ASSESSMENT OF WATER STATIONS THROUGH PHYSICO-CHEMICAL AND BACTERIOLOGICAL TESTING PARAMETERS IN NAVARRO, GENERAL TRIAS CITY, CAVITE

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ABSTRACT

The study was conducted from November 2019 to January 2020 to assess the drinking water and to determine the source and water treatments used by the selected 6 water refilling stations in Barangay Navarro, General Trias City, Cavite and evaluate the results gathered in accordance to the Philippine National Standard for Drinking Water (2017) released by Department of Health. Specifically, this study intends to: 1) Determine the source of water in water refilling stations; 2) Determine the water treatment used by the water refilling stations; 3) Examine and measure the water quality of different water refilling stations in General Trias City, Cavite through drinking-water quality testing parameters such as pH level, Temperature, Total Dissolved Solid, Residual Chlorine (Physico-Chemical testing parameters), Heterotrophic Plate Count, Total Coliform, Fecal Coliform, Escherichia coli (E. coli) (Bacteriological testing parameters) and; 4) Provide statistical report from physicochemical and bacteriological assessment and compare it to the Philippine

National Standard for Drinking Water (PNSDW). Samuel Christian College Senior High School Department A mark of excellence A testimony of faith A heart to serve Navarro, General Trias City, Cavite 456 – 9955 samuelchristiancollege@ymail.com The researchers gathered drinking water samples from the 6 different water refilling stations and conducted an interview with the owners of each stations who agreed to be part of this study. All the samples gathered tested in Department of Science and Technology (DOST) Water and Wastewater Testing and Laboratory (CWWTL) in Trece Martires City, Cavite. The results were then evaluated and compared with the Philippine National Standard for Drinking Water (2017). During the discussion, the researchers named the water refilling stations anonymously for confidentiality purposes. Based on the results of the study, the source of water from the refilling stations were from: one used groundwater, three from deep well and two from water districts. The most frequent water treatment used by the respondents are Ultraviolet Water Sterilizer and Multimedia Carbon. On the other hand, two (2) out of six (6) water refilling stations exceeded the limit value of E. coli set by PNSDW while one (1) water refilling station failed for Heterotrophic Plate Count test and three (3) stations failed the coliform and fecal coliform test.

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INTRODUCTION

People drink water up to eight to ten glasses a day everyday to stay hydrated and to avoid being thirsty. Since water in our body is continually being used and essential for life, it has to be replaced also with water (The Importance of Water, n.d.). Also, having better water and sanitation improves people's health, strength to work, and the ability to go to school. However, according to the United Nations (2010), water pollution is now one of the major problems in the whole world, especially in the rural areas and some developing countries.

In addition, an article released by Water Environment Partnership in Asia or WEPA (2016) stated that with the rapid increase in population, industrialization and urbanization reduced the quality of water. The discharged waste materials from different commercial buildings had caused extensive pollution in the receiving- water bodies and the effluents (i.e. fertilizer, detergents, oil, solid waste) have been contaminating it causing noxious effects in human.

Furthermore, according to the World Health Organization (2008), 844 million people all around the world have no access to improved and safe drinking water. As a result, diseases like diarrhea (about 88% of diarrhea was caused by unsafe water, poor hygiene, and insufficient sanitation) causing more than 4,500 children to die every day.

The Department of Health (DOH) has been concerned with the health aspects of everyone that they launched their most recent version of the Philippine National Standards for Drinking Water (PNSDW) of 2017. The policy in the DOH Administrative Order No. 10 Series of 2017 prescribed the standards and guidelines on drinking safe and high-quality water aiming to protect the consumer and public's health. The latest version of PNSDW applies to all drinking- water service stations nationwide. To ensure the safety of drinking water, some guidelines must be followed. These includes measuring the water quality, water sampling, and examinations, other modes of distribution of drinking-water, evaluation of results, classification of quality parameters, quality control for water laboratories, water safety plan (WSP) and quality surveillance.

The initiatives of the researcher to gather data serves as a comprehensive source of information which can educate the manager of water refilling stations, the barangay officers and the community of the selected areas.

OBJECTIVES OF THE STUDY

This study aims to assess and evaluate every water refilling stations in Barangay Navarro in General Trias City, Cavite and to ensure the safety of the public's health.

Specifically, this intends to:

1. Determine the source of water in water refilling stations;

2. Determine the water treatment used by the water refilling stations;

3. Examine and measure the water quality of different water refilling stations in General Trias City, Cavite through drinking water quality testing parameters:

3.1 Physico-Chemical testing parameters;

3.1.1 pH level;

3.1.2 Temperature;

3.1.3 Total Dissolved Solid;

3.1.4 Residual Chlorine;

3.2. Bacteriological testing parameters;

3.2.1 Heterotrophic Plate Count;
3.2.2 Total Coliform;
3.2.3 Fecal Coliform;

3.2.4 Escherichia coli (E. coli) and;

4. Provide statistical report from physicochemical and bacteriological assessment and compare it to the Philippine National Standard for Drinking Water (PNSDW).

Significance of the Study

This study was conducted to examine the quality of drinking water from different services. Through this study, the action will be used by the different services and stations to provide a good quality of water that will be harmless to the public.The different water treatment are also assessed to be aware of the certain quantities that affect the results and security of water potability. The results of the study, the source of water in each water refilling stations, the water treatment of each water refilling stations will serve as a valuable information about the water refilling industry in Barangay Navarro, General Trias City, Cavite.

Community. This study will help the community to have safe and clean drinking- water and to ensure the safety of the public's health.

Administrators of Water Stations. This study will raise awareness about the quality of their water services and produce good quality of water to ensure the safety of their consumers.

Future Researchers. This study will help future researchers to use this as their related literature. This study contains information that will be helpful and can justify their study.

Scope and Limitations of the Study

The study focuses on performing the drinking water testing on six (6) different water refilling stations in Barangay Navarro, General Trias City, Cavite by using the specific testing parameters such as pH level, Temperature, amount of Residual Chlorine, Total Dissolved Solids, total amount of Heterotrophic Plate Count, Coliform, Fecal Coliform and E.coli present in the drinking water. The results of the study was based on the Philippine National Standard for Drinking Water (PNSDW). Also, the water samples were gathered from water refilling stations and not in households. The amount of drinking water needed for each water stations is 2 Liters and 300mL.

The laboratory of Department of Science and Technology (DOST) Water and Wastewater Testing and Laboratory (CWWTL) in Trece Martires City, Cavite provided the specialized bottle needed for each water samples. For the bacteriological testing, six (6) sterilized glass were needed and for physico-chemical testing, 12 polyethylene bottles are needed. The researchers did not do the monitoring type in gathering the water samples. To determine the water treatment used by the water stations, the source of water in each water refilling stations, the researchers provided survey questionnaires and conducted face to face interview. The gathering of water samples proceeded on November 2019 – January 2020.

Time and Place of the Study

The study was conducted from November 2019 to January 2020 in Barangay Navarro, General Trias City, Cavite. Secondary data was obtained from the barangay hall of Barangay Navarro, General Trias City, Cavite

Figure 1. Map of Barangay Navarro, General Trias City, Cavite

CONCEPTUAL FRAMEWORK

INPUT

The researchers will assess and compare the drinking water quality through testing the specific parameters such as pH level, Temperature, amount of Residual Chlorine, Total Dissolved Solids, total amount of Heterotrophic Plate Count, Coliform, Fecal Coliform and E.coli present in the drinking water from different water refilling stations in Barangay Navarro, General Trias City, Cavite.

PROCESS

- Gather drinking-water samples from different stations.
- Test the data gathered using the specific parameters such as pH level, Temperature, amount of Residual Chlorine, Total Dissolved Solids, and total amount of Heterotrophic Plate Count, Coliform, Fecal Coliform and E.coli present in the drinking- water.
- Conduct a Face-to-Face Inteview using Survey Questionnaires.
- Evaluate the data gathered.

OUTPUT

The researchers found out that some of the water refilling stations in Barangay Navarro, General Trias City, Cavite have safe and good drinking water quality and they are following the standards of drinking water maintenance.

