Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(5), 198-203 | ISSN:2251-6727

# Groundwater Monitoring in Lantawan Municipality, Philippines: Evaluating Potability Through Multivariate Water Quality Parameters

**Rachel L. Rodriquez[1], Leticia M. Babas[2], Ralph Angelo D. Alipio[3], Alejandro A. Jalil[4]**

1. *College of Education, Basilan State College, Isabela City, Basilan, Philippines*
2. *College of Allied Health, Basilan State College, Isabela City, Basilan, Philippines*
3. *Institute of Hotel and Restaurant Management, Basilan State College, Isabela City, Basilan, Philippines*
4. *College of Agriculture, Basilan State College, Sta. Clara Campus, Lamitan City, Basilan, Philippines*

***(Received: 16 July 2025 Revised: 20 August 2025 Accepted: 02 September 2025)***

**KEYWORDS**

Heavy Metal

Bacteriological

Lantawan

Physicochemical

Basilan

**ABSTRACT:**

Groundwater remains a vital water source in rural and island communities across the Philippines, particularly in the municipality of Lantawan, Basilan, where access to piped water is limited. This study assessed the potability of groundwater in the area through a multivariate evaluation of key water quality parameters, including physicochemical properties, heavy metal concentrations, and bacteriological content, in comparison with standards from the World Health Organization (WHO) and the Philippine National Standards for Drinking Water (PNSDW)

Water samples were collected from four sites across the municipality and analyzed for pH, total dissolved solids (TDS), electrical conductivity (EC), nitrate, sulfate, fluoride, and major ions such as sodium, potassium, and calcium. Results showed that all physicochemical parameters were within acceptable limits, except for pH, which ranged from 5.48 to 6.89, indicating mildly acidic conditions in some areas. Heavy metals—including mercury, arsenic, lead, cadmium, and chromium- were all below their respective health-based thresholds, suggesting minimal geogenic or anthropogenic contamination.

However, the bacteriological analysis revealed a serious concern: both fecal and total coliform bacteria exceeded the allowable limits of <1.1 MPN/100mL. This indicates the presence of microbial contamination from human or animal waste and poses a significant public health risk if the water is consumed untreated.

In conclusion, while the groundwater in Lantawan is generally safe in terms of its chemical and heavy metal profile, it is not microbiologically safe for direct human consumption. The findings highlight the urgent need for water disinfection, improved sanitation infrastructure, and regular water quality monitoring.

## 1. Introduction

Groundwater is a natural resource in many rural and island communities. In the Philippines, where over 7,600 islands make up the national landscape, groundwater provides drinking water for more than 50% of the population and serves as a critical source for irrigation, sanitation, and small-scale industry [1-2]. In areas like Lantawan Municipality, Basilan, where piped water infrastructure is limited, communities depend almost exclusively on wells and springs to meet their daily water needs.

However, the quality of groundwater is increasingly under threat. As population growth, land use change, and environmental degradation persist, so too does the risk of contamination from both natural and anthropogenic sources [3-4]. Pathogens from improper sanitation, fertilizers and pesticides from agriculture, and trace heavy metals from geogenic and human activities can all compromise the safety of groundwater [5-6]. These pollutants can cause chronic and acute health problems, including waterborne diseases, developmental disorders, and even cancer when exposure is prolonged [7-8].

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(5), 198-203 | ISSN:2251-6727

To accurately assess groundwater safety, a multivariate evaluation of key water quality parameters is essential. This approach goes beyond single-variable testing by integrating a range of physicochemical, bacteriological, and heavy metal indicators, all of which contribute uniquely to the water's overall potability [9-10] Such holistic assessments are especially important in coastal areas like Lantawan, where saltwater intrusion, fluctuating tides, and seasonal changes can affect groundwater composition [11-12]. Ultimately, this research seeks not only to measure contaminants but to amplify local awareness, empower communities to act, and support evidence-based water governance in one of the country's most vulnerable yet overlooked regions.

## 2. Objectives

The study generally aims to assess the overall potability of groundwater in Lantawan Municipality, Basilan, by evaluating its physicochemical, bacteriological, and heavy metal parameters using a multivariate approach and comparing results with WHO and PNSDW standards and specifically.

1. To analyze the physicochemical properties of groundwater samples from different parts of Lantawan, such as pH, electrical conductivity (EC), total dissolved solids (TDS), $Cl^-$, $SO_4^{2-}$, $NO_3^-$, $Na^+$, $Ca^{2+}$, K, $CO_3^{2-}$, and $HCO_3^-$.
2. To evaluate the presence of microbial contaminants, specifically fecal and total coliforms, to determine the biological safety of groundwater sources.
3. To determine the concentration of heavy metals such as Mercury (Hg), Arsenic (As), Cadmium (Cd), Copper (Cu), Iron (Fe), Zinc (Zn), Manganese (Mn), Nickel (Ni), Chromium (Cr), Lead (Pb), Barium in groundwater and assess their compliance with WHO and PNSDW drinking water standards.

