Quality, Utilization and Management of Groundwater in Barangay Badas, Mati, Davao Oriental

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Abstract

The study was conducted to assess the quality of groundwater and the management practices of the residents in Barangay Badas, Mati, Davao Oriental Specifically, this included the water utilization profile, biological characteristics - Most Probable Number (MPN) of coliforms per 100 ml. sample, chemical characteristics-pH. total dissolved solids, total hardness, chloride, nitrates, sodium, magnesium, and calcium There were 208 respondents interviewed for the determination of water utilization profile, potential source of contamination, and water management practices of the residents in Barangay Badas, Mati, Davao Oriental Five sampling sites were established for the collection of water samples which were then submitted to University of Immaculate Conception, Davao City for analysis The Philippine National Standard for drinking water was used for water quality assessment The 1-Test was used for data analyses in comparing the experimental mean to the standard value. Majority of the residents in Barangay Badas used their water for domestic purposes. The main possible sources of groundwater contamination in this area were the waste from agricultural activities, improper waste disposal and improper sanitation. The results for Most Probable Number of coliforms per 100 ml. sample and sodium were above the maximum level. The pH levels were within the safe limits for drinking water The results for total dissolved solids, total hardness, chlorides, nitrates differ from one station to another. Magnesium and calcium had no standard values The residents of Barangay Badas should be educated on the importance of water management in order to conserve one of its non-renewable natural resources, the groundwater.

Keywords: Biological, Coliforms, Contamination, Disposal, Groundwater

Introduction

Groundwater is the largest reservoir of unfrozen fresh water in the hydrologic cycle When precipitation falls and infiltration occurs, gravity continues to draw the water downward until an impermeable rock or soil layer is reached and the water begins to accumulate above it (Montgomery, 1989). Humans require about a gallon of water per day per person for domestic industrial processes and power generation, for livestock and irrigation. A domestic activity in urbanized areas requires a great deal of water This includes water for drinking, cooking. bathing, washing, flushing toilets and watering lawns and gardens (Enger and Smith, 2001).Groundwater supply renews 1,400 years. These supplies are replenished or recharged, but in many areas, it is being withdrawn faster from aquifers than natural recharge (Cunningham, 1995). Exceeding withdrawal can lead to surface subsidence, salt water intrusion, and decrease water supply which greatly affect groundwater quality. However, variation of water quality stems from human activities such as waste disposal on the land surface.

Once polluted, purification of groundwater system may take centuries and incredible sum of money. While some contaminants are evident because they are obnoxious in taste, odor, color, or the like, others are silent killers that pose a more serious problem. If these poisons go undetected for a long period of time, they can cause diseases in humans, animals and plants. Hence, this study is conducted to assess and determine the quality of groundwater in Barangay Badas, Mati Davao Oriental. This focused on the water utilization, biological and chemical characteristics. It also included identifying human activities that pose a threat to groundwater quality Besides, this provides baseline information for the community and government agencies in formulating policies for sustainable management of the groundwater resources. As with so many environmental hazards, it will then be difficult to trace the exact cause of illness (or death) to its source. The study is also relevant to government agencies because it could inform them of the water utilization's profile and the quality of groundwater in the said area so that they can make actions and some management planning for this resource.

This study focused on determining the Most Probable Number (MPN) for coliform, and levels of pH, total dissolved solid, total hardness, chloride, nitrates, sodium, magnesium, and calcium The collection of water samples from five shallow wells was done during fine weather condition for ease of sampling and handling. The collection of these samples was simultaneously done at 7:00 o'clock in the morning. The respondents in every sitio were subjected for interview using questionnaires to evaluate the water utilization and management practices in. Slovin's formula was used in determining the number of respondents.

Methodology

Description of the study area

The study was conducted in Barangay Badas, Mati, Davao Oriental, which is six kilometers away from Mati Poblacion. It consists of eleven sitios located on the western part of Mati with 26 puroks and 1,014 households. The types of water supply in this area are the shallow wells and spring (Barangay Profile, 2001). Figure 1 shows the identified sampling sites of the study.

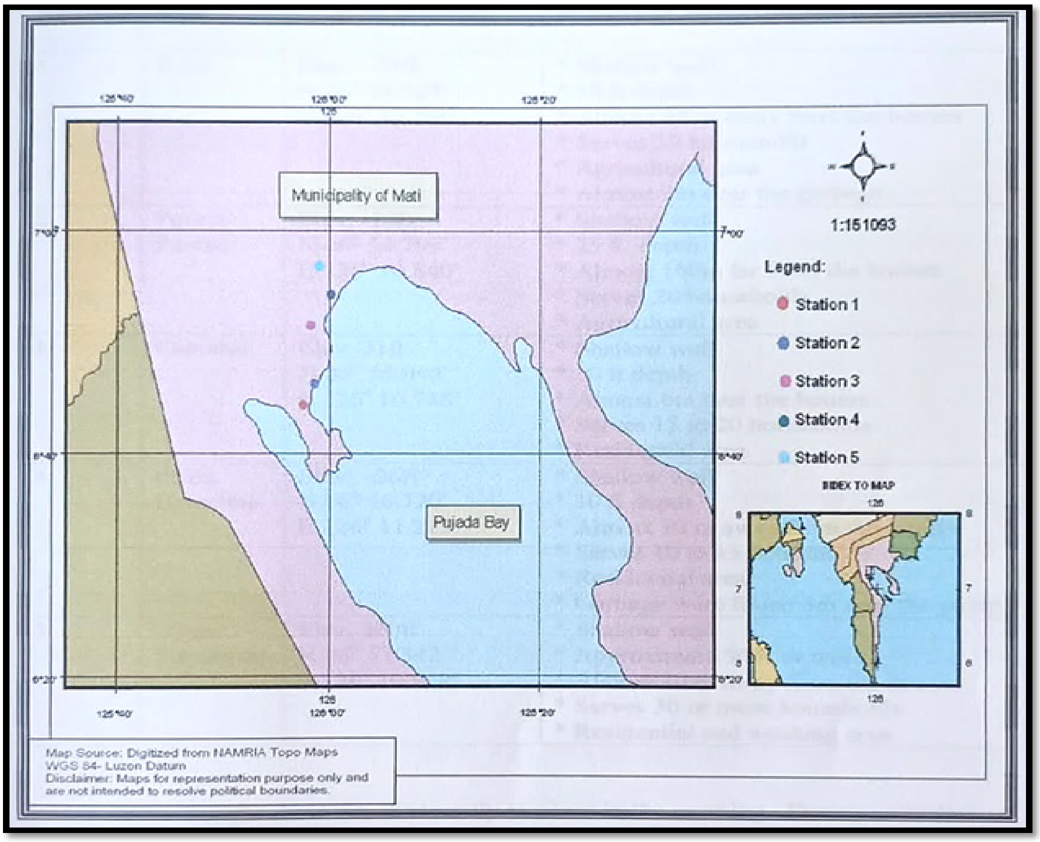

Figure 1. Map showing the locations of geographically referenced study stations at Barangay Badas, Mati City, Davao Oriental

Five sampling stations were identified using the following criteria (1) the representative well for the area, (2) accessibility of the well, and (3) the number of households served.

