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Biological and Chemical Characteristics of Groundwater in a Rural Settlement Area of Davao Oriental

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Abstract

The study was conducted to assess the quality of groundwater in Barangay Badas, City of Mati, Davao Oriental. Specifically, this included the 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. The t-Test was used for data analyses in comparing the experimental mean with the Philippine National Standards (PNS) and World Health Organization (WHO) standard for drinking water. The results for Most Probable Number (MPN) of coliforms per 100 mL sample and sodium were above the maximum level. The pH levels were within the safe limit for drinking water. The results for total dissolved solids, total hardness, chlorides, nitrates, magnesium and calcium varied from one station to another ranging from below to above the standard values. These results serve as baseline data for the local government units in formulating policies for public safety and sustainable management of the groundwater resources.

Keywords: Biological; Chemical; Groundwater; Philippine National Standard; Rural settlement; Water quality

1. Introduction

Groundwater is the largest reservoir of unfrozen fresh water in the hydrologic cycle. It is essential not only for industrial processes and power generation, for livestock and irrigation but for domestic purposes as well. It is a source of drinking water [1]. While groundwater supply is replenished and renews 1,400 years, its withdrawal from aquifers is faster than natural recharge [2]. Urbanization had greatly affected the availability and quality of water. Excessive withdrawal can lead to surface subsidence, salt water intrusion, and decrease water supply which greatly affect groundwater quality.

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Furthermore, the urban and agricultural run-off such as oils, fertilizers and pesticides, which are pollutants in surface water, can migrate downward, especially in the areas where there is intensive pumping and declining groundwater levels [3]. The variation of water quality also stems from human activities such as waste disposal on the land surface. Household garbage and waste dumps may contain toxic chemicals that can slowly seep into the groundwater [4]. Contamination may also include pathogenic organisms which are major cause of water borne diseases like amoebic dysentery, typhoid, polio,cholera and hepatitis [2].

The quality of water affects the health of individuals and the community as a whole. In a rural area of Davao Oriental, water treatment is absent or inadequate, if available. Further, there is very little available information in relation to their quality of water. Hence, this study was conducted to assess the chemical and microbiological properties of drinking water in Badas, City of Mati, Davao Oriental, Philippines. It specifically aimed to determine MPN, pH, total dissolved solids, total hardness, chlorides, nitrates, sodium, magnesium and calcium levels of their drinking water. The water quality determination ensures that water is safe for drinking and provides baseline information for the community and government agencies in formulating policies for sustainable management of the groundwater resources.

2. Materials and Methods

2.1 Description and Establishment of Sampling Sites

The study was conducted in Barangay Badas, Mati, Davao Oriental, Philippines. It consisted 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 were shallow wells and spring [5]. Figure 1 shows the identified sampling sites of the study using the following criteria: (1) the representative well for the area, (2) accessibility of the well, and (3) the number of households served. These were the descriptions of the different sampling sites with respective coordinates on the Global Positioning System (GPS): **station 1** – agricultural area (N 6° 56.327' E 126° 10.565; **station 2** – agricultural area (N 6° 54.799' E 126° 10.840') ; **station 3** – residential (N 06^{o} 56.040' E 126^{o} 10.748'); **station 4 –** residential (N 06^{o} 56.720' E 126^{o} 11.215'); **station 5 –** residential **(**N 06^{o} 57.342' E 126^{o} 10.958').

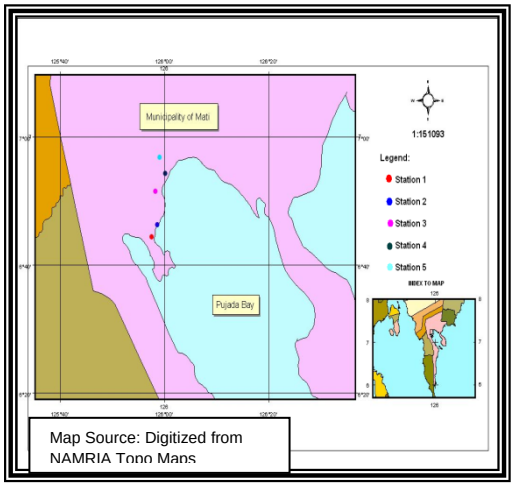

Figure 1: Map showing the locations of geographically referenced study stations at Barangay Badas, Mati, Davao Oriental.

2.2 Sample collection

Collection of water samples was done by heating the edges of the faucet. Water samples were collected after the pump or faucet had been running for ten to fifteen minutes. Before filling, the bottle was rinsed two to three times with the water collected. A two liter of water sample was collected for the chemical analyses [6]. For the microbiological characteristics, a 200- mL sterile container free of microbial inhibitors was filled with water sample [7].

The chemical parameters were analyzed using the following methods: pH using Glass Electrode method [6], 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 [7]. For microbiological parameter, the Most Probable Number Determination technique was used [7]. The Philippine National Standard (PNS) [8] for Drinking Water, 1993 and World Health Organization (WHO) [9] standard were used for its quality assessment. One sample t-Test was used in comparing with the standard value.

