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Assessment of physico-chemical, heavy metal, and microbiological quality of spring water sources in Jasaan, Misamis Oriental, Philippines

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ABSTRACT

This study evaluated the water quality of three major spring sources—Dumaguing, Faustina, and Napapong—in the municipality of Jasaan, Misamis Oriental, Philippines. Water samples were analyzed for physico-chemical parameters, heavy metal concentrations, and microbiological quality (Total Coliform and *Escherichia coli*). The results indicated that the physico-chemical characteristics of all three springs, including pH, turbidity, total dissolved solids (TDS), and chlorides, were well within the Philippine National Standards for Drinking Water (PNSDW), as well as USEPA and WHO guidelines. Heavy metal analysis showed that lead, cadmium, aluminum, arsenic, mercury, antimony, copper, and iron were generally below detection limits, with only trace amounts of zinc detected in Dumaguing spring. However, microbiological analysis revealed a significant health risk for Faustina and Napapong springs, which tested positive for *E. coli* and exhibited high total coliform counts (TNTC). Dumaguing spring was found to be free of *E. coli* with minimal coliform presence. The study concludes that while the physico-chemical and heavy metal profiles suggest the water is chemically safe, the microbial contamination in two of the three springs necessitates immediate disinfection and regular monitoring to ensure public health safety.

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INTRODUCTION

Access to safe and potable water is a fundamental human right and a critical component of public health. Groundwater, including springs, serves as a primary source of drinking water for many communities in the Philippines, particularly in rural and semi-urban areas. However, these sources are increasingly vulnerable to contamination from anthropogenic activities, agricultural runoff, and natural geological processes. The consumption of contaminated water is a leading cause of waterborne diseases, making regular water quality monitoring essential (Besagas *et al.*, 2015; Besagas *et al.*, 2003a; Besagas *et al.*, 2023b; Bansilay *et al.*, 2017; Leopoldo *et al.*, 2017).

The province of Misamis Oriental has numerous freshwater sources that support its population. Previous studies in neighboring municipalities such as Alubijid, El Salvador, and Gingoog City have highlighted the importance of assessing physico-chemical properties and microbial load to determine potability. While many deep well and spring sources in the region often meet chemical standards, microbial contamination remains a persistent challenge due to inadequate sanitation and protection of water sources (Besagas *et al.*, 2015; Besagas *et al.*, 2023c; Besagas *et al.*, 2024; Leopoldo *et al.*, 2017).

The municipality of Jasaan, located in the province of Misamis Oriental, presents a unique case study for water quality assessment. Situated approximately 28 kilometers east of Cagayan de Oro City, Jasaan is a second-class coastal municipality with a total land area of 77.02 km². According to the 2020 Census of Population and Housing, the municipality has a total population of 57,055 inhabitants (Philippine Statistics Authority [PSA], 2021). Its geography is characterized by a sharp topographic gradient, transitioning from the coastal shores of Macajalar Bay to rugged, mountainous interiors reaching elevations of over 400 m. This diverse terrain facilitates a rich hydrological network, making Jasaan a well-known destination for spring-fed resorts and a hub for community-managed water systems.

However, Jasaan's rapid transition into an industrial and tourism center introduces potential risks to its groundwater quality. The municipality hosts the Jasaan Misamis Oriental Ecozone, which supports large-scale industrial operations, including oleochemical manufacturing. The proximity of industrial zones to residential areas and natural springs raises concerns regarding heavy metal leaching into the water table. Furthermore, with a population density of approximately 741 inhabitants per km², the lack of centralized sewerage systems in some barangays increases the risk of microbiological contamination, specifically from fecal coliforms.

Physico-chemical parameters, such as pH, turbidity, and dissolved solids, serve as the first line of indicator for water safety, yet they do not tell the full story. The presence of heavy metals poses long-term health risks through bioaccumulation, while microbiological pathogens can lead to immediate outbreaks of waterborne diseases. Given that many residents in Jasaan's 15 barangays rely on these springs for drinking, cooking, and recreation, a comprehensive evaluation is necessary.

This study aims to evaluate the physico-chemical, heavy metal, and microbiological quality of selected spring water sources in the municipality of Jasaan. Through the systematic analysis of these parameters, the research seeks to determine the suitability of the spring waters for public consumption and to generate scientific evidence that can inform local government initiatives on water resource management and environmental protection.

Focusing on three major spring sites—Dumaguing, Faustina, and Napapong—this investigation compares measured water quality indicators with national standards set by the Philippine National Standards for Drinking Water (PNSDW) and international benchmarks established by the USEPA, WHO, and the EU. The study aims to produce baseline data that will support informed decision-making, strengthen local water governance, and help safeguard the health and well-being of the Jasaan community.

