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Potable Water Hunt: An Alternative Water Sources Assessment in Selected Areas in Negros Occidental

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ABSTRACT

This study assessed the suitability of alternative water sources for drinking in selected areas of Negros Occidental. Water samples were collected from two types of sources: a hand-dug well and a borehole hand pump. Researchers evaluated these samples based on microbial and physicochemical parameters and classified them according to the standards set by the Department of Environment and Natural Resources (DENR). Physicochemical analyses took place at the Negros Prawn Producers Cooperative Analytical and Diagnostic Laboratory (NPPC). Meanwhile, microbial analyses were conducted at the NONESCOST laboratory using the standard multiple-tube fermentation technique. Results showed that the alternative water sources in Kabankalan City, Himamaylan City, San Carlos City, Escalante City, and Sagay City had high coliform levels. This indicates that water from these sources is not safe for drinking. Based on physicochemical parameters, these sources were assigned to Class B (Recreational Water, Class I). Microbial analysis categorized them as Class A (Public Water Supply, Class II). In contrast, the alternative water source in La Carlota City produced better results. Its physicochemical parameters mostly met the DENR standards for drinking water, except for chloride and total hardness levels. Despite these minor exceedances, the water source was classified as freshwater under Class AA, which is suitable as a Public Water Supply, Class I, based on microbial indicators. The findings of this study provide crucial baseline information on the quality and safety of alternative water sources in Negros Occidental. This information is particularly useful for local communities and authorities in finding safe drinking water sources during times of insufficient supply and during emergencies or disasters.

Keywords: potable water, alternative water sources, public water supply

How to Cite:

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INTRODUCTION

Safe drinking water is a basic need for life and good health. Despite its importance, many people around the world still lack reliable access to clean and safe water. In 2012, the World Health Organization (WHO) reported that diarrheal diseases made up about 3.6% of the global disease burden, causing roughly 1.5 million deaths each year. This highlights the serious health risks tied to unsafe water consumption (Lomboy et al., 2017). These health problems are often linked to poor water quality, lack of sanitation, and limited access to safe drinking water.

In the Philippines, water quality is a significant concern. According to reports on the Philippine water crisis (2018), about nine million people out of the country's 101 million still depend on unsafe and unreliable water sources. Additionally, around 19 million lack access to improved sanitation facilities. Many families without safe water at home must spend a lot of time and effort getting water from other sources, which are not always safe to drink.

Data from the Philippine Statistics Authority (2014) show that about 58% of deaths from waterborne diseases are tied to unsafe water supply, poor sanitation, and insufficient hygiene practices (Howard et al., 2003). These statistics stress the need to ensure that community water sources meet safety standards. Groundwater quality is particularly vital since it is widely used for drinking, household use, and other domestic activities. The suitability of groundwater for these purposes mainly relies on its physical, chemical, and microbial qualities (Saleem et al., 2015). Therefore, drinking water sources must be protected from contamination caused by commercial, residential, and recreational activities (Tanvir et al., 2014).

While several studies have looked at water quality in different areas of the Philippines, there has been little research on the safety and classification of alternative water sources in selected cities of Negros Occidental, especially regarding microbial contamination and physicochemical properties. Many communities continue to rely on hand-dug wells, borehole pumps, and other alternative sources during water shortages or disasters, but the safety of these sources is not always monitored or recorded.

This study aims to provide baseline information on the safety of alternative drinking water sources in Negros Occidental through monitoring and assessment. Specifically, it seeks to determine the water quality and physicochemical parameters of selected alternative water sources in various cities of Negros Occidental, based on the standards set by the Department of Environment and Natural Resources (DENR). The findings may help local communities and authorities identify safer alternative water sources and improve water resource management in the province.

OBJECTIVES OF THE STUDY

This study aimed to identify and assess the water quality of alternative water sources in selected cities of Negros Occidental. Specifically, it aimed to answer the following:

1. Determine the quality of alternative water sources based on microbial and physicochemical parameters.

2. Identify the categories/classes of the alternative water source based on the Department of Environment and Natural Resources (DENR) standards.

