Journal of Advances in Microbiology

22(3): 63-72, 2022; Article no.JAMB.84694
ISSN: 2456-7116

An Analytical Physicochemical and Bacteriological Drinking Water Quality Assessment - University of Eastern Philippines - Main Campus

Flyndon Mark S. Dagalea [a,b*], Karina Milagros C. Lim [a,b], Manuela Cecille G. Vicencio [a,c] and Felisa L. Sanico [b]

[a] *Department of Physical Sciences, College of Science, University of Eastern Philippines, Catarman, Northern Samar 6400, Philippines.*
[b] *University Research Office, University of Eastern Philippines, Catarman, Northern Samar 6400, Philippines.*
[c] *Department of Biological Sciences, College of Science, University of Eastern Philippines, Catarman, Northern Samar 6400, Philippines.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMB/2022/v22i330448

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/84694

Original Research Article

Received 12 January 2022
Accepted 16 March 2022
Published 22 March 2022

ABSTRACT

Water is one of the most important commodity, which is essentially required for the survival of all types of life, including sustenance of ecosystems and bio-diversities. Human wellbeing hinges around availability of sufficient qualitative and quantitative water affordability for a quality life. People need to live and survive that's why they must be aware of water quality parameters that are required for quality water. Water quality is determined by assessing its biological, chemical, and physical characteristics. In this study, a water quality assessment was carried out at the University of Eastern Philippines water system; which included a water refilling station, traditional water pumps, and the Alma Beach. The water samples, after the collection, were tested to identify the color, odor, pH, salinity, temperature, calcium content, magnesium content, sodium content, potassium content, and coliform count. After evaluation, all water samples conformed to the set standard by the PNSDW. However, the bacterial analysis showed that there is a sampling site that is not allowable for human consumption. In another area, the water quality assessment result for the Alma beach revealed that

**Corresponding author: E-mail: flyndondagalea@gmail.com;*

it is safe for recreational purposes and other recreational sports. But this does not mean that we should lay down our back, this calls for proper sanitary and environmental compliance regularly for the water systems in the university.

Keywords: Water quality; Alma Beach; UEP; Escherichia coli; traditional water pumps; water refilling stations.

1. INTRODUCTION

The Department of Health presented a prescribed standard and procedure on drinking water quality aiming to protect the public and consumers' health. To ensure the safety of drinking water, seven guidelines must be followed. These include measuring the quality; water sampling and examination; other modes of distribution of drinking water; evaluation of results; classification of quality parameters; quality assurance/ quality control for water laboratories; and water safety plan and quality surveillance (Philippine National Standards for Drinking Water, 2017).

In the characterization of water bodies, there are three major components: hydrology, physico-chemistry, and biology. A complete assessment of water quality is based on appropriate monitoring of these components (UNESCO/ WHO/UNEP, 1996). In this study, the researcher focused on the physical and chemical properties and bacteriological content.

Water is considered as the universal solvent which suits perfectly for the water to be used for all purposes. Water considering its unique property made its way to play a vital role in human life. From which, water is the material that makes life possible on earth. All organisms are composed of cells that contain at least 60 percent water and their metabolic activities take place in a water solution (Smith, Enger, 2010). All living things large or small, animal or plant needs water.

Water is essential to life; it is essential for health and sanitation. In the Philippines, freshwater resources are degrading even before the entire population can benefit from them. As the population grows, there is a greater need for water particularly for drinking purposes.

Purified drinking water from commercial stations was usually bacteria-free but is also mineral-free. These minerals are useful for human health. On the other hand, groundwater contains useful minerals but is usually contaminated by bacteria. Increasing population contributes to the contamination of drinking water sources [1].

It is in this light that the researchers found this study of great significance to the present setting. They have investigated the water quality in Alma Beach, Catarman, Northern Samar in terms of its physicochemical properties. The researchers have also measured the coliform count in Alma Beach. They have also investigated the anthropogenic activities of the residents and resort employees and staff which greatly affects the coastal waters in Alma Beach. This should help in providing plausible recommendations for the better treatment of the beach waters that applies, not only to the local setting but also nationwide. Knowing the safety of water gives a wider impact on the community, clean water is vital to the livelihood and daily needs of the local populations.