Sampling technique

A one-shot sampling was done in the month of December 2006. It was done during fine weather condition for ease of sampling and handling Care was observed to establish a sample that is truly a representative of the existing conditions, and to handle it in such a way that it doesn't deteriorate or become contaminated before it reaches the laboratory for analysis (PCARRD, 1980).

Sampling site description

Table 1. Description of established sampling sites.

Number	Sitio	GPS Reading	Remarks/Characteristics
1	Baso	Elev -95ft N 06 54.327' 2 E 126" 10.565'	• Shallow well • 30 ft depth • Almost 25 m away from the houses • Serves 39 households • Agricultural area • Almost 3m near the garbage

2	Pulang Pantad	Elev-19ft N 06 54 799 E 126° 10.840’	• Shallow well • 25 ft. depth • Almost 100m far from the houses • Serves 20 households’ • Agricultural area
3	Camansi	Elev- 31ft N 06° 56.040’ E 126” 10.748	• Shallow well • 30 ft depth • Almost 6m near the houses • Serves 15 to 20 households • Residential area
4	Punta Gemelina	Elev. -26f N 06° 56.720 E 126 11.215	• Shallow well • 30 ft depth • Almost 10 m away from the houses • Serves 10 to 15 households • Residential area • Garbage was found 5m near the pump
5	Upper Tagawisan	Elev 200ft N 06° 57 342’ E 126° 10.958	• Shallow well • Approximate 50 ft or more • Almost 10 m away from the houses • Serves 30 or more households • Residential and washing area

Sampling was done simultaneously at seven in the morning. During collection of water samples, the edges of the faucet were heated. Well samples were collected after the pump had been running for ten to fifteen minutes. Before filling, the sterilized glass bottle was rinsed two to three times with the water collected A two liter of water sample was collected for the chemical analyses (PCARRD, 1980). The water samples were labeled properly with the following information (1). name of water body or well, (2) location, (3) date and time of collection, (4) weather condition and (5) name and designation of collector The same procedure was done for the biological characteristics, however, a 200-mL sterile container free of microbial inhibitors was used (AOAC, 1995) Collected samples were stored at 4°C and submitted to the University of Immaculate Conception Laboratory, Davao City for chemical and biological analysis Determination was done preferably within 24 hours, otherwise, samples should be preserved with 40 mg/L HgCl (AOAC, 1995).

Analytical method

The chemical parameters were analyzed using the following methods pH using Glass Electrode method (PCAAR, 1980), Gravimetric method for total dissolved solids, EDTA Titration for total hardness, Argentometric for chlorides, Brucine Colorimetric method for nitrates, Atomic Absorption Spectrophotometry for sodium, magnesium, and calcium (AOAC, 1995) (Appendix A). For biological parameter the Defined Substrate Technology (DST) or Colilert Method was used (AOAC, 1995) (Appendix A).
using Slovin’s formula.

Data gathering for utilization and management

In gathering this data, a questionnaire (Appendix B) was used to determine the water utilization and the management done by the people in the area. The 280 respondents were determined using Slovin's formula.

To determine the sample size, the Slovin's Formula was used.

$$n = \frac{N}{1 + N(e)^2}$$

Where: n = sample of the population

N = number of population

e = allowable error

1= constant

Data analysis

Data were analyzed through descriptive statistics such as frequency count and percentage The Philippine National Standard for Drinking Water, 1993 (Appendix C) was used for its quality assessment. One sample t-Test was used in comparing the standard value, wherein means, standard deviation and t- value was tabulated.

Statistical formulas for:

Mean

$$x = \frac{\sum x^{i} \; i = 1}{n}$$

$$\text{Standard deviations} = \sqrt{\frac{n \sum x^2 - (n \sum x_i)^2}{n\,(n-1)}}$$

t- Test:

$$x - x_T = ts/\sqrt{n}$$

Where:

X = mean value n = number of samples

X_T = standard value s = standard deviation

Results and Discussion

Water utilization

Barangay Badas used shallow wells, water system and rain water as sources of their daily water needs. Figure 2 shows the percentage of the respondents that used shallow wells, water system and rain water.

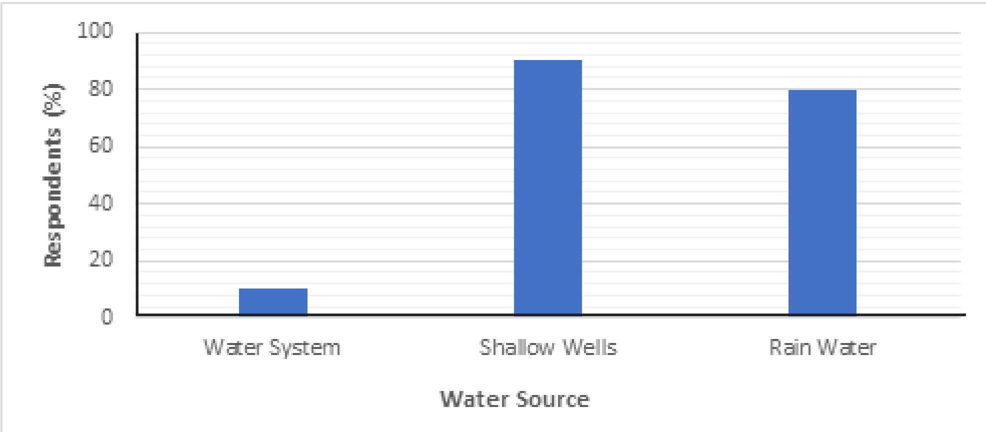

Figure 2. Different sources of water consumed everyday.

Figure 3 shows that 100% of the residents in Barangay Badas used water for cooking, drinking, washing, bathing, and watering for plants. Some residents (0.71%-7.85%) also used water for poultry and livestock, agricultural and car washing.