Figure 2: *Conceptual Framework*

DEFINITION OF TERMS

- **Assessment –** is the evaluation of drinking water quality.
- **Bacteria** – is pathogens or microorganisms in water that contaminates and causes illness.
- **Contamination-** a general term referring to the introduction of materilas not normally found in water.
- **Chlorine** – is used for detoxifying water and remove certain types of bacteria.
- **Diarrhea** – is an illness of having loose and watery stools
- **Disinfection**- a water treatment process designed to destroy disease- causing microorganisms.
- **Drinking water quality testing parameters –** this operation will be able to determine the water potability.
- **Effluent** -is a liquid waste or sewage discharged into a river or the sea.
- **Escherichia coli (E. coli)-** presence of E.coli in water indicates the sewage and animal feces contamination which contain many types of diseases.
- **Fecal Coliform-** a subgroup of coliform bacteria that has high positive correlation with fecal contamination. Thses organisms can ferment lactose at 44.5°C and produce gas.
- **Heterotrophic Plate Count (HPC)-** is a method that measures the whole bacteriological quality of a certain drinking water.
- **Most Probable Number (MPN)-** a statistical method of determining microbial populations.
- **Parameters** – is a numerical or other measurable factor forming one of a set that defines a system or sets the conditions of its operation.
- **pH** – is a measure of acid to alkaline proportions in a water.
- **Potable** - safe to drink; drinkable.
- **Total Coliform bacteria-** this bacteria are not dangerous for health but it can be an indicator for other harmful organism that is found in drinking water and able to ferment lactose at either 35 or 37°C with the production of acid and gas within 24-28 hours.

- **Total Dissolved solids (TDS)**– is the measure of the dissolved combined content of all inorganic and organic substances present in a liquid and it is the overall indicator of the quality of water.
- **Total Suspended Solids (TSS)** - is the dry-weight of suspended particles, that are not dissolved.
- **Water safety plan** – is a plan to ensure the safety of drinking water through the use of a comprehensive risk assessment and risk management approach.
- **Water treatment system-** is used by the owner of each water refilling stations to treat their water and to provide a good quality product.

REVIEW OF RELATED LITERATUTE

Water Station

According to Espineli (2015), due to increasing population, rapid industrialization, commercialization, and urbanization water are rapidly being used in many parts of the world. In the Philippines, there is an abundant supply of freshwater from the river, lakes, spring, and groundwater, but the water supply is decreasing and further aggravated by pollution and contamination by untreated domestic, industrial, and commercial waste. In addition to this, the government created a mandate to provide safe drinking water that lies with local water utilities. However, due to the pollution and contamination of water, local utilities failed to meet the demand for safe and clean water. Furthermore, this state of water supply system of the Philippine gave rise to water refilling stations as a new player in the water service industry.

Moreover, according to Espineli (2015), water refilling stations are the one which are accountable if the service of local water utilities failed to provide the demand of people for clean drinking water. However, an undetermined number of water refilling stations are not properly regulated and are reported to be using groundwater as a source of water without rights from the government. Due to this, in some communities, disease outbreaks are attributed to sanitation problems in some water refilling stations.

Number and Sources of Water Stations in Cavite in the Year 2015

In the year 2015, Cavite has a proliferation of water refilling stations that is unprecedented. The Provincial Government-Environment and Natural Resources Office (PGENRO) estimated that there are probably more than 2000 water refilling stations in Cavite. In addition to this, on November 2013 to July 2014, the Provincial Government-Environment and Natural Resources Office (PGENRO) conducted a consultative meeting with operators of water refilling stations in Cavite that showed that many water refilling stations in Cavite are not registered with the Business Permitting and Licensing Office (BPLO). This indicates that more than half of the water refilling stations do not also have a sanitary permit, zoning permit, environmental protection permit, and other permits that are requirements in applying for a business permit.

According to Espineli (2015), the number of water refilling stations in Cavite, 6th District, Amadeo, General Trias City, Tanza, and Trece Martires City, has a total of 57 water refilling stations. Out of 57 water refilling stations, General Trias City has a total of five (5) water refilling stations. Also, there are four sources of water utilized by water refilling stations in the province of Cavite. These are deep wells, local water districts, private water providers, and both deep wells and local water districts. The 6th district has 50 sources of water supply: 23 is deep well; 23 is local water districts; four (4) is deep well and local water districts; and zero (0) private water service providers.

However, not all those water sources are safe. One study assessed the quality of drinking water from different sources in Laoang, Northern Samar. The findings of this study revealed that although most water sources were within the permissible limits for pH level, color, Total Dissolved Solids, salinity, odor, dissolved oxygen and nitrite, the total hardness and alakalinity were beyond the allowable limits. Also, all water samples were positive for fecal coliforms (Poblete & Tonog, 2015).

Features of Water Refilling Stations

Magtibay (2004) stated the ideal features of water refilling stations in the Philippines are as follows:

1. Water refilling stations are located and can be operated with a minimum area of 20 – 25 square meters and are comprised into:

    a. Refilling and selling room;

    b. Enclosed purification room;

    c. Container washing and sanitizing room;

    d. Source water storage facility;

    e. Storage room for emptied and refilled containers and;

    f. Office and toilet

2. At least five (5) employees are needed to operate the water store, namely:

    a. Manager;

    b. Accountant/Bookkeeper;

    c. Administrative Assistant;

    d. Front Liner;

    e. Technical Assistant and;

    f. Delivery Man

3. The processes in a water refilling station depend on raw water quality and the machines that could be installed for the different processes are the following:

    a. Multi-media sediment filter;

    b. Ion exchanger;

    c. Activated carbon filter;

d. Reverse osmosis membrane;

e. Post-carbon filter;

f. Ultra-violet lamp and;

g. Ozone generator

4. Water refilling stations must comply with regulation authorized by the Philippine health government and the frequency of monitoring are as follows:

a. At least monthly for bacteriological quality testing;

b. At least every six (6) months for physico-chemical quality testing;

c. At least once a year for biological testing quality and;

d. Monitoring of radioactive contaminants must be done if the area is exposed to radiation

Water Treatment

Every drinking water must have proper cleaning, treatment, and filtration because it improves the quality and the cleanliness of the water that is safe to human. Accorfing to Lanfair, Scroth, & Amburkar (n.d) the water purification procedure reduces the concentration of contaminants such as suspended particles, parasites, bacteria, algae, viruses, and fungi (para.1).

Water filtration and treatment helps the distributors to supply a good and healthy water in the community. Filters and treatments that are used in the water refilling station: Ultraviolet water sterilizer is advisable to use when the drinking water is suspected of having E.coli; Alkaline Water Purifiers are used to remove acid in drinking water that is harmful to human's health; Water filter is used to remove lead, and prevents toxic elements to enter the human body; Flushing valve is used to improve the quality of the drinking water; Multimedia carbon is used to remove sediment, color and chlorine; Brine refill is used to remove sodium ions and replace it with calcium and magnesium; Multimedia softeners are used as ion exchange, the process to remove hardness from water; Carbon filter is used to remove contaminants and organics that can cause bad odors and unwanted taste; Sediment filters remove solid waste from water; Multimedia Sediment removes small particles, TSS, SDI and other microorganism; Reverse Osmosis System is used to remove water contaminants by the use of pressure; RO Membrane revomes particles and molecules, lastly; Activated Carbon is used to bring out the natural taste, odor and organic compound in water.

According to Biotech Water Researchers (2019), there are advantages in using water treatments and filters such as: it is easy to use; it is cheap and effective, and; it also improves the physical features of the water like taste, odor and color.

Drinking Water

Water plays a significant role as it is the one who is responsible to human health and welfare so having clean drinking water is only natural for everyone to have as to ensure their safety (Rahmanian et al., 2015). However, it is getting more difficult to provide and secure potable water due to the depletion of water sources as the population of human is increasing rapidly (Del Rosario, n.d.). In addition, a study says that chemicals coming from typhoon also can contaminate the water upon restoration. One of the examples of this case is the City of Cagayan De Oro as it has become a typhoon hotspot recently (Alambatin et al., 2017, p.3). Ensuring clean and safe drinking water is now the top priority of each country.

According to Fetter, J. (2013), drinking water comes from natural resources that are either groundwater or surface water. The earth is covered about 72% of water. Unfortunately, people cannot use most of that for drinking water. Moreover, water plays a significant role in our body. It helps the human's body to flush toxin out of the organs, eliminate waste, carries nutrients and oxygen to the cells, and keep the body at a 98 F. However, drinking water is exposed to pollutants such as bacteria, lead, and nitrates that can cause health problems.

One researcher conducted a study which is to examine and evaluate the drinking water quality from different water refilling stations in Saudi Arabia. The researcher tested the drinking water through bacteriological testing parameters (determination of Hetero Plate Count, determination of total coliforms, detection of E. coli and Staphylococcus Aureus). According to the outcome of the study, the bacteriological and sanitary quality of drinking water from five drinking water stations varied from one station to another. The high percentage of bacteriological testing parameters such as HPC, total coliforms, E.coli and S. aureus were 40-50%, 60-68.8%, 31.2-37.5% and 10-25%, respectively, which were higher than the established safe limits of drinking water are from tankers that indicate the absence of necessary sanitary conditions required in these water tankers and inadequate water treatment process. Hence, the bacteriological and sanitary results indicate that the drinking water quality from water stations in Makkah Al-Mokarama, Saudi Arabia is not acceptable (Mihdhdir, 2009).

