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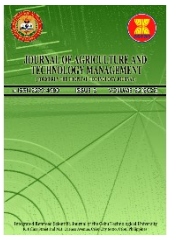

Original article

Biophysicochemical characterization of potential water sources in Camotes Islands, Cebu Philippines

Martha Joyce G. Garciano and Maximino R. Abejo III*

Cebu Technological University - San Francisco Campus, Northern Poblacion, San Francisco, Cebu

ABSTRACT

Checking water quality is essential to ensure safe drinking water. Safe drinking water provides the health of the consumers. This study employed descriptive research which characterized the water (biophysicochemical) qualities of potential water sources in Camotes Islands, Central Visayas, Philippines. Water samples were gathered and tested by the Department of Science and Technology (DOST) water laboratory for microbiological and chemical qualities and had undergone senses inspection and traditional laboratory processes such as filtration and evaporation for the physical analysis. Results revealed that water samples were high in disease-causing microorganisms or coliforms. Total hardness revealed an increased level of calcium carbonate value that contributed to water hardness. The physical characteristics of these potential water sources revealed that they conformed with the standards regarding color, taste, odor, and turbidity. These potential water sources revealed disease-causing factors that could lead to less-fitting for drinking or household consumption. It is then recommended that these potential water sources should undergo proper treatment, reconstruction, or rehabilitation of the reservoir and enhance the piping system. Furthermore, a repeat study might be conducted to the same site or other potential water sources for confirmation and determination of the level of contamination.

KEYWORDS: *Biophysicochemical, Calcium Carbonate, Characterization, Coliform, Escherichia coli, Renal Calculi*

1 INTRODUCTION

Water is imperative for the survival and daily needs of plants, animals, and humans. Water is the most crucial substance because it is required for all living processes: photosynthesis, respiration, circulation, and digestion, to name a few (Jéquier and Constant, 2010). Man needs water for drinking, food preparation, cooking, and for other household activities (WHO and UNICEF, 2010). With extreme hot climatic conditions, man needs to drink as much as ten glasses of water every day. As water is ingested, it enters body cells and plasma through osmosis. Water is essential in cellular processes necessary for growth and development. Sixty to eighty percent (60 – 80%) of the human body is composed of water (Chao-Jun and Liang, 2006).

Water exists in nature as colorless, tasteless, and odorless fluid with a specific gravity of 1.0, freezes at 00C, and boils at 1000C. It dissolves most inorganic and some organic substances, thus making it prone to contamination. Since it contains oxygen, microorganisms thrive in water at room temperature (Chao-Jun and Liang, 2006). It is then imperative that water for human and household consumption is free from contaminants and hazardous substances to ensure its safety for drinking and household consumption.

According to the data of Department of Health (DOH)-FHSIS as of 2015, one of the leading causes of morbidity in Region 7 was diarrhea and gastroenteritis of presumed infectious origin with 0.203%, though the causative agent was unknown while in 2016, it was recorded that 0.115% of the same cause, while mortality leading cause in 2016 noted 0.12% cases of renal diseases. With this objective evidence, water might be one of the reasons for these conditions. In a rural community, like Camotes Group of Islands, water for households and people's consumption came from natural springs, which, in many cases, were uncared for and vulnerable to contamination and abuse. Water cooperatives in the four towns of the Camotes Group of Islands were established to regulate, control, and care for these sources, and established systems for water distribution to the household consumers. Such water cooperatives were governed by the Local Government units of such Municipalities of San Francisco, Poro, Tudela, and Pilar, in the Camotes Group of Islands, Cebu Philippines. However, complete biophysicochemical water analysis is not regularly monitored.

During summer and the long dry season, the supply of water regulated by such cooperatives could not suffice the needs of the public; in such a manner that residents

*corresponding author: maximinoabejo@ctu.edu.ph
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opted to utilize unregulated potential water sources in the area not minding that the quality of water for human and household consumption are necessary to maintain health and wellness. As the saying goes, "A healthy society brings a healthy nation. A healthy nation brings progress and development to the country" (American Medical Association, 2015).

Hence, this research was undertaken and conceived to characterize the biophysicochemical quality of the potential water sources in Camotes Islands, Central Visayas, Philippines, and its possible implication to the health of the residents.

Specifically, this study aimed to determine the following:

1. The presence and concentration of total coliform and Escherichia coli (E. coli) concentration;
2. Physical characteristics such as color, odor, specific gravity, taste, and turbidity;
3. Chemical characteristics such as the pH value, alkalinity, total hardness, salinity, total dissolved solids; and
4. The implication of the result of such water analysis to the consumers' health.