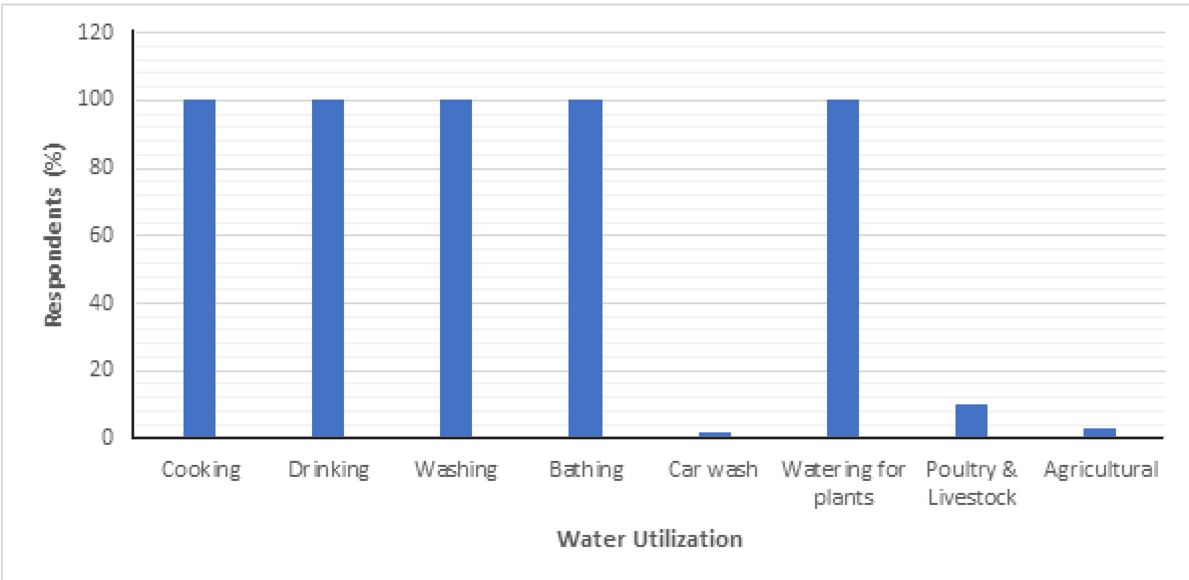

Figure 3. The different uses of water.

In Barangay Badas, the highest estimated water consumption per person daily in liters was about 160-200 liters, which comprised 26.78% of the respondents. While the lowest was 300 liters, which was 8.93% Figure 4 shows the different daily water consumption in liters.

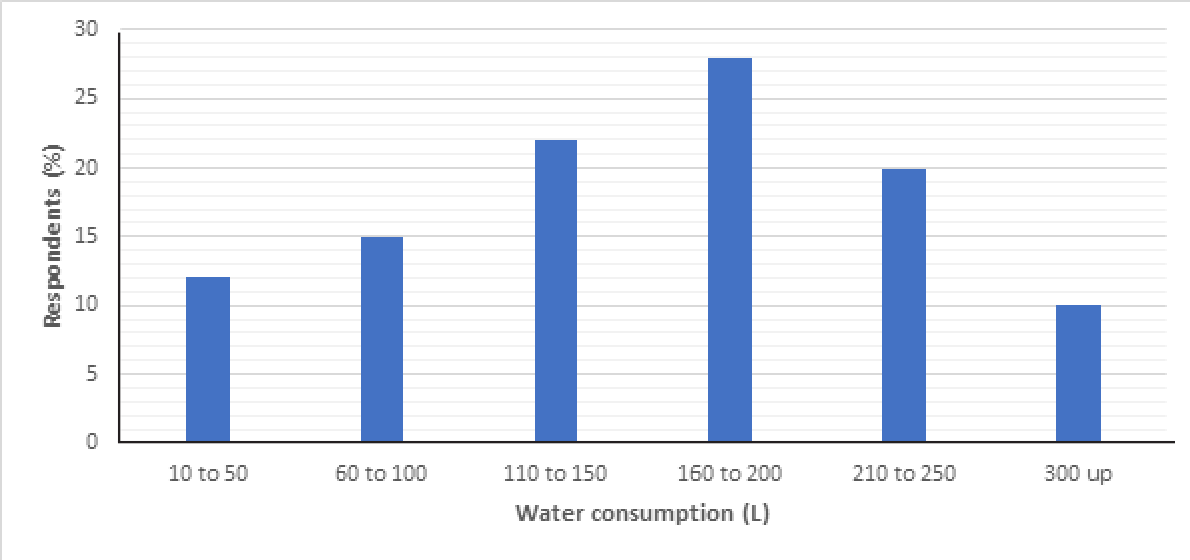

Figure 4. Different daily uses of water (liter).

Only 18.93% of the residents own an artesian well while 81.07% sourced their water from shallow wells, water system and rainwater. There were 2.14% respondents who had artesian wells, but these were not used since the water was salty About 64.64% of the residents didn't experience any problem related to consumption while 35.36% encountered some problems like pump damage (3.03%), far from water source (5.05%), limited hour in getting water supply (73.74%), turbid water (5.05%), dry season (3.05%), and the shortage of water (10.10%). In terms of water shortages, 78.57% enjoyed the unlimited water supply, while only 21.43% experienced water shortage.

Potential sources of groundwater contamination

The main possible factors of groundwater contamination in Barangay Badas were the chemicals and fertilizers used by the people for agricultural activities. The large bulk of improper waste disposal and improper sanitation of people in this place were the biggest contributor or the main possible source of the pathogenic bacteria of the water. Based on ocular inspection, two sampling stations were situated on an agricultural land According to key informants interviewed, application of fertilizer was done to this land, which was planted with corn and vegetables. These fertilizers contained chemicals like nitrogen , phosphorous (P), and potassium (K) that eventually seep to the ground and react with other chemicals that greatly affect the chemical characteristics of the groundwater (Buell and Girard, 1994). Table 2 shows that majority of the residents (96.07%) disposed their garbage in the open dumps. Waste from open dumps may contain toxic chemicals that may slowly seep into the ground and cause contamination of groundwater (Lavides et al., undated). They also disposed their garbage to the sea (1 79%) and some buried it (2.14%). Furthermore, only 21.43% of the respondents had sanitary toilets, 35.71% without sanitary toilets, and 42.86% had no toilets. This can probably lead to an increased level of pathogenic bacteria in the water on this area (Tujan, 2000). In terms of animal waste disposal, 16.43% did not practice proper disposal and only 179% disposed it properly. Moreover, large percentage of the respondents that (57.14%) had septic tanks and 42.86% had none. Some of these septic tanks were located near the pump (10.71%) Majority of the people in Barangay Badas didn't have proper drainage system. Large percentage of the residents (35.75%) disposed their laundry water near the water source or anywhere (25%). They also disposed it near the house (14.29%) canal (10.71%), comfort room (7 14%), plants and sea (3.57%) 72.5% of the respondents in the area revealed that other possible sources of groundwater contamination were from the garbage disposed near the pump, 20% from stagnant water, and 75% from farm waste. This might be the reason why 7.14% of the respondents experienced some water related health problems, such as diarrhea (65%), stomachache (20%), and loose bowel movement (15%) 92.86% of the respondents did not experience any water related health problems.