On the other hand, in Philippines, many researchers try to examine drinking water quality. Although the drinking water samples were not directly collected from the water refilling stations, it is also a drinking water and can be consumed by everyone. One of those studies is the research conducted in selected District II areas in Cagayan de Oro. Overall, all studied drinking water samples from selected stations passed the drinking water regulations except for conductivity but nonetheless, the drinking water samples were safe to drink (Alambatin et. al, 2017).

A study was also conducted to assess the drinking water in the province of Capiz. The findings of the study showed that the drinking water samples collected from deep well and dug well without distribution had higher percentage of E.coli test while other drinking water samples from the water districts and local water utilities administration were found to be at low risk level and this indicates a decreased likehood of contamination of E.coli. In addition, most of the drinking water samples tested for chlorine residual did not meet the DOH/WHO standard amount of chlorine residual requirements (Chuang, Millspaugh, Patrick, & Trottier, 2010).

Additionally, one study regarding the drinking water quality conducted in a public school in Tarlac City, Central Luzon, Philippines examined the physicochemical and bacteriological quality of bottled water, tap water and water from dispensers. The results showed that most of water samples had normal physicochemical properties except of two samples with high total dissolved solids with a total amount of 621.67 mg/L and 556.67 mg/L. For bacteriological quality, there is a high total of coliform count, fecal coliform and Heterotrophic Plate Count and had indicated the presence of E. Coli. Among those drinking waters, bottled water is the safest drinking water available in all schools and some waters from water dispensers were not fit for drinking unless boiled. According to them, "Water from dispensers and tap water must be boiled prior to drinking because some samples had generated positive bacterial content and owners of drinking water businesses must set up their own quality control protocol to ensure safe water for the public" (Corpuz, Mati, & Mina, 2016).

Standards for Drinking Water

The World Health Organization (2016) produced guidelines for drinking water and is used as the primary basis for regulation and standard-setting all over the world. The Guidelines for Drinking-Water Quality (GDWQ) promote the protection of public health through advocating locally health-based targets, adoption of water safety plans, and independent surveillance to ensure that water safety plans are being implemented and are effective to meet the national standards.

Most people in the United States who live in cities get their water from a public water supply. A private industry delivers water to their home through a network of underground pipes from a large source of water that they share with their neighbors and community. The United States Environmental Protection Agency (US EPA) has established the Safe Drinking Water Standards, based on research and water testing. The Safety Drinking Water Standards states that amount of each of these pollutants is acceptable in drinking water (Fetter, 2013).

The Department of Health (DOH) issued its latest version of the Philippine National Standards for Drinking Water 2017 (PNSDW 2017). This new version of the drinking water standards covers the requirements for the acceptable value of each parameter in testing and measuring the water quality. These testing parameters include physical, chemical, bacteriological, microbiological and radiological compositions of the water.

Potential of Hydrogen (pH level)

According to Puetz (2013), pH is a term used to refer the degree of activity of an acid or base in the water. pH stand for "potential of hydrogen". In addition, pH is a determined value on a defined scale and is similar to temperature. pH of water is a figure between 0 and 14 defining how acidic or basic the water is. Seven is neutral, meaning there is a balance between alkalinity and acidity. A measurement below 7 means acid is present and a measurement above 7 is alkaline or basic ("pH of Water", 2013).

Moreover, water with a low pH could contain a high level of toxic metals such as iron, manganese, copper, and lead. It can cause aesthetic problems such as sour taste, staining of laundry, and the characteristic blue-green staining of sinks and drains. Meanwhile, water with a pH that is greater than 8.5 could indicate that the water is hard and can cause aesthetic problems (Oram, 2014). According to World Health Organization (2017), the pH is of importance in determining the corrosion in water. In general, the lower the pH level, the higher the potential level of corrosion of water.

According to the World Health Organization, the pH level of most drinking water lies within the range 6.5 to 8.5 and 6 to 8.5 for groundwater systems. The pH level of stomach fluid, which contains hydrochloric acid is between 1.0 and 3.5; lemon juice with a pH of 2.4 and vinegar with a pH of 2.8. Natural waters can be of lower pH, as a result, for example, acid rain or higher pH in limestone areas (Fawell, 2007). Similarly, according to Philippine National Standard for Drinking Water (2017), the pH level of drinking water should range between 6.5 to 8.5.

It is recommended that the water should be tested as soon as possible with a pH of 7 at 25°C so that it will not be exposed to carbon dioxide that will result in a pH level of approximately 5.2. Moreover, the pH of the water is not a measure of the concentration of the acidic or basic solution and alone does not provide a full picture of the characteristics or limitations with the water supply (Oram, 2014).

Temperature

Water temperature is an important factor in determining whether a body of water is acceptable for human consumption and use. It is present in the environment and it gives certain conditions for different kinds of aquatic life to live in. Temperature influences the rate of chemical and biological reactions. It affects the dissolved oxygen level in water, photosynthesis of aquatic plants, metabolic rates of aquatic organisms, and the sensitivity of these organisms to pollution, parasites, and disease.

An anonymous researcher (n.d.) stated that "when chemical treatment is involved, generally the rates of chemical reactions decrease with decreasing temperature because of the temperature dependence of most chemical reactions." Furthermore, the relative concentrations of reactants and products in chemical equilibria can also change with temperature. Therefore, temperature can affect every aspect of the treatment and the delivery of potable water. The only accepted water temperature is between 28°C and 44°C.

Climate change could also affect the water quality for potable water. For example, places with higher precipitation can lead to soil corrosion and runoffs that goes onto any body of water it leads to. Conditions like this can increase TDS in water and other chemicals unsafe for ingestion of humans.

Residual Chlorine

Chlorine is used to disinfect water in swimming pools. It is also used to manufacture papers, plastics and other thing (Blaszczak, 2018). According to CDC Safe Water System (n.d.), the presence of residual chlorine in drinking water indicates that a sufficient amount of chlorine was added to the drinking water to kill some of the bacterias and viruses that can cause diarrhea and the water is protected from recontamination. In addition, chlorine is used to sterilize drinking water that can reduce waterborne diseases, but chlorine has strong impact in human body in terms of breathing problems. One researcher emphasized that too much chlorine will harm human body and it will result to reproductive failure and cancer, heart attacks and problem with immune system (Robins, 2017).

In addition, one researcher says that, "The problems with chlorine stem from the very reason it's so useful – its ability to kill bacteria. When chlorine is introduced into water, it kills pathogenic bacteria. But when it's introduced into the human body, it destroys our beneficial gut bacteria, where an estimated 70% of our immune system operates" (para.6). Robins (2017) described that if a person wants to remove the chlorine in his water, he can boil it or pour tap water in a glass and let it sit in the refrigerator with open air 24 hours. He can use test kits to examine it but that is not reliable like the test and results that is from the laboratory because the test kits can affect the certain chemical or the temperature.

Furthermore, one foundation for safe drinking water stated that, "Chlorination is one of many methods that can be used to disinfect water. This method was first used over a century ago, and is still used today. It is a chemical disinfection method that can uses various types of chlorine or chlorine—containing substances for the oxidation and disinfection of what will be the potable water source." This method is good for cleaning water because it is cheap yet effective. This method can be used easily and by that, many people use this method as much as they can. This method also quickly breaks down other bacteria and viruses that can harm the human's body.

The foundation also describes that chlorination can be done at anytime and anyplace. The first step to be done is to put the chlorine in the raw water immediately to remove other bacteria so that it will not affect the larger portion of the water. Also, a process called pre-chlorination was found to be effective in removing the color and the odor of the water as it controls the biological growth of viruses and bacteria. In the filtration step, it will remove the other chemicals like iron and manganese. It is also called disinfection. Chlorination is the last step. This is to additionally disinfect the water and to ensure that the chlorine residuals will remain at the water as it travels the distribution system. To maintain the chlorine residuals, re-chlorination process is done (Safe Drinking Water Foundation, n.d.).

According to World Health Organization (2016), the accepted amount of concentration of Residual Chlorine must be 0.2 to 1 mg/liter. However, the accepted amount of Residual Chlorine in the drinking water must be 0.2 to 0.5 mg/liter according to Philippine National Standard for Drinking Water (2017).

Total Dissolved Solids

All dissolved minerals in water are measured as Total Dissolved Solids or TDS. Some of those minerals are potassium, magnesium, chlorides, sulfates, calcium, and bicarbonates (The Berkey: Purify your Water, 2019). According to Philippine National Standards for Drinking Water (2017), the maximum amount or level of total dissolved solids in a drinking-water is 500 mg/L. If the water exceeds the maximum amount or value of TDS which is 500 mg/L, there will be deposits in the water, salty taste and staining in the water. These are not harmful however, it is noticeable (The Berkey: Purify your Water, 2019).