## 3. Methods

### The Study Area

Lantawan Municipality is located in the western part of Basilan Province, within the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM), Philippines, an area of approximately 438.86 square kilometers. Geographically, it lies between 6°33' to 6°43' North latitude and 121°45' to 121°58' East longitude, and serves as home to a population largely dependent on agriculture, fishing, and natural water sources for everyday survival.

This municipality experiences a tropical rainforest climate, with high rainfall throughout the year and average temperatures ranging from 26°C to 32°C [13]. The terrain is a mix of gently sloping hills and flatlands, underlain by sedimentary and volcanic rock formations.

In the absence of a centralized water system, most households in Lantawan depend on shallow wells, hand pumps, and springs for their water needs. This makes groundwater a vital lifeline.

### Results

*Table 1. Comparison of Analyzed Concentration of Physico-Chemical with the WHO and PNSDW Standards for the Groundwater of Lantawan Municipality*

| Parameter | Range of Physico-Chemical content (mg/L) | WHO PNSDW Limit (mg/L) | Status |
|---|---|---|---|
| Electrical Conductivity (EC) | 20.48 - 49.28 | - | Acceptable |
| pH | 5.48 - 6.89 | 6.5 - 8.5 | SW1-SW3 acidic |
| Total Dissolved Solids (TDS) | 16 - 37 | 1000 | Within limit |
| Chloride (Cl) | 3 - 7.9 | 250 | Within limit |
| Sulfate ($SO_4$) | 10 - 11.1 | 250 | Within limit |
| Total Alkalinity (TA) | 23 - 42.6 | - | Acceptable |
| Total Hardness (TH) | 16.4 - 109 | 500/300 | Within limit |
| Nitrate ($NO_3^-$) | 0.08 - 0.37 | 50 | Within limit |
| Fluoride ($F^-$) | 0.23 - 0.33 | 1.5 | Within limit |
| Potassium (K) | 0.1 - 2 | - | Acceptable |

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(5), 198-203 | ISSN:2251-6727

| | | | |
|---|---|---|---|
| Sodium (Na) | 2.9 - 5.9 | 200 | Within limit |
| Magnesium (Mg) | 0.3 - 3.1 | - | Acceptable |
| Calcium (Ca) | 0.04 - 6.7 | - | Acceptable |

*Table 2. Comparison of Analyzed Concentration of Heavy Metals with the WHO and PNSDW Standards for the Groundwater of Lantawan Municipality*

| Parameter | Range of Heavy Metal Content (mg/L) | WHO PNSDW Standard (mg/L) | Status |
|---|---|---|---|
| Mercury (Hg) | 0.001 | 0.006 | Within limit |
| Arsenic (As) | 0.005 | 0.01 | Within limit |
| Cadmium (Cd) | 0.002 | 0.003 | Within limit |
| Copper (Cu) | 0.01 | 2.0 | Within limit |
| Iron (Fe) | 0.03 – 0.1 | 0.3/1.0 | Within limit |
| Zinc (Zn) | 0.02 | 5.0 | Within limit |
| Manganese (Mn) | 0.04-0.1 | 0.4 | Within limit |
| Nickel (Ni) | 0.01 | 0.07 | Within limit |
| Chromium (Cr) | 0.03 | 0.05 | Within limit |
| Lead (Pb) | 0.01 | 0.01 | Within limit |
| Barium (Ba) | 0.009 – 0.01 | 0.7 | Within limit |

*Table 3. Comparison of Analyzed Concentration of Heavy Metals with the WHO and PNSDW Standards for the Groundwater of Lantawan Municipality.*

| Parameter | Range of bacteriological Content (mg/L) | WHO PNSDW Standard (mg/L) | Status |
|---|---|---|---|
| Fecal Coliform (F. Coli) | >8.0 – 2.6 MPN/100mL | <1.1 | Not compliance |
| Total Coliform (T. Coli) | >8.0 MPN/100m | <1.1 | Not compliance |

**Discussion**

**Physicochemical Analysis**

Table 1 shows the results of several key water quality parameters, comparing them with safety limits set by the World Health Organization [1] and the Philippine National Standards for Drinking Water [14](PNSDW, 2017). Most of the measured values fall well within acceptable ranges, but a few aspects call for further attention, particularly the pH levels.

