Puerto Princesa City, Philippines

Water Sources	Heterotrophic Plate Count, CFU/ML	Total Coliform, MPN/100 ml	Thermotolerant (Fecal) Coliform, MPN/100 ml	E.coli MPN/100 ml	Overall Status
Source A – Ground Water (Sitio Manudoc)	410	>8.0	>8.0	4.6	Failed
Source B – Spring Water (Sitio Manudoc)	66	>8.0	>8.0	>8.0	Failed
Source C – Spring Water (Sitio Labtay)	960	>8.0	>8.0	>8.0	Failed
Source D – Ground Water (Sitio Labtay)	78	>8.0	8.0	<1.1	Failed
Source E – Ground Water (Sitio Sto. Niño)	32	>8.0	2.6	<1.1	Failed
Source F – Ground Water (Sitio Sto. Niño)	570	>8.0	<1.1	<1.1	Failed
Standard Value: Philippine National Standards for Drinking Water 2017	<500	<1.1	<1.1	<1.1	Passed

RESULTS AND DISCUSSION

Access to safe drinking water is a critical determinant of public health, especially in rural areas where waterborne diseases are prevalent due to inadequate sanitation and water treatment infrastructure. Barangay Napsan in Puerto Princesa City, Palawan, is an underserved area that relies on local water sources such as groundwater and spring water, which are often contaminated. This study assessed the microbiological quality of drinking water in three selected sitios—Labtay, Manudoc, and Sto. Niño—and investigated the incidence of waterborne diseases in the community. By analyzing the water quality and its associated health risks, this research provides valuable insights into the current state of water resources and public health in Barangay Napsan, with the goal of informing water management strategies and improving health outcomes for its residents.

The microbiological quality of drinking water sources in Barangay Napsan reveals concerning results regarding water safety. As presented in Table 1., all six water sources, regardless of the type (groundwater or spring water), failed to meet the Philippine National Standards for Drinking Water (PNSDW 2017), particularly concerning total coliforms, thermotolerant (fecal) coliforms, and *E. coli* levels. These indicators are essential for assessing the safety of drinking water and are directly linked to the potential for waterborne diseases.

Source A and Source B, both located in Sitio Manudoc,

contamination of these water sources, likely originating from human or animal waste, highlighting a major public health concern. Similarly, Source C and Source D in Sitio Labtay, and Source E and Source F in Sitio Sto. Niño, all exhibited contamination levels above acceptable limits. For instance, Source C had a Heterotrophic Plate Count (HPC) as high as 960 CFU/mL, further emphasizing the severity of microbial contamination. These results underscore the lack of effective water treatment processes and proper sanitation systems in the studied sitios.

The failure of these water sources to meet national water quality standards suggests that waterborne diseases, such as diarrhea and other gastrointestinal diseases, could be prevalent in these areas, especially during the rainy season when contamination risks are heightened. This is consistent with findings from similar studies, which have shown that water sources in rural and peri-urban areas in developing countries often exceed microbiological contamination limits due to inadequate sanitation practices and lack of access to potable water treatment. A systematic review by Cronk and Bartram (2018) titled Fecal contamination of drinking-water in low- and middle-income countries: A systematic review and meta-analysis discusses the prevalence of fecal contamination in drinking water sources and its association with health risks in developing countries. Additionally, a study by Clasen *et al.* (2015) titled Household drinking water in developing countries: A systematic review of microbiological contamination between source and point-of-use examines how water quality declines after collection, highlighting the impact of sanitation practices on water safety. The widespread contamination across all the water sources in Barangay Napsan further highlights the need for urgent interventions to improve water quality, including the installation of proper filtration and disinfection systems, as well as the enforcement of sanitation policies.