In addition, according to the World Health Organization (2016), total dissolved solids (TDS) is used to describe the inorganic salts and small amounts of organic matter present in water. The TDS level of drinking water is as follows: excellent, less than 300 mg/liter; good, between 300 and 600 mg/liter; fair, between 600 and 900 mg/liter; poor, between 900 and 1200 mg/liter; and unacceptable, greater than 1200 mg/liter. Moreover, there is no recent data on health effects that are associated with the TDS in drinking water. However, according to Philippine National Standard for Drinking Water (2017), the maximum level of accepted Total Dissolved Solids must be 500 mg/liter.

Total Dissolved Solids and Total Suspended Solids are two different categories in particles present in water. Total Suspended Solids refers to the suspended particles that are not dissolved in water particles. One of this indicator is the turbidity of water which measures the estimated total suspended solids in water. The more solids present in the water, the less clear the water will be (Fondriest Environmental Learning Center, 2017). Since water is a great type of solvent, it can dissolve a lot of particles that can be dissolved which includes impurities and other substances. A researcher stated that " dissolved solids refer to any minerals, salts, cations, anions or metals dissolved in water" (Oram, 2014, para. 1).

With all the solids dissolved in the water, it can result to changing of taste and odor of the drinking water. It could either be in salty or bitter taste that might not be a good sign for drinking water to have since good drinking water is tasteless, odorless and colorless. Like TSS, sources of water affected by factors like urban run-off, sewage, industrial wastewaters, chemicals used in treatment processes and type of plumbing structure can cause dissolved solids to accumulate. Oram

(2014) also stated that " the total dissolved solids concentration is the sum of cations and anions in the water. Therefore, the Total Dissolved Solids test provides a qualitative measure of the number of dissolved ions but not telling the nature of ion relationships" (para.4).

The amount of TDS in the water does not harm the health of people because it is more of an aesthetic than a health hazard. According to Water Research Center, these are the indications for an elevated TDS: first is that the number of dissolved ions might be corrosive, or in brackish taste that might affect the performance of heating water and; second, most contain an elevated number of ions like nitrate, arsenic, aluminum, copper, lead, etc. that are above the Standard of Drinking Waters. There are ways to test the TDS. One is by filtering a certain amount of water into a glass fiber filter, then in a ceramic dish that is heated up in an oven at 103°C intended to dry. It will be increased again at 180°C to remove water molecules in matter matrix.

Heterotrophic Plate Counts

Heterotrophic Plate Counts can be seen in lab test results and other data providing a critical assessment of the HPCs for the safety of drinking waters. Heterotrophs are groups of microorganisms that use organic carbon as their source of growth. These organisms like yeasts, molds can be found in all types of water and are important for the drinking water management.

According to Marietta (2003), the National Primary Drinking Water Regulations established by the U.S. EPA states that, "lower concentration of heterotrophic bacteria in the drinking water is linked to a better maintenance of the treatment and distribution systems." She also added that heterotrophs does not have any health risk for humans but high percentages of these organisms in drinking waters can be an ideal habitat for much more dangerous bacteria to live in. To disinfect water systems from having this condition, solutions like ultraviolet disinfection, continuous chlorination, shock chlorination, distillation and activated carbon are many ways to reduce the heterotrophic counts. According to Georgia (2003), UV lights in water management systems destroys the DNA in these organisms making them unable to reproduce. Continuous and shock chlorination both involves chlorine in the process for either a permanent or temporary disinfection. Distillation is a long process that really kills all types of microorganisms that just really takes a lot of time and much more complex that other purification methods. Active Carbon is used to absorb dissolved organics making the heterotrophs' food unavailable for them to eat.

Heterotrophic Plate Count is of utmost value for public water producers specially those of drinking water since it will affect the drinking water quality they produce and also the needed precautions needed in their water management systems to prevent dangerous situations. According to World Health Organization, the acceptable HPC levels in municipal drinking water have been set at less than 500 CFU/ml.

Total Coliform

Water is the most essential thing in the world because people use it in their daily lives like cleaning, doing laundry, cooking and also for drinking. Drinking water must be safe and clean before distributed in the community, dirty and threatening water may affect the human health and it may lead to death. According to Department of Health (2016), "Total coliform is a large collection of different kinds of bacteria." (Coliform Bacteria and Drinking Water, para. 3). Total coliform's source is the environment, so if the laboratory detected a water that has total coliform, it might investigate where the source of water is and how the bacteria contaminated the water. Laboratory will help to repair the source and to treat the water to make it safe for the consumers. They can also educate people who manage the source of drinking water on how to maintain the cleanliness and the safe of the water. In addition,Washington State Department of Health (n.d.) describe what to do if there are total coliforms in the drinking water: if total coliform bacteria is confirmed (at least 2 samples with coliform bacteria present) in the drinking water, the water system should be inspected to find and eliminate any possible sources of contamination. Once the source is identified, it can usually be resolved by making system repairs, flushing, and adding chlorine for a short period of time. Lastly, Health Department works with water systems and utility managers to help resolve such problems. (Coliform Bacteria in Drinking Water. para.9).

Fecal Coli1form

Fecal coliform bacteria is a subgroup of coliform bacterias which are microscopic organisms that live in the intestines of warm-blooded animals. They also live in the waste material, or feces, excreted from the intestinal tract like Escherichia Coli. They are more likely to be indicators because their presence affects the amount of other harmful pathogens to live in their surroundings. According to Oram (2014), fecal coliforms are lactose-fermenting in 24 hours at 44.5°C, and which can grow with or without oxygen.

Generous amounts of such coliform bacterias in water meant that it had received fecal matter from either humans or any warm blooded animals. Oram (2014) also states that diseases and illnesses that can be contracted in water with high fecal coliform counts include typhoid fever, hepatitis, gastroenteritis, dysentery and ear infections. Fecal coliform can be treated by chlorination or distillation. If these matters are not treated well, it will decay in the water and deplete the presence of oxygen in it.

Escherichia coli

According to Philippine National Standards for Drinking Water (2017), coliform organisms refer to countless rod-shaped bacteria and are capable of growth in the presence of bile salts. E.coli indicates the animal feces contamination in water which contains many diseases and these organisms are easy to detect. The standard values of E. coli (feces) present in the drinking water should be 0 mL as the absence of E. coli in a drinking- water indicates as well the absence of feces and pathogens which are harmful.

Also, E. coli indicates that there is a high risk of having a disease especially on those people who consume the water. Those diseases include diarrhea, urinary tract infection (UTI), pneumonia and other clinical infections (Madappa, 2019).

According to APEC Water (n.d), escherichia Coli or also known as E. coli are found in the intestines of healthy humans and animals, but these substances can produce toxins that can be very harmful and can result to an extreme illness. The presence of this in a drinking water is a proof of sewage contamination and must be taken care of immediately. There are reasons why E. Coli can be found in water. Precipitation is one way to help the flow of water that might go onto streams, rivers or creeks. As water stations collect their sources from the water wells and convert it into drinking water, several treatments must be ensured to be taken place or substances like E. coli may end up in drinking waters.

In addition, according to Department of Health US (2016), coliform bacteria is always present in the environment. It can also causes illnesses, however, their presence in drinking water indicates that disease-causing organisms such as pathogen could be present in water system. In addition, pathogens can contaminate water supplies that comes from the environment such as feces of humans and animals. E. coli is a specific bacteria of fecal coliform, while fecal coliform is part of a coliform bacteria. Each of these bacteria has a different level of risk and an indicator of water quality.

Moreover, according to the World Health Organization (2016) there is no maximum level or limit of E. coli should be found in drinking water. The acceptability of drinking water should be 0 mg for every 100 mL of drinking water tested, there is no total E. coli should be detective.

METHODOLOGY

Materials

NAME OF MATERIALS	PICTURES	QUANTITY	DESCRIPTION
Drinking Water		2 L and 300mL	Drinking water from different stations received the treatment.
Sterilized Glass		6 sterilized glass (300 mL)	Each sterilized glass had labels in accordance with the specific water stations. For bacteria testing, a clear and sterilized bottle was used.
Plastic Polyethylene Bottles		12 bottles (1 liter)	Drinking water was put in a plastic polyethylene bottles and it was stored until it reached the laboratory. For physico-chemical testing parameters, a clean plastic

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			polyethylene bottle was needed.
PHPaper		1 box	It can be used to determine the pH level of the drinking water.
Digital TDS Meter		1 piece	It can be used to check the performance of water-filter and to make sure that the drinking water is clean.
Ice Box Jar (Cooler)		4 pieces	The collected water samples were put here until it reached the laboratory to avoid unusual changes in water quality.

