The Seybold Report
ISSN 1533-9211
DOI: 10.5281/zenodo.11044509

ASSESSMENT OF MICROBIAL QUALITY OF SPRING WATER SOURCES IN SELECTED BARANGAYS OF TAGOLOAN, LANAO DEL NORTE, PHILIPPINES

ROHAIMA B. ALI [1], AIDA D. PERPETUA [2], RODOLFO B. TRINIDAD [3], WENCESLAO A. CORONADO [4] and SONNIE A. VEDRA [5]

[1] Tagoloan Integrated School, Tagoloan, Lanao del Norte, Philippines.
[1,2,3,4,5] Mindanao State University at Naawan, Misamis Oriental, Philippines.
Email: [5]sonnie.vedra@msunaawan.edu.ph

Abstract

Ensuring access to safe and sustainable water is crucial for public health, particularly in Tagoloan, Lanao del Norte, Philippines. This study delves into the vital role of community participation in maintaining the quality and sustainability of water supply in selected barangays. The research specifically focuses on evaluating the microbial quality of spring water sources. Through a comprehensive methodology involving laboratory analysis, water samples were collected from various sites, including the primary spring source and designated stations within Barangays Kiazar, Dimayon, and Darimbang. The results revealed the presence of microbial contaminants, signaling potential health hazards associated with water consumption. These findings underscore the urgent necessity for community-driven initiatives aimed at tackling water quality issues, highlighting the significance of collaborative endeavors among local authorities, researchers, and residents. Emphasizing the importance of community engagement, this study contributes to the broader dialogue on water security, emphasizing the indispensable role of collective action in safeguarding the sustainability of water resources.

Keywords: Microbial Parameter, Assessment, Water Quality, Heterotrophic Plate Count, *E. Coli.*

INTRODUCTION

While the Earth is rich in water resources, only a small fraction, approximately 0.3%, is available for human use, consisting mainly of freshwater and lakes (0.009%), inland seas (0.008%), soil moisture (0.005%), atmosphere (0.001%), rivers (0.0001%), groundwater (0.279%), while the majority is composed of oceans (97.2%), glaciers, and other ice (2.15%) (Bibi et al., 2016). Access to safe and high-quality drinking water is paramount for human survival and well-being. It is essential for various purposes including domestic use, food production, and recreational activities. Improved water supply, sanitation, and effective water resource management are pivotal for economic growth and poverty alleviation. Recognizing the significance of water, the UN General Assembly acknowledged the human right to water and sanitation in 2010, ensuring access to safe, sufficient, continuous, and affordable water for personal and domestic use (Aghazadeh et al., 2010).

Groundwater, in particular, holds immense importance as a vital resource for drinking, domestic, agricultural, and industrial purposes globally (Shakerkhatibi et al., 2019). Groundwater, predominantly sourced from springs and wells, serves as a primary drinking water source for many communities (Aghazadeh et al., 2010). However, the sustainable

The Seybold Report
ISSN 1533-9211
DOI: 10.5281/zenodo.11044509

utilization of groundwater necessitates thorough assessment of its quality (Jasmin et al., 2014). Sustainable Development Goal Target 6.1 advocates for universal access to safe and affordable drinking water, but approximately 1.5 billion people worldwide, mostly in rural areas, lack access to safely managed drinking water sources (WHO and UNICEF, 2017). Many mountainous communities rely on mountain springs for their drinking water needs.

In both rural and urban settings, groundwater is extensively used for drinking and irrigation purposes (Kumar et al., 2013; Magesh and Chandrasekar, 2013). The evaluation of physicochemical and biological parameters is essential for assessing groundwater quality (Fatombi et al., 2012; Kulandaivel et al., 2009; Senthilkumar and Meenambal, 2007). However, microbial contamination remains a significant concern for drinking water quality, with chemical pollutants posing additional threats. These pollutants originate from various sources such as industrial activities, agricultural practices, and urbanization, impacting both surface and groundwater quality (Kekes et al., 2023).