Conceptual Framework of the Study

Alternative water sources are needed, especially during disasters. This research is based on the assumption that there are alternative sources of water in different areas in Negros Occidental that can be used in times of disasters. According to Abbasnia *et al.* (2018) the calculation of water quality index (WQI) for groundwater samples, indicated that 25% of the samples could be considered as excellent water, 50% of the samples were classified as good water category, and 25% of the samples showed poor water category. The concept of the study aimed to assess the alternative water sources for potable water in selected areas of Negros Occidental and to categorize the sources according to DENR water standards.

Figure 1 shows the input, process, and output of the study determining the water quality assessment of an alternative water source.

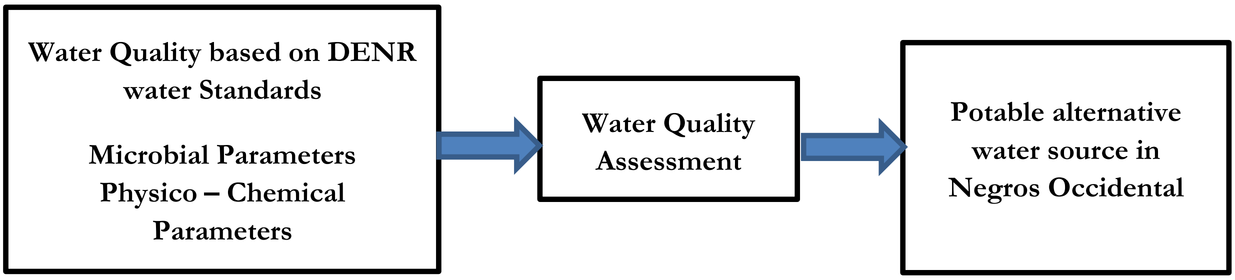

Figure 1. Input, Process, and Output Design of the Study.

LITERATURE REVIEW

Water Quality Act

The Philippines being the locus of tropical cyclones, tsunamis, earthquakes, and volcanic eruptions, is a hotbed of disasters. These natural hazards inflict loss of life and costly property damage. Situated in a region where climate and geophysical tempest is common, the Philippines will inevitably suffer from calamities similar to those experienced recently. With continued development and population growth in hazard-prone areas, it is expected that damage to infrastructure and human losses would persist and even rise unless appropriate measures are immediately implemented by the government. In 2012, the Philippines launched a responsive program for disaster prevention and mitigation called the Nationwide Operational Assessment of Hazards (Project NOAH), specifically for government warning agencies to be able to provide a 6 hr lead-time warning to vulnerable communities against impending floods and to use advanced technology to enhance current geo-hazard vulnerability maps.

Measurement of water quality provides important information about the integrity of a body of water. The most widely used method is the measurement of its physical, chemical, and bacteriological constituents. The quality of water is measured or monitored to determine if it is meeting the prescribed water quality for its intended uses (DENR Administrative Order No. 2005-10, 2005).

According to Republic Act (RA) 9275 or the Philippine Clean Water Act (CWA) of 2004, water quality is "the characteristics of water which define its use in terms of physical, chemical, biological, bacteriological or radiological characteristics by which the acceptability of water is evaluated." This definition implies that there is no singular measure of good water quality. While it can be agreed generally that water of good quality should be clear and free from harmful substances, the presence of certain concentrations of such substances is acceptable provided those are within the water quality guideline values corresponding to the beneficial uses of the water. Clean and pure water containing almost no chemical, bacteriological, and radiological constituents is desirable for water intended for drinking and food preparation, but it is not really necessary or even advisable to have the same water quality for other uses. Different uses of water require different water quality. For instance, sufficient concentration of nitrogen, phosphorous and other micronutrients is good for irrigation water, but the same concentration of such chemicals is not good for drinking water. To put it simply, a water body that sustains its beneficial uses has good water quality. A water body that does not sustain its beneficial uses has poor water quality.