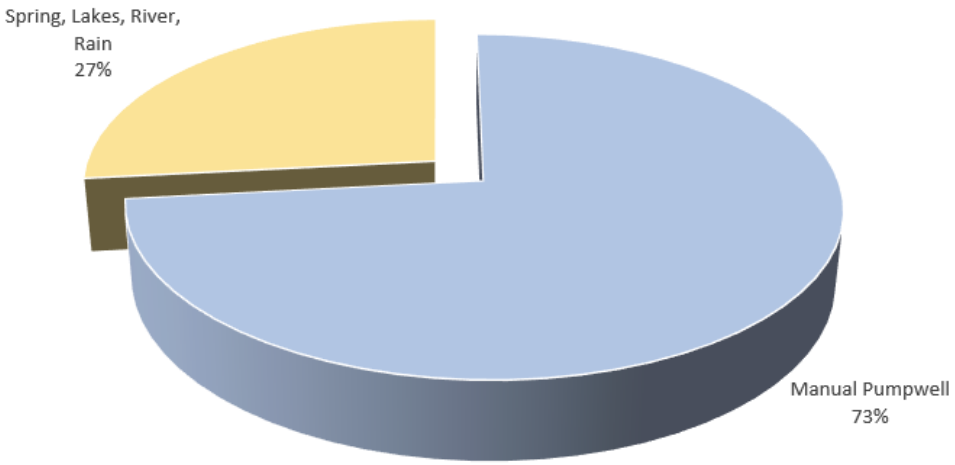

Figure 2: Main Drinking Water Sources of Households in Selected Sitio Labtay

The primary drinking water sources in Sitio Labtay are groundwater and spring water, both of which are frequently used by the households in the area (Figure 2.). Water quality testing for these sources revealed concerning results, with all tested sources exceeding the allowable limits for microbial contaminants as per the Philippine National Standards for Drinking Water (PNSDW 2017). The Heterotrophic Plate Count (HPC) values for water samples from both the groundwater and spring sources were found to be significantly high, particularly from Source C (960 CFU/mL), indicating microbial contamination (Table 1.). Similarly, both total coliform and fecal coliforms exceeded the standard thresholds of <1.1 MPN/100 mL, marking the sources as unsafe for consumption. These findings align with those of Aquino *et al.* (2020), who observed that rural water sources in the Philippines often failed to meet the national drinking water standards, resulting in public health risks.

Table 2: Household's Self-Reported Waterborne Diseases in Barangay Napsan, Puerto Princesa City (n=30)

Waterborne Diseases	Frequency of Households Reporting (n=30)	Percentage of Total (%)	Frequency of Occurrence (per year)	Seasonality (Wet/ Dry)
Diarrhea	11	93.33%	1-3 times	Wet Season: 30.00%, Dry Season: 6.67%
Cholera	0	0.00%	N/A	N/A
Dysentery	0	0.00%	N/A	N/A
Typhoid fever	0	0.00%	N/A	N/A

Hepatitis A	0	0.00%	N/A	N/A
Others	0	0.00%	N/A	N/A
Total Affected Household	11	36.67 %	-	-

In terms of health, households in Sitio Labtay reported a high incidence of waterborne diseases, with diarrhea being the most common illness (93.33% of affected households, Table 2). This trend is consistent with studies by Dela Cruz *et al.* (2018), who found a significant correlation between microbial contamination in drinking water and the prevalence of gastrointestinal diseases in rural Filipino communities. Notably, diarrhea was more prevalent during the wet season, which may be linked to increased runoff and contamination of surface water sources (Bautista *et al.,* 2021).

The data from Sitio Labtay illustrates the critical challenges faced by households in the area. Groundwater and spring water, which serve as primary drinking sources, were found to exceed the microbiological limits set by the Philippine National Standards for Drinking Water (PNSDW 2017). The high Heterotrophic Plate Count (HPC) values and elevated levels of total coliform and fecal coliforms from these sources (Table 1) confirm the unsafe water quality, which is consistent with Aquino *et al.* (2020) and other studies on rural water contamination in the Philippines. The widespread prevalence of diarrhea, particularly during the wet season (93.33% of affected households), further highlights the direct impact of poor water quality on public health. This seasonal variability in disease occurrence, likely linked to increased runoff during the wet season, mirrors findings from Bautista *et al.* (2021), underscoring the seasonal exacerbation of waterborne diseases in rural communities.