Pollution of water resources, particularly in developing regions like Pakistan, poses significant challenges, jeopardizing public health and economic development (Mohsin et al., 2013). Population growth, industrial expansion, and inadequate wastewater management contribute to the deterioration of water quality. Millions of people in developing countries lack access to clean drinking water, resorting to untreated water sources for domestic use (Welch et al., 2000; Jamielson et al., 2004).

Agricultural activities further exacerbate water quality degradation, particularly in surface water bodies. Waterborne diseases resulting from contaminated water pose serious health risks, imposing substantial economic burdens on communities. Therefore, ensuring access to safe drinking water is imperative for public health and socioeconomic development. This study aims to evaluate the microbial quality of spring water, a crucial drinking water source for the community, through an enzyme-substrate coliform test, thereby contributing to safeguarding public health and promoting sustainable water management.

MATERIALS AND METHODS

Study Area

Tagoloan Municipality is classified as rural, with residents primarily relying on shared pipelines for accessing drinking water. Sampling sites were strategically chosen based on the proximity to drinking water sources and the population distribution in the area. Selection criteria included barangays utilizing spring water for drinking purposes and their respective population sizes. A total of four sampling sites were identified, comprising the main springwater source and one station per selected barangay, for the collection of water samples.

ISSN 1533-9211
DOI: 10.5281/zenodo.11044509

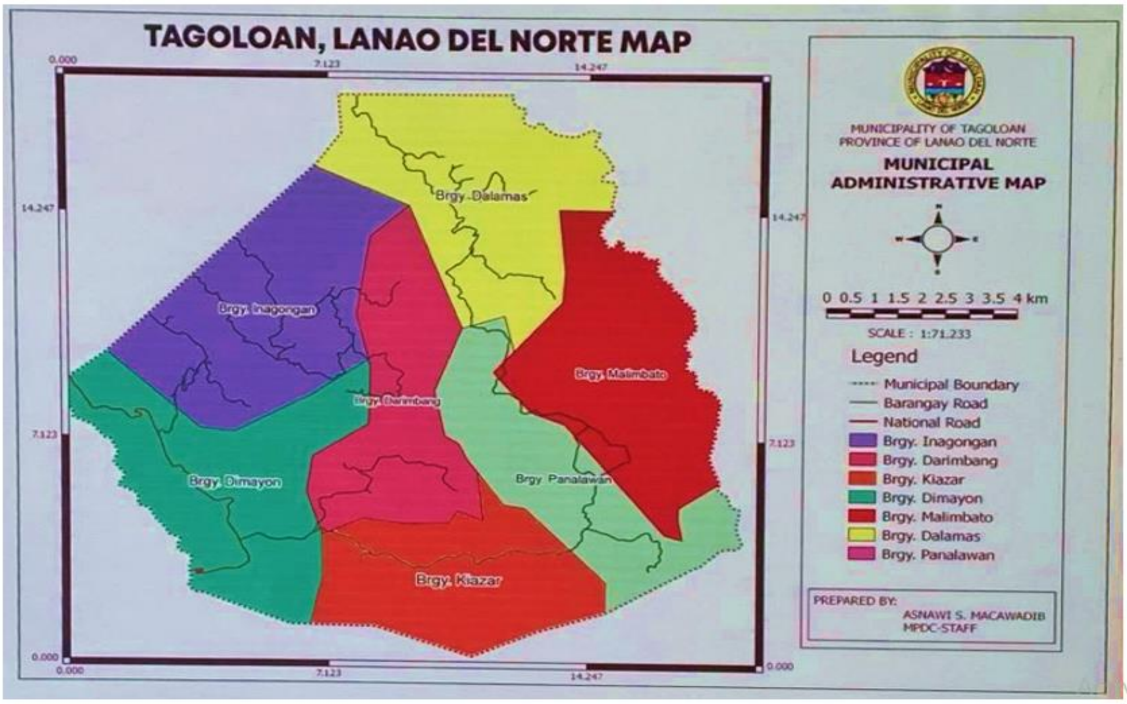

Figure 2: Map showing the study areas in 1) Barangay Kiazar 2) Barangay Dimayon, and 3) Barangay Darimbang, Tagoloan, Lanao del Norte, respectively. Source: Google Maps