Table 2. Water and health related information.

Garbage disposal	**Respondents (%)**
Open dumps	96.07
Land fills	0
Buried Sea	2.14
Sea	1.79
Types of toilet	**Respondents (%)**
With sanitary toilet	21.43
Without sanitary toilet	35.71
Without a toilet	42.86
Practice proper disposal of animal waste	**Respondents (%)**
Practice	1.79
None	16.43
N/A	81.79
Respondents that have septic tank	**Respondents (%)**
With septic tank	57.14
Without septic tank	42.86
Respondents that have septic tank located near water source	**Respondents (%)**
Located near water source	10.71
None	89.29
Disposal of water from laundry	**Respondents (%)**
Anywhere	25
Near the water source	35.71
Canal	10.71
Plants	3.57
Sea	3.57

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Comfort room	7.15

Other possible source of groundwater contamination	Respondents (%)
Garbage	72.50
Stagnant water	20
Farm waste	7.50
Health problems	**Respondents (%)**
Diarrhea	65
Stomach ache	20
Loose bowel movement	15

Total coliform, Most Probable Number (MPN)/100 mL

For drinking water, where no coliform of any kind should be present, total coliforms are used as an indication of fecal pollution. Water used for drinking and bathing can serve as a vehicle for the transmission of a variety of human enteric pathogens that can cause water borne diseases (McGhee, 1991). Figure 5 shows the mean value of total coliform (MPN/100mL) of water sample in different sites. It ranged from 2.2 to 16 MPN/100ml. The highest level of total coliform bacteria was recorded in station 4. This had lower elevation and maybe the man-made waste from upland activities had greatly affected the levels of coliform on this site through direct discharge of raw sewage. This improper disposal of human waste can be the main source of disease-causing organisms (Cunningham, 2006) Septic tank too close to the well was also noted which may also be a source of contamination. Moreover, rocky areas can have fairly large underground conduits and surface water reaching the groundwater system through cracks or tunnels had caused microbial contamination of the groundwater (Henry and Heinky, 2000). Stations 2, 3 and 5 had the lowest total coliform concentration These sites had average vegetation which maybe one factor of trapping some waste causing contamination of water supply from land surface All stations were above the maximum level as stated by the Philippine National Standard. Figure 5 below shows the comparison of MPN/100 ml. to the standard value where in the results in every station were above the standard value set by the Philippine National Standard for Drinking Water The presence of coliform is taken as an indication that pathogenic organisms are present. Thus, the water is not free from disease producing organisms.

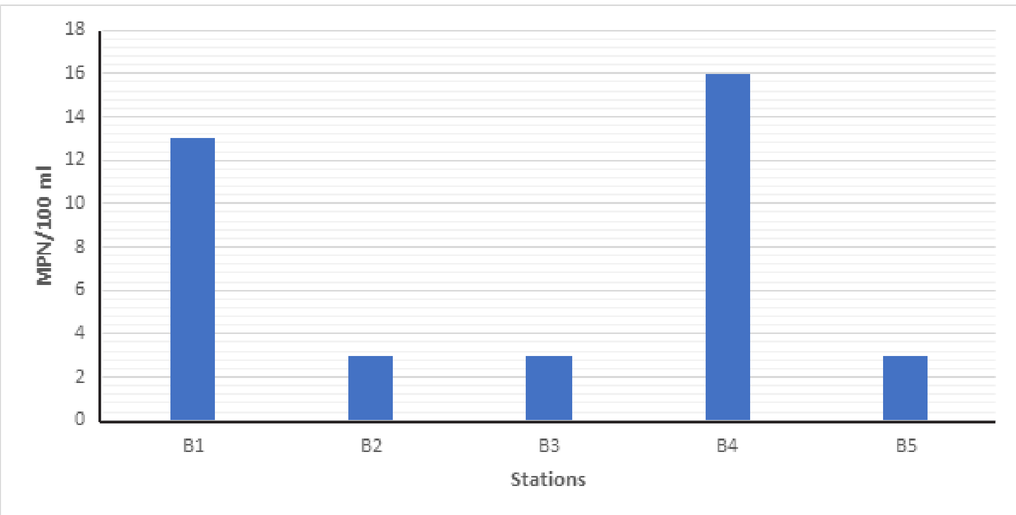

Figure 5. The comparison of experimntal mean of MPN/100ml with the standard Value

Water pH level

Groundwater accumulates slowly by percolation of surface water If groundwater is acidified, contamination of acid-soluble metal such as Pb, Co and Zn can occur through leaching from water pipes and containers, and aluminum coming from the bedrock itself. The risk that this groundwater will become contaminated by heavy metals and aluminum increases substantially as the pH of rain and percolated soil water fall leading to adverse effects (Henry and Heinkie, 2000).

Figure 6 shows the pH value of the water samples collected in Barangay Badas, which ranged from 7.0 to 7.15. Station 5 had the highest pH value High pH value maybe due to its average vegetation compared to the other stations Increasing pH level can be due to the usage of hydrogen molecules in photosynthesis that decreases the concentration of hydrogen ions (Murphy, 2001). The low pH value of 7.0 was observed in station 3. Nearby residents of this station disposed domestic waste improperly that led to the increase of hydronium ion concentration. When domestic waste is degraded, it will produce organic acids that can change the levels of pH (Water Research Journal, 1988). Generally, the pH levels of groundwater in Baragay Badas were within the safe limits for drinking water as set by the Philippine National Standard. This comparison is shown in figure 6.