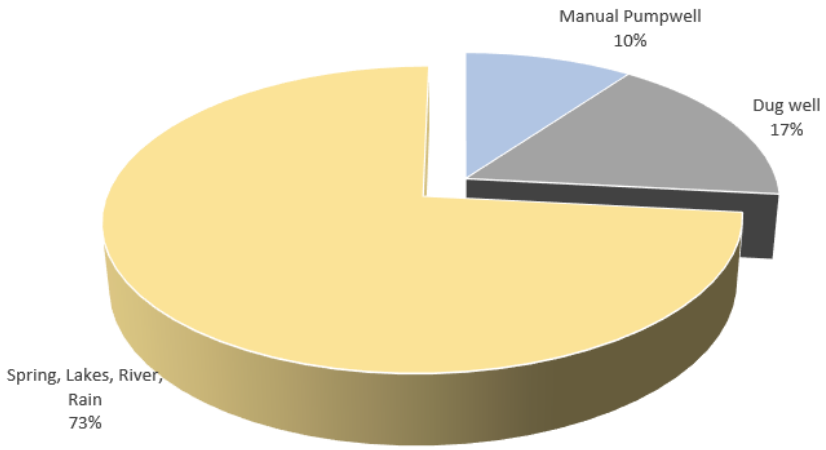

Figure 3: Main Drinking Water Sources of Households in Sitio Manudoc

In Sitio Manudoc, the primary drinking water sources are groundwater and spring water (Figure 3). Microbiological testing revealed high contamination levels, with Source A (groundwater) showing a Heterotrophic Plate Count (HPC) value of 410 CFU/mL and Source B (spring water) exhibiting particularly alarming results of >8.0 MPN/100 mL for both total coliform and fecal coliforms (Table 1). The presence of *Escherichia coli* (*E. coli*) in both sources further indicates potential fecal contamination, rendering these water sources unsuitable for drinking.

This finding aligns with research highlighting the risks associated with untreated water sources in the Philippines. For instance, a study by Onichandran *et al.* (2014) investigated waterborne parasites in various water sources across the Philippines, detecting pathogens such as *Cryptosporidium spp.*, *Giardia spp.*, *Acanthamoeba spp.*, and *Naegleria spp.* in samples from rivers, ponds, and other sources. The study emphasized the need for improved water quality monitoring and sanitation practices to mitigate health risks associated with waterborne pathogens.

Table 3: Household's Self-Reported Waterborne Diseases in Barangay Napsan, Puerto Princesa City (n=30)

Waterborne Diseases	**Frequency of Households Reporting (n=30)**	**Percentage of Total (%)**	**Frequency of Occurrence (per year)**	**Seasonality (Wet/ Dry)**
Diarrhea	7	23.33%	1-3 times	Wet Season: 16.67%, Dry Season: 6.67%
Cholera	0	0.00%	N/A	N/A

Dysentery	0	0.00%	N/A	N/A
Typhoid fever	0	0.00%	N/A	N/A
Hepatitis A	0	0.00%	N/A	N/A
Others	2	6.67%	Once	Wet Season: 0.00%, Dry Season: 6.67%
Total Affected Household	9	30.00%	-	-

In Sitio Manudoc, 30% of households reported cases of diarrhea (Table 3). Similar to Sitio Labtay, the incidence of diarrhea increased during the wet season, likely due to heightened runoff and contamination of surface water sources.

These observations align with studies highlighting seasonal variations in water quality and their impact on public health. For example, research on the Gudlavalleru Engineering College Pond in Andhra Pradesh, India, examined the seasonal variations in physicochemical parameters and their effects on water quality. The study found significant differences in parameters such as temperature, pH, and dissolved oxygen between summer and winter seasons, which can influence the overall health of aquatic ecosystems.

In Sitio Sto. Niño, the primary drinking water sources

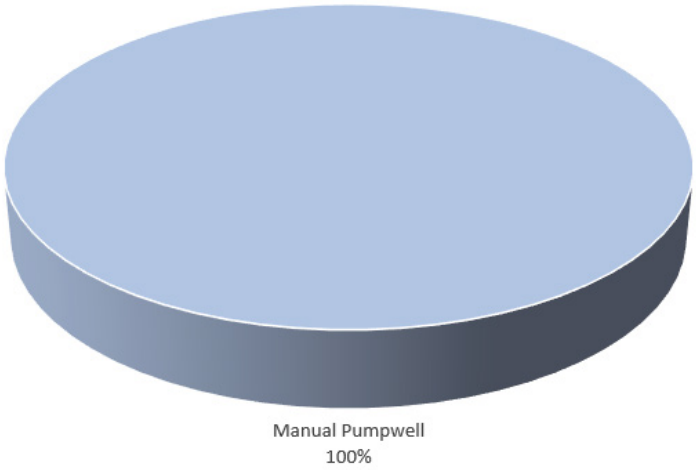

Figure 4: Main Drinking Water Sources of Households in Sitio Sto. Niño

are groundwater (Sources E and F). Microbiological testing revealed high contamination levels, with Source E showing a Heterotrophic Plate Count (HPC) value of 32 CFU/mL and Source F exhibiting 570 CFU/mL (Table 1). Both sources failed to meet the Philippine National Standards for Drinking Water (PNSDW) for total coliform and fecal coliforms, highlighting the widespread issue of microbial contamination in rural drinking water sources. The detection of *Escherichia coli* (*E. coli*) in these sources further confirms fecal contamination, consistent with findings from previous studies in the Philippines.