Description of the Study Sites

Tagoloan, situated in the landlocked province of Lanao del Norte, covers an area of 69.70 square kilometers or 26.91 square miles, comprising 2.08% of Lanao del Norte's total expanse. As per the 2020 Census, Tagoloan had a population of 15,091, accounting for 2.09% of Lanao del Norte's total population and 0.30% of the Northern Mindanao region's overall population. This calculates to a population density of 217 inhabitants per square kilometer or 561 inhabitants per square mile.

Kiazar, previously known as Poblacion, is a barangay within Tagoloan municipality, Lanao del Norte province. Its population recorded in the 2020 Census was 2,153, constituting 14.27% of Tagoloan's total population. Over the span of three decades, Kiazar's population surged from 795 in 1990 to 2,153 in 2020, marking an increase of 1,358 individuals. The latest census data indicates a growth rate of 2.21%, representing an additional 212 residents compared to the previous count of 1,941 in 2015. Kiazar is located at approximately 8.1226, 124.3181, on Mindanao Island, with an estimated elevation of 632.1 meters or 2,073.8 feet above mean sea level.

Dimayon, another barangay in Tagoloan municipality, Lanao del Norte province, had a population of 2,779 according to the 2020 Census, constituting 18.41% of Tagoloan's total population. The population of Dimayon saw an increase from 1,833 in 1990 to 2,779 in 2020,

The Seybold Report
ISSN 1533-9211
DOI: 10.5281/zenodo.11044509

indicating a rise of 946 individuals over three decades. However, the latest census data in 2020 shows a negative growth rate of 1.99%, signifying a decrease of 278 people compared to the previous count of 3,057 in 2015. Dimayon is positioned at approximately 8.1360, 124.2706, on Mindanao Island, with an estimated elevation of 436.9 meters or 1,433.4 feet above mean sea level.

Darimbang, a barangay within Tagoloan municipality, Lanao del Norte province, had a population of 1,846 according to the 2020 Census, representing 12.23% of Tagoloan's total population. The household population of Darimbang in the 2015 Census was 1,345, distributed across 260 households, with an average of 5.17 members per household.

Collection of Samples and Analysis

A formal meeting was held with the Municipal Mayor to seek permission for conducting the study within the municipality. Additionally, prior to commencing the study in each barangay, in-person discussions were held with the respective Barangay Chairmen.

Laboratory analysis, specifically focusing on the assessment of enzyme substrate coliforms, including thermotolerant coliforms and E. coli, was conducted. Water samples were obtained from designated stations directly connected to the main water source, following the water sample collection procedures outlined by the Water-Life Laboratory. These procedures were in accordance with the guidelines provided in the National Reference Laboratory Training Manual on Water Microbiology. Adhering to standardized protocols is essential to ensure accurate and dependable results. To maintain quality control, the researcher meticulously prepared the necessary materials, including securing sterile bottles provided by the laboratory.

During the actual sampling process, the researcher strictly followed the guidelines prescribed by the Water-Life Laboratory, which is recognized as a DOH-Accredited Water Testing Laboratory. Samples were collected and placed in four sterilized bottles labeled with the corresponding station numbers (T30 for Barangay Dimayon, G3 for Barangay Kiazar, H90 for Barangay Darimbang, and L70 for the main source). These samples were then carefully stored in Styrofoam boxes with ice packs to maintain their integrity and transported to the Water-Life Laboratory Water Testing Services, located in Tominobo, Iligan City, Lanao del Norte, Philippines.