2. LITERATURE REVIEW

The capacity of each water for serving recreational interests will vary, but generally the greater the number of people using an area at any one time, the greater the risk of a decline in water quality. Some activities are potentially more damaging than others. The use of motorboats can lead to beach and shoreline erosion, dissemination of aquatic weed nuisances, chemical contamination, turbulence, and turbidity in shallow waters (Notado, 2014). Such is the effect of abusing coastal resources. Though tourism is one of those factors which drive the economy of the country, disregarding the conditions our natural resources are in should not be tolerated since it has adverse effects to such and later affects human health.

Poblete [2] studied the physical, chemical, and bacteriological properties in selected Level 1 drinking water sources in Laoang, Northern Samar. She determined the color, odor, ph, and total dissolved solids, salinity, nitrate, dissolved oxygen water hardness and alkalinity, and fecal coliform. He found out that all the parameters were within the permissible limit of the DENR standards for drinking water.

Groundwater is not also exempted from contamination, Getalado [3] reveals that the groundwater from the Seaside and Hillside areas of UEP, Catarman exceeded the permissible limit set by the Philippine National Standard for Drinking Water in terms of physical and chemical characteristics which only shows that proper treatment of these, sources of water is necessary before use for drinking and other household or personal use. He studied the physical, chemical, and bacteriological analysis of groundwater at the University of Eastern Philippines.

Beaches near the cities have greater *E. coli* than those isolated areas, Alisasis (2003) proves that it is dangerous to swim or take a bath in the beaches fronting Gaisano and Terminal areas of San Juanico Strait. The coliform counts for San Juanico Straits fronting Gaisano and Terminal areas are too numerous to count (TNTC), *Salmonella*, *Klebsiella,* and other organisms were also isolated. Although there seems to be no official report of patients being infected with coliform bacteria resulting from swimming in the beaches studied, it cannot be discounted that swimmers or bathers exposed to a high level of bacteria could suffer from gastro-intestinal illnesses, skin rashes, and eye or ear infections [4,5]. Hence it is no longer safe to recreate in such waters and if the Local Government Unit does not put effort into rehabilitating the area, this may lead to the total depletion of the life forms existing there and greater health concerns may arise.

In the study cited by Marites and Calumpiano, Total coliform (TC) and Fecal Coliform (FC) of the surface water of Cancabato Bay, Tacloban City were monitored from October 2010 to January 2011 to evaluate the sustainability of the area for shellfish cultivation and recreational activities. Using the standards proposed by the Department of Environmental and Natural Resources – Environmental Management Bureau, this bay cannot be considered suitable for shellfish culture and recreational activities based on the data gathered during the period of the study [4,6].

The lack of facilities for liquid drainage and wastewater and garbage disposal encourages waste to be thrown into nearby streets and gutters. Such habitats for rodents, breeding points for flies, and media for the growth of microorganisms. A study done in Africa revealed that 85% of the vendors prepared foods like fish, fruit salads, roasted maize, and chips in unhygienic conditions, given that garbage and dirty waste were conspicuously close to the stalls. In these areas, large amounts of garbage accumulate which provides harborage for insect animal pests that are linked to the enteric disease transmission of Shigella, Salmonella, and *E. coli* (Fang, 2002).

3. STUDY OBJECTIVES

This study aimed to test if the water samples from the traditional water pumps in the area are drinkable. Through the course of this study, the researchers were able to find out the reason why people still drink unsafe water even though they already know that it's not safe for their health. By using a water tester, the researchers were able to determine if the water is safe for drinking. The main purpose of this research is to give knowledge to people to be aware of the water produced by their water pumps is not always safe and will make their lives at risk.

