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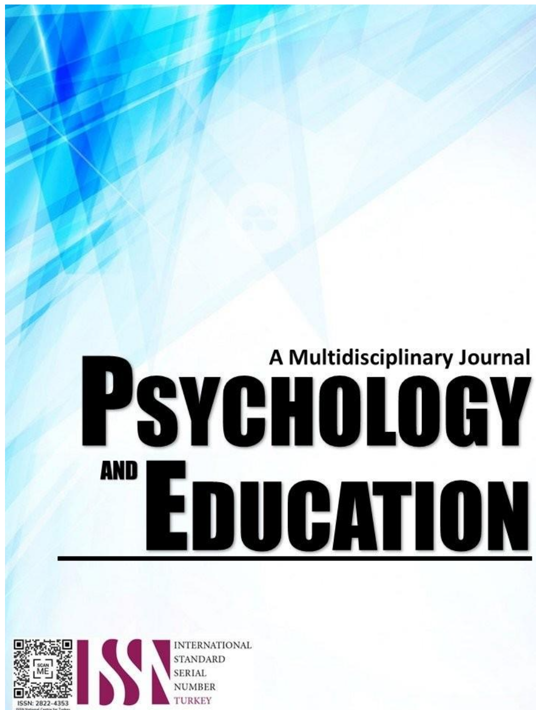

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Research Article

Assessment of Bacterial Contamination in Freshwater Stations: Implications for Drinking Water Safety Based on PNSDW 2017 Standards

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Abstract

Water is universally recognized as a fundamental necessity for life, playing a critical role in physiological processes, sanitation, and overall ecosystem balance. However, the accessibility and quality of drinking water remain pressing public health issues in many rural and underserved areas. This study investigates the microbiological quality of freshwater sources by assessing bacterial contamination levels, focusing on Thermotolerant Fecal Coliforms and Total Coliforms. Employing a descriptive cross-sectional research design, water samples were systematically collected from four freshwater stations, with three random sampling points per station to ensure representative data. Samples were immediately transported to the Cotabato Regional Medical Center – Department of Pathology for laboratory analysis. Quantitative results were interpreted based on the Philippine National Standards for Drinking Water (PNSDW, 2017), which set microbiological safety thresholds for potable water. Findings revealed that Stations 1 and 2 harbored high levels of bacterial contamination (CFU > 8.0 MPN/100 ml), significantly exceeding the permissible limits, thereby classifying them as FAILED in terms of safety for human consumption. Conversely, Stations 3 and 4 demonstrated acceptable microbial levels (<1.1 CFU MPN/100 ml), thus meeting the standards for PASSED potability. The data underscore a critical public health concern and reflect the need for immediate intervention through water purification systems, regular monitoring, and community education on safe water practices. This study provides empirical evidence supporting policy formulation and localized efforts to improve water safety and prevent waterborne diseases.

Keywords: *bacterial contamination, water quality assessment, thermotolerant fecal coliforms, total coliforms, potable water, and microbiological analysis*

Introduction

Water is an indispensable resource that supports all life forms, serving as a fundamental requirement for human survival, economic development, and environmental sustainability. It plays a vital role in maintaining proper hygiene, ensuring food security, facilitating agricultural productivity, and promoting public health. Despite its critical importance, access to clean and safe drinking water remains a global challenge, particularly in rural and marginalized communities. According to the World Health Organization (WHO), an estimated 2 billion people worldwide consume water contaminated with feces, leading to the spread of various waterborne diseases such as diarrhea, cholera, dysentery, and typhoid fever.

In the Philippine context, the Department of Health (DOH), through the Philippine National Standards for Drinking Water (PNSDW 2017), sets guidelines and quality thresholds to ensure that drinking water is free from harmful microbial and chemical contaminants. One of the primary indicators of microbial water contamination is the presence of coliform bacteria—specifically Thermotolerant Fecal Coliforms and Total Coliforms—which signal potential fecal contamination and the presence of pathogenic organisms. Consuming water that exceeds these permissible limits poses serious health risks, especially to children, the elderly, and immunocompromised individuals.