RESULTS AND DISCUSSION

Ensuring the safety and quality of drinking water is paramount for safeguarding public health. Water quality assessment involves meticulous scrutiny of various microbial indicators to ascertain contamination levels and potential health risks. One such assessment involves analyzing parameters such as Heterotrophic Plate Count (HPC), Total Coliform, and *E. coli* levels (Aziz, 2005). These indicators offer valuable insights into the microbiological quality of water and help identify potential sources of contamination. In this report, the researcher delves into the results of a recent water sample analysis, highlighting the presence of microbial constituents, deviations from regulatory standards, and implications for water safety (Aghazadeh et al., 2010).

The Seybold Report
ISSN 1533-9211
DOI: 10.5281/zenodo.11044509

The results of microbiological analysis of the spring water source specifically the main source with a sample code L70 and the three sampling stations from different barangays with sample codes T30 for Barangay Dimayon, H90 for Barangay Darimbang, and G3 for barangay Kiazar are presented in Table 1.

Table 1: Drinking water analysis for bacteriological tests at Tagoloan, Lanao del Norte.

Source	Heterotrophic Plate Count (CFU/mL)*	Total Coliform (MPN/100mL)	*E. coli* (MPN/100mL)	Remarks**
Main Spring Source	195	Present	Absent	Failed
Dimayon	160	Present	Absent	Failed
Darimbang	155	Present	Absent	Failed
Kiazar	240	Present	Absent	Failed

**values for microbiological quality for drinking water <500 CFU/mL*

***based on Philippine National Standards for drinking water*

Results revealed that all sampled water used for human drinking had presence of heterotrophic microbes, although below the standards of <500 CFU/mL. Total coliform was present in all sampled drinking water, however, no presence of *E. coli*. Generally, all drinking water consumed by the residents did not pass the standards for drinking water set by the Philippine National Standards.

Elevated levels of heterotrophic bacteria may cause unpleasant tastes and odors in drinking water, leading to consumer dissatisfaction (Patterson et al., 1995). Heterotrophic bacteria can contribute to the formation of biofilms in water distribution systems. These biofilms can lead to the growth of slime layers on pipes and surfaces, potentially causing clogging, corrosion, and deterioration of water infrastructure (Flemming, 2000). While not all heterotrophic bacteria are harmful, their presence can indicate potential contamination of drinking water from other microorganisms, including pathogens. Monitoring heterotrophic bacteria levels is often used as an indicator of overall water quality and the effectiveness of water treatment processes (LeChevallier, 1996). Although heterotrophic bacteria themselves may not cause illness, their presence can suggest the potential presence of other pathogens that pose health risks to consumers. Certain vulnerable populations, such as immunocompromised individuals, may be at increased risk of waterborne illnesses (van der Wielen, 2013). These issues underscore the importance of monitoring and controlling heterotrophic bacteria in drinking water to protect public health and ensure the delivery of safe and high-quality drinking water to consumers. As shown in the figures, the HPC count of 195 CFU/mL (L70), 160 CFU/mL (T30), 155 CFU/mL (H90), and 240 CFU/mL (G3) falls below the maximum allowable limit of 500 CFU/mL. This suggests that the level of heterotrophic bacteria in the source is within acceptable limits.

Coliform bacteria, particularly total coliforms and Escherichia coli (E. coli), are commonly used as indicators of fecal contamination in drinking water. The presence of coliform bacteria suggests that water may be contaminated with fecal matter, which can harbor harmful pathogens such as bacteria, viruses, and parasites (Sinton, 1999). While not all coliform bacteria are harmful themselves, their presence can indicate the potential presence of other

The Seybold Report
ISSN 1533-9211
DOI: 10.5281/zenodo.11044509

pathogens that pose health risks to consumers. Ingestion of water contaminated with fecal pathogens can lead to waterborne illnesses such as gastroenteritis, diarrhea, and other gastrointestinal infections (Payment and Locas, 2011).

Coliform bacteria can persist in water distribution systems and storage facilities, leading to ongoing contamination of drinking water. Factors such as inadequate disinfection, biofilm formation, and cross-contamination can contribute to the persistence of coliform bacteria in water supplies (LeChevallier, 1996). Detection of coliform bacteria in drinking water can erode public confidence in the safety and quality of the water supply. Consumers may perceive water with coliform contamination as unclean or unsafe for consumption, leading to decreased trust in water authorities and utilities (Ferguson, 2003).