3. Results and Discussion

The mean values for the microbiological and chemical analyses of groundwater and the PNS or WHO Standards are summarized in bar graphs below.

The Total coliform (MPN/100mL) of water samples for the different sampling sites ranged from 2.2 to 16 MPN/100mL. These were above the maximum level as stated by the Philippine National Standard for drinking water. The presence of coliform is taken as an indication that pathogenic organisms were present. It was noted that septic tanks were too close to the wells which may be a source of contamination [10].

The pH is one of the important parameters for water quality determination. It is greatly affected by anthropogenic activities. Water pH lower than 6.5 may cause leaching of toxic metals from water pipe while pH greater than 8.5 has adverse effect on the disinfection process [11]. The pH values, on the other hand, ranging from 7.0 to 7.15 were within the safe limits for drinking water (PNS, 1993).

The permissible total dissolved solids for drinking water is 500 ppm. It was found out that three sampling stations were beyond the limit . The range of TDS level in the study area was 378 to 1088 ppm. The highest TDS concentration at Station 2 was due to dense residential area and intensive irrigation activity [1]. Although generally, high level of TDS is not harmful to humans but it can affect persons with kidney and heart conditions [12].

Total hardness of the groundwater samples ranged from 271mg/L to 659.5 mg/L. The levels in four sampling stations were beyond the permissible limit with station 2 having the highest level which is located near the coast. This high level could also be attributed to the large bulk of agricultural waste and disposed water from laundry along this site. Station 5 had the lowest concentration of 271 mg/L. This station had high elevation causing man made waste to run off and minimal percolation.

The chlorides concentration ranged from 17.74 mg/L to 312.5 mg/L. High level of chloride in Station 4 was attributed by its location near the coast. Saline water contains much chloride ions. Generally, chloride content was found to be well within the permissible levels.

The levels of nitrate varied from 1.2 mg/L to 67.35 mg/L. The nitrate value for the study area was found to be within the permissible limit except for station 2 which was situated on an agricultural area. 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 to livestock manure application [13].

Sodium concentration ranged from 35.63 mg/L to 227 mg/L. The highest level of sodium was noted in station 4, which was located near the coast. Saline intrusion can increase sodium levels in this station. Furthermore, results indicate that nearby residents threw their laundry water near the stations. Laundry soap contains builders like tripolyphosphate (Na5P3O10) to soften and fillers (Na2SO4) to add bulk and act as drying agent [14]. 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.

The permissible level set by WHO standard for magnesium and calcium were 30 mg/L and 75 mg/L respectively. All sampling stations except Station 5 exceeds the limit with concentrations ranging from 20.88 mg/L to 96.25 mg/L for magnesium and 74.25 mg/L to 117.5 mg/L for calcium. In order to have safe drinking water, conservation of water natural sources is very essential. Strategies like protection, treatment and distribution management can lead to its sustainability.

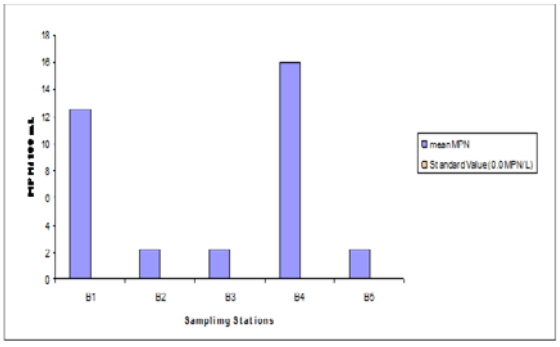

Figure 2: The comparison of MPN mean with the standard value.

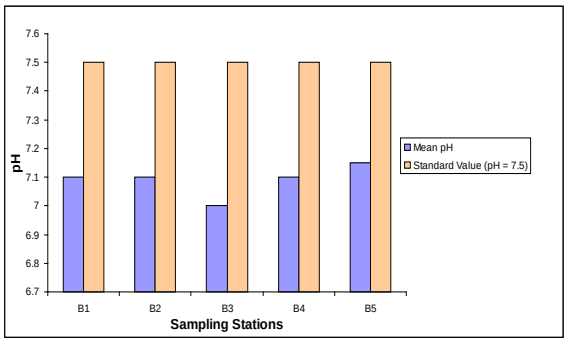

Figure 3: The comparison of pH mean with the standard value.

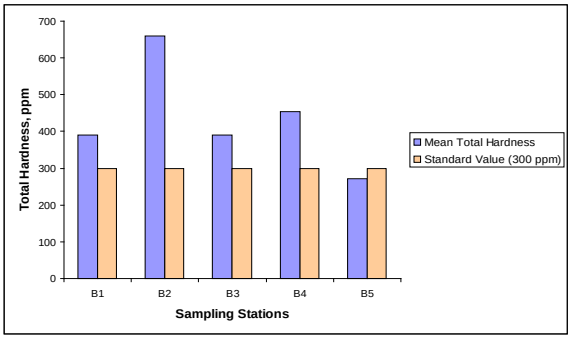

Figure 4: The comparison of TH mean with the standard value.