According to Ballance (1982), a sequence of necessary events in the development of a community water supply can be summarized in nine steps: planning, information, organization, training, finance, design, construction, management, and education. There may be variations to this sequence, and some of the events will necessarily appear more than once, while others may be more or less continuous activities.

Water Bodies in the Philippines: Classification According to Beneficial Use

The Environmental Management Bureau projected a classification of one thousand nineteen (1,019) water bodies in the country according to beneficial use by CY 2019. Seven hundred ninety-one of these are already classified according to beneficial use, and two hundred twenty-eight (228) are targeted to be classified by CY 2019. The identification of these one thousand nineteen (1,019) waters bodies is listed according to regional distribution and location by province. The classification according to beneficial use of seven hundred ninety-one (791) water bodies from the identified one thousand nineteen (1,019) water bodies, as well as the identified Water Quality Management Areas (WQMAs) and their respective classifications are integrated in the aforementioned information.

The classification serves as a benchmark; water bodies and their tributaries within WQMAs shall keep their water quality within the Water Quality Guidelines, conforming to the water body's classification (e.g., Class C or Class SC) or even improve the quality to a higher classification (e.g., from C to B or SC to SB). A WQMA Action Plan shall be prepared in order to address water quality issues and problems in the area and later result in the improvement or better water quality of the said water body. To date, there are thirty-seven (37) officially- designated WQMAs, including the areas within the jurisdiction of LLDA, which was designated as one management area by virtue of the Clean Water Act. The water quality is assessed based on the set beneficial use as defined in DENR Administrative Order Number 2016-08 (Water Quality Guidelines and General Effluent Standards). Table 1 shows the classification of bodies of water and the usage of freshwater, respectively.

Table 1

Water Body Classification and Usage of Freshwater.

PARAMETER	UNIT	CLASS	CLASS	CLASS	CLASS	CLASS
Physico-chemical		AA	A	B	C	D
Color	PCU	15	50	--	--	--
pH		6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.0-9.0
Dissolved Oxygen	% satn mg/L	5.0	5.0	5.0	5.0	5.0
TDS	mg/L	500	1000	-	-	1000
Chloride	mg/L	250	250	-	350	-
Microbial		AA	A	B	C	D
Total Coliform	MPN/100ml	50	1,000	1,000	5,000	-
Fecal Coliform	MPN/100ml	20	100	200	-	-

Table 2 shows the underground water classification and categories according to its microbial and physico-chemical parameters based on DENR freshwater standards

Table 2

Underground Water Classification and Categories

Water Body Classification and Usage of Freshwater	
	INTENDED BENEFICIAL USE
CLASS AA	Public Water Supply Class I – Intended primarily for waters having watersheds, which are uninhabited and/or otherwise declared as protected areas, and which require only approved disinfection to meet the latest PNSDW
CLASS A	Public Water Supply Class II – Intended as sources of water supply requiring conventional treatment (coagulation, sedimentation, filtration and disinfection) to meet the latest PNSDW
CLASS B	Recreational Water Class I – Intended for primary contact recreation (bathing, swimming, etc.)
CLASS C	1.Fishery Water for the propagation and growth of fish and other aquatic resources 2.Recreational Water Class II – For boating, fishing or similar activities 3.For agriculture, irrigation and livestock watering
CLASS D	Navigable waters

Groundwater Studies

Chaurasia *et al.* (2018) explained that groundwater is an important source of water supply throughout the world. It occurs almost everywhere beneath the earth's surface, not in a single widespread aquifer but in multiple local aquifer systems and compartments that have similar characteristics. Groundwater is a finite resource, and it is a rare benefit in many parts of the world. In the countries where water is a limited resource, the competition is rampant among agriculture, industry, and domestic use. Groundwater resources are affected in principle by three major activities. First is the excessive use of fertilizers and pesticides in agricultural areas. The second is untreated/partially treated wastewater to the environment, and the third is excessive pumping and improper management of aquifers. According to world Health Organization (WHO), about 80% of all diseases in human beings are caused by contaminated water.