4. MATERIALS AND METHODS

4.1 Study Description

The water quality assessment was conducted at the Chemistry Laboratory in the College of Science, University of Eastern Philippines, University Town, Catarman Northern Samar. The water samples were collected in three designated areas dividing the University Town (Zone I, Zone II, and Zone III). Another location was Alma Beach, which is located inside the university. The beach serves as a leisure area every weekend to the community near it.

4.2 Methodology

The following procedures conform to the AOAC International and US FDA Bacteriological Analytical Manual (BAM) standard procedure. After the collection, a test analysis was carried out, as under:

4.2.1 Determination of the physical properties of water samples

Color and **Odor.** The color and odor of the water samples were identified by five (5) respondents using their sense of sight and sense of smell, respectively. The perceived color of most respondents was recorded as the color of the water sample, on the odor, the perceived odor was recorded as to the odor of the water sample.

pH. An on-site digital pH meter was used placed in the water sample after the collection. After 1 minute, the registered pH was recorded. This was done in three (3) trials. **Salinity.** The salinity of the water sample was tested also on-site after the collection of the water sample. A drop of the water sample was placed on the glass side of the refractometer. The salinity reading was converted from percent to part per thousands (ppt). **Temperature.** The temperature of the water sample was determined using an infrared thermometer.

4.2.2 Determination of the mineral contents of water samples

Calcium Ion Test. One (1) mL of the water sample was placed in a test tube. The acidity of a sample solution was tested with litmus paper. Once it is acidic, three (3) molar of NH_3 was added until basic. Then added with 0.2M $(NH_4)_2C_2O_4$ solution. The formation of a white precipitate indicates the presence of Ca^{2+}. The result was confirmed by adding a few drops of concentrated HCl and analyzed using a flame test. **Flame Test Confirmatory for Calcium Ion.** The wire loop was cleaned by dipping into HCl and rinsed with distilled water. The cleanliness of the wire loop was tested by placing it into the flame of the bunsen burner. The procedure was repeated until the loop does not emit color from the flame. When the wire loop is cleaned, it will be dipped into the sample solution that contains calcium ions and it will be placed into the blue flame of the Bunsen burner. When the flame produced a brick red color, there is a presence of Ca^{2+}. The observation was recorded and repeated in three trials.

Magnesium Ion Test. Five (5) mL of water sample was poured into a small beaker and was added with 5mL of 2M HCl. Then 15±5mL of 2M NaOH was added. The precipitate was observed closely. A white, jelly-like precipitate indicates the presence of magnesium ions. The observation was recorded, and the test was repeated thrice.

Sodium and **Potassium Ion Test.** The test used flame analysis. An evaporating dish was thoroughly cleaned. One (1) mL water sample was poured into a clean evaporating dish. The evaporating dish with the water sample was heated until it evaporated completely. The dish was then allowed to cool, afterwards, 1mL of denatured alcohol was added. The alcohol in the evaporating dish was then ignited. The flame produced was observed and recorded. Sodium was identified by a yellow flame color and potassium was identified by lavender or purple flame color. The result was recorded and repeated thrice.

4.2.3 Determination of *E. coli* contents of water samples

A commercially available 6404/6414 *E. coli/* coliform count plate, 3M Petrifilm [7] was used. A water sample was placed in clean and sterilized bottles. Care was an exercise to ensure that the sample collected was properly labeled as representative of the water to be tested and so that the samples are not contaminated at the time of the collection. To preserve the water samples collected, these were placed inside a cooler (an icebox) to ensure that no exposure to sunlight happened. The collected water samples were taken to the UEP-College of Science Chemistry Laboratory for the determination of *E. coli* content using 3M Petrifilm.

A 6404 *E. coli/* coliform count plate, 3M Petrifilm plate was placed on a leveled surface. The top film was lifted to start the inoculation of the sauce samples. One (1) mL of inoculum was distributed aseptically into the 3M Petrifilm *E. coli* count plates using a new sterile pipette. A spreader was placed on top of the film and pressure was gently applied to distribute the inoculum over the circular area. An incubator creates the proper growth temperature and other conditions. This promotes the multiplication of the microbe over hours, days, and even weeks. In this study, following the AOAC Official Method 991.14, the samples were incubated for 24±2 hours. Incubation produces a culture, the visible growth of the microbe in or on a medium. The temperature used to grow *E. coli* was 35±1ºC.