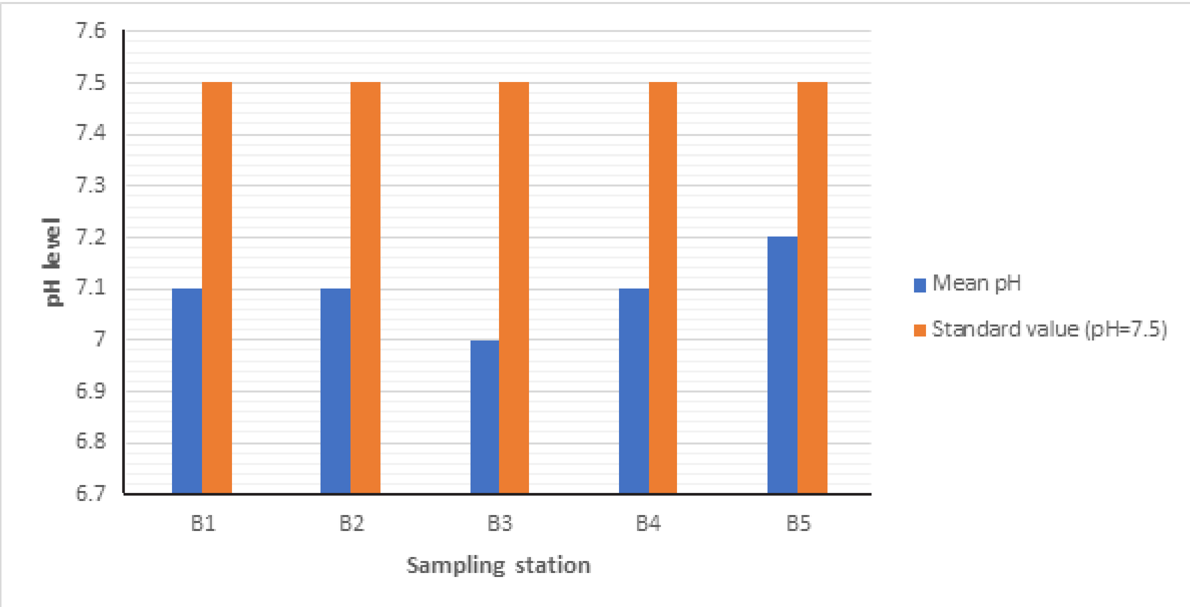

Figure 6. The comparison of pH mean with the standard value.

Total dissolved solids

Total dissolved solids are the sum of the concentration of all dissolved solid chemicals in the water, which include organic and inorganic contaminants (Montgomery, 1989). Inorganic contaminants, which include aluminum, arsenic, barium, cadmium, chromium, fluorine, lead, mercury, nitrate, selenium and silver have chronic or toxic health impacts even in little amount Organic contaminants come from pesticides, herbicides and during water chlorination. Most of these are toxic or carcinogenic (McGhee, 1991). Figure 8 shows the different levels of total dissolved solids for the five sampling sites. The highest TDS value was obtained at station 2, which is located along the coastal area. A nearby plantation of corn and vegetables were spotted Results revealed that residents near the area disposed their wastewater after washing their clothes and taking their baths just near the sampling site. This contributed to a greater amount of TDS in groundwater because of the sampling site. This contributed to a greater amount of

TDS in groundwater because of the chemicals and salt concentration associated in this agricultural activity and household products that will eventually percolate downward to the groundwater (Davis and Masten, 2004). The lowest TDS value of 378 mg/L was obtained in station 5. Figure 7 shows the comparison of the experimental mean with the standard value of the TDS. According to the Philippine National Standard for drinking water, the maximum level of TDS is only 500 mg/L. It was noted that only station 3 and 5 were within the safe level. The other stations were above the tolerable limits unfit for drinking purposes.

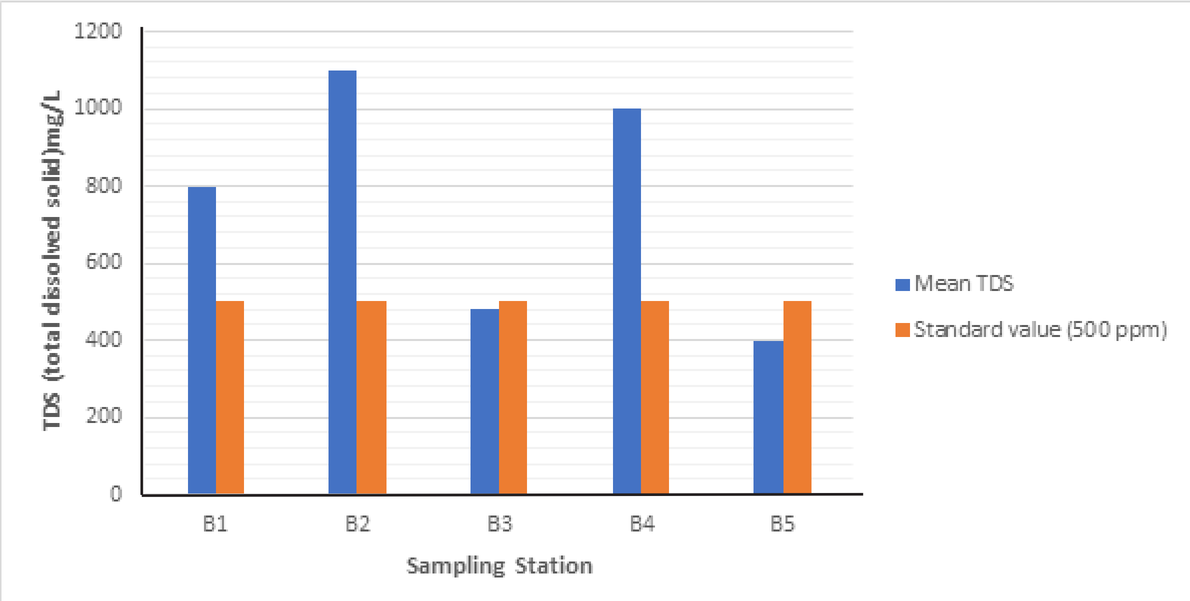

Figure 7. The comparison of TDS mean with the standard value.

Total hardness

Hardness is caused by relatively high concentration of calcium, magnesium and iron salts that are dissolved in water (Dolgoff, 1996). Total hardness for the groundwater in Barangay Badas ranged from 292.5 mg/L to 659.5 mg/L. The highest total hardness value was noted in station 2 situated near the coast. This could be attributed to the large bulk of agricultural waste and disposed water from laundry along this site. Hard water requires more soap, because the calcium and magnesium ions form complexes with soap, preventing the soap from studding. Hardness generally represents the concentration of calcium (Ca) and magnesium (Mg) ions, because these are the most common polyvalent cations (Murphy, 2005). The Total Hardness level in station 5 had the lowest concentration of 271 mg/L. This station had high elevation that probably caused the run off of man-made waste to lower elevation and minimized its percolation to the ground. Figure 8 shows that only station 5 is within the safe limit for drinking water as recommended by the Philippine National Standard for Drinking Water. The rest of the stations were above the standard value. These high values give an unpleasant taste to the water and prevent soap lathering.