As studied by Islam *et al. (2001),* five tube-wells in Matlab, Bangladesh, were selected for analysis of selected bio-physicochemical parameters. The results showed that all tube-well water samples contained zooplankton and bacteria. Results for some of the parameters were outside the accepted limits recommended by the World Health Organization for drinking water. It is concluded that water from tube-wells should be treated if used as drinking water.

According to Baker, Wiley, Seelbach, and Carlson, (2003), biological, chemical, and physical attributes of aquatic ecosystems are often strongly influenced by groundwater sources. Nonetheless, widespread access to predictions of subsurface contributions to rivers, lakes, and wetlands at a scale useful to environmental managers is generally lacking. Model predictions were calculated in units of specific discharge (meters per day) for a 30-m2-cell raster map and interpreted as an index of potential subsurface water flux (shallow groundwater and event through-flow. Although it does not incorporate any information about the actual water table surface, by quantifying spatial variation of key constraints on groundwater-related attributes, the model provides strata for more intensive study, as well as a useful spatial tool for regional and local conservation planning, fisheries management, wetland characterization, and stream assessment

According to Babiker, Mohamed, and Hiyama (2007), assessing the quality of groundwater is important to ensure sustainable, safe use of these resources. However, describing the overall water quality condition is difficult due to the spatial variability of multiple contaminants and the wide range of indicators (chemical, physical, and biological) that could be measured.

The need for providing water quality information to consumers has been repeatedly emphasized (Blette, 2008); this communication should also be transparent (Pene & Levi, 2011). Consumers want more information about their tap water (Roper Starch Worldwide, 1999), and have expressed concerns about its quality (Means *et al.,* 2002)

Rahman (2008), stated that surface water quality can be determined by hydrological responses that vary geographically. The sub-surface hydrologic environment, however, has a primary influence on groundwater movement and hence pollutant migration to the sub-surface water, and on the other hand, high concentrations of human/economic activities, e.g., industrial, agricultural, and household, represent real or potential sources of groundwater contamination. There is a need to conduct studies on groundwater pollution. Therefore, there are several point and non-point pollution sources, and groundwater quality is under threat (Şener, Şener, & Davraz, 2017).

METHODOLOGY

Field study assessment of water quality of alternative water sources based on the DENR water standards in selected cities in Negros Occidental was used in the study, and its purpose is to assess the alternative water supply and to categorize the alternative water sources based on the classification of the potability of water. The research was conducted in three (3) areas in the southern part and three (3) in the northern part of selected areas in the province of Negros Occidental.

The descriptive assessment approach was used to systematically examine and describe the existing condition of the water sources without manipulating any variables. This method allowed the researchers to gather and analyze data on the physicochemical and microbial characteristics of the water samples and determine whether these sources meet the DENR standards for potable environmental water sources. Through this descriptive evaluation, the study was able to classify the alternative water sources according to the established water quality categories and identify whether these sources are safe or unsuitable for drinking purposes. The use of a descriptive assessment design was appropriate for this study because it provided a structured way to observe, measure, and evaluate the current quality of alternative water sources in the selected cities, thereby generating reliable information that can support water resource monitoring and management in Negros Occidental.

Study Area and Sampling

In terms of alternative water sources, it includes a hand-dug well and a borehole hand pump were identified as underground water in the study area in selected cities with the aid of a geographical positioning system (GPS). A sample was collected near the evacuation area, where the locations were identified.

Table 3 shows that the sample of alternative water sources was taken by randomly collecting three (3) samples of underground water on different days and times of collection in the southern (Kabankanlan City, Himamaylan City, and La Carlota City) in the province of Negros Occidental. Three hundred fifty milliliters (350 ml) of water for microbial parameters and one thousand milliliters (1000 ml) for physico-chemical parameters were predicted in a sterile glass bottle. The samples were placed inside the styro box with ice packs and were brought 6-24 hours.