Experimental Units

The researchers gathered 2 L (for physico-chemical testing parameters) and 300 mL (for bacteriological testing) of drinking water samples from six (6) different water stations in Barangay Navarro, General Trias City, Cavite. After collecting the drinking water samples, the laboratory procedures were used and the researchers conducted physico-chemical and bacteriological testing to determine the amount of Residual Chlorine, Heterotrophic Plate Count, Coliform, Fecal Coliform and E. coli present in the drinking water. For unstable parameters, such as pH level, Temperature and Total Dissolved Solids were measured at the sampling site as the results might change if exposed to external factors. The experimental unit is the drinking water since it will be the one to receive the treatment.

Experimental Design

The researchers used a quantitative and qualitative purposive sampling approach to research as the experimental unit received experimental treatment and the related information is gathered with a qualitative approach.

Experimental Treatment

The researchers conducted a laboratory analysis of six water refilling stations in Barangay Navarro, General Trias City, Cavite through physico-chemical and bacteriological testing in the laboratory of Department of Science and Technology (DOST) Water and Wastewater Testing and Laboratory (CWWTL) in Trece Martires City to determine the total amount of Residual Chlorine, Heterotrophic Plate Count, Coliform, Fecal Coliform and E. coli present in the drinking water. For unstable parameters, such as pH level, Temperature and Total Dissolved Solids were measured at the sampling site as the results might change if exposed to external factors.

Data to be Gathered

The researchers gathered 2 L (for physico-chemical testing parameters) and 300 mL (for bacteriological testing) of drinking water samples from six (6) different water refilling stations in Barangay Navarro, General Trias City, Cavite. The drinking water samples are examined through physico-chemical and bacteriological testing to determine the total amount of Residual Chlorine, Heterotrophic Plate Count, Coliform, Fecal Coliform and E. coli present in the drinking water. For unstable parameters, such as pH level, Temperature and Total Dissolved Solids were measured at the sampling site as it might change if exposed to external factors. The results were then interpreted by using the Code on Sanitation of the Philippines or the updated version of the Philippine National

Standards for Drinking Water (PNSDW 2017). Lastly, the researchers also conducted a survey interview to gather related information from the respondents and the survey interview was evaluated after.

Data Gathering Procedure

The researchers requested a list of number of water refilling stations in Barangay Navarro from the barangay hall of Navarro, General Trias City, Cavite and then asked for a permission for each water refilling stations to conduct a study. Afterwards, the researchers gathered 2 L (for physico-chemical testing parameters) and 300 mL (for bacteriological testing) of drinking water samples from the water refilling stations. Before the sampling, all the sterilized glass and polyethylene bottles that were needed were washed and rinsed thoroughly with detergent and distilled water. The drinking water samples that were collected were examined through a laboratory physico-chemical and bacteriological testing to determine the total amount of Residual Chlorine, Heterotrophic Plate Count, Coliform, Fecal Coliform and E. coli present in the drinking water. For unstable parameters, such as pH level, Temperature, and Total Dissolved Solids were measured at the sampling site as the results might change if exposed to external factors. To determine the pH level of the drinking water, the researcher used pH paper and the results were based on the manual instructed in the packaging; one (1) to six (6) is acid, seven (7) is neutral, and eight (8) to 14 is basic. To determine the Total Dissolved Solids and Temperature, a Digital TDS Meter (with temperature) was used by the researchers. After use, the excess water was shaken off from the meter and the cap was replaced before proceeding to another sampling site. As per stated by the Department of Science and Technology (DOST) Water and Wastewater Testing and Laboratory (CWWTL), all the samples were collected within the same day and must submit to them before 12:00 pm.

The most recent version of the Philippine National Standards for Drinking Water 2017 (PNSDW 2017) or also known as the Code on Sanitation of the Philippines is the standard for sample collection of the study.

PARAMETERS	UNIT	PNSDW LIMITS
Ph	-	6.8 – 8.5
Total Dissolved Solids	mg/L	500
Residual Chlorine	mg/L	0.2 – 0.5
Heterotrophic Plate Count	CFU/mL	< 500
Fecal Coliform	MPN/100mL	< 1.1
Coliform (Potability)	MPN/100mL	< 1.1
E. coli	MPN/100mL	< 1.1

Table 2. The safe limits of PNSDW for determining drinking water quality

To determine the water treatment used by the water refilling stations, the source of water of each water refilling stations, and other related information, the researchers provided survey questionnaires and conducted a face to face interview with the owners of each water refilling stations.

Statistical Treatment

The qualities of drinking water were evaluated according to the standards suggested by the Philippine National Standard for Drinking Water (2017) (Table 1) in order to calculate the number of samples that complied and did not comply with the guideline values. Basic statistical parameters such as minimum, maximum, and average were used to analyze the data and to evaluate the values for each parameters.

For the data from the survey questionnaires, the researchers used a frequency count, percentage distribution and mean to evaluate the data collected.

a. **Frequency Count** is used to organize the data and is counted into desire form that summarizes the frequency of the values in the sample.

b. **Percentage Distribution** is the percentage of a given frequency obtained by dividing the frequency with the total number of the population and then multiplying it to the quotient by a hundred.

c. **Mean** is the average of all values of samples obtained by adding all the values and then dividing by the total number of samples.

RESULTS AND DISCUSSION

This chapter is the presentation, interpretation, and analysis of data gathered by the researchers regarding the assessment of water refilling stations located in Navarro, General Trias City, Cavite. This includes the sources of water, different water treatment, physicochemical and bacteriological parameters and other related informations.

Water Refilling Stations

A total of six water refilling stations were chosen to assess their water quality including their sources of water and treatment system uses to treat their water. To determine the total number of the water refilling stations located in Navarro, the researchers requested a list of number from the barangay hall. There is a total of twelve (12) water refilling stations listed from the barangay hall. Out of twelve stations, only six of them agreed to be part of the study. Futhermore, to assess first the quality of their water refilling stations, a survey questionnaire and a face to face interview were conducted.

Backgroud of Water Refilling Station Profile

Based on the owners response, table 3 shows the datas as background profile of each water refilling stations. One (1) out of six (6) water refilling stations only registered in DTI while the rest are registered to have business permit in City Hall of General Trias, Cavite. The years of operation of the water refilling stations ranges from 2016 to 2019 which implies that some of them are still new in this business. According to PNSDW, the standard checking for Bacteriological Quality is done monthly while the standard checking for Physico-Chemical Quality is every six (6) months. All the stations follow these standards and cooperate to the monthly and every half-year checking as answered by the respondents during the survey. Lastly, the recent testing for their drinking water for each water refilling stations is between October 2019 to November 2019.

Table 3. Background of Water Refilling Stations according to the owners

WATER REFILLING STATIONS	REGIS-TRATION	YEARS OF OPERA-TION	YEAR OF START OF OPERATION	TIMES OF TESTING	RECENT TESTING
STATION 1	Yes	1 year	2018	Every month	October 2019
STATION 2	Yes	1 year and 6 months	2017	Every month	November 2019
STATION 3	Yes	11 months	2019	Every month	November 2019
STATION 4	Yes	3 years	2016	Every month	November 2019
STATION 5	Yes	3 years	2016	Every month and every 6 months	October 2019

STATION 6	Yes	3 months	2019	Every month	November 2019

Source of Water

Table 4 shows the different sources of water used by different water stations such as ground water, deep well, and district water. Majority of the water refilling stations uses deep well with 50%, next is from the district water with 33% and the last is from ground water with only 17 %. According to Espineli (2015), there are four sources of water that utilized every water refilling stations here in Cavite. Those are deep wells, district waters, private water providers and both deep wells and local district waters. Out of those four sources, the most used sources are deep wells and district waters with a 23 out of 50 users of water supply here in Cavite.

Table 4. Different Water Sources used by different Water Refilling Stations

	FREQUENCY	PERCENTAGES
Deep Well	3	50
District Water	2	33
Ground Water	1	17
TOTAL	6	100

Water Treatment

Table 5 shows the different water treatment used by different water stations. Overall, the most used water treatment are Ultraviolet Water Sterilizer and Multimedia Carbon with a percentage of 15%. Second, water treatment are Multimedia Softener, Sediment Filter, Reverse

Osmosis Membrane, and Multimedia Sediment with a percentage of 10%. Lastly, the lowest used of water treatment are Alkaline Water Purifiers, Water Filter, Flushing Valve, Brime Refill, Carbon Filter, and Activated Carbon who has a percentage of 5%.

Table 5. Different water treatment used by different water stations.