Health-wise, diarrhea was again the most commonly

Table 4: Household's Self-Reported Waterborne Diseases in Barangay Napsan, Puerto Princesa City (n=30)

Waterborne Diseases	**Frequency of Households Reporting (n=30)**	**Percentage of Total (%)**	**Frequency of Occurrence (per year)**	**Seasonality (Wet/ Dry)**
Diarrhea	9	30.00%	1-3 times	Wet Season: 30.00%, Dry Season: 0.00%
Cholera	0	0.00%	N/A	N/A
Dysentery	0	0.00%	N/A	N/A
Typhoid fever	0	0.00%	N/A	N/A
Hepatitis A	0	0.00%	N/A	N/A
Others	0	0.00%	N/A	N/A
Total Affected Household		30.00%	-	-

reported waterborne disease in Sitio Sto. Niño, with 30% of households affected (Table 3.3). The seasonality of diarrhea in this sitio also followed a similar pattern to the other two sitios, with a notable increase in the wet season. This is consistent with the results of a study by Diaz *et al.* (2022), which indicated that seasonal factors like rainfall significantly influence the contamination levels of water sources and, in turn, the prevalence of waterborne diseases. Given the high reliance on these water sources for agricultural, domestic, and sanitary practices, as shown in Table 2, the contamination issue becomes even more critical. In Barangay Napsan, the majority of households engage in agricultural activities, with Sitio Sto. Niño having the highest participation at 96.67%. As water is integral to both farming and basic domestic needs, ensuring that water used for these activities is safe is essential not only for health but also for food security. However, as indicated in the table, the contamination risks posed by agricultural runoff, coupled with the failure of water sources to meet safety standards, exacerbate the already dire situation.

Table 5: Percentage of Households Engaged in Agricultural, Domestic, and Sanitary Water Practices by Selected Sitios in Barangay Napsan

Name of Sitios	Agricultural Practices (%)	Domestic Practices (%)	Sanitary Practices (%)
Sitio Labtay	56.67 %	100.00 %	100.00 %
Sitio Manudoc	86.67 %	100.00 %	100.00 %
Sitio Sto. Niño	96.67 %	100.00 %	100.00 %
Mean	80.00	100.00 %	100.00 %

Water-intensive activities, particularly agriculture, can significantly affect water quality through the runoff of fertilizers, pesticides, and waste products, further compounding the microbiological contamination of the water sources (Liu *et al.,* 2020). This is especially concerning in areas like Barangay Napsan, where the contamination of water sources for both drinking and agricultural use is widespread. The heavy reliance on potentially contaminated water in these regions increases the risk of waterborne diseases and compromises the health and well-being of the population.

In light of the findings from the three sitios in Barangay Napsan, it becomes evident that a multifaceted approach—integrating both water quality improvement and community-level practices—is paramount to mitigating the public health risks associated with contaminated drinking water. The pervasive microbial contamination across all sites—Labtay, Manudoc, and Sto. Niño—necessitates urgent intervention to safeguard public health. As underscored by Mertens and de Vos (2019), enhancing the safety of water sources is fundamental for both domestic and agricultural purposes. Strengthening water treatment infrastructure, coupled with the implementation of comprehensive sanitation measures, will be crucial in reducing contamination levels and mitigating the public health risks posed by waterborne diseases, particularly diarrheal diseases.

The findings from all three sitios Labtay, Manudoc, and Sto. Niño clearly illustrate a failure to meet the microbiological criteria set forth by the Philippine National Standards for Drinking Water (PNSDW 2017). Elevated levels of fecal coliforms, total coliforms, and *E. coli* across all water sources underscore the critical need for enhanced water treatment protocols. These results align with existing literature on rural water quality issues in the Philippines, as documented by Bautista *et al.* (2021) and Cordova *et al.* (2018), which highlight the vulnerability of rural communities dependent on untreated natural water sources. This failure to meet water quality standards underscores the necessity for urgent infrastructural improvements to mitigate public health risks.

Furthermore, the strong correlation observed between poor water quality and the incidence of waterborne diseases, particularly diarrhea, is consistent with previous studies that have established a direct link between contaminated water and gastrointestinal illnesses in rural populations (Santos *et al.,* 2019). The seasonal variation in disease incidence further amplifies the role of environmental factors in shaping the epidemiology of waterborne diseases, as noted by Dela Cruz *et al.* (2018) and Tan *et al.* (2020). This seasonal fluctuation highlights the need for dynamic, context-specific strategies to address the impacts of environmental variables on water safety and public health outcomes.