2 MATERIALS AND METHODS

This study employed a descriptive research method. Permission to conduct the study was sought from the Campus Director of Cebu Technological University-San Francisco Campus through the Campus Research and Development Director. A written permit was then issued by the Municipal Mayors of the Municipalities of San Francisco, Poro, Tudela, and Pilar after presenting the study before the Sanguniang Bayan, and informing each Barangay Captains, where the water sources were located, about the study. A preliminary interview was conducted after permission was granted from the landowners of the water sources.

Water samples were gathered from the primary source or reservoir, and from the first household/consumer which was located about five hundred (500) meters to one (1) kilometer away from the primary source. Two liters to one gallon of midstream water samples were collected from each water source. Such collection was dependent on the required volume of sample per analysis procedure. In-situ inspection was done to determine preliminary physical data.

Considering the distance of the water sources and the location of the laboratories where analyses were to be held, the collection was done at a time within the four-hour period of viability of any microorganisms that might be present in the water samples, and assurance of samples' quality. Such samples were placed in the following: sterilized glass bottles were filled in with 2 liters of water samples per bottle intended for the microbiological analysis; while a gallon of water samples were placed each in plastic bottles intended for the physicochemical analyses. All samples were placed in iced-laden buckets to preserve their quality. In-situ inspection was done to determine initial data of physical parameters. Some samples were brought to the Campus laboratory for the Sedimentation test. While most of the samples were brought to the DOST Laboratory in Cebu City for the microbiological and chemical analyses.

Study sites were chosen based on the number of consumers utilizing such water sources, especially during the dry season. These sites were divided into four (4) areas comprising the Pacijan Island where the Municipality of San Francisco was located, Poro Islands consisting of the Municipalities of Poro and Tudela, and Ponson Island where the Municipality of Pilar was located. Another consideration in choosing such water sources was that these water sources would not dry up during the dry season, and many consumers were utilizing such for both household usage and for drinking.

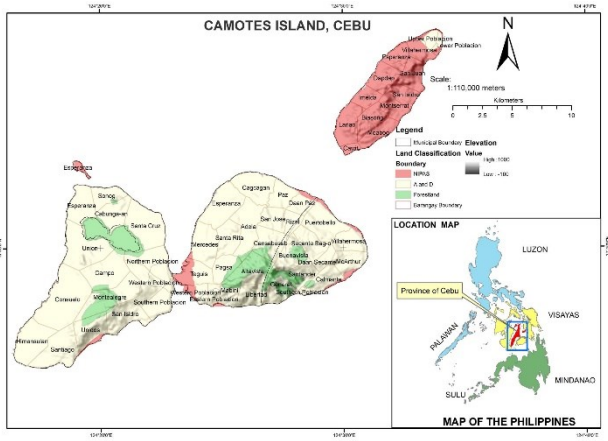

Figure 1. Location Map of Camotes Group of Islands

Water Analysis:

Microbiological analysis: the DOST employed the Standard Methods for the Examination of Water and Wastewater, 16th ed., Part 900, 907A Pour Plate Method for Heterotrophic Plate Count; 908A Standard Total Coliform Multiple-tube (MPN) tests; 908D Estimation of Bacterial Density; 908C Fecal Coliform MPN procedure; and confirmed test for E. coli following Bacteriologic Analytical Manual, 8th ed. Chapter 5.

Physical qualities: manual inspection was done during the time of inspection using the senses except for specific gravity which was measured using Orion pH meter by DOST, and turbidity which the researchers have used traditional methods such as filtration and evaporation to determine the presence of residues in the water samples.

Chemical analysis: the DOST employed the Method

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References from Orion pH meter, APHA AWWA 21st edition 2005 for 2710F, 2340C, 4500-Cl-, 2320B, 2540B, 2540C, 4500P, CSOP-3-112 , CSOP-3-111 and by computation for Total Suspended Solids.