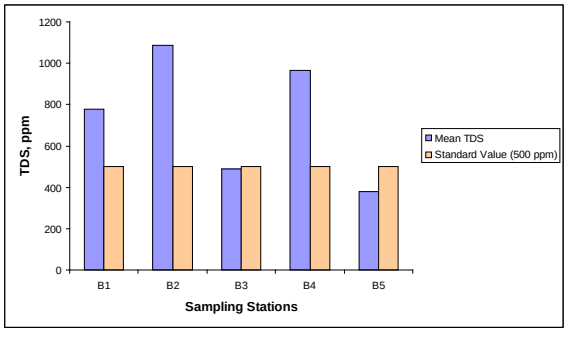

Figure 5: The comparison of TDS mean with the standard value.

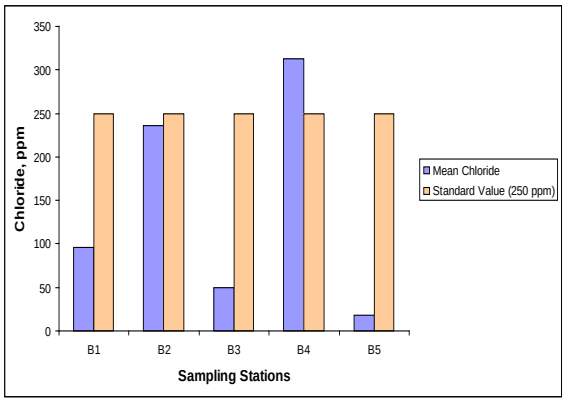

Figure 6: The comparison of Cl^- mean with the standard value.

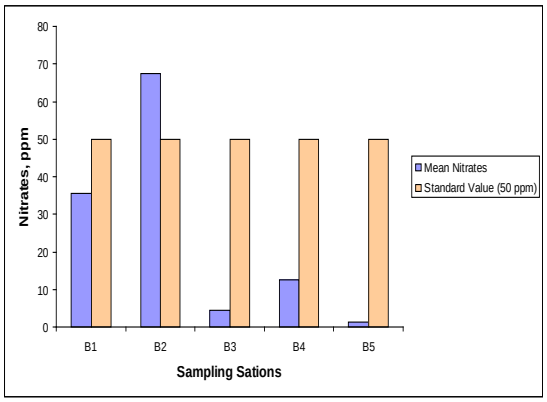

Figure 7: The comparison of Nitrate mean with the standard value.

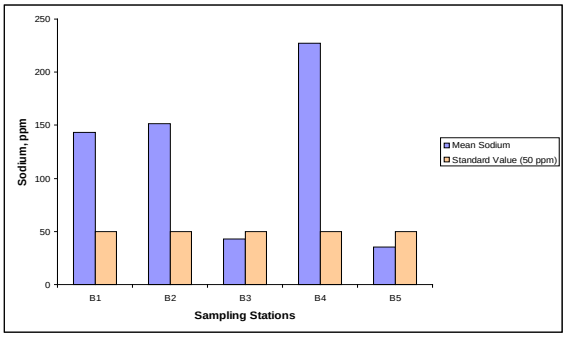

Figure 8: The comparison of sodium mean with the standard value.

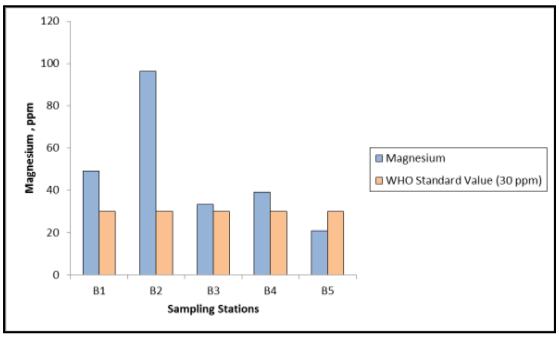

Figure 9: The comparison of magnesium mean with the standard value.

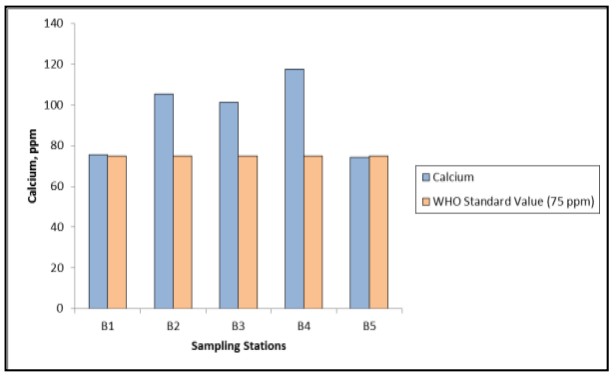

Figure 10: The comparison of calcium mean with the standard value.

4. Conclusion

The most probable number (MPN) value exceeded the limit set by Philippine National Standard for Drinking Water. The results showed that water, if not treated, was not safe for drinking. The pH values were within the tolerable level while most of the parameters differed from one station to another. These variation was mainly due to its elevation and its land use which greatly affected the quality of groundwater.

Acknowledgment

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