E. coli is a common indicator organism used to assess fecal contamination in water sources. Its presence in drinking water indicates the potential presence of fecal pathogens, such as other bacteria, viruses, and parasites, which can cause waterborne illnesses (Sinton, 1999). Certain strains of *E. coli*, such as *E. coli* O157:H7, can cause severe gastrointestinal illnesses, including diarrhea, abdominal cramps, and vomiting. Ingestion of water contaminated with pathogenic *E. coli* can lead to outbreaks of illness, especially among vulnerable populations such as children, the elderly, and immunocompromised individuals (Scallan, 2011). *E. coli* bacteria can persist in water distribution systems and storage facilities, especially if disinfection measures are inadequate. Biofilm formation, pipe corrosion, and cross-contamination can contribute to the persistence of *E. coli* in water supplies, posing ongoing health risks (LeChevallier, 1996). Detection of *E. coli* in drinking water can result in public health advisories and boil water notices, leading to consumer anxiety and decreased confidence in the safety of the water supply. Waterborne outbreaks associated with *E. coli* contamination can have significant social, economic, and reputational impacts on communities and water utilities (Painter, 2013). The overall remarks of "failed" likely indicate that the water sample does not meet the required standards for safe drinking water. This failure is due to the presence of total coliform bacteria and/or the high HPC count, indicating potential contamination and a risk to public health. Addressing these problems requires vigilant monitoring, effective treatment, and robust management of E. coli contamination in drinking water supplies to protect public health and maintain regulatory compliance.

CONCLUSION AND RECOMMENDATION

Spring sources in the selected barangays of Tagoloan, Lanao del Norte, Philippines were assessed and water samples were tested. Findings showed that HPC count is within acceptable limits, presence of total coliform bacteria in the sample exceeds the standard for safe drinking water, suggesting coliform contamination. However, absence of *E. coli* is notable, and that, generally, overall results of water analysis did not pass the drinking water standards set, hence, the water is not safe for human consumption or is not a potable drinking water source. Thus, results of study needs the collective management strategies among all stakeholders in securing the attainment of achieving access to safe and affordable drinking water by virtue of SDG Target 6.1.

ISSN 1533-9211
DOI: 10.5281/zenodo.11044509

Acknowledgments

The author would like to express her gratitude to Water-Life Laboratory for systematically analyzing the water samples. Her gratitude as well to the Municipality of Tagoloan, Lanao del Norte from the Municipal Local Government Unit down to the Barangay Local Government Unit for their invaluable support of the study. Moreover, her sincerest thanks to her dissertation adviser and panel members for their untiring guidance to make through this study.

References

1) Aghazadeh, N., & Mogaddam, A. A. (2010). Investigation of hydrochemical characteristics of groundwater in the Harzandat aquifer, Northwest of Iran. *Environmental Monitoring and Assessment, 176*(1–4), 183–195. https://link.springer.com/article/10.1007/s10661-010-1575-4. Accessed 22 October 2020

2) Aziz, J.A. (2005). Management of source and drinking-water quality in Pakistan. *EMHJ - Eastern Mediterranean Health Journal, 11 (5-6), 1087-1098,* https://apps.who.int/iris/handle/10665/117042. Retrieved on October 19,2020.

3) Fatombi, J.K., A. T. Ahoyo., O. Nonfodji and T. Aminou. (2012). Physico-chemical and bacterial characteristics of ground water and surface water quality in the Lagbe town: Treatment essays with Moringa Oleifera seeds. Water Res. Protect. 4: 1001 -1008.

4) Ferguson, A.S. (2003). Perception of bottled drinking water quality: empirical evidence from Newfoundland. Journal of Environmental Management, 68(2), 165-175.

5) Flemming, H.C. (2000). Biofilms in drinking water systems: a review. Biofouling, 14(2), 89-106.

