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Physicochemical and Microbial Analysis of Water from Selected Hand-Dug Wells in Ayeduase, Kumasi

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Abstract

Groundwater is a major source of water for commercial and drinking purposes for majority of the populace of developing nations. This study was carried out to assess the physicochemical and bacteriological quality of water from twenty five different hand-dug wells from five locations within the Ayeduase community. The study was carried out during the month of February and April which represent the dry season and rainy season respectively. The physicochemical parameters analysed include: pH, turbidity, conductivity, temperature, apparent/true colour, suspended solids, total solids, total dissolved solids, total alkalinity, total hardness, calcium hardness, and magnesium hardness, chloride (Cl^-) and nitrite (NO_2^-). Metals analysed are calcium (Ca), magnesium (Mg), and iron (Fe). The bacteriological quality was analysed using total and faecal coliform while employing the pour plate count method. Most of the parameters determined were within the World Health Organisation guideline limits for portable water. However, the values determined for total coliform exceeded the World Health Organisation limit for drinking water.

Keywords

Physicochemical, Bacteriological, Hand-Dug Wells

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1. Introduction

Groundwater is generally considered as a safe drinking water but rapid population growth, increasing standard of living in urban areas and industrialisation have resulted in greater demand for quality water while on the other hand, pollution of water sources is increasing steadily. Water is necessary for the healthy development of man, animals, and plants. The preference for ground water to surface water may be due to the need for purification of the latter prior to distribution [1]. Drinking water plays a significant role in the intake of trace elements by man. It is, therefore, imperative that physicochemical and bacteriological characteristics are determined to find out its suitability for domestic use by man. For this reason, many scientists have performed various experiments to ascertain the quality of ground water being used by people for domestic purposes [2-5].

In as much as safe drinking water is essential to health, a community lacking good quality drinking water will be saddled with a lot of health problems which could otherwise be avoided [6]. According to World Health Organization [7], in the next thirty years alone, accessible water is unlikely to increase more than ten percent (10%) but the earth's population is projected to rise by approximately one-third. Unless the efficiency of water use rises, this imbalance will reduce quality water services, reduce the conditions of health of people and deteriorate the environment and the world. Approximately 70% of freshwater is consumed by agriculture [8], and water is vital to the life of an organism and that the content in the body be maintained, as an animal

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will die more rapidly if deprived of water than if deprived of food [9].

Water-related diseases are responsible for 80% of all illnesses/death in developing countries [10]. However, poor sanitation and persistent faecal contamination of water sources is responsible for a large percentage of people in both developed and developing countries not having access to microbiologically safe drinking water and suffering from diarrhoeal diseases. Hard water leads to excessive use of soap and detergents in households which is either environmentally friendly or sustainable [7]. Groundwater pollution in urban areas is mostly due to infiltration of urban storm water, leakage of waste waters and septic reservoirs and improper industrial activities [11-13].

The greatest risk from microbes in water is associated with consumption of drinking water that is contaminated with human and animal excreta, although other sources and roots of exposure may also be significant. Detection of each pathogenic microbe organism in water is technically difficult, time consuming and expensive and therefore, not used for routine water testing procedures [14]. Instead, indicator organisms are routinely used to access the microbiological quality of water and provide an easy, rapid and reliable indication of the microbiological quality of water supplies [14, 15]. The intestinal tract of man contains countless rod shaped bacteria known as coliform organisms.

Many households in the Kumasi metropolis, especially the suburbs where the flow of pipe-borne water is inconsistent, have dug wells from which they draw water for their use. Ayeduase is one of such suburbs with a large student population and many hostels which depend on hand dug wells. The purpose of this study was to determine the quality of water from the hand-dug wells from various sources in Ayeduase community where most of the non-resident students of the Kwame Nkrumah University of Science and Technology (KNUST) reside.

2. Methods and Material

2.1. Study Area Description

The Ayeduase community where the research was carried out is located within the Kumasi Municipality in the Ashanti Region of Ghana. Ayeduase is a satellite town of KNUST with a lot of hostels to accommodate students due to lack of accommodation on campus. It is located at an elevation of 246 meters above sea level and population amounts to 29748 people. The Ayeduase community is located between latitude of 6.66667 and longitude of -1.56667. The major economic activities within the community are petty trading and hostels or room rental for non-resident students of the KNUST.