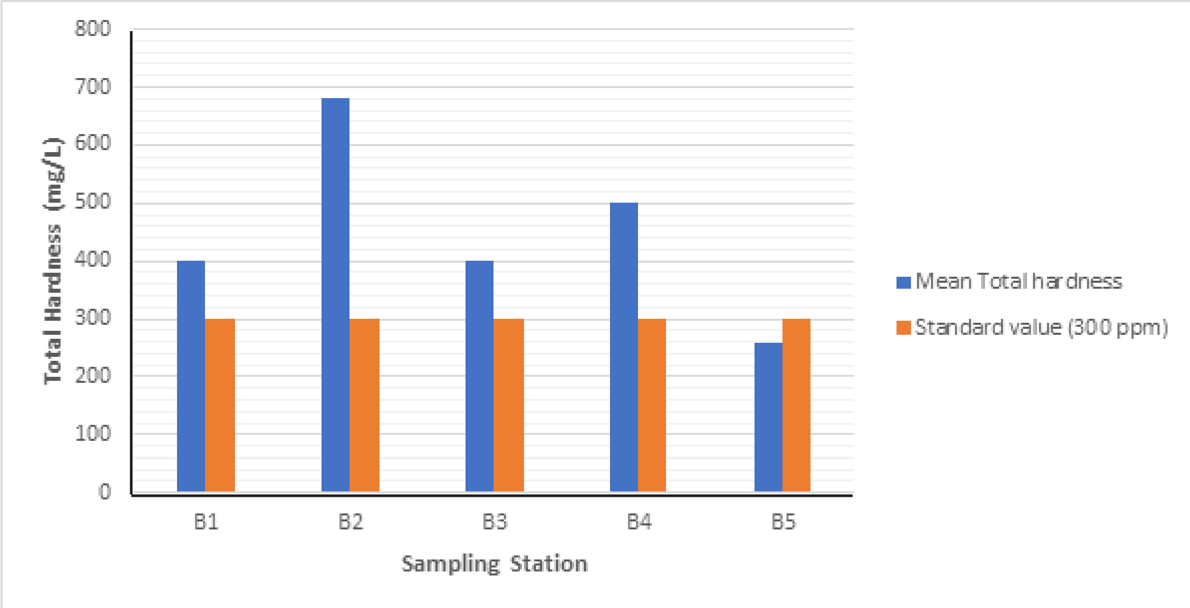

Figure 8. The comparison of TH mean with the standard value

Chloride

Chloride in high concentration can contribute to salty taste of water and is sometimes an indication of sewage contamination, since chloride concentration increases when water is used for domestic purposes (Mc Ghee, 1991). The result of chlorides ranged from 17.74 mg/L to 312.5 mg/L. Figure 9 shows that station 4 had the highest level of chloride, since it was situated near the coast. Saline water contains much chloride ions. Moreover, high chloride concentration can also be due to the residents practice of disposing the used water for laundry and bathing that eventually percolates to the groundwater (McGhee, 1991). The lowest level of chloride was recorded in station 5, which was far from the coast and had a high elevation. As stated by the Philippine National Standard for Drinking Water that the standard value for chloride is only 250 mg/L. Figure 9 shows that only station 4 was above the tolerable limit and is not fit for drinking purposes because of the salty taste due to high chloride concentration.

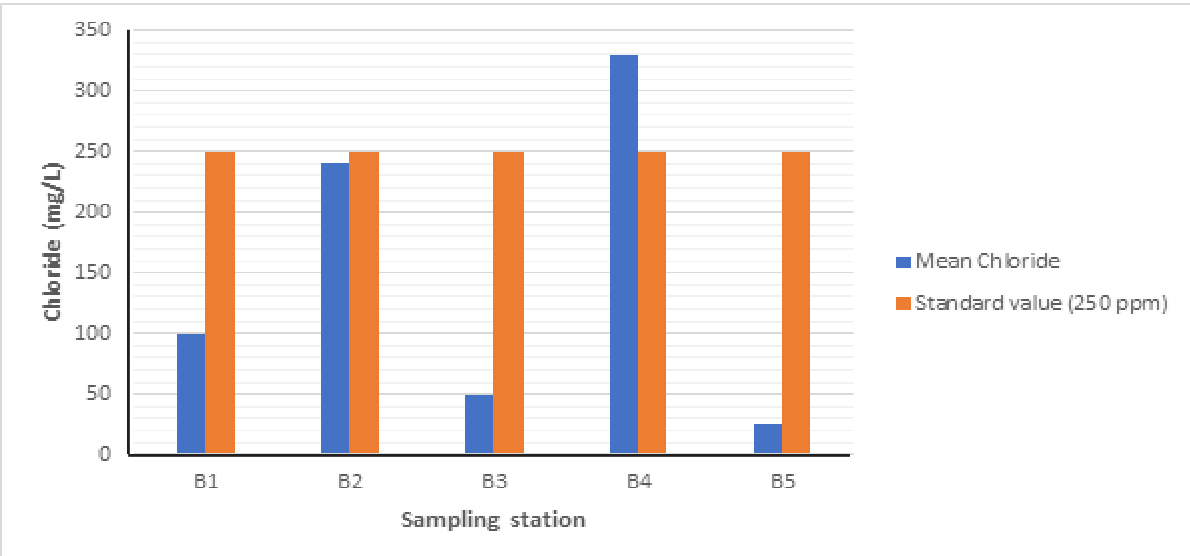

Figure 9. The comparison of chloride mean with the standard value.

Nitrates

Nitrates pose threats to human health since the human body is capable of reducing nitrates to nitrites in the digestive system. Nitrite can oxidize the hemoglobin to methemoglobin which is incapable of transporting oxygen in the bloodstream. This condition is known as blue baby disease. Furthermore, nitrite can combine to various amines in the gastrointestinal tract to form nitrosamines, which are known to be carcinogenic (Henry and Heinkie, 2000). The levels of nitrate in Barangay Badas as shown in Figure 10 ranged from 1.2 mg/L to 67 35 mg/L. The highest level of nitrates was obtained in station 2, which was situated on an agricultural land. As stated by Henry and Heinke, the use of fertilizers can be the source of nitrates and other nutrients in an agricultural land. High nitrates in this area may have been attributed by manure from livestock to make the soil more fertile. The lowest level of nitrates was recorded in station 5, where there were no agricultural activities.

Figure 10 shows the comparison between nitrate analyses for every sampling station with the standard value as set by the Philippine National Standard for Drinking Water The graph shows that only station 2 was above the tolerable limit, which was 50ppm. Consumption of very dilute solutions of nitrates can cause methemoglobinemia or blue baby syndrome in infants.