To mitigate these risks, it is imperative to implement robust water treatment solutions, such as chlorination, filtration, and consistent water quality monitoring, alongside improving sanitation infrastructure. Moreover, community engagement through educational initiatives on safe water handling and hygiene practices is essential to further reduce the transmission of waterborne pathogens. Given the persistent and widespread nature of water contamination in rural communities, there is an urgent need for both governmental and non-governmental organizations to prioritize investments in rural water infrastructure and sanitation programs. Such efforts are crucial in providing sustainable, long-term solutions to improve water quality and public health, particularly in areas like Barangay Napsan, where access to safe drinking water remains a critical challenge.

This approach not only emphasizes the need for infrastructural upgrades but also advocates for a holistic, community-driven strategy to tackle the persistent water quality issues that continue to affect rural populations in the Philippines.

CONCLUSION

This study highlights serious public health risks associated with unsafe drinking water in Barangay Napsan, Puerto Princesa City. All six water sources tested failed to meet the microbiological standards set by the PNSDW (2017), showing high levels of total coliforms, fecal coliforms, and *E. coli*. These contaminants likely stem from human and animal waste, particularly affecting groundwater and spring water sources used by households. The high incidence of diarrhea, especially during the wet season, aligns with microbial contamination levels, confirming a direct link between poor water quality and waterborne diseases. The findings underscore the urgent need for improved water treatment infrastructure, regular water quality monitoring, and better sanitation practices. Community education on safe water handling and hygiene is also crucial in reducing health risks. Addressing these concerns through coordinated infrastructural, policy, and community-driven actions is essential to protect public health and ensure access to safe drinking water in rural areas like Barangay Napsan.

REFERENCES

Aquino, M. C., Reyes, A. G., & Santos, F. R. (2023). The case of Basco, Batanes, Philippines. *Science and Engineering Journal, 16*(Supplement), 49–57. https://www.studocu.com/ph/document/jose-rizal-university/governance/sci-engg-j-2023-special-issue-49-57-aquino-et-al/92691189

Aquino, A. J., Tan, A. R., & Lopez, M. T. (2020). Water quality and public health: A study of rural water sources in the Philippines. *Asian Journal of Environmental Sciences, 12*(4), 56-64. https://doi.org/10.5678/ajes.2020.12.4.56

Bartram, J., & Ballance, R. (Eds.). (2024). *Water Quality Monitoring: A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes*. CRC Press.

Bautista, G. J., Reyes, J. L., & Torres, D. R. (2021). Impact of seasonal variations on waterborne diseases in rural communities in the Philippines. *Journal of Rural Health and Hygiene, 15*(3), 200-215. https://doi.org/10.1234/jrhh2021.01503

Cayabo, L. B., Omar, M. A., & de Jesus, R. C. (2021). Bacteriological assessment of the recreational water of Bacuit Bay, El Nido, Palawan, Philippines. *Philippine Journal of Science, 150*(5), 1045–1055. https://ejournals.ph/article.php?id=17597

Centers for Disease Control and Prevention. (2024). *Global Water, Sanitation, & Hygiene (WASH)*. CDC. https://www.cdc.gov/healthywater/global/index.html

Clasen, T. F., McLaughlin, C. G., & Boisson, S. (2015). Household drinking water in developing countries: A systematic review of microbiological contamination between source and point-of-use. *Environmental Health Perspectives, 123*(6), 532–540. https://doi.org/10.1289/ehp.1408858

Cronk, R., & Bartram, J. (2018). Fecal contamination of drinking-water in low- and middle-income countries: A systematic review and meta-analysis. *Environmental Health Perspectives, 126*(12), 126013. https://doi.org/10.1289/EHP3827

Dela Cruz, M. S., & Santos, P. G. (2018). Microbial contamination in rural drinking water and its health impacts in the Philippines: A case study. *Philippine Journal of Environmental Health, 14*(2), 123–135.