	FREQUENCY	PERCENTAGES
Ultraviolet Water Sterilizer	3	15
Multimedia Carbon	3	15
Reverse Osmosis Membrane	2	10
Multimedia Softener	2	10
Sediment Filter	2	10
Multimedia Sediment	2	10
Alkaline Water Purifiers	1	5
Water Filter	1	5
Flushing Valve	1	5
Brime Refill	1	5
Carbon Filter	1	5
Activated Carbon	1	5

Physico-Chemical Parameters

As part of the study, physico-chemical parameters of drinking water quality included pH level, Temperature, Total Dissolved Solids (TDS), and Residual Chlorine.

Potential of Hydrogen (pH) determines the level of alkalinity and acidity of a water. Data in Table 6 shows the pH level of each water refilling stations. The pH level of all the drinking water samples resulted with 7 (neutral). According to Philippine National Standard for Drinking Water (2017), the standard value for pH level ranges from 6.8 to 8.5 which means all the water refilling stations passed the standard value for pH level of drinking water. According to World Health Organization (2017), it is impossible to ascertain the direct relationship between the human health and the pH of drinking water as it is closely associated with the other aspects of water quality which means that any effect on health is likely to be indirect. However, failure to control the pH of the water can result in the contamination of the drinking water and has an effects on its taste, odour, and apperance.

Temperature. (°C) The temperature of the six (6) different water refilling stations range between 29.8 °C to 31.8 °C. Water refilling stations 1 and 3 have the same temperature which is 29.8°C; water refilling stations 2, 4, and 6 have a temperature of 30.8°C while water refilling station 5 has a temperature of 31.8°C.

Table 6. pH level and temperature of water refilling stations

Water Refilling Stations	**Temperature (°C)**	**pH level**	**Remarks**
1	29.8 °C	7	**Passed**
2	30.8 °C	7	**Passed**
3	29.8 °C	7	**Passed**

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4	30.8 °C	7	**Passed**
5	31.8 °C	7	**Passed**
6	30.8 °C	7	**Passed**
Range		**6.8 – 8.5**	

Total Dissolved Solids. Measuring of the inorganic matters and small amount of organic matter which are present as solution in water. Data in Table 7 shows the amount of Total Dissolved Solids of each water refilling stations. The standard allowed value of the TDS set by PNSDW (2017) is maximum of 500 mg/L. The highest TDS value of 386 mg/L and the lowest TDS value of 5 mg/L correspond to samples from Station 1 and Station 5, respectively (Table 1.2). Furthermore, it indicates that all of the water refilling stations passed the standard value for TDS set by PNSDW. In addition, according to World Health Organization (2016), there is no data regarding on health effects with the association of TDS. All sources of natural waters have a presence of total dissolved solids. According to Berkey Water Filters (n.d.), "The TDS in drinking water comes from natural water sources, sewage, urban run-off, industrial wastewater and chemicals used in the water treatment process, and the hardware or piping used to distribute water". Moreover, drinking water with very low concentrations of TDS may be unacceptable to the consumers because of its flat and insipid taste while the presence of high levels of TDS in the drinking water may be objectionable to the consumers owing to the resulting taste (WHO, 2016).

Table 7. Total Dissolved Solids of water refilling stations

Water Refilling Stations	**Total Dissolved Solids (mg/L)**	**Remarks**
1	386	**Passed**
2	7	**Passed**
3	16	**Passed**

4	13	**Passed**
5	5	**Passed**
6	45	**Passed**
Range	**500**	

Residual Chlorine. It is used to sterilize drinking water and can reduce waterborne diseases. However, too much intake of chlorine has a harmful effect in terms of breathing problems (WHO, 2017). The standard value set by PNSDW (2017) ranges between 0.2 to 0.5 mg/L. The values found from the drinking water of each water refilling stations was precisely less than 2 mg/L. It indicates that six (6) out of six (6) water refilling stations failed to the standard value for residual chlorine set by PNSDW (2017). According to CDC Safe Water System (n.d.), any drinking water that has a minimum of 0.2 mg/L of residual chlorine ensures the microbiologically clean water. Also, it is recommended that the drinking water should not exceed the limits of residual chlorine due to breathing problems, taste concerns and residual chlorine decays over time in stored water.

Table 8. Residual Chlorine of water refilling stations

Water Refilling Stations	Residual Chlorine (mg/L)	Remarks
1	< 2	**Failed**
2	< 2	**Failed**
3	< 2	**Failed**
4	< 2	**Failed**
5	< 2	**Failed**
6	< 2	**Failed**
Range Standard (PNSDW)	**0.2 – 0.5**	

All the water stations had the same neutral pH level of 7. Station 5 got the highest level of temperature with 31.8 °C while station 1 and 3 got the lowest temperature for their water samples of 29.8 °C. The garnered average temperature of all the water stations is 30.63 °C. In the Total Dissolved Solids, station 1 got the highest amount of 286 mg/L of TDS while station 5 got the lowest amount of 5 mg/L of TDS in their water samples. They garnered an average amount of TDS of 78.6 mg/L.

Table 9. Average amount for physico-chemical parameters of water refilling stations

	AVERAGE		
Water Refilling Stations	**pH level**	**Temperature (°C)**	**Total Dissolved Solids (mg/L)**
1	7	29.8 °C	386
2	7	30.8 °C	7
3	7	29.8 °C	16
4	7	30.8 ° C	13
5	7	31.8 °C	5
6	7	30.8 °C	45
	7	**30.63 °C**	**78.67**

Bacteriological Parameters

In this study, bacteriological testing parameters included Heterotrophic Plate Count, Coliform (Potability), Fecal Coliform and Escherichia Coli test. Accoding to DENR (2017), the primary objective of bacterial examination of drinking water is the detection of fecal pollution and the essential indicator for fecal pollution is E. coli. These organisms are easy to detect since they are commonly found in the environemnt and their presence in water meant that it is contaminated with organisms that can causes diseases. Water used for drinking water must be free from pathogenic organisms such as bacteria, viruses, protozoans, and helminthes that is responsible for waterborne diseases.

Heterotrophic Plate Count. Table 10 shows the results of the Heterotrophic Plate 10ount using SMEWW 9215 B. Pour-Plate of the six (6) water refilling stations. The standard value set by PNSDW (2017) for HPC must be less than 500 CFU/mL to indicate good water quality. The highest value for HPC is 950 CFU/mL and the lowest value is 15^ CFU/mL correspond to samples from Station 4 and 5, respectively. One (1) out of six (6) water refilling stations exceeded and failed the standard value means that it has a high percentage that these organisms in drinking water can be an ideal habitat for much more dangerous bacteria to live in Marietta (2003). Water samples that had failed the standards for HPC are still safe for drinking and is not harmful for intake, nevertheless, owners should still be wary of the standards because high HPC can turn their waters into an ideal habitat for more dangerous microorganisms. According to Marietta (2003), "lower concentration of heterotrophic bacteria in the drinking water is linked to a better maintenance of the treatment and distribution systems."

Table 10. Heterotrophic Plate Count of water refilling stations

STATIONS	**Heterotrophic Plate Count (CFU/mL)** Method: SMEWW 9215 B. Pour-Plate	**Remarks**
1	230	**Passed**
2	65	**Passed**
3	36	**Passed**
4	950	**Failed**
5	15^	**Passed**
6	410	**Passed**
PNSDW STANDARDS	< **500**	

***CFU= Coliform Forming Unit ^ Estimated **MPN= Most Probable Number

Total Coliform. Table 11 shows the results using the coliform test of the six (6) water refilling stations. The standard value set by PNSDW (2017) for total coliform must be less than 1.1 MPN/100mL. The highest value for total coliform is 8.0 MPN/100mL found in station 4 and the lowest value is less than 1.1 MPN/100mL found in station 2, 3, and 5. The station 1 and 6 have the same results which is exact 1.1 MPN/100mL. Value that is equal and greater than 1.1 MPN/100mL is already considered failed. Furthermore, three (3) out of six (6) water refilling stations which are 1, 4, and 6 exceeded and failed the standard value for total coliform set by PNSDW (2017). Water stations that had failed the total coliform test are also still fine for human intake, but it puts the water products in great risk for more harmful microorganism that will inhabit their waters. Also, owners should analyze which sub group of total colifrom bacterias are present in their samples because harmful subgroups can cause illnesses.

Table 11. Amount of Total Coliform of each water refilling stations

STATIONS	**Total Coliform Test (MPN/100mL)** Method: SMEWW 9221 B. Multiple Tube Fermentation Technique	**Remarks**
1	1.1	**Failed**
2	< 1.1	**Passed**
3	< 1.1	**Passed**
4	8.0	**Failed**
5	< 1.1	**Passed**
6	1.1	**Failed**
PNSDW STANDARDS	**< 1.1**	

*CFU= Coliform Forming Unit ^ Estimated **MPN= Most Probable Number

Fecal Coliform. Data in Table 12 shows the results of fecal coliform present in each drinking water samples. For the presence of fecal coliform, station 1, 4, and 6 exceeded the standard value for fecal coliform set by PNSDW (2017) wherein, it must be less than 1.1

MPN/100mL. The highest indicated value for fecal coliform is 2.6 MPN/100mL and the lowest value is less than 1.1 MPN/100mL. Furthermore, it indicates that three (3) out of six (6) water refilling stations failed the standard value for fecal coliform set by PNSDW (2017).