6) Jamielson R., Gordon R., Joy D., Lee H. (2004). Assessing Microbial Pollution of rural surface waters: a review of current watershed scale modeling approaches. Agric. Water Manag.;70:1–17.

7) Kekes T, Tzia C, Kolliopoulos G. (2023). Drinking and Natural Mineral Water: Treatment and Quality–Safety Assurance. Water, 15(13):2325. https://doi.org/10.3390/w15132325

8) Kulandaivel, A.R.K., P.E. Kumar, V. Perumal and P.N. Magudeswaran. (2009). Water quality index of river Cauvery at Erode region, Tamilnadu, India. Nat. Environ. Pollut. Technol, 8:343 – 346.

9) Kumar, A., N.G. Bhawsar, S. Khandelwal, S.S. Sakir and S. Ahuja. (2013). Physico-chemical parameters apply to analysis of drinking water from some selected area of Betul district, Madhya Pradesh. Int. J. Pharmaceut. Chem. Biol. Sci., 3: 1109-1114

10) LeChevallier, M.W. (1996). A review of bacterial regrowth in distribution systems and its impact on drinking water quality. Environmental Science & Technology, 30(11), 293-299.

11) Magesh, N.S. and N. Chandrasekar. (2013). Evaluation of spatial variations in groundwater quality by WQI and GIS technique: A case study of Virudunagar District, Tamil Nadu, India. Arabian J. Geosci., 6: 1883-1898.

12) Mohsin, M., Safdar, S., Asghar, F., and Jamal, F. (2013). Assessment of drinking water quality and its impact on residents health in Bahawalpur city. International Journal of Humanities and Social Science 2013. https://www.researchgate.net/profile/Farrukh_Jamal/publication/273724845_Assessment_of_Drinking_Water_Quality_and_its_Impact_on_Residents_Health_in_Bahawalpur_City/links/5509c1250cf26198a639aecc.pdf. Retrieved on October 19,2020.

13) Painter, J.A. (2013). Attribution of foodborne illnesses, hospitalizations, and deaths to food commodities by using outbreak data, United States, 1998–2008. Emerging Infectious Diseases, 19(3), 407-415.

14) Patterson, W.F. (1995). Microbiological aesthetic problems associated with chlorinated and chloraminated water supplies. Water Science and Technology, 31(7), 139-147.

The Seybold REPORT
ISSN 1533-9211
DOI: 10.5281/zenodo.11044509

15) Payment, P., and Locas, A. (2011). Pathogens in water: value and limits of correlation with microbial indicators. Groundwater, 49(1), 4-11.

16) Scallan, E. (2011). Foodborne illness acquired in the United States—major pathogens. Emerging Infectious Diseases, 17(1), 7-15.

17) Senthilkumar, S and T. Meenambal. (2007). Study of ground water quality near Sipcot industrial estate of Perundurai of Erode district, Tamilnadu. Nat. Environ. Pollut. Technol, 6:741 – 744.

18) Shakerkhatibi M, Mosaferi M, Pourakbar M, Ahmadnejad M, Safavi N, Banitorab F. (2019). Comprehensive investigation of groundwater quality in the north-west of Iran: physicochemical and heavy metal analysis. Groundw Sustain Dev 8:156–168. https://doi.org/10.1007/s12665-019-8655-8.

19) Sinton, L.W. (1999). Enteric virus behavior in water and sediment. In: D. Kay, editor. Proceedings of the IX International Symposium on Health-Related Water Microbiology. Amsterdam: Elsevier Science.

20) van der Wielen, P.W. (2013). Pathogens in drinking water: are there any new ones? Netherlands Journal of Medicine, 71(2), 72-77.

21) Welch P., David J., Clarke T.A.P.D., Berston S., McDougall L., Adesiyin A.A. (2000). Microbial sanitation of water in rural communities of Trinidad. Pan Am. J. Public Health. 8(3):172–180.

22) World Health Organization and UNICEF. (2017). Progress on drinking water, sanitation, and hygiene: 2017 update and SDG baselines. World Health Organization, Geneva, CH.