This study was conducted to assess the presence and levels of bacterial contaminants in freshwater stations used as potential drinking water sources. The research adopts a descriptive cross-sectional design and involves the collection and laboratory analysis of water samples to determine their microbiological safety. The study seeks to provide empirical data that will support local efforts in environmental health monitoring, water safety awareness, and the formulation of responsive interventions aimed at ensuring community access to potable water. Specifically, the results aim to determine whether the freshwater sources meet the microbiological standards set by the PNSDW 2017 and to identify which stations pose a risk to human health.

This study highlights the extent of bacterial contamination in selected freshwater sources and emphasizes the urgent need for regular water quality assessment and proper sanitation practices. The findings are expected to inform health authorities, community leaders, and policymakers, ultimately contributing to efforts to safeguard public health through safe and sustainable water resource management.

Research Questions

The study aims to determine the presence of bacteria in various water stations in Sitio Balisawan, Barangay Tomado, Aleosan, Cotabato. Specifically, it seeks to answer the following questions:

1. What types of bacteria are present in the different freshwater stations?
2. What are the concentration levels of the bacteria in the different freshwater stations?
3. Is there a significant difference in the concentration levels of bacteria among the freshwater stations?

4. What are the possible sources of contamination?
5. What action plan can be proposed based on the findings?

Literature Review

The Vital Role of Safe Drinking Water in Human Health

Water is universally acknowledged as the cornerstone of life, supporting biological survival and social and economic development. According to the World Health Organization (WHO, 2022), adequate water quality and quantity is essential for human health, nutrition, hygiene, and productivity. The availability of clean drinking water is closely linked to overall well-being and quality of life. However, despite its importance, waterborne diseases continue to affect millions of people, especially in low-resource settings. Contaminated water can lead to severe health risks, particularly in communities with limited sanitation and hygiene facilities.

UNICEF (2021) reported that over 700 children under five die daily due to diarrheal diseases caused by unsafe drinking water, poor sanitation, and inadequate hygiene. The link between unsafe water and a range of illnesses—such as cholera, typhoid, hepatitis A, and polio—has been well-established through epidemiological studies. Ensuring access to potable water is not merely a development goal but a public health priority that reduces disease burden and improves life expectancy.

Microbiological Indicators of Water Quality

One of the most common methods to determine water safety is microbial analysis, particularly the detection of coliform bacteria. Coliforms are a group of bacteria naturally found in the environment, including soil, vegetation, and the intestines of warm-blooded animals. Their presence in water indicates possible fecal contamination and, potentially, the presence of pathogenic microorganisms. Total Coliforms and Thermotolerant Fecal Coliforms (including Escherichia coli) are considered the most significant indicators among the coliform group.

LeChevallier and Au (2004) emphasized that detecting coliform bacteria, especially Thermotolerant Fecal Coliforms, is a warning sign of possible infiltration of disease-causing organisms. This approach to water monitoring is cost-effective and allows for early detection and mitigation of health hazards. Total Coliforms provide an overview of the general bacterial contamination of water, while Fecal Coliforms more accurately indicate recent fecal pollution and the likelihood of enteric pathogens.

Water Quality Standards and Legal Frameworks

Various international and national institutions have established water quality standards to safeguard human health. The WHO Guidelines for Drinking Water Quality provide a scientific basis for regulatory frameworks across countries, recommending zero detectable fecal coliforms in 100 ml of drinking water. Aligning with this, the Philippine National Standards for Drinking Water (PNSDW, 2017) under the Department of Health (DOH) mandates that potable water must be free from Thermotolerant Fecal Coliforms and Total Coliforms.

The PNSDW serves as the official benchmark for evaluating water's microbiological, chemical, and physical parameters intended for human consumption. According to DOH (2017), any coliform bacteria in water samples for public supply systems is a clear violation and poses a significant health threat. The standards are designed to guide water providers, local government units, and health authorities in monitoring, maintaining, and improving the quality of water distributed to communities.