Table 3

Selected Cities in Southern Negros, Negros Occidental

GEOGRAPHICAL POSITIONING COORDINATES		
AREA	Latitude	Longitude
SOUTHERN AREA		
KABANKALAN CITY	N09°59'658"	E122°48'793"
HIMAMAYLAN CITY	N10°07'711"	E122°52'183"
LA CARLOTA CITY	N10°25'062"	E122°52'687"
NORTHERN AREA		
SAN CARLOS CITY	N10°29'055"	E123°24'511"
ESCALANTE CITY	N10°51'153"	E123°29'144"
SAGAY CITY	N10°56'493"	E123°25'334"

Microbial Analysis

The representative of underground water samples collected and analysed in accordance with the standard parameters recommended for water quality monitoring by DENR (2008). The standard multiple-tube fermentation technique is used to enumerate positive presumptive, confirmed, and completed tests. The coliform, total coliform, fecal coliform, and *E.coli* was test in the study. This technique gives a most probable number (MPN) of coliforms present in a given sample of alternative water source in the southern and northern parts of Negros Occidental. The underground water contamination at unknown locations is determined based on the distance and direction of observation using a spatial interpolation method (Adhikary *et al.,* 2012).

Physico-Chemical Analysis

The collected water samples were analyzed for various physico-chemical parameters in Negros Prawn Producers Cooperative Analytical and Diagnostic Laboratory (NPPC), Bacolod City. The parameters were analyzed for color, pH, dissolved oxygen, total dissolved solids, and chloride. The analysis was categorized based on the DENR water standards.

Data Analysis

Microbial Parameters

The multiple-tube fermentation technique is a three-stage procedure in which the results are statistically expressed in terms of the most probable number (MPN). After 24 hours to 48 hours of incubation, the bacterial coliform, total coliform, fecal coliform, and *E. coli* bacteria that ferment with gas formation at 35 degrees Celsius were observed and recorded. The MPN levels were then compared for the density of coliform bacteria in a sample obtained from the MPN table, based on the number of positive tubes in each dilution of the presumptive, confirmed, or completed test. All MPN values for water samples were reported on the basis of a 100-mL sample. Table 4 shows MPN indices and 95% confidence limits for potable water testing for coliform, total coliform, fecal coliform, and *E.coli*. Table 5 shows the MPN Water analysis sample report for potable water.

Physico-chemical Parameters

The water sample collected was directly sent to Negros Prawn Producer's Cooperative Analytical and Diagnostic Laboratory (NPPC). Physico-chemical parameters are analyzed for color, pH, dissolved oxygen, total dissolved solids, and chloride based on DENR category and standards. (See table 2)

Table 4

MPN Index and 95% Confidence Limits for Various Combinations of Positive and Negative Results when five 10-ml Portions are used

Number of tubes giving positive reaction out of 5 of 10mL each	MPN Index per 100 mL	95% Confidence limits	
		Lower	Upper
0	<2.2	0	6
1	2.2	0.1	12.6
2	5.1	0.5	19.2
3	9.2	1.6	29.4
4	16	3.3	52.9
5	>16	8	Infinite

Table 5

MPN Water Analysis Sample Report

PARAMETERS	UNIT PER ML	REQUIREMENTS	METHODS
Coliform	Per 100mL	Negative	MTFT
Total Coliform	Per 100mL	Negative	MTFT
Fecal Coliform	Per 100mL	Negative	MTFT
E.Coli	Per 100mL	Negative	MTFT

RESULTS AND DISCUSSION

Table 6 shows the location of the alternative water source were randomly selected from the southern and northern parts of Negros Occidental. The underground water sample was taken from the hand-dug well and the borehole hand pump. Underground water sample was taken form Hand-dug well in Sagay city and in Himamaylan city, the borehole hand pump water sample was taken in San Carlos City, Escalante City, Kabankalan City, and La Carlota City. The location was identified based on latitude and longitude using the geographical positioning system (GPS). The water sample collection was taken on different dates and times.