In counting the colonies in the 3M Petrifilm the plate was placed in an improvised colony counter (lamp shade and magnifying lens) which will enlarge the colonies and enable us to see clearly and start counting which followed a method that was used in counting the red blood and white blood cell in a snake-like pattern. An estimate was to be made on the plate if it contains greater than 150 colonies by counting the number of colonies using the bacterial colony counter in one or more representative squares and determining the average number per square multiply the average number by 20 to determine the estimated count per plate.

5. RESULTS AND DISCUSSION

5.1 Water Refilling Stations

The result of this study aimed to assess the water refilling stations in three barangays of UEP, Catarman, Northern Samar.

Table 1 shows the physical properties of the water samples collected from the water refilling stations in the three barangays of UEP. The color of the water samples is colorless, indicating that no formation of colored substances is present in the water samples. The odor is odorless. The pH for drinking water ranges from 6.5 to 8.5 [8], the average pH of the water samples conforms to the national standard. The salinity of the water samples is zero, which implies that there are no salt components that are detectable during the sampling. The temperature of the water samples conforms to the standard temperature range of 25-32ºC for drinking water [9,10].

Table 2 shows the available mineral content among the water samples. Calcium, Magnesium, and Potassium are all absent in the water samples. The sodium ion is present in all of the water samples, this implies that it could help the human body to maintain blood pressure, control fluid levels, and for normal nerve and muscle function.

Table 3 shows the bacteriological analysis of the water samples collected from the water refilling stations in the three barangays of UEP. The table shows that water samples from these water refilling stations are allowable for consumption/drinking as there were no bacteria found in the water sample. However, the owners must subject the water refilling station to proper sanitary and environmental compliance regularly to maintain the safety of the water they sell.

5.2 Traditional Water Pumps

Table 4 shows the physical properties of water samples collected in the three (3) zones of the University of Eastern Philippines, University Town. The color of the collected water samples was colorless, it indicates that it has no formation of colored substances present in the water samples. Most of the collected samples were odorless, but Area 2 has the Bleach Odor and Area 3 has the Rusty Odor. The pH for drinking water ranges from 6.5 to 8.5 [8,11], the average pH of the water sample conforms to the national standard. Most of the salinity of the collected samples was zero except for Area 2 and 3 which has the result of 2, indicating that most of the areas have no salt components that are detectable during the sampling. The temperature of the water samples conforms to the standard temperature range of 25-32°C for drinking water [9,12].

Table 5 shows the available mineral content among the water samples. Calcium, Magnesium, and Sodium-ion are all present in the water samples. Sodium-ion is present in all of the water samples, this implies that it could help the human body to maintain blood pressure, control fluid levels, and for normal nerve and muscle function. Intake of Calcium may reduce the rate of age-related bone loss and hip fractures. Studies show that Magnesium intake has an inverse relation to the occurrence of ischemic heart disease, cardiac arrhythmias, and sudden death [13,14].

Table 6 shows the bacteriological analysis of the water sample collected from different water pumps around the University Town, Catarman, Northern Samar. All of the water samples are not allowable for drinking consumption for they had contamination of *E. coli* above the detection limit. Some of the test areas are TNTC, which indicates that the water is highly contaminated with *E. coli.*

Table 1. Summary result of the physical properties from the refilling stations

Sampling Site	Parameters				
	Color	**Odor**	**pH**	**Salinity**	**Temperature**
Area 1	Colorless	Odorless	7.30	0	30.3ºC
Area 2	Colorless	Odorless	7.41	0	30.2ºC
Area 3	Colorless	Odorless	7.40	0	30.3ºC
Area 4	Colorless	Odorless	7.47	0	30.3ºC

***All results are average of the three (3) trials conducted*

Table 2. Summary result of the mineral content of the water samples from the refilling stations