Water Contamination in Rural and Marginalized Communities

Rural communities often depend on natural water sources such as rivers, wells, and springs for daily water needs. Unfortunately, these sources are frequently exposed to contamination risks, including animal waste, agricultural runoff, domestic sewage, and improper disposal. Majeed and Lee (2017) found that rural water sources in Southeast Asia, particularly in regions with agricultural activity and limited sanitation infrastructure, frequently fail to meet bacteriological standards.

In the Philippine context, access to safe drinking water remains uneven, with significant gaps in rural and geographically isolated areas. Studies such as those by Cuizon et al. (2020) reveal that shallow wells and unprotected springs commonly used in barangays show high levels of microbial contamination, particularly during the rainy season when runoff from nearby latrines and agricultural lands increase. These findings reinforce the need for localized water testing and tailored interventions in rural communities to ensure water safety and public health protection.

Health Risks and Disease Burden from Bacterial Contamination

Unsafe drinking water is a leading cause of gastrointestinal diseases, especially among children, the elderly, and immunocompromised individuals. According to Fewtrell and Bartram (2001), ingestion of water contaminated with fecal matter is strongly associated with outbreaks of diarrhea, which remains one of the top five causes of mortality among children under five years old globally. Furthermore, long-term exposure to contaminated water can lead to chronic conditions such as malnutrition, stunted growth, and weakened immune response.

Fecal contamination also increases the likelihood of contracting serious illnesses caused by bacteria such as E. coli, Salmonella, Shigella, and Vibrio cholerae. These pathogens can be transmitted through direct ingestion or indirect exposure via food preparation, bathing, and washing. The consequences of poor water quality are health-related and socio-economic, as frequent illness limits productivity, increases medical expenses, and hampers educational attendance.

Methods for Water Sampling and Bacteriological Analysis

Water quality analysis involves systematic collection, transportation, and laboratory testing of water samples. A cross-sectional approach is commonly used to assess water quality status at a specific time point across different locations. Ahmed et al. (2019) state that water samples should be collected aseptically from multiple stations to ensure accuracy and representativeness. Standard microbiological procedures, such as the Most Probable Number (MPN) method, quantify bacterial populations in water.

The MPN method is widely accepted for estimating bacterial density in water, especially in low-resource settings. In this method, water samples are incubated in selective media, and bacterial growth is interpreted statistically to determine the probable concentration of coliforms per 100 ml. Statistical tools, including Descriptive Statistics and Analysis of Variance (ANOVA), help researchers compare bacterial levels across multiple stations and identify significant differences that may indicate localized sources of contamination.

Community-Based Action and Policy Implications

Research findings on water contamination must inform public health action. Community-level interventions—such as installing water filtration systems, chlorination, boiling campaigns, and public education on hygiene—can significantly reduce bacterial exposure. According to the Centers for Disease Control and Prevention (CDC, 2020), effective community engagement and inter-agency coordination are critical to promoting water safety and sustainability.

Moreover, data-driven action plans can aid local government units (LGUs) and health departments in developing ordinances, allocating resources for infrastructure improvement, and enforcing compliance with water safety standards. Policies promoting environmental protection, proper waste disposal, and watershed management are vital in reducing contamination risks. Therefore, this study's findings have implications beyond the scientific realm, serving as a basis for local governance and community-based water safety advocacy.

Methodology

Research Design

This study employed a descriptive cross-sectional design, which is appropriate for assessing the status of bacterial contamination in selected freshwater stations. This design allowed the researchers to collect data at a specific time to describe bacterial contaminants' presence and concentration without manipulating any variables. This non-experimental method ensured a straightforward, real-time water quality analysis across multiple sites.