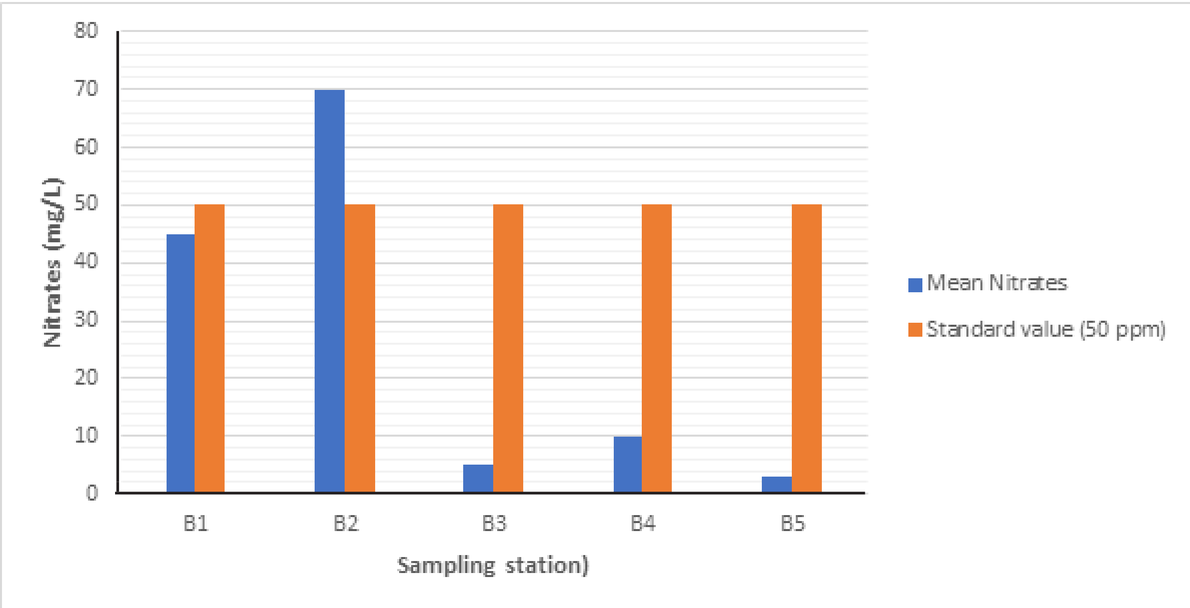

Figure 10. The comparison of nitrates mean with the standard value.

The natural source of sodium is weathering of salts deposits and contact of water with igneous rock (Manahan, 1994). Figure 12 shows the mean ppm or mg/L of sodium. Sodium concentration ranged from 22.7 mg/L. to 151 5 mg/L. The highest level of sodium was noted in station 4, which was located near the coast. One factor that may have probably caused the increased of sodium levels in this station, was the saline water that intruded in the groundwater Furthermore, results indicate that nearby residents threw their laundry water near the stations. Laundry soap contains builders, which softens water Common builders are tripolyphosphate (NagP:010). Na SO, also serves as fillers to add bulk to the powder and act as a drying agent to keep the powder flowing freely (Manahan, 1994). Station 5 was observed to have low level of sodium that was situated far from the coast. Sodium may be harmful if used as drinking water by persons on a “salt-free” (low sodium) diet for health reasons. Figure 11 shows the difference between the standard values to the experimental mean of sodium concentration. Result showed that stations 1, 2, and 4 were above the 50 mg/L.

tolerable limit set by the Philippine National Standard for Drinking Water High levels of sodium contribute to high blood pressure.

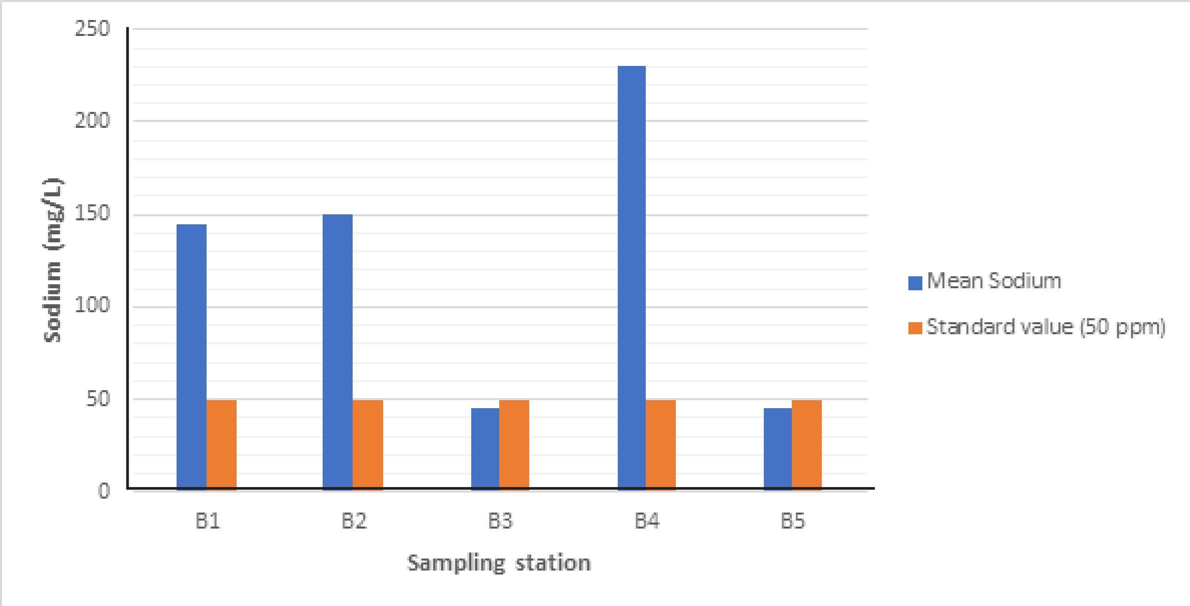

Figure 11. The comparison of sodium mean with the standard value.

Magnesium

Figure 12 shows the magnesium level of the different sites. The highest level of magnesium was recorded in station 2, which was 96.25 mg/l. that corresponds to the result for its total hardness. This area was noted as an agricultural land and near the coast. Also, it had low elevation that allowed waste from upland agricultural and domestic activities to accumulate through run off during rainfall which may have greatly affected the levels of magnesium. The lowest level of magnesium was noted in station 5 with a value of 20.87 mg/L, that was noted to be highly elevated and with high vegetation. Figure 12 shows no basis for standard value.