2.2. Sampling Site

Table 1. Samples and the locations from which they were sampled.

SAMPLE	LOCATION		
	Longitude	Latitude	Elevation
A	W001°33.617	N06°40.537	936 feet
B	W001°33.427	N06°40.516	903 feet
C	W001°33.320	N06°40.471	920 feet
D	W001°33.289	N06°40.514	961 feet
E	W001°33.321	N06°40.502	945 feet

2.3. Sample Collection

The Ayeduase community was divided into five locations. A total of twenty five different wells were randomly selected to represent the study area, with five wells from each of the five locations. The samples were collected directly from groundwater source with resident buckets at the wells and put into 1.5 litre sterilised plastic bottles which had been prewashed with the water sample to be taken. The bottle was tightly closed with the cap immediately after pouring the water into them and then labelled to aid easy identification. Sampling was done during dry season and rainy season. Sampling was done in the morning between the hours of 6am to 7am. Collected water samples were kept in ice chests loaded with iced blocks, to prevent possible alteration of parameters by light and to ensure that the microorganisms remained viable though dormant. The samples were then transported to the laboratory and then stored in the refrigerator until they were analysed. Test on bacteriological parameters were conducted within six hours after sampling.

2.4. Laboratory Analysis

Standard methods prescribed in America Public Health Association [16] and the Environmental Protection Agency of America was used to analyse the water samples.

The pH and turbidity were measured with HACH 31 pH meter and HACH model 2100P and on site. Conductivity and Total dissolved solids were determined on site using Jenway 4510 conductivity meter. A thermometer was used to measure the temperature on site. The colour, calcium, magnesium and total suspended solids were analysed using DR 5000 spectrophotometer. Alkalinity and total hardness were determined by titrimetric method whereas chloride was determined by Mohr Argentometric method using spectrophotometric method. Iron was analysed with phenanthroline methods.

2.5. Bacteriological Determination

Pour plate count method was used to determine the presence and abundance of bacteria. 1ml of each sample was taken into a pour plate with different pipette and 10ml of macconkey agar was added. This was then incubated at 37°C for total coliform and 44°C for faecal coliform and left over night for fermentation to take place, and the number of spots observed in the plate was counted and recorded.

3. Results and Discussion

The mean values obtained for the physicochemical and microbial tests during the dry and rainy seasons are recorded in Table 2 and Table 3 respectively. The pH ranged from 6.27 – 6.74 during the dry season and 6.41 – 6.85 during the rainy season. These values were all within the WHO limits for pH. At extremely high or low pH levels (for example 9.6 or 4.5), the water becomes unsuitable for most organisms. Relatively high pH values were recorded for all the samples during the rainy season than during the drying season.

Turbidity values recorded in the dry season were generally lower than in the rainy season, except at location B. The mean values ranged from 0.50 – 2.36 during the dry season with location B recording the abnormally high value of 2.36. The remaining four locations recorded value below 1.00. However, only location A had an acceptable mean turbidity value of 0.50 NTU during the dry season. All the mean turbidity values in the five locations were above the W.H.O. limit of 0.50 during the rainy season.

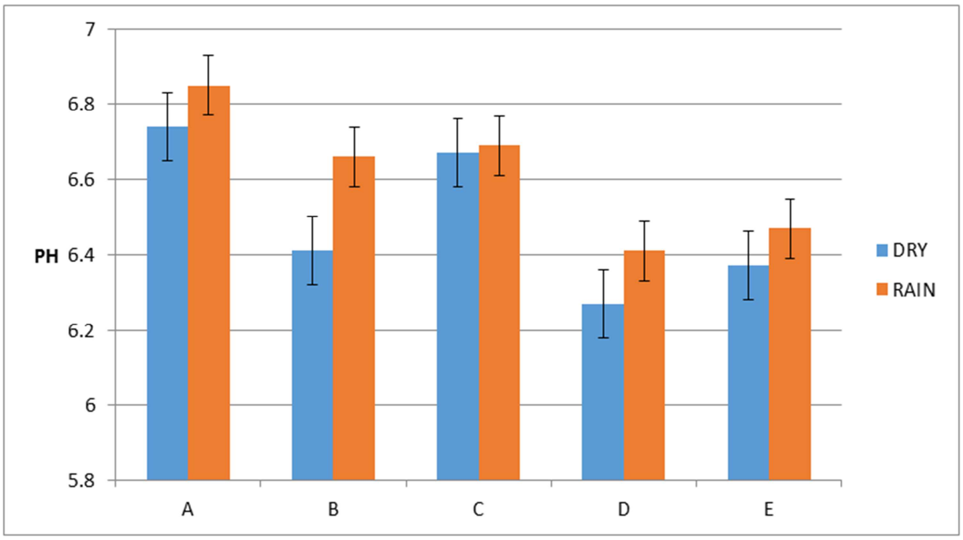

Fig. 1. Seasonal variations in pH levels in samples.