Respondents

The research targeted four freshwater stations as the study population. Using purposive sampling, the stations were selected based on accessibility, frequency of use by residents, and reported cases of waterborne illnesses in the area. From each station, three random sampling points were identified to ensure variability and representativeness of the water source. This resulted in a total of 12 water samples collected for microbiological testing.

Instrument

The main tool used for bacterial assessment was the laboratory-standard MPN test kits, which determine the bacterial count per 100 ml of water. Laboratory technicians followed standardized procedures based on the Philippine National Standards for Drinking Water (PNSDW 2017). No other instrumentation was used, as the study relied on expert analysis from a certified facility.

Procedure

Sterilized 500 ml glass bottles collected water samples from each sampling point. Samples were collected early in the morning and were immediately placed in ice boxes to maintain appropriate temperature and minimize bacterial changes during transport. Samples were submitted within 4–6 hours to the Regional Medical Center, Department of Pathology, for laboratory analysis.

Microbiological analysis used the Most Probable Number (MPN) method to detect and quantify Total Coliforms and Thermotolerant Fecal Coliforms. This method is widely used in environmental microbiology and recommended by the Department of Health and the World Health Organization for drinking water assessment.

Data Analysis

The data collected were organized and processed using descriptive statistics, such as mean, frequency, and standard deviation, to summarize the concentration levels of bacteria in each station. A One-Way Analysis of Variance (ANOVA) was applied to compare differences in bacterial levels across the stations. A significance level of 0.05 was set to determine if the observed differences were statistically significant.

Ethical Considerations

Prior to conducting the study, permission was sought from local authorities and community leaders. The purpose and benefits of the study were clearly explained to residents who depend on these water sources. Although human respondents were not directly involved, ethical considerations were observed to ensure that findings would be communicated responsibly to stakeholders to improve community health and water safety.

Results and Discussion

The findings, statistical analysis, and interpretations are based on the collected data concerning bacterial contamination in freshwater stations. The study focused on determining the presence and concentration levels of Total Coliforms and Thermotolerant Fecal Coliforms in four freshwater stations. Furthermore, this chapter offers insights into the possible contamination causes and presents an action plan to address the identified issues.

Bacterial Contamination in Freshwater Stations

Table 1. *Presence of Total Coliforms (TC) and Thermotolerant Fecal Coliforms (TFC)*

Station	*Sample Point*	*Types of Bacteria Detected*
Station 1	A, B, C	TC and TFC
Station 2	A, B, C	TC and TFC
Station 3	A, B, C	TC and TFC
Station 4	A, B, C	TC and TFC

As shown in Table 1, Total Coliforms and Thermotolerant Fecal Coliforms were consistently detected across all sampling points in the four stations. The presence of these coliforms in treated or spring-sourced water indicates possible cross-contamination, pipeline leaks, or failure in water purification. Stations near residential areas may be particularly susceptible to wastewater intrusion and domestic waste runoff.

Detecting coliform bacteria is a key sanitary indicator, as these organisms are commonly associated with human and animal fecal waste. According to Aram et al. (2021), their presence suggests an elevated risk of waterborne diseases. Chinfak et al. (2023) further emphasized that bacterial pollution in water bodies, especially fecal coliforms, remains a serious public health concern in rural and urban environments.

Concentration Levels of Coliform Bacteria

Table 2. *Average Levels of Total Coliforms and Thermotolerant Fecal Coliforms*

Station	*Sample Point*	*TC (MPN/100ml)*	*TFC (MPN/100ml)*	*Remarks*
Station 1	A, B, C	>8.0	>8.0	FAILED
Station 2	A, B, C	>8.0	>8.0	FAILED
Station 3	A, B, C	<1.1	<1.1	PASSED
Station 4	A, B, C	<1.1	<1.1	PASSED

The results presented in Table 2 show that Stations 1 and 2 exceeded the acceptable limit of bacterial concentration set by the Philippine National Standards for Drinking Water (PNSDW, 2017), which requires 0 detectable MPN of coliforms per 100 ml. The recorded >8.0 CFU/100ml for both TC and TFC denotes non-compliance, classifying these stations as unsafe for drinking purposes.