Figure 2. Photos of the Potential Water Source

3 RESULTS AND DISCUSSIONS

The water source from the Municipality of Poro was high in the number of microorganisms consisting of yeasts, molds and bacteria (heterotrophs). All water samples from the four (4) municipalities were high in the presence of disease-causing organisms (coliforms). The water sources from the Municipalities of San Francisco and Poro were high E. coli. Bacterial indicators such as total coliforms, E. coli, and fecal enterococci were used to assess microbiological water quality. Total number of coliforms could provide basic information on water quality, but they were not an index of fecal contamination; however, E. coli and enterococci were both fecal contamination indicators (Payment et al., 2003). E. coli was the most commonly used indicator for fecal contamination (WHO, 2008). These microorganisms thrived in the intestines of animals and humans. Their presence in the water samples could indicate that waste products from animals, including human waste, might be contaminating the water sources. While, for the Municipality of Pilar, consumers obtained water directly from the reservoir. There was no household near the site, and the spillage became an animal sanctuary. This could imply that these potential water sources might be harmful to consumers' health since there was evidence of contamination from animal or human wastes that might have infiltrated these water sources.

Historically, studies evaluating better drinking water sources and drinking water treatments in underdeveloped countries have focused on the fecal indicator bacteria, specifically E. coli, for microbiological water quality assessment (Semenza et al., 1998; Cobbina et al., 2009).

All water samples showed no evidence of deviation from the normal quality or standard in terms of odor, color, taste, and turbidity, while the specific gravity revealed values within the normal range. These implied that the water sources might be physically fit for consumption. However, the increased value of the number of coliforms and E. coli were not detected right away since these organisms thriving in such water sources were microscopic and needed microscopic analysis. It would then be necessary that consumers should be educated about the presence of microorganisms in these water sources for safe water consumption. And they should also be taught to regularly boil any water samples before consumption.

The water source from the Municipality of Pilar was highly alkaline, with the amount of calcium carbonate concentration (CaCO3) per letter of sample was high. This result was congruent with Total Hardness in which the amount of calcium carbonate (CaCO3) in these water sources was also increased. It was also noted that the water sources from the Municipalities of Poro and Pilar showed a higher amount of CaCO3 compared to the water sources from the Municipalities of San Francisco and Tudela. The other results were within the normal range. Based on the Standard Methods for the Examination of Water and Wastewater (2005), the presence of CaCO3 in water might increase its capacity to precipitate soap, thereby increasing amounts of sediments and, if ingested, can form calculi or renal

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Table 1. Presence and Concentration of Microbiological Components in Water

Parameters	**Reference Standard (DOST)**	**San Francisco**		**Tudela**		**Poro**		**Pilar**	
		Source	Household	Source	Public / Open Pool	Source	Household	Source	Household
Heterotrophic plate count	5.0x10² cfu/mL	1.0x10² cfu/mL	2.0x10² cfu/mL	1.0x10² cfu/mL	1.7x10² cfu/mL	8.1x10² cfu/mL	**8.1x10² cfu/mL**	4.3x10² cfu/mL	
Total coliform count	<1.1 MPN/ 100mL	**7.0 MPN/ 100mL**	**>8.0 MPN/100 mL**	**7.0 MPN/ 100mL**	**8.0 MPN/ 100mL**	**240 MPN/ 100mL**	**TNTC***	110 MPN/100mL	Not used (Animal Sanctuary)
E. coli count	**<1.1 MPN /100 mL**	**7.0 MPN/ 100mL**	**>8.0 MPN/100 mL**	<1.0 MPN/100mL	<1.1 MPN/100mL	**240 MPN/100mL**	**TNTC***	<1.1 MPN/100mL	

*TNTC-too numerous to count

Table 2. Physical Characteristic of Water Sample

Parameters	**Reference (Manual)**	**Results**				**Interpretation**
		San Francisco	**Tudela**	**Poro**	**Pilar**	
Color	Colorless	Colorless	Colorless	Colorless	Colorless	Absence of discoloration noted
Odor	Odorless	Odorless	Odorless	Odorless	Odorless	Absence of foul or peculiar odor noted
Specific gravity	1.00 g/ml	0.9971	1.0052	1.0076	1.0013	Within the normal value
Taste	Tasteless	Agreeable	Agreeable	Agreeable	Agreeable	Absence of peculiar taste noted
Turbidity	Clear	Clear	Clear	Clear	Clear	Absence of residues

stones. Empirical evidence from the studies of (Iosub et al., 2009; Chatterjee et al., 2012) indicating people living in places with high calcium concentrations in their drinking water had a higher incidence of renal calculi.

Several studies revealed that one of the factors in the formation of renal calculi or kidney stones was the quality of water (Girija et al., 2007; Bhatt et al., 2008). About 75% of urinary stones were calcium compound-based, and in some cases were mixed stones (Coe et al., 1992, as cited by Aslin Shamema et al., 2015; Wison et al., 2010). Urinary stone formation was significantly brought about by the presence of toxic minerals in the groundwater (Karthikeyan et al., 2010; Murray and Dent, 1973, as cited by Aslin Shamema et al., 2015), and such would have a significant effect on the health of the consumers.