MATERIALS AND METHODS

Sampling

Water samples were collected in clean, acid-washed polyethylene bottles that had been rinsed with distilled water. For microbial testing, separate sterile bottles were utilized in accordance with aseptic techniques. During transport to the laboratory, all samples were maintained at low temperature in ice-filled polystyrene foam boxes.

Physico-chemical analyses

The following parameters were analyzed: pH, temperature, turbidity, conductivity, total dissolved solids (TDS), salinity, chlorides, total hardness, and total organic carbon (TOC). Conductivity, TDS, and salinity measurements were performed using a HACH Sension5 Conductivity Meter.

Chloride concentration was derived from salinity using the specified formula:

$$Chloride\left(\frac{mg}{L}\right) = \frac{Salinity\ (in\ ppt)}{1.80655} \times 1000$$

Turbidity was measured onsite with the HACH 2100Q turbidimeter. Total hardness was assessed via the standard EDTA titration method. TOC quantification followed the spectrophotometric procedure outlined by Hach—Method 10129 (Direct Method), suitable for TOC concentrations ranging from 0.3 to 20.0 mg/L. This technique is based on the color change of an indicator resulting from pH variation caused by CO_2 production during the oxidation of organic carbon by persulfate within a reagent vial. Absorbance readings were taken at wavelengths of 598 nm and 430 nm using the HACH DR 5000 UV-Vis spectrophotometer.

Analysis of heavy metals and other metals

This study evaluated nine metals: arsenic, cadmium, copper, mercury, lead, aluminum, zinc, iron, and antimony. Flame atomic absorption spectroscopy was employed to analyze zinc, copper, iron, lead, and cadmium. Mercury levels were determined using cold vapor spectrometry, while antimony was measured with inductively coupled plasma–optical emission spectroscopy. Arsenic detection utilized silver diethyldithiocarbamate, and aluminum was quantified via eriochrome cyanine R. Samples not analyzed within 24 hours were preserved by adjusting the pH to 2.0 with concentrated nitric acid.

Microbiological test (Total coliform and *Escherichia coli*)

Microbiological analysis was conducted using membrane filtration. Total coliform counts were obtained, and Escherichia coli presence was identified based on colony morphology.

RESULTS AND DISCUSSION

Physico-chemical characteristics

All sources exhibited a "Colorless-clear" appearance. The pH levels ranged from 7.04 to 7.08, falling safely within the 6.5–8.5 range recommended by PNSDW and USEPA. Turbidity values were low (0.25–1.06 NTU), well below the standard limit of 5 NTU, indicating clear water with low suspended particulate matter (Table 1). Total Dissolved Solids (TDS) and Chlorides were also found to be significantly lower than the maximum allowable limits (500 mg/L and 250 mg/L, respectively), suggesting low salinity and mineralization. Total Hardness ranged from 71.79 to 78.19 mg/L, which is below the 300 mg/L limit, classifying the water as relatively soft to moderately hard but not of health concern.

Heavy metal concentrations

Table 2 summarizes the heavy metal concentrations. Remarkably, almost all potentially toxic metals—Lead (Pb), Cadmium (Cd), Aluminum (Al), Arsenic (As), Mercury (Hg), Antimony (Sb), Copper (Cu), and Iron (Fe)—were below the method detection or reporting limits (<0.003, <0.002, etc.) for all three springs. This indicates that the geological formations in the area do not leach significant amounts of these toxic elements into the groundwater. Zinc (Zn) was detected in Dumaguing Spring at 0.013 mg/L, but this is negligible compared to standard limits. The absence of heavy metal contamination aligns with similar findings in other parts of Misamis Oriental, where industrial heavy metal pollution is often localized or absent in upland sources (Besagas *et al.*, 2015; Besagas *et al.*, 2022).