Table 2. Mean values recorded for the physicochemical and microbial tests during the dry season.

PARAMETER	SAMPLES					W.H.O. Limit
	A	B	C	D	E	
PH	6.74	6.41	6.67	6.27	6.37	6.5-8.5
Turbidity (NTU)	0.50	2.36	1.00	0.72	0.75	0-5
Conductivity (µs/cm)	514	185.2	13.80	18.60	18.81	0-1000
Temperature (^{o}C)	23.7	23.0	23.9	23.7	22.6	-
App/ True Colour(Hz)	0	4	2	1	1	0-15
Calcium(mg/L)	21.6	5.6	7.2	4.8	6.4	200
Magnesium(mg/L)	7.80	2.44	1.95	1.46	1.43	150.00
Iron(Total) (mg/L)	0.00	0.00	0.00	0.00	0.00	0-0.3
Chloride(mg/L)	30.0	22.0	12.0	11.0	12.0	250.0
Nitrite(NO_2-N) (mg/L)	0.006	0.008	0.002	0.002	0.005	3.0 max
Suspended Solids(mg/L)	0	0	0	0	0	-
Total Dissolved Solids(mg/L)	309.00	111.20	8.52	11.17	11.33	1000.00
Total Solids(mg/L)	309.0	111.2	8.52	11.17	11.33	-
Total Alkalinity(mg/L)	14.0	12.0	20.0	20.0	14.0	-
Total Hardness(mg/L)	86.0	24.0	26.0	18.0	22.0	500.0
Calcium Hardness(mg/L)	54.0	14.0	18.0	12.0	16.0	-
Magnesium Hardness(mg/L)	32.0	10.0	8.0	6.0	6.0	-
Total Coliform(cfu/100ml)	0	376	TNTC	72	56	0
Faecal Coliform(cfu/100ml)	0	0	0	0	0	0

TNTC – Too numerous to count

Table 3. Mean values recorded for the physicochemical and microbial tests during the rainy season.

PARAMETER	SAMPLES					W.H.O. Limit
	A	B	C	D	E	
PH	6.85	6.66	6.59	6.41	6.47	6.5-8.5
Turbidity (NTU)	1.99	1.23	2.35	1.16	7.44	0-5
Conductivity (us/cm)	1007	122	336	256	300	0-1000
Temperature(°C)	25.9	26.4	26.6	25.9	25.6	-
App/ True Colour(Hz)	0	4	2	1	1	0 -15
Calcium(mg/L)	21.6	5.6	7.2	4.8	6.4	200
Magnesium(mg/L)	7.8	2.44	1.95	1.46	1.43	150
Iron(Total)	0.00	0.00	0.00	0.00	0.00	0 -0.3
Chloride(Mg/L)	30.0	6.0	16.0	16.0	26.0	250
Nitrite(NO_2_N)	0.006	0.008	0.002	0.002	0.005	3.0max
Suspended Solids(mg/L)	0	0	0	0	0	-
Total Dissolved Solids(mg/L)	604	74	201	154.3	180.4	1000
Total Solids (mg/L)	309	111.2	8.52	11.17	11.33	-
Total Alkalinity(mg/L)	8.0	24.0	200	24.0	16.0	-
Total Hardness(mg/L)	76.0	12.0	22.0	16.0	32.0	500
Calcium Hardness(mg/L)	40.0	6.0	18.0	14.0	12.0	-
Magnesium Hardness(mg/L)	36.0	6.0	4.0	2.0	20.0	-
Total Coliform(cfu/100ml)	94	4	115	27	61	0
Faecal Coliform(cfu/100ml)	0	0	0	0	0	0