November 12, 2018(Kabankalan city @ 8:45 am, Himamaylan City @ 9:41 am, and La Carlota City @ 11:02 am), January 22, 2019 (Kabankalan city @ 8:34 am, Himamaylan City @ 10:15 am, and La Carlota City @ 12:30 am), and January 26, 2019 (Kabankalan city @ 8:13 am, Himamaylan City @ 10:05 am, and La Carlota City @ 11:45 am) in the southern part of Negros Occidental. November 08, 2018 (San Carlos City @ 9:59 am, Escalante City @ 12:13 pm and Sagay City @ 11:55 am), January 17, 2019 (San Carlos City @ 9:13 am, Escalante City @ 11:55 am and Sagay City @ 12:36 pm) and January 19, 2019 (San Carlos City @ 8:15 am, Escalante City @ 9:30 am and Sagay City @ 7:00 am) in the northern part of the Negros occidental.

Table 6

Geographical Coordinates Using Geographical Positioning System (GPS)

Geographical Positioning System					
AREA	**Geographical Coordinate**		**Date and Time of sampling**		
SOUTHERN AREA	**Latitude**	**Longitude**	**11/12/18**	**1/22/19**	**1/26/19**
KABANKALAN	N09°59'658"	E122°48'793"	8:48am	8:34am	8:13am
HIMAMAYLAN	N10°07'711"	E122°52'183"	9:41am	10:15am	10:05am
LA CARLOTA	N10°25'062"	E122°52'687"	11:02am	12:30pm	11:45am
NORTHERN AREA	**Latitude**	**Longitude**	**11/08/18**	**1/17/19**	**1/19/19**
SAN CARLOS	N10°29'055"	E123°24'511"	9:59am	9:13am	8:15am
ESCALANTE	N10°51'153"	E123°29'144"	12:13pm	11:55am	9:30am
SAGAY	N10°56'493"	E123°25'334"	1:29pm	12:36pm	7:00am

Table 7 shows the DENR water standard and categories of fresh water of Kabankalan City. The result has a Class B water in terms of total coliform and fecal coliform from three samples taken in terms of physico-chemical parameters, the result has a Class AA in terms of color, TDS, pH, and dissolved oxygen, and Chloride is identified as Class A water. The result is identified in the underground water categories according to its microbial and physico-chemical parameters based on DERN freshwater standards.

Table 7

DENR Freshwater Standards and Categories of Water in Kabankalan City

KABANKALAN CITY				DENR FRESH WATER STANDARDS AND CATEGORIES OF WATER					
Microbial	MPN/100 mL			Categories		Physico-chemical			Categories
Parameters	A	B	C	CLASS	Parameters	A	B	C	CLASS
Total Coliform	>16	>16	16	B	Color	10	1	5	AA
Fecal Coliform	>16	>16	16	B	TDS	341	204	207	AA
					pH	7.23	8.43	8.21	AA
SOURCE					Chloride	24.0	265	213	A
BOREHOLE HAND PUMP					DO	3.5	4	4	AA

TDS – Total Dissolve d Solid, DO- Dissolved Oxygen

Class AA - Public Water Supply Class I

Class A - Public Water Supply Class II

Class B - Recreational Water Class I

Class C - Recreational Water Class II

Class D - Navigable waters

Table 8 shows the DENR water standard and categories of fresh water in Himamaylan City. The result gave a Class B water in terms of total coliform and fecal coliform from three samples taken, and in terms of physico-chemical parameters, the result gave a Class AA in terms of color, TDS, pH, and dissolved oxygen, and Chloride and DO were identified as Class A water. The result identifies the underground water categories according to their microbial and physico-chemical parameters based on DERN freshwater standards.

Table 8

DENR Fresh Water Standards and Categories of Water in Himamaylan City

HIMAMAYLAN CITY				DENR FRESH WATER STANDARDS AND CATEGORIES OF WATER					
Microbial	MPN/100 mL			Categor ies		Physico-chemical			Categories
Parameters	A	B	C	CLASS	Parameters	A	B	C	CLASS
Total Coliform	>16	>16	>16	B	Color	9	1	7	AA
Fecal Coliform	>16	>16	>16	B	TDS	192	333	301	AA
					pH	7.26	7.9	7.97	AA
SOURCE					Chloride	25.0	191	352	A
HAND-DUG WELL					DO	3.4	4	5.6	A

TDS – Total Dissolved Solid, DO- Dissolved Oxygen

Class AA - Public Water Supply Class I

Class A - Public Water Supply Class II

Class B - Recreational Water Class I

Class C - Recreational Water Class II

Class D - Navigable waters

Table 9 shows the DENR water standard and categories of fresh water of La Carlota City, the result gave a Class AA water in terms of total coliform and fecal coliform from three samples taken and in terms of physico-chemical parameters the result gave a Class AA in terms of color, TDS, pH, dissolved oxygen and Chloride. The result identifies in the underground water categories according to its microbial and physico-chemical parameters based on DENR fresh water standards.