Conversely, Stations 3 and 4 demonstrated satisfactory <1.1 CFU/100ml bacterial levels, meeting the national standards and considered microbiologically safe for consumption. The lower contamination levels in these stations could be attributed to better spring protection, less human activity near the water source, and possibly reduced exposure to septic systems or domestic runoff.

Statistical Analysis: ANOVA Results

Table 3. *ANOVA Summary of Bacterial Levels*

Source	*Df*	*Sum of Squares*	*Mean Square*	*F-value*	*p-value*	*Interpretation*	*Decision*
Between Groups	3	155.5	51.84	4.10e+31	<2e-16	Highly Significant	Reject Null Hypothesis
Residual	8	0.0	0.00				

A one-way Analysis of Variance (ANOVA) results demonstrate a significant difference in bacterial contamination levels across the four freshwater stations, with a p-value of <2e-16, far below the 0.001 threshold. This indicates that the variation in coliform concentration is not due to random chance but is statistically meaningful.

Stations 1 and 2 had significantly higher bacterial means (~8.0 CFU/100ml) compared to the relatively low mean (~1.1 CFU/100ml) in Stations 3 and 4. Thus, the null hypothesis of no significant difference is rejected, confirming that bacterial levels vary significantly among the stations.

Sources of Contamination and Field Observations

Ocular visits and environmental scanning during the sampling period revealed several possible sources of bacterial contamination:

- Human Activities: Washing clothes directly in or near the water sources introduces bacteria from soiled fabrics and soaps.
- Improper Waste Disposal: Garbage accumulation near the springs can leach bacteria into the water, especially during rainfall.
- Defective Pumps and Pipes: Using unsealed or algae-coated hoses and pumps may allow the infiltration of contaminated surface water.
- Nearby Septic Systems: Leaking septic tanks near Stations 1 and 2 will likely contribute to high fecal contamination levels.

These human-induced activities increase the vulnerability of water sources to pollution, underscoring the importance of regulating access and promoting safe sanitation practices.

Discussion and Implications

The findings affirm that bacterial contamination significantly threatens public health, particularly in underserved rural communities. The unsafe water conditions at Stations 1 and 2 calls for urgent remedial measures, including water disinfection, repair of infrastructure, and implementation of community sanitation protocols. Meanwhile, the compliance of Stations 3 and 4 serves as a benchmark for the best practices in local water management, which can be replicated in other areas.

The use of Total and Thermotolerant Fecal Coliforms as sanitary indicators is supported by literature, such as the work of Niyuyitungiye et al. (2020), who emphasized their reliability in evaluating potential fecal contamination and public health risks.

Proposed Action Plan

Table 4. *Action Plan for Water Sanitation and Awareness*

Objective	*Activities*	*Strategies*	*Persons Involved*	*Budget*	*Time Frame*	*Expected Output*
Disseminate findings and promote hygiene	- Educational Drive - Community Cleanup - Water Purification Demonstration	- Coordinate with Barangay Council - Organize clean-up drives - Facilitate educational sessions and demos	Community Leaders Barangay Officials NDMC Faculty IP Members	₱10,000	April 2025	- Increased community awareness - Improved hygiene practices - Reduced waterborne risks - Empowered local residents

The action plan outlines a holistic approach to water quality improvement—engaging the community, improving sanitation practices, and promoting sustainable water use. According to Rotary Service and Engagement (2018), integrated sanitation and hygiene campaigns combined with grassroots participation are crucial in protecting water resources and public health.

Conclusions

The results highlight critical differences in bacterial contamination levels among water sources, underscoring the urgent need for targeted interventions in Stations 1 and 2. These findings support ongoing water quality monitoring, community engagement, and sanitation infrastructure development. To ensure long-term impact, this study advocates for the strengthening of local policies, awareness campaigns, and adoption of basic water purification methods to safeguard public health and improve water accessibility.

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