Electrical Conductivity (EC) was very low, ranging from 20.48 to 49.28 µS/cm. This is a good sign, suggesting the water is fresh and not affected by saltwater intrusion or heavy pollution. This matches findings from other rural areas in Southeast Asia, where groundwater is often clean and low in dissolved salts [15-16]. However, pH levels were a bit on the acidic side, ranging from 5.48 to 6.89. The recommended range is 6.5 to 8.5, so some of the samples, especially from Sampling Wells 1 to 3, fell below the minimum limit. While slightly acidic water is not uncommon in areas with lots of rainfall or organic-rich soils, it can be a concern because it may cause plumbing corrosion and make certain metals like lead or iron more likely to dissolve [17]. Similar acidic groundwater has been reported in other parts of the Philippines, often linked to natural geological processes such as silicate weathering or carbon dioxide from soil [18].

Total Dissolved Solids (TDS) were very low (16 to 37 mg/L), much lower than the 1000 mg/L limit. The water is therefore considered "very fresh" and unlikely to cause taste or health problems. Chloride and Sulfate levels were also very low, between 3–7.9 mg/L and 10–11.1 mg/L, respectively, far below the threshold of 250 mg/L. These results suggest that the water has not been affected by seawater mixing or human wastewater, which is consistent with similar rural aquifer findings in the country [19].

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(5), 198-203 | ISSN:2251-6727

The hardness of the water, which is related to calcium and magnesium content, ranged from soft to moderately hard (16.4 to 109 mg/L), well within safety limits. Likewise, nutrients like nitrate (0.08 to 0.37 mg/L) and fluoride (0.23 to 0.33 mg/L) were very low and safe for drinking. Elevated nitrate levels often indicate pollution from fertilizers or sewage, so the low values here point to a relatively clean environment [20].

Other minerals, such as sodium, potassium, magnesium, and calcium, were all within safe or acceptable ranges, indicating natural background levels. These minerals are essential for human health in small quantities and add to the nutritional profile of the water [21-22].

**Heavy Metals Analysis**

Table 2 presents the results of groundwater tests for heavy metals in Lantawan Municipality. All the tested metals were found at levels within the safe limits set by the World Health Organization [1] and the Philippine National Standards for Drinking Water [13].

Mercury (Hg) was found at 0.001 mg/L, much lower than the 0.006 mg/L limit. Mercury is very toxic, even in small amounts, and can affect the brain and kidneys [1].

Arsenic (As) was 0.005 mg/L, also below the safe limit of 0.01 mg/L. Arsenic can cause cancer and other serious health issues if consumed regularly over a long time [23].

Cadmium (Cd) came in at 0.002 mg/L, under the 0.003 mg/L limit. Cadmium is often linked to kidney problems [24].

Lead (Pb) was right at the 0.01 mg/L limit. Lead is one of the most harmful metals, especially for children's brain development [25]. Even though it's still within the safe range, being exactly at the limit suggests this should be closely monitored in the future.

Iron (Fe) and Manganese (Mn) were found in small amounts (0.03–0.1 mg/L and 0.04–0.1 mg/L, respectively), well below the standards. These two metals are common in groundwater and usually not harmful at low levels, although they can sometimes cause a metallic taste or staining in sinks.

Zinc (Zn) and Copper (Cu) were also present in very small amounts (0.02 and 0.01 mg/L). These are essential nutrients for the body, and the levels found here are both safe and beneficial [26].

Nickel (Ni) and Chromium (Cr) were below their limits, too. High levels of these can cause allergic reactions or, in some cases, cancer [27], but there's no immediate risk based on the current data.

Barium (Ba) at only 0.009 to 0.01 mg/L, lower than the 0.7 mg/L limit. At high levels, barium can affect the heart and nervous system [28], but that's not a concern here**.**

**Bacteriological Analysis**

Table 3, Fecal Coliform (F. coli) and Total Coliform (T. coli) levels exceeded the allowable standards set by both the World Health Organization [1]and the Philippine National Standards for Drinking Water [13].

Fecal Coliform counts were reported as greater than 8.0 to 2.6 MPN/100mL, where the standard is <1.1 MPN/100mL.

Total Coliform levels were also greater than 8.0 MPN/100mL, again far exceeding the maximum allowable value of <1.1 MPN/100mL.

This indicates non-compliance and suggests the presence of fecal contamination, likely from human or animal waste. According to [1], the presence of any coliform bacteria in drinking water is unacceptable, as it may signal the entry of pathogens such as *E. coli*, *Salmonella*, *Shigella*, and other disease-causing organisms.