Sampling Site	Parameters			
	Calcium	**Magnesium**	**Sodium**	**Potassium**
Area 1	Absent	Absent	Present	Absent
Area 2	Absent	Absent	Present	Absent
Area 3	Absent	Absent	Present	Absent
Area 4	Absent	Absent	Present	Absent

***All results are average of the three (3) trials conducted*

Table 3. Summary result of the bacteriological analysis of the water samples from the refilling stations

Sampling Site	Parameters	
	Result of Analysis	**Interpretations**
Area 1	0	Allowable for drinking
Area 2	0	Allowable for drinking
Area 3	0	Allowable for drinking
Area 4	0	Allowable for drinking

***All results are average of the three (3) trials conducted*

Table 4. Summary result of the physical properties from the traditional water pumps

Sampling Sites	Parameters				
	Color	**Odor**	**pH**	**Salinity**	**Temperature**
Area 1	Colorless	Odorless	7.3	0	27.3°C
Area 2	Colorless	Bleach Odor	7.2	2	28.0°C
Area 3	Colorless	Rusty Odor	7.4	2	27.0°C
Area 4	Colorless	Odorless	6.9	0	27.0°C
Area 5	Colorless	Odorless	7.0	0	29.0°C
Area 6	Colorless	Odorless	6.0	0	27.8°C
Area 7	Colorless	Odorless	7.6	0	28.8°C

***All results are average of the three (3) trials conducted*

Table 5. Summary result of the mineral content of the water samples from the traditional water pumps

Sampling Site	Parameters			
	Calcium	**Magnesium**	**Sodium**	**Potassium**
Area 1	Present	Present	Present	Absent
Area 2	Present	Present	Present	Absent
Area 3	Present	Present	Present	Absent
Area 4	Present	Present	Present	Absent
Area 5	Present	Present	Present	Absent
Area 6	Present	Present	Present	Absent
Area 7	Present	Present	Present	Absent

***All results are average of the three (3) trials conducted*

5.3 Alma Beach

Table 7 presents the results of the analysis of the physicochemical properties of the water samples gathered from the experimentations conducted in Alma Beach, Northern Samar.

The first parameter is salinity which refers to the total dissolved salts in the sampling site expressed in parts per thousand (ppt) or by percentage (%). The standard salinity levels in recreational waters usually lie at 35 ppt. Variations to such may be brought about by external factors such as climate change, weather disruptions such as typhoons and storms, or various anthropogenic factors. This would greatly affect the overall water quality and destroy the harmony with local species inhabiting the site.

To further investigate, the researchers measured from each station in 7 meters, 14 meters, and 21 meters away from the shoreline. With the use of a refractometer on-site, the water was tested by placing a drop on the instrument, then the results were recorded. From the tabular data presented above, it can be observed that the salinity levels of the water samples vary from 15 ppt to 30 ppt which do not exceed the standard salinity level at 35 ppt.

The second parameter which is pH (power of hydrogen) is another factor in maintaining the water quality. An extreme imbalance in this may cause great disruptions to the living conditions of species in the area. An analysis of the pH levels in Alma Beach, a pH meter was used on-site to establish such measurements displayed above. In each area, the instrument was dipped into the water for 1 (one) minute to achieve accuracy, after which, the pH meter was submerged in a buffer solution to reset the acidity. From the data presented above, it can be observed that the pH levels of the water samples vary at a range of 7.1 to 8.4. This is within the standard pH measures in sea waters of 6.0 to 9.0. This would indicate that the water in Alma Beach ranges from slightly neutral to basic.

The third parameter is turbidity which is the measure of clarity or cloudiness of the water which may be due to observable particulate matter present. The turbidity of water is based on the amount of light scattered by particles in the water columns. The more particles that are present, the more light will be scattered (Fondriest Environmental, Inc., 2014). With the use of a Secchi disk, the depth and turbidity were measured and recorded. As presented above, the results show that out of the nine (9) sampling areas, only four (4) of which resulted to be relatively turbid.