These drinking water samples were further tested for the presence of E. coli which is a more pathogenic bacterial strain that contaminate water. Presence of E. coli indicates fecal contamination which could be from human and animals. An immediate investigation must be conducted to eliminate the source of contamination (DOH, 2016). Failing the total fecal coliform test puts great risk to human health. Not only are these waters contaminated with indicator bacterias but diseases such as typhoid fever, hepatitis, gastro-enteritis, dysentery and ear infections can be acquired (Oram, 2014).

Table 12. Amount of Fecal Coliform of water refilling stations

STATIONS	**Fecal Coliform Test (MPN/100mL)** Method: SMEWW 9221 E. Multiple Tube Fermentation Technique	**Remarks**
1	1.1	**Failed**
2	< 1.1	**Passed**
3	< 1.1	**Passed**
4	2.6	**Failed**
5	< 1.1	**Passed**
6	1.1	**Failed**
PNSDW STANDARDS	**< 1.1**	

***CFU= Coliform Forming Unit ^ Estimated **MPN= Most Probable Number

Escherichia Coli. Results of amount of E. coli present in each drinking water samples. Based on Table 13, two (2) out of six (6) water refilling stations are failed in the standard value

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given by the PNSDW (2017) wherein it must be less than 1.1 MPN/100mL. Failing the standard value of Escherichia Coli in the water samples indicates that there is presence of fecal matters that can cause diseases including diarrhea, urinary tract infection (UTI), pneumonia and other clinical infections (Madappa, 2019).

Table 13. Amount of E. coli of water refilling stations

STATIONS	**E. Coli Test (MPN/100mL)** Method: SMEWW 9221 F. Multiple Tube Fermentation Technique	**Remarks**
1	< 1.1	**Passed**
2	< 1.1	**Passed**
3	< 1.1	**Passed**
4	1.1	**Failed**
5	<1.1	**Passed**
6	1.1	**Failed**
PNSDW STANDARDS	**< 1.1**	

*****CFU= Coliform Forming Unit ^ Estimated **MPN= Most Probable Number

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SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

This study aims to assess the drinking water quality of the different six water refilling stations in Barangay Navarro, General Trias Cavite in terms of Physico-Chemical testing parameters: pH level; Temperature; Total Dissolved Solids and; Residual Chlorine and Bacteriological testing parameters: Heterotrophic Plate Count; Fecal Coliform; Coliform (Potability) and; E. coli. Furthermore, this study aims to determine the source and water treatment system of each water refilling station by conducting a survey and face to face interview with the respondents.

The study was started by collecting the drinking water samples from each water refilling stations. The drinking water samples were placed in their designated bottle, sterilized bottle for bacteriological parameters and polyethylene bottles for physico-chemical parameters. Then, the water samples were placed in an ice box to preserve their temperature from the sampling site to the DOST Water and Wastewater Testing and Laboratory (CWWTL) in Trece Martires City, Cavite. After gathering the samples, the samples were brought to the laboratory and the researchers conducted a laboratory procedure to determine the total amount of Residual Chlorine, Heterotrophic Plate Count, Coliform, Fecal Coliform and E.coli present in the drinking water. For unstable parameters, such as pH level, Temperature and Total Dissolved Solids were measured at the sampling site. Lastly, the results were interpreted by using the Code on Sanitation of the Philippines or the updated version of the Philippine National Standards for Drinking Water (PNSDW 2017).

The standard value of pH level of drinking water ranges from 6.8 to 8.5 and 500 mg/L for TDS. All water refilling stations passed and did not exceed the allowed value of pH level and TDS. On the other hand, all water refilling stations failed and exceeded the standard value of Residual Chlorine which ranges from 0.2 to 0.5 mg/L. The standard value of Heterotrophic Plate Count of drinking water must be less than 500 CFU/mL and one (1) station failed. Three (3) stations failed the Total Coliform test and Fecal Coliform test as it exceeded the standard value which is it must be less than 1.1 MPN/100mL. Two (2) stations failed the test for E. coli as it exceeded the allowed value which is also 1.1 MPN/100mL.

All the survey interviews were evaluated through the use of basic statistical treatments that includes frequency count, percentage distribution and mean of all datas.

CONCLUSION

This research describes a test and survey carried out in six water refilling stations in Barangay Navarro, General Trias City, Cavite to assess the physico-chemical and bacteriological quality of different drinking water samples from each water refilling stations. It is provided and contributed information to identify the main concerns regarding the quality of drinking water in order to suggest appropriate solutions to reduce the observed contamination and to motivate the public to plan future interventions regarding this issue.

In terms of water sources, one (1) water refilling station prefers a ground water source and three (3) stations prefer a deep well source. The source of the two (2) remaining stations is the district water, the safest and most preferred source for drinking water. With different water sources, the researchers were able to detect which microorganisms and parameters have huge amounts in the specific source. These sources are subjected to regular monitoring because the water treatment needed for purifying the source water depends on it.

The most frequent water treatment used by the respondents are Ultraviolet Water Sterilizer and Multimedia Carbon. These two water treatment systems are included in the ideal features of a water refilling stations. However, some water refilling stations do not have these kind of treatment systems and it can affect the quality of their product. With correct knowledge, the following suggested water treatments should be followed by each of the respondents.

For physico-chemical parameters, the values of drinking water quality such as pH and TDS from all samples collected from different water refilling stations were found to be within the recommended limits of PNSDW. The results was that most of the drinking water samples have a reasonably good physicochemical quality, with exceptions related to the high amount of residual chlorine as all of the six (6) water refilling stations failed and exceed the standard value for residual chlorine set by PNSDW. This needs an immediate interventions as too much intake of chlorine has a harmful effect in terms of breathing.

As regards of bacteriological parameters, some drinking water samples had high Heterotrophic Plate Count; high total coliform count; high amount of fecal coliform. One (1) out of six (6) water refilling stations failed the test for Heterotrophic Plate Count while three (3) stations failed the coliform test and fecal coliform test. Some drinking water samples were not fit for drinking unless boiled. Further, an analysis of E. coli, the major indicator of the presence of fecal contamination is needed. Two (2) out of six (6) water refilling stations exceeded the limit value of E. coli set by PNSDW. This needs an immediate interventions too as it indicates a bacteria present in the drinking water. The problem is mainly because of the water treatment system and distribution.

Furthermore, DOH must conduct random tests to assess the drinking water quality and to ensure the public's health. Owners of drinking water services must follow the right procedure and maintenance set by officials and they must have the complete and ideal water treatment system that could be installed for the different processes. These are all needed to ensure the safety of the customers.

RECOMMENDATIONS

Based on the results, the following are recommended:

1. Each water refilling stations must have the seven ideal water treatment systems for the best quality of drinking water and to ensure everyone's health. Those are:
    - Ultra-violet lamp
    - Multi- media sediment filter
    - Activated carbon filter

- Ion exchanger
- Reverse Osmosis Membrane
- Post-carbon filter
- Ozone generator

2. The manager of water refilling stations must test their product once a month for bacteriological parameters and every six months for physicochemical parameters in accordance of compliance to PNSDW
3. The authorities should relay to the data gathered to know what action must be done.

For the future researchers, the following are recommended:

1. Add more different parameters for the testing of water quality of water refilling stations.
2. Compare the treated water from the main source (faucet) to the products in their corresponding containers and evaluate whether the container has a contribution to the quality of drinking water.
3. Check the state of the water sources of each water refilling stations.

REFERENCES

(2019). Retrieved from The Berkey: Purify your Water: https://theberkey.com/blogs/water-filter/what-is-theacceptable-total-dissolved-solids-tds-level-in-drinking-water

Alambatin, J. C. (2017). Drinking Water Quality of Selected Tap Water Samples in Cagayan de Oro (District II), Philippines. *JOURNAL OF SUSTAINABLE DEVELOPMENT STUDIES*, 3.

Blaszczak-Boxe, A. (2018, April 25). *Facts About Chlorine*. Retrieved from Live Science: https://www.livescience.com/28988-chlorine.html

Center, F. E. (2017). *Turbidity, Total Suspended Solids & Water Clarity*. Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/

Corpuz, A. M., Mati, N. L., & Mina, E. C. (2016). Physicochemical and Bacteriological Analysis of Drinking Water in Public Schools of Tarlac City, Central Luzon, Philippines. *Journal of Research*, 11.