**Conclusion**

The study found that the groundwater in Lantawan Municipality is mostly safe in terms of chemicals and heavy metals. Important parameters such as nitrate, lead, arsenic, and total dissolved solids were all within the safe limits set by the World Health Organization (WHO) and Philippine standards. This means that, overall, the water does not appear to be polluted by industrial waste, farming chemicals, or other harmful substances. However, there is one major concern: the bacteriological quality of the water. Tests showed that both fecal and total coliform bacteria were found in levels far above what is considered safe. These bacteria from human or animal waste, and as an indicator that the water could carry diseases like diarrhea, typhoid, or hepatitis if consumed untreated.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(5), 198-203 | ISSN:2251-6727

**References**


1. World Health Organization (WHO). (2022). *Drinking-water fact sheet*. https://www.who.int/news-room/fact-sheets/detail/drinking-water
2. David, C. P., et al. (2020). Water security in the Philippines: Challenges and opportunities. *Environmental Science and Policy*, 114, 118–125.
3. Lapworth, D. J., et al. (2017). Urban groundwater quality: A global perspective. Environmental Pollution, 223, 488–500.
4. Bwire, G., Malimbo, M., Maskery, B., Kim, Y. E., Mogasale, V., & Levin, A. (2019). The burden of cholera in Uganda. PLOS Neglected Tropical Diseases, 13(6), e0007422.
5. Shrestha, S., Kazama, F., & Nakamura, T. (2016). Multivariate statistical techniques for the assessment of surface water quality of Fuji river, Japan. Environmental Monitoring and Assessment, 180(1–4), 101–113.
6. Li, P., Wu, J., & Qian, H. (2019). Groundwater quality assessment using entropy-weighted water quality index and multivariate statistical techniques. Environmental Earth Sciences, 78(1), 18.
7. World Health Organization (WHO). (2017). Guidelines for Drinking-Water Quality (4th ed.).
8. Kumar, M., & Puri, A. (2012). A review of permissible limits of drinking water. Indian Journal of Occupational and Environmental Medicine, 16(1), 40–44.
9. Sánchez, A., Romero, J., & Silva, M. (2020). Multivariate analysis of groundwater quality in a tropical coastal aquifer. Science of The Total Environment, 726, 138607
10. Subba Rao, N. (2021). Groundwater quality assessment for drinking and irrigation use in a semi-arid region of south India. Environmental Earth Sciences, 80(13), 469.
11. Ferguson, G., & Gleeson, T. (2012). Vulnerability of coastal aquifers to groundwater use and climate change. Nature Climate Change, 2(5), 342–345.
12. Park, E., Lee, K., & Lee, H. (2021). Assessment of saltwater intrusion in coastal aquifers due to climate change. Hydrological Processes, 35(2), e13981.
13. Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). (2023). 2022 Annual Climate Bulletin. Climatology and Agrometeorology Division, Department of Science and Technology, Republic of the Philippines. Philippines experienced its 7th-wettest and 6th-warmest year since 1991 due to prolonged La Niña conditions
14. Department of Health (DOH). (2017). Philippine National Standards for Drinking Water (PNSDW) 2017. Health Facilities and Services Regulatory Bureau, Department of Health, Republic of the Philippines. Retrieved from https://doh.gov.ph
15. Suthar, S., Chabukdhara, M., & Nema, A. K. (2009). Groundwater quality in the vicinity of industrial clusters in India. Environmental Monitoring and Assessment, 152(1–4), 123–134.
16. Todd, D. K., & Mays, L. W. (2005). Groundwater Hydrology. John Wiley & Sons.
17. Bartram, J., & Ballance, R. (1996). Water Quality Monitoring: A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes. E&FN Spon.
18. Del Rosario, J., Ballesteros, F., & Orquiza, M. (2021). Hydrochemical evolution of groundwater in volcanic terrains of the Philippines. Environmental Earth Sciences, 80(5), 278.
19. Custodio, E., & Llamas, M. R. (2013). Hydrogeology of the Karstic Carbonate Aquifers in the Philippines. In: Hydrogeology and Environmental Problems in Karst Terrains. Springer.
20. Spalding, R. F., & Exner, M. E. (1993). Occurrence of nitrate in groundwater—A review. Journal of Environmental Quality, 22(3), 392–402.
21. Reimann, C., & de Caritat, P. (1998). Chemical Elements in the Environment: Factsheets for the Geochemist and Environmental Scientist. Springer-Verlag
22. Smedley, P. L., & Kinniburgh, D. G. (2002). A review of the source, behavior and distribution

of arsenic in natural waters. Applied Geochemistry, 17(5), 517–568.
23. Smith, A. H., et al. (2000). Contamination of drinking-water by arsenic in Bangladesh: a public health emergency. Bulletin of the World Health Organization, 78(9), 1093–1103.
24. Järup, L. (2003). Hazards of heavy metal contamination. British Medical Bulletin, 68(1), 167–182.
25. Needleman, H. L. (2004). Lead poisoning. Annual Review of Medicine, 55, 209–222.
26. Reimann, C., & de Caritat, P. (1998). Chemical Elements in the Environment. Springer.
27. IARC (2012). A Review of Human Carcinogens: Metals, Arsenic, Dusts, and Fibres. International Agency for Research on Cancer.
28. US EPA (2005). Barium in Drinking Water. U.S. Environmental Protection Agency.