The analysis for color measurements was conducted simultaneously with the analysis for turbidity for in measuring the color of the water, the Secchi disk plate is also involved. While the disk is submerged into the water, the color is measured with the use of the Florel Ule Color Scale. The analysis for the color of water resulted in the same for every area and station at 1 FU. This indicates that the color of the water in Alma Beach is closest to the first color in the scale which is an indigo-blueish color, typical of clear water bodies.

The next column presents the measurements for temperature in each of the 9 sampling areas. The researchers measured the temperature with the use of an infrared thermometer which is used by pointing the instrument on the water until it indicates the temperature. Temperature plays a vital role in maintaining habitable conditions for local species. From metabolism and homeostasis in aquatic animals to food-making in plants, a great part of the environment will suffer if the temperature experiences drastic changes.

With the data gathered as presented above, it can be observed that the temperature levels in Alma Beach range from 22.4°C to 30.9°C. With the standard temperature for recreational waters at 26-30°C, only Area 2 exceeded the standard limit.

For the last of the physicochemical properties, the measurements for total suspended solids from each of the water samples gathered from the sampling site are presented in the next column. These solids include anything drifting or floating in the water, from sediment, silt, and sand to plankton and algae. Organic particles from decomposing materials can also contribute to the TSS concentration. As algae, plants, and animal decay, the decomposition process allows small organic particles to break away and enter the water column as suspended solids. Even chemical precipitates are considered a form of suspended solids. Total suspended solids are a significant factor in observing water clarity. The more solids present in the water, the less clear the water will be (Fondriest Environmental, Inc., 2014).

For this study, one (1) liter of water samples for each measure in the sampling site were gathered and transported to the lab for filtration. The residues trapped on the pre-weighed filter paper were then dried in an oven then weighed again. The recorded results were the total suspended solids. As observed, the amount of total suspended solids present in the water samples lies at 0.05 g/L to 0.17 g/L. With the standard total suspended solids at 0.07 grams per liter, one-third of the measures in the sampling areas exceed the standard limit.

Table 8 presents the total coliform count taken as a result of incubating nine (9) Petri films with samples from the nine (9) measures in the sampling site. The presence of such is of great concern, especially in recreational water bodies such as Alma Beach. Traces of origin can be said as environmental and fecal pollution, and nonetheless poses a hazard to human health when not treated properly.

Table 6. Summary result of the bacteriological analysis from the traditional water pumps

Sampling Site	Parameters	
	Results of Analysis	Interpretations
Area 1	TNTC	Not allowable for drinking
Area 2	>10.0	Not allowable for drinking
Area 3	TNTC	Not allowable for drinking
Area 4	>10.0	Not allowable for drinking
Area 5	>10.0	Not allowable for drinking
Area 6	>10.0	Not allowable for drinking
Area 7	>10.0	Not allowable for drinking

**TNTC= Too Numerous to Count*
***All results are average of the three (3) trials conducted*

Table 7. Physicochemical properties analysis in Alma Beach

Sampling Site		Parameters					
		Salinity	pH	Turbidity	Color	Temp.	TSS
Station 1	Area 1 (7m)	30 ppt	7.1	Not turbid	1 FU	29.4°C	0.09 g/L
	Area 2 (14 m)	15 ppt	8.1	Not turbid	1 FU	30.9°C	0.05 g/L
	Area 3 (21 m)	30 ppt	8.4	Turbid	1 FU	27.8°C	0.08 g/L
Station 2	Area 4 (7m)	30 ppt	8.4	Not turbid	1 FU	24.3°C	0.07 g/L
	Area 5 (14 m)	20 ppt	8.3	Turbid	1 FU	26.4°C	0.07 g/L
	Area 6 (21 m)	20 ppt	8.4	Not turbid	1 FU	25.2°C	0.17 g/L
Station 3	Area 7 (7m)	20 ppt	8.2	Not turbid	1 FU	24.9°C	0.06 g/L
	Area 8 (14m)	20 ppt	8.4	Turbid	1 FU	24.6°C	0.08 g/L
	Area 9 (21m)	30 ppt	8.2	Turbid	1 FU	22.4°C	0.08 g/L