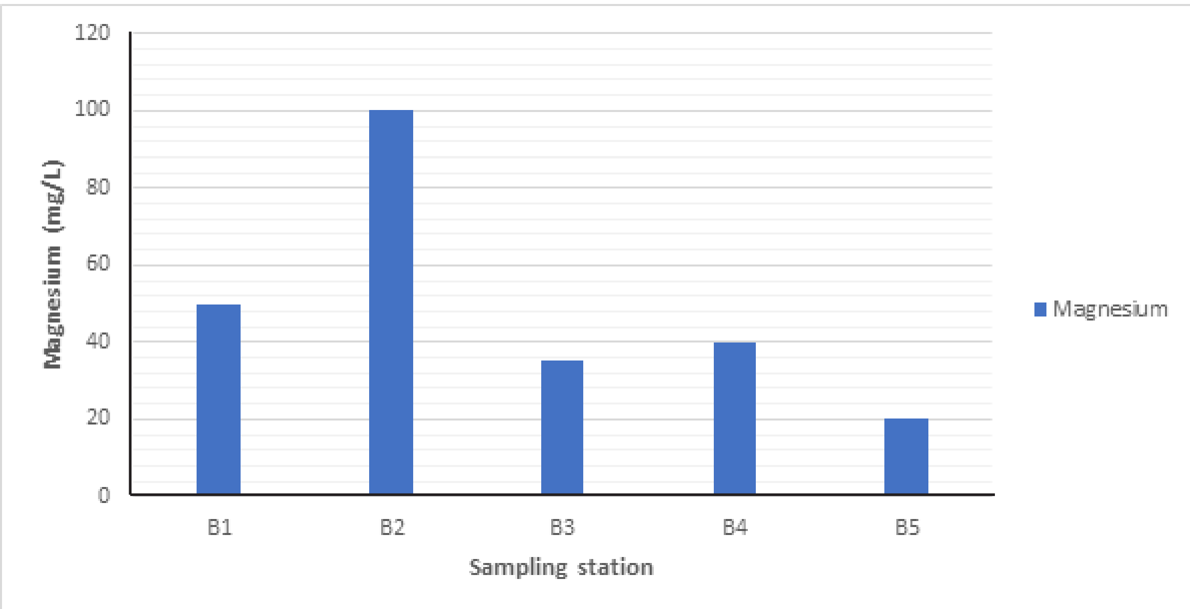

Figure 12. Mean magnesium content of sampled water.

Calcium

Calcium, magnesium and sometimes iron account for water hardness. The mean calcium concentrations of water at different stations are shown in Figure 13. Calcium level in Barangay Badas ranged from 74.25 mg/L to 105.5 mg/L. Station 4 had the highest value of 105.5 mg/L. Aside from the fact that this site was near the coast, this area had a slow rate in terms of run off, because of very low elevation. Low calcium levels were observed at station 5 probably because this area was highly elevated and the disposed water from laundry that may contain calcium and any man-made waste run off faster because of its slope Figure 13 shows no basis for standard value.

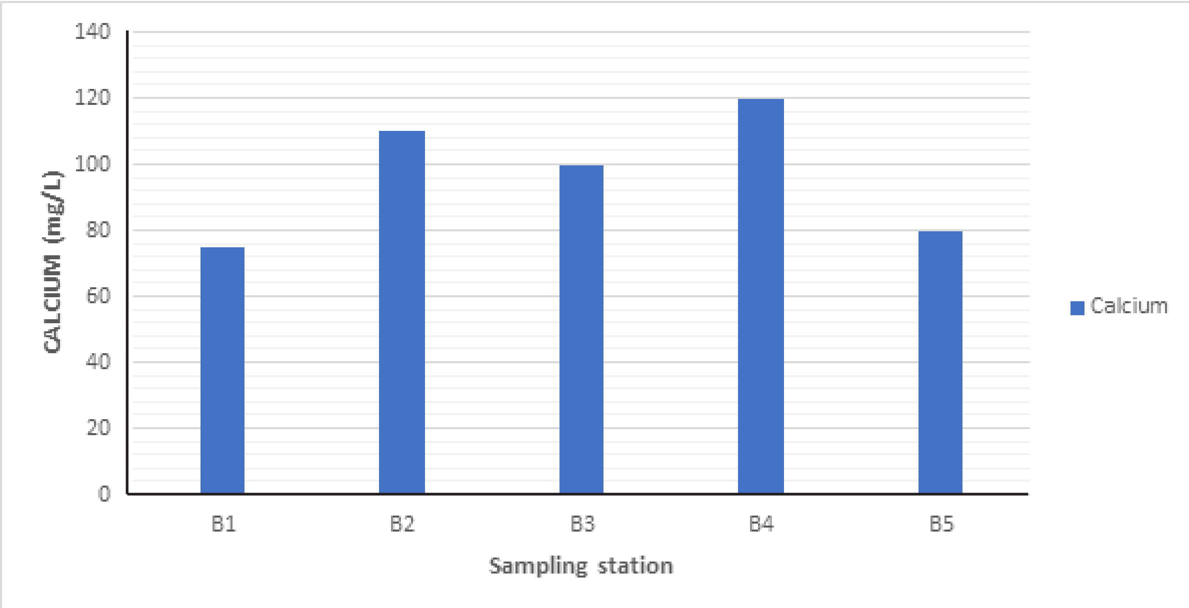

Figure 13. Mean calcium content of sampled water.

Water management practices

Table 3 shows that majority of the respondents in Barangay Badas (72.14%) conserved water by using a reservoir (67.33%), minimizing its use (32.18%), and the reusing of water (0.50%). Only 27,86% of the residents were not conserving the water due to abundant water supply (74.36%) and near the water source (25.64%). Furthermore, 29 29% reuse water for washing tricycle (6 10%), watering the plants (34.15%), washing the toilet (36.59%), and poultry and livestock (23.17%). The reasons for reusing it were to save water (82.93%) and to conserve the resource (17.07%), 70.71% did not reuse it since water was already dirty (84.34%), and there was plenty of water supply (15.66%). In Barangay Badas, 82.14% of the respondents had no reservoir for water use while only 17 86% had reservoir. Some residents (1.07%) had attended seminar about water conservation and management and only 33 33% adopted it.

Table 3. Water resource management related information.

Respondents that conserve water	Respondents (%)
Conserve water	72. 14
Not conserve	27.86

How	
Using a reservoir	67.33
Minimizing the use of water	32.18
Reusing the water	0.50
Reason/s (Conserve)	
Conservation	69.30
Support water needs	30.69
Reason/s (Not conserve)	
Abundance of water	74.36
Near the water source	25.64

Respondents that Reused Water	
None	70.71
Reused	29.29
How	
Washing toilet	36.59
Watering the plant	34.15
Poultry/livestock	23.17
Washing tricycle	6.10
Reason/s (Reused)	
To save	82.93
To conserve	17.07
Reason/s (For not using)	
Water is dirty	84.34
Plenty of water	15.66
Have Reservoir for Used Water	
None	82.14
Have	17.86

Statistical analysis

Reality the comparison between the standard value to the experimental mean showed no difference. To assess the significance or validity of the results from water analysis, the T-Test was used. The test was based on a comparison between the experimental mean and the true value with the largest difference that could be expected as a result of indeterminate error If (X-1)>ts/vn, the hypothesis that there was significant difference exist was rejected (Hargis, 1988). Table 11 to table 12 shows no basis for standard value.

Conclusion

Majority of the residents in Barangay Badas were using shallow wells. The common uses of their water were for cooking, drinking, washing, bathing, and watering of plants. This study found out that possible sources of groundwater pollutants were the improper sanitation, domestic sewage disposal and the use of fertilizers which greatly affected the quality of water Based on the Philippine National Standard for Drinking Water, MPN value exceeded the normal level. pH values were within the tolerable level while most of the parameters differed from one station to another Majority of the residents in Barangay Badas practiced water conservation by using reservoir, minimizing its utilization, and reusing of it.

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