Table 9

DENR Fresh Water Standards and Categories of Water in La Carlota City

LA CARLOTA CITY					DENR FRESH WATER STANDARDS AND CATEGORIES OF WATER				
Microbial	MPN/100 mL			Categories		Physico-chemical			Categories
Parameters	A	B	C	CLASS	Parameters	A	B	C	CLASS
Total Coliform	<2.2	<2.2	<2.2	AA	Color	6	5	5	AA
Fecal Coliform	<2.2	<2.2	<2.2	AA	TDS	177	224	296	AA
					pH	7.45	7.37	7.98	AA
SOURCE					Chloride	22.0	227	354	AA
BOREHOLE HAND PUMP					DO	3.1	3.8	4.5	AA

TDS – Total Dissolve d Solid, DO- Dissolved Oxygen

Class AA - Public Water Supply Class I

Class A - Public Water Supply Class II

Class B - Recreational Water Class I

Class C - Recreational Water Class II

Class D - Navigable waters

Table 10 shows the DENR water standard and categories of fresh water of San Carlos City, the result gave a Class B water in terms of total coliform and fecal coliform from three samples taken and in terms of physico-chemical parameters the result gave a Class AA in terms of color, TDS, pH, dissolved oxygen and Chloride. The result identifies in the underground water categories according to its microbial and physico-chemical parameters based on DENR fresh water standards.

Table 10

DENR fresh water standards and categories of water in San Carlos City

SAN CARLOS CITY					DENR FRESH WATER STANDARDS AND CATEGORIES OF WATER				
Microbial	MPN/100 mL			Categories		Physico-chemical			Categories
Parameters	A	B	C	CLASS	Parameters	A	B	C	CLASS
Total Coliform	>16	>16	>16	B	Color	4	1	2	AA
Fecal Coliform	>16	>16	>16	B	TDS	272	259	130	AA
					pH	7.43	7.11	7.38	AA
SOURCE					Chloride	11	18	32	AA
BOREHOLE HAND PUMP					DO	3.3	4.0	5	AA

TDS – Total Dissolved Solid, DO- Dissolved Oxygen

Class AA - Public Water Supply Class I

Class A - Public Water Supply Class II

Class B - Recreational Water Class I

Class C - Recreational Water Class II

Class D - Navigable waters

Table 11 shows the DENR water standard and categories of fresh water of Escalante City, the result gave a Class A water in terms of total coliform and fecal coliform from three samples taken and in terms of physico-chemical parameters the result gave a Class AA in terms of color, TDS, pH and dissolve oxygen and Chloride identifies as Class B water. The result identifies in the underground water categories according to its microbial and physico-chemical parameters based on DENR fresh water standards.

Table 11

DENR Fresh Water Standards and Categories of Water in Escalante City

ESCALANTE CITY				DERN FRESH WATER STANDARDS AND CATEGORIES OF WATER					
Microbial	MPN/100 mL			Categories	Physico-chemical				Categories
Parameters	A	B	C	CLASS	Parameters	A	B	C	CLASS
Total Coliform	9.2	<2.2	9.2	A	Color	3	1	2	AA
Fecal Coliform	2.2	2.2	2.2	A	TDS	238	234	115	AA
					pH	6.91	6.60	7.12	AA
SOURCE					Chloride	17.0	332	42	A
BOREHOLE HAND PUMP					DO	4.5	4	5.6	AA

TDS – Total Dissolved Solid, DO- Dissolved Oxygen

Class AA - Public Water Supply Class I

Class A - Public Water Supply Class II

Class B - Recreational Water Class I

Class C - Recreational Water Class II

Class D - Navigable waters

Table 12 shows the DENR water standard and categories of fresh water of Escalante City. The result gave a Class B water in terms of total coliform and fecal coliform from three samples taken, and in terms of physico-chemical parameters, the result gave a Class AA in terms of color, TDS, pH, and dissolved oxygen, and Chloride is identified as Class A water. The result identifies the underground water categories according to their microbial and physico-chemical parameters based on DERN freshwater standards.