The chemicals being tested revealed that water samples from Poro and Pilar were high in Calcium. This conformed with Table 3, Chemical Characteristics, which showed a high level of calcium carbonate concentration. Calcium is an important biomineral and is abundant in both living things and the natural environment. Amount of metals, such as Lead and Iron were negligible, which could mean that toxic and hazardous substances might not be present or, if present, were in an amount that could not affect consumers' health.

4 CONCLUSION

Water is vital for life's processes, ensuring its safety and freedom from contamination. Determining the characteristics of potable water sources is imperative to increase consumers' awareness of the status of water

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Table 3. Chemical Characteristic of Water Sample

Parameters	Reference Point (DOST)	Results			
		San Francisco	Tudela	Poro	Pilar
pH value	6.5 – 8.5	7.32	7.53	7.64	7.45
Total alkalinity	Based on 500 mg/L TDS	162 mg $CaCO_3$/L	180 mg $CaCO_3$/L	292 mg $CaCO_3$/L	590 mg $CaCO_3$/L
Total hardness	10 – 250 mg $CaCO_3$/L	265 mg $CaC0_3$/L	330 mg $CaCO_3$/L	416 mg $CaCO_3$/L	590 mg $CaCO_3$/L
Salinity	<2.0 ppt	<2.0 ppt	<2.0 ppt	<2.0 ppt	<2.0 ppt
Total Solids	500 mg/L	0.017%	0.021%	0.032%	0.040%
Total dissolved solids	500 mg/L	0.010%	0.017%	0.028%	0.035%
Total suspended solids	-	0.007%	0.004%	0.004%	0.005%

Table 4. Actual Amount of Chemicals Present

Actual Amount of Chemicals Present	Reference Point (DOST)	Results			
		San Francisco	Tudela	Poro	Pilar
a. Chlorides	200 mg/L	18.5 mg/L	14.8 mg/L	14.8 mg/L	14.8 mg/L
b. Phosphates	0.025 mg/L	0.012 mg/L	0.012 mg/L	0.012 mg/L	0.012 mg/L
c. Calcium	75 mg/L	35.7 mg/L	45.0 mg/L	76.0 mg/L	109 mg/L
d. Iron	0.3 mg/L	<0.09 ppm	<0.09 ppm	<0.061 ppm	<0.061 PPM
e. Lead	0.1 mg/L	<0.08 ppm	<0.08 ppm	<0.112 ppm	<0.112 ppm
f. Potassium	2.5 mg/L	<0.28 ppm	<0.28 ppm	<0.001 ppm	<0.001 ppm
g. Sodium	20 mg/L	3.80 mg/L	4.79 mg/L	3.55 mg/L	4.53 mg/L

being consumed. Potential water sources could be a medium for contamination and growth of disease-causing microorganisms since its regulation and control might not have been put in order. Biological analysis revealed high coliform content in the potential water samples in the Camotes Islands, which might have significant impact on the health of the consumers when consumed for drinking or other domestic use. Physically, water samples were acceptable based on manual inspection. Chemical analysis revealed that CaCO3 contributed to the hardness of such water samples, as confirmed by the high amount of calcium in the water samples. Such results might negatively impact the health of the consumers since these could develop infection and the

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formation of renal calculi. Generally, the water samples being tested as the potential water sources in the Islands of Camotes, Cebu should less be advised for utilization, especially for drinking and other domestic consumption, unless proper sanitation procedures are implemented.

RECOMMENDATIONS

Based on results, it was highly recommended that further microscopic studies be undertaken to determine the specific microorganisms (heterotrophs) contaminating the water sources aside from the Escherichia coli for an effective treatment of the cause of contamination. It could also be recommended that the specific area of salt infiltration (primary sources or along the distribution lines) be identified and pointed out for proper management, like enhancing the piping system with non-corrosive pipes in the distribution lines and placing sturdy covers on the reservoirs. Traditional methods of filtration and water purification might be applied during the rehabilitation and re-construction of the reservoirs, like the establishment of multi-compartment-reservoirs. Such reservoirs should be periodically cleaned and treated with anti-microbial chemicals suitable for drinking while preventing corrosion and contamination.

In addition, determination of other toxic minerals and salts from the ground water sources, aside from calcium carbonate, might be undertaken for proper water management and treatment. And most of all, monitoring of the health condition specifically the kidney functions of the consumers would be highly recommended

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