Table 1. Physcio-chemical characteristics of the spring water

Parameter	Spring water source [mean (sd)]			Standard limits			
	Dumaguing spring	Faustina spring	Napapong spring	PNSDW[1]	USA[2]	EU[3]	WHO[4]
Appearance	Colorless-clear	Colorless-clear	Colorless-clear			Acceptable; no abnormal change	
Turbidity (NTU)	0.50 (0.03)	0.25 (0.04)	1.06 (0.21)	5	<5	Acceptable; no abnormal change	<5
Temperature (˚C)	24.9 (1.3)	24.5 (3.9)	26.1 (1.7)				
pH	7.07 (0.15)	7.04 (0.26)	7.08 (0.08)	6.5-8.5	6.5-8.5	6.5-9.5	Not of health concerns at levels found in drinking water
Conductivity (µS/cm)	180.9 (19.5)	194.4 (2.9)				2,500	
TDS (mg/L)	75.6 (9.2)	92.70 (1.47)	92.10 (18.90)	500	500		
Salinity (ppt)	0.1	0.1	0.1				
Chlorides (mg/L)	55.3	55.3	55.3	250	250	250	
TOC (mg/L C)	3.56 (1.53)	4.31 (0.94)	1.74			No abnormal change	
Total hardness (mg/L $CaCO_3$)	71.79 (0.66)	78.19 (4.74)	72.90 (1.05)	300			Not of health concerns at levels found in drinking water

[1]Philippine National Standards for Drinking Water (2007)

[2]Drinking Water Standards and Health Advisories-USEPA (2012)

[3]Drinking Water Directive-European Union (1998)

[4]Guidelines for Drinking Water Quality-WHO (2011)

Table 2. Heavy metal concentrations

Heavy metal	Spring water source [mean (sd)]			Standard limits			
	Dumaguing Spring	Faustina Spring	Napapong Spring	PNSDW[1]	USA[2]	EU[3]	WHO[4]
Pb (mg/L)	<0.003**	<0.003**	<0.003**	0.01	0.015	0.01	0.010
Cd (mg/L)	<0.002**	<0.002**	<0.002**	0.003	0.005	0.005	0.003
Al (mg/L)	<0.02**	<0.02**	<0.02**	0.2	0.05-0.02	0.2	
As (mg/L)	<0.005*	<0.005*	<0.005*	0.05	0.010	0.010	0.01
Hg (mg/L)	<0.001**	<0.001**	<0.001**	0.001	0.002	0.0010	0.006
Sb (mg/L)	<0.01*	<0.01*	<0.01*	0.02	0.006	0.0050	0.02
Zn (mg/L)	0.013 (0.023)	<0.002*	<0.002*	5.0	5.0		
Cu (mg/L)	<0.002*	<0.002*	<0.002*	1.0	1.3	0.0020	0.200
Fe (mg/L)	<0.005*	<0.005*	<0.005*	1.0	0.3	0.200	

*Method Detection Limit, **Reporting Limit

[1]Philippine National Standards for Drinking Water (2007)

[3]Drinking Water Directive-European Union (1998)

[2]Drinking Water Standards and Health Advisories-USEPA (2012)

[4]Guidelines for Drinking Water Quality-WHO (2011)

Microbiological quality

The microbiological results (Table 3) present a contrasting picture. While Dumaguing Spring showed a Total Coliform count of 2.8 cfu/100 mL and was negative for *E. coli*, both Faustina and Napapong springs recorded "Too Numerous To Count" (TNTC) for Total Coliform and tested positive for *E. coli*. The presence of *E. coli* is a definitive indicator of fecal contamination, likely from human or animal waste entering the water table or the spring outlet. According to PNSDW, USEPA, and WHO standards, drinking water must have zero (absent) *E. coli*. Therefore, water from Faustina and Napapong is currently unsafe for direct consumption without treatment.

Table 3. Total coliform count and *E. coli*

	Source	Total coliform (cfu/100 mL)	*E. coli*
Spring water	Dumaguing spring	2.8 (1.3)	Absent
	Faustina spring	TNTC	Present
	Napapong spring	TNTC	Present
Standards	PNSDW Std.[1]	<1; not more than 5% of samples positive in a month	Absent
	USA Std.[2]	Not more than 5% of samples positive in a month	Absent
	EU Std.[3]	0	Absent
	WHO Std.[4]		Absent

[1]Philippine National Standards for Drinking Water (2007)

[2]Drinking Water Standards and Health Advisories - USEPA (2012)

[3]Drinking Water Directive-European Union (1998)

[4]Guidelines for Drinking Water Quality-WHO (2011)

CONCLUSION

The assessment of spring waters in Jasaan, Misamis Oriental reveals that the sources are chemically excellent but microbiologically compromised in specific locations. Dumaguing, Faustina, and Napapong springs all meet the stringent physico-chemical and heavy metal standards set by national and international bodies. However, the presence of *E. coli* and high coliform counts in Faustina and Napapong springs poses a serious health risk to consumers. It is recommended that immediate disinfection measures (such as chlorination or boiling) be implemented for these two sources. Furthermore, source protection protocols should be enforced to prevent surface runoff and fecal contamination from entering the spring systems.

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