Table 12

DENR Fresh Water Standards and Categories of Water in Sagay City

SAGAY CITY				DENR FRESH WATER STANDARDS AND CATEGORIES OF WATER					
Microbial	MPN/100 mL			Categories	Physico-chemical				Categories
Parameters	A	B	C	CLASS	Parameters	A	B	C	CLASS
Total Coliform	>16	16	>16	B	Color	2	1	7	AA
Fecal Coliform	>16	>16	>16	B	TDS	582	627	310	AA
					pH	7.17	7.49	7.9	AA
SOURCE					Chloride	133	27	340	A
HAND-DUG WELL					DO	5.6	4.5	4.1	AA

TDS – Total Dissolved Solid, DO- Dissolved Oxygen

Class AA - Public Water Supply Class I

Class A - Public Water Supply Class II

Class B - Recreational Water Class I

Class C - Recreational Water Class II

Class D - Navigable waters

CONCLUSION

Based on the findings of the study, most of the alternative water sources examined in the selected cities of Negros Occidental did not meet the acceptable microbial standards for potable water. Five out of the six sampling areas showed high microbial contamination, particularly elevated coliform levels beyond the safe potability range. This indicates that the water from these sources must undergo proper disinfection prior to consumption in order to reduce the risk of water-borne diseases. Among the sampled locations, only the alternative water source in La Carlota City met the microbial standards and was considered potable.

In terms of physicochemical parameters, the majority of the water samples met the required standards, except for chloride and total hardness, where several samples exceeded the recommended limits. Based on the Department of Environment and Natural Resources (DENR) water classification standards for freshwater sources, the alternative water sources in Kabankalan City, Himamaylan City, San Carlos City, and Sagay City were categorized as Class B (Recreational Water, Class I).

The water source in Escalante City was classified as Class A (Public Water Supply, Class II), while the water source in La Carlota City was classified as Class AA (Public Water Supply, Class I), indicating that it is the most suitable for drinking water supply among the areas studied.

Although most of the samples met the physical and chemical standards, the presence of elevated microbial contamination and the exceedance of certain chemical parameters suggest that these alternative water sources require conventional water treatment processes, such as coagulation, sedimentation, filtration, and disinfection, to comply with the latest Philippine National Standards for Drinking Water (PNSDW).

Overall, the study highlights the importance of regular monitoring, proper treatment, and protection of alternative water sources to ensure their safety and suitability for public consumption, particularly during periods of water shortage or emergencies.

RECOMMENDATIONS

Based on the results and conclusions of the study, several recommendations are proposed to ensure the safety and sustainability of alternative water sources in Negros Occidental. The alternative water source located in La Carlota City should be preserved as a potential emergency water supply and should undergo continuous testing and monitoring to ensure that its quality remains within acceptable standards. It is also recommended that alternative water sources undergo appropriate treatment before being used for drinking or domestic purposes to minimize health risks associated with contamination. Local government units (LGUs) should implement educational programs that promote awareness of water protection and proper management of water sources within their communities. In addition, borehole hand pumps and hand-dug wells should be regularly monitored through periodic water quality analyses to ensure their safety and suitability for use.

Conducting proper site surveys prior to the installation of borehole hand pumps and hand-dug wells is also important to prevent contamination and ensure that the selected locations are suitable for groundwater extraction. Long-term monitoring studies are further recommended to continuously assess coliform populations and detect possible changes in water quality over time. LGUs are also encouraged to preserve and protect potential potable alternative water sources that may be used during emergencies or water shortages.

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