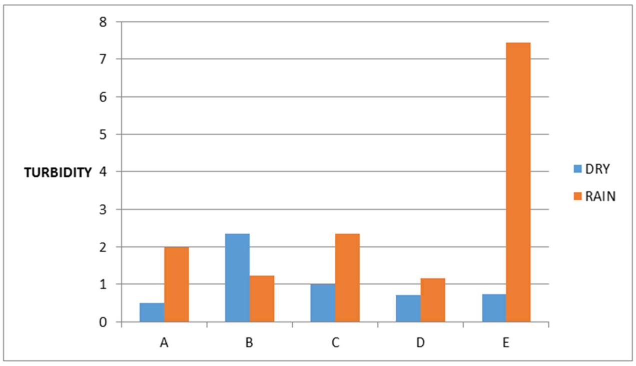

Fig. 2. Seasonal variations in turbidity levels in samples.

In both seasons, no values were recorded for total suspended solids for all the samples analysed.

During the dry season, mean values of total dissolved solids ranged from 8.52 mg/L to 309 mg/L and in the rainy season values ranged from 74 mg/L to 604 mg/L. The WHO permissible level is 1000 mg/L, hence all the sample fell within the acceptable limit. The acceptability of water in terms of taste with TDS values close to 600 mg/L is generally considered to be beneficial. Drinking water becomes unpalatable when TDS concentration becomes higher than 1000 mg/L. All the water sample except sample B recorded high TDS values during the rainy season and low TDS values during the dry season.

Mean values for total alkalinity ranged from 12.0mg/L for sample B to 20.0mg/L for sample C and D in the dry season and from 8.0mg/L for sample A to 24.0mg/L for sample B. Comparing to WHO standard of 200mg/L, all the water samples in both seasons fell within the recommended limits, meaning the water is safe for drinking.

Mean values for total hardness ranged from 18.0mg/L to 86.0 mg/L in the dry season and from 12.0 mg/L to 76.0 mg/L in the rainy season. These value are well below the W.H.O. standard value of 500 mg/L, meaning the water is safe for consumption.

In the dry season, mean values recorded for calcium hardness ranged from 12.0 mg/L to 54.0 mg/L and 4.0 mg/L to 18.0 mg/L in the rainy season. Sample A, B and E recorded high values in the dry season than in the rainy season. Sample D recorded high value in the rainy season compared to that of the dry season. Sample C shows no variations in both seasons.

Magnesium hardness value for the dry season ranged from 6.0 mg/L for sample D and E to 32.0 mg/L for sample A. Values in the rainy season ranged from 2.0 mg/L for sample D to 36.0 mg/L for sample A. Samples A and E recorded high values of magnesium hardness during the rainy season and low value in the dry season. Samples B, C and D recorded high values in the dry season and low values in the rainy season.

Magnesium hardness mean value for the dry season ranged from 6.0 mg/L for sample D and E to 32.0 mg/L for sample A. Values in the rainy season ranged from 2.0 mg/L for sample D to 36.0 mg/L for sample A. Samples A and E recorded high values of magnesium hardness during the rainy season and low value in the dry season. Samples B, C and D recorded high values in the dry season and low values in the rainy season.

Total coliform counts ranged from 0.00 to TNTC CFU (Colony Forming Units) per 100ml during the dry season for sample A and B respectively. During the rainy season counts ranged from 4.0 to 115 CFU/100ml for sample B and C respectively. Sample A did not record any count during the dry season, hence the water was safe for drinking during this season but unsafe in the rainy season. The rest of the samples recorded some counts in both seasons compared to WHO standard of zero count. This shows the extent of danger or health risk associated with water from these wells.

Faecal coliform refers to coliform organisms which grow at 44°C and ferment lactose to produce acid and gas. In practice, some organisms with these features may not be faecal in origin and the term thermo tolerant coliform is commonly used. None of the water sample recorded faecal coliform count in both seasons and hence no risk associated with faecal contamination, indicating that none of the wells are sited close to a latrine or any faecal contamination material. Proper well construction and location as well as the controling of human activities to prevent sewage from entering water body are the keys to the avoiding bacteria contamination of drinking water [13].

4. Conclusion

In this study, the investigated physicochemical parameters in the water from hand – dug wells from Ayeduase in the Ashanti region of Ghana were generally within the W.H.O. guideline values. However, the quality of groundwater supplied by wells were not satisfactory with respect to total coliform indicator bacteria since they were above the W.H.O. recommended limits. Such well water must therefore be treated to eliminate total coliform before consumption.

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