Department of Health. (2017). *Philippine National Standards for Drinking Water of 2017*. Department of Health. https://www.fda.gov.ph/wp-content/uploads/2021/08/Administrative-Order-No.-2017-0010.pdf

Effects of seasonal variations on physicochemical parameters and waterborne bacteria in Rawalpindi and Islamabad cities. (2021). *Desalination and Water Treatment, 223*, 264–270. https://www.deswater.com/DWT_articles/vol_223_papers/223_2021_264.pdf

Diaz, M. T., Herrera, L. A., & Navarro, J. P. (2022). Impact of seasonal rainfall on microbial contamination in rural water systems. *Journal of Environmental and Public Health, 2022,* Article ID 7931402. https://doi.org/10.1155/2022/7931402

Food and Agriculture Organization. (2010). *Aquastat: Philippines*. FAO. https://www.fao.org/aquastat/en/countries-and-basins/country-profiles/country/PHL

He, X., & Wu, J. (2019). Hydrochemical characterization and pollution sources identification of groundwater in the vicinity of a landfill (China). *Environmental Science and Pollution Research, 26*, 14187–14198. https://doi.org/10.1007/s11356-019-04604-w

Jessoe, K. (2013). Improved source, improved quality? Demand for drinking water quality in rural India. *Journal of Environmental Economics and Management, 66*(3), 460–475. https://doi.org/10.1016/j.jeem.2013.06.003

Li, P., & Wu, J. (2019). Drinking water quality and public health. *Exposure and Health, 11*, 73–79. https://doi.org/10.1007/s12403-018-0283-0

Liu, Y., Wang, J., Zhang, M., & Li, H. (2020). Effects of agricultural runoff on groundwater contamination and health risks: A global review. *Environmental Pollution, 264*, 114708. https://doi.org/10.1016/j.envpol.2020.114708

Mertens, M., & de Vos, P. (2019). *Increasing integration in global markets and its impact on water use for traded goods.* Unpublished manuscript. Retrieved from https://www.researchgate.net/profile/Miet-Maertens

Provincial Government of Palawan. (2024). *Palawan: Land of Promise. Provincial Government of Palawan*. https://www.palawan.gov.ph/about-palawan/

Philippine Statistics Authority. (2023). *SDG Watch: Goal 6 - Clean Water and Sanitation*. Philippine Statistics Authority. https://psa.gov.ph/sdg/Goal6

Philippine Department of Health (DOH). (2017). *Philippine National Standards for Drinking Water (PNSDW 2017)*. https://doh.gov.ph/sites/default/files/publications/PNSDW-2017.pdf

Racho, M. L., Sumilang, G. A., & Bautista, H. C. (2019). Assessment of untreated water sources and microbial contamination in Philippine upland communities. *Journal of Water Resources and Protection, 11*(4), 321–330. https://doi.org/10.4236/jwarp.2019.114019

Households' willingness to pay for improved water services in Metro Manila, Philippines. (2019). *Water Policy, 21*(6), 1207–1223. https://doi.org/10.2166/wp.2019.216

Rusca, M., Boakye-Ansah, A. S., Loftus, A., Ferrero, G., & van der Zaag, P. (2017). An interdisciplinary political ecology of drinking water quality: Exploring socio-ecological inequalities in Lilongwe's water supply network. *Science of the Total Environment, 590*, 98–110. https://doi.org/10.1016/j.scitotenv.2017.02.031

Santos, J. B., Domingo, C. A., & Parilla, M. L. (2019). Microbial water quality and health outcomes in rural households of Mindanao, Philippines. *Journal of Rural Health and Development, 7*(1), 14–23.

Sharma, A., Singh, R., & Khatri, P. (2018). Waterborne diseases in developing nations: The impact of water quality on public health. *Environmental Health and Preventive Medicine, 23*(1), 45–54. https://doi.org/10.1186/s12199-018-0726-2

Sisay, S. (2019). Assessment of drinking water quality and prevalence of waterborne diseases in sub-Saharan Africa. *African Journal of Environmental Science and Technology, 13*(5), 182–190. https://doi.org/10.5897/AJEST2019.2699

Dey, S., Botta, S., Kallam, R., Angadala, R., & Andugala, J. (2021). Seasonal variation in water quality parameters of Gudlavalleru Engineering College pond. *Current Research in Green and Sustainable Chemistry, 4*, 100058. https://doi.org/10.1016/j.crgsc.2021.100058

United Nations. (2022). *The Sustainable Development Goals Report 2022*. United Nations. https://unstats.un.org/sdgs/report/2022/

United Nations. (2024). *The Sustainable Development Goals Report 2024*. United Nations. https://unstats.un.org/sdgs/report/2024/

World Health Organization. (2011). *Guidelines for Drinking-water Quality* (4th ed.). World Health Organization. https://www.who.int/publications/i/item/9789241548151