Table 8. Total coliform count analysis results and interpretations in Alma Beach

Sampling Site		Parameters	
		Results of Analysis	Interpretations
Station 1	Area 1 (7m)	<10.0	Safe for recreational use
	Area 2 (14m)	<10.0	
	Area 3 (21m)	<10.0	
Station 2	Area 4 (7m)	<10.0	
	Area 5 (14m)	>10.0	
	Area 6 (21m)	<10.0	
Station 3	Area 7 (7m)	<10.0	
	Area 8 (14m)	<10.0	
	Area 9 (21m)	<10.0	

The data that is presented on the table for the total coliform count was manually counted and recorded after 24 hours of incubation. It can be observed that none of the water samples exceeded the standard total coliform count which is 150 counts per plate in recreational waters and is therefore interpreted as "safe for recreational use".

The researchers also surveyed anthropogenic activities. It was identified within the same period the researchers were testing the sampling site for the physicochemical properties. An analysis of such activities being conducted in the premises of the sampling site, the researchers were able to observe the common practices.

For one, the people visiting the beach make it a norm to bring snacks and disposable utensils. Evident are those improperly disposed plastics everywhere on the sand, grass, and around the cottages. The management put up signs for littering and proper waste segregation while being lenient on keeping the cleanliness in the area. Residents also make it a habit to dump their sacks of weekend garbage onto the undeveloped areas near the beach. The water flowing from the sewage connecting to the beach brings about household wastes which greatly contributes to the pollution in Alma Beach.

5.4 Water Treatment Practices and Technologies at Refiling Station

In the Philippines, the main process in a water refilling station is dictated by raw water quality. The typical steps are filtration (in several stages), softening, and disinfection. To give an overview of the water purifying, here are some steps are taken from Magtibay [15,16]: (1) multi-media sediment filter, (2) ion-exchange, (3) activated carbon filter, (4) reverse osmosis membrane, (5) post-carbon filter, (6) ultraviolet lamp, and (7) ozone generator. These filtration stages make sure that harmful bacteria are killed, and sediments are filtered throughout the process.

6. CONCLUSION

In terms of the refilling stations, the physical properties of the water sample collected were accepted based on the Philippine National Standard for Drinking Water (PNSDW) and Department of Environment and Natural Resources (DENR) standards for drinking water. Sodium-ion is the only mineral available in the water samples. Sodium-ion helps to regulate body fluids. All four refilling stations were found suitable for drinking purposes. However, the owners must subject the water refilling station to proper sanitary and environmental compliance regularly to maintain the safety of the water they sell.

In terms of the traditional water pumps, all the water samples appeared to be colorless and odorless. The average pH conforms to the national standard. The water was found to have zero to low levels of salinity. All the samples conform to the standard temperature. Based on the gathered data, all the water samples are contaminated with *E. coli*, exceeding the permissible limit for drinking water of 10 counts per ml. Some test area is also TNTC, which indicates that the water is highly contaminated with *E. coli*. This tells the public that the water from the water pumps is not suitable for drinking.

Through the conduct of this study, it was found out that the water in Alma Beach is relatively safe for recreational use, as intended, for all the nine (9) sampling areas resulted below the standard limit for the total coliform count.

7. RECOMMENDATIONS

The following are recommended for continued surveillance to ensure water safety inside the university premises. Establishment of water expert organization/management which should manage and ensure safe drinking water to students and other individuals. The university must install a mini water treatment plan to ensure that wastewater is treated first before disposal. Installations of hypo chlorinators at pumping stations to remove microbial contamination. Routine testing of heavy metals and trace elements in drinking water must also be done. Periodic and regular water quality monitoring SOPs. Further research is to be undertaken on this subject to ascertain the causes of contamination. Lastly, collaboration with the engineering department on developing a low-cost filtration set up so that far-flung community could use it as an alternative to the present refilling station which is inaccessible to them.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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