DOH LAUNCHES PHILIPPINE NATIONAL STANDARDS FOR DRINKING WATER OF 2017. (2017, December 12). Retrieved from Department of Health: https://www.doh.gov.ph/node/12121

Drinking Water. (2019, June 14). Retrieved from World Health Organizaion: https://www.who.int/news-room/fact-sheets/detail/drinking-water

Drinking Water Contaminants - Escherichia Coli,. (n.d.). Retrieved from APEC WATER: https://www.freedrinkingwater.com/water-contamination/ecoli-bacteria-removal-water.htm

Ernesto J. Del Rosario, P. (n.d.). *PURIFICATION AND QUALITY OF DRINKING WATER:ISSUES AND CONCERNS.* Philippines: National Academy of Science and Technology Philippines.

Fawell, J. (2003). *Fluoride in Drinking-water:Background document for development of WHO Guidelines for Drinking-water Quality*. United KIngdom.

Fawell, J. (2007). *pH in Drinking-water:Revised background document for development of WHO Guidelines for Drinking-water Quality*. United Kingdom.

Fondriest Environmental, Inc. "pH of Water." Fundamentals of Environmental Measurements. (2013, November 13). Retrieved from Fondriest Environmental, Inc. "pH of Water." Fundamentals of Environmental Measurements. : < https://www.fondriest.com/environmental-measurements/parameters/water-quality/ph/ >

Health, W. S. (n.d.). *Coliform Bacteria in Drinking Water*. Retrieved from Community and Environment: https://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/Contaminants/Coliform#TotalColi

Khasim. (n.d.). Retrieved from DISCOVERING ALKALINITY IN OUR SCHOOL WATER:

https://www.thirteen.org/edonline/studentstake/water/schoolwater/alkalinity/alkalinity.htm

Marrone, R. (2016). *Water Pollution in the Philippines: Causes and Solutions.* Seattle,WA: The Borgen Project.

Mihdhdir, A. A. (2009). Evaluation of Bacteriological and Sanitary Quality of Drinking Water Stations and Water tankers in Makkah Al-Mokarama. *Pakistan Journal of Biological Sciences*, 404.

N. Rahmanian, 1. S. (2015). Analysis of Physiochemical Parameters to Evaluate the Drinking Water Quality in the State of Perak, Malaysia. *Journal of Chemistry*, 2.

Oram, B. (2014). Nitrates and Nitrites in Drinking Water Groundwater and Surface Waters. *Water Research Center*.

Organization, W. H. (2016). *Guidelines for*.

Patty Chuang, J. M. (2010). Water Quality Testing and Water Use Assessment in Capiz Province, Philippines. *Final Report Capiz, Philippines*, 43.

Philippine Standards for Drinking water 1993 under the provision of Chapter II,Section 9 of PD 856, otherwise known as the Code on Sanitation of the Philippines. (2017). *DENR Administrative Order No.26-A Series 1994*, 2-7.

Poblete, M. N. (2015). Drinking Water Quality Assessment in Selected Barangays in Laoang, Northern Samar, Philippines. *International Journal of Environmental Science and Development*, 29.

Puetz. (2013). The Book on Water Clarity Reliable, Safe, and Effective Water Treatment Solutions. *The Book on Water Clarity*.

Robbins, O. (2017, August 10). *You Probably Drink Chlorine in Your Water Every Day — But Is It Harmful?* Retrieved from Food Revolution Network: https://foodrevolution.org/blog/chlorine-water-harmful/

Safe Drinking Water Foundation. (2017, January 23). Retrieved from What is Chlorination?: https://www.safewater.org/fact-sheets-1/2017/1/23/what-is-chlorination

Tarun Madappa, M. (2019). *Escherichia coli (E coli) Infections.* New York: WebMD LLC.

The Importance of Water. (n.d.). Retrieved from Australian Capital Territory Government Health: https://goodhabitsforlife.act.gov.au/kids-at-play/importance-water

US, D. o. (2016). Coliform Bacteria.

Water Education Foundation. (2019, September 12). Retrieved from NITRATE CONTAMINATION: https://www.watereducation.org/aquapedia/nitrate-contamination

APPENDIX FIGURES

Figure 3. Water in a jar to determine the pH Level and Total Dissolved Solids

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Figure 4. Washed the Total Dissolved Meter

Figure 5. Determined the Total Dissolved Solids

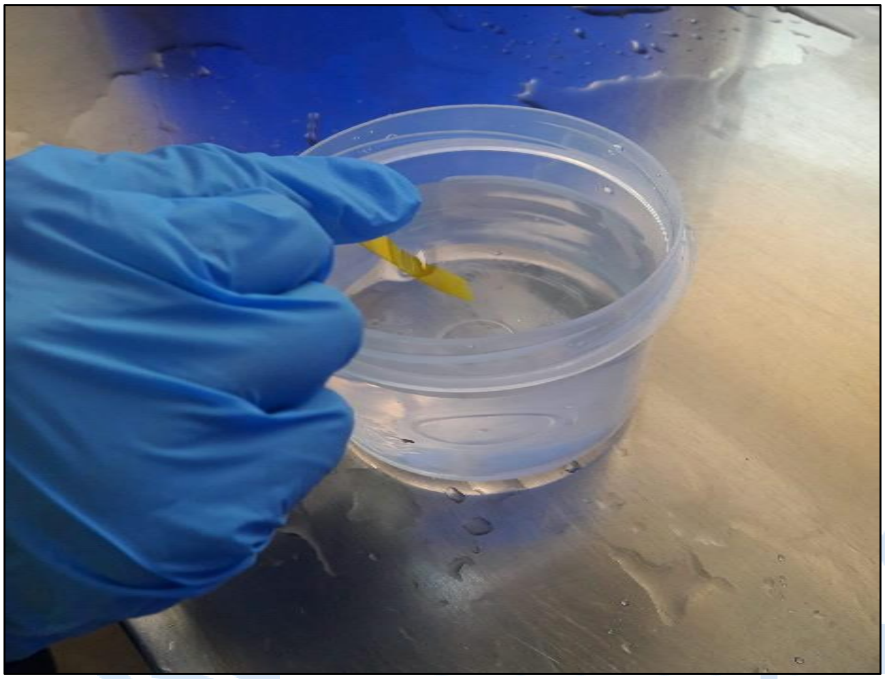

Figure 6. Soaked the pH paper

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Figure 7. Determined the pH Level

Figure 8. Rinsed the polythelyne bottle for Residual Chlorine

Figure 9. Filled the polythelyne bottle with water

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Figure 10. Stored in the ice box

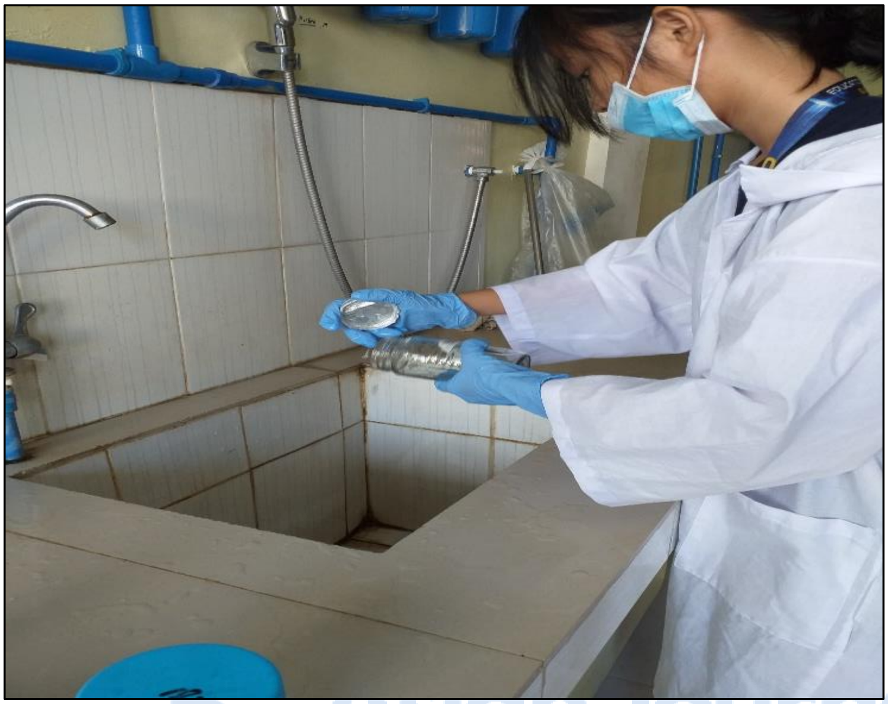

Figure 11. Rinsed the sterilized bottle for Bacteriological parameters

Figure 12. Filled the sterilized bottle with water

Figure 13. Stored in the ice box

Figure 14. Delivered to the laboratory for testing

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