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ScopeMed

Prevalence study of microbiological and physicochemical quality of water from Boreholes and Hand-dug wells located in Ejisu-Juaben Municipal District's urban communities

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ABSTRACT

Aim: The microbial and physico-chemical quality of water from boreholes and hand-dug wells in urban communities within the Ejisu-Juaben Municipality of Ashanti region was studied. **Methods:** Water samples were collected from three boreholes and three hand-dug wells selected randomly from each community and the water samples analyzed using various standard methods. **Results:** pH of the water from boreholes and hand-dug wells ranged from pH 4.34-5.13 units which fell below WHO guideline value for drinking water. The water was non-saline with all TDS values less than 1000 mg/l and soft to slightly hard (18.89-127.00 mg/l $CaCO_3$). The anion (SO_4^{-2}, NO_3^-, Cl^- and F^-) levels in the water samples from selected boreholes and hand-dug wells were observed to be low and fell within the WHO guideline values. One borehole at Ejisu and two boreholes at Juaben recorded total coliform in water samples with mean values of 2.08×10^4 and 3.06×10^4 CFU $100ml^{-1}$ respectively with zero counts for faecal coliform and *E. coli*. Boreholes at Fumesua and Bonwire recorded zero counts for total coliforms, faecal coliforms and *E. coli*. Only one borehole at Besease recorded total coliforms, faecal coliforms and *E. coli* in water samples. Most hand-dug wells selected for the study recorded total coliforms, faecal coliforms and *E. coli* in samples with mean values of 4.92×10^5, 1.01×10^5 and 3.81×10^4 CFU $100ml^{-1}$ respectively. The mean differences of total coliforms, faecal coliform and *E. coli* counts between boreholes and hand-dug well was highly significant ($p=0.001$, $p=0.014$ and $p=0.001$ respectively). **Conclusion:** Bacteriological quality of the water from all hand-dug wells were very poor (above detectable limits) compared to the boreholes and thus must be treated before use.

KEY WORDS: Ejisu Juaben Municipality; Urban communities; Boreholes; Hand-dug wells; Total coliforms; Faecal coliforms; *E. coli.*

INTRODUCTION

Water is life and one of the earth's most precious resources. It is very crucial for survival yet over one billion men, women, and children do not have enough safe water to drink and thus their chance of living a healthy life is compromised [1]. Those mostly affected are innocent children and desperate families living in overcrowded urban slums, in refugee camps, and in poverty-stricken towns and villages in rural areas of developing countries around the world [2]. The consumption of water worldwide increases yearly while most of the world's water resources continue to dwindle due to improper environmental management practices. Pathogenic microorganisms cause waterborne diseases and are most commonly transmitted in contaminated water. Infection commonly results during bathing, washing, drinking, in the preparation of food, or the consumption of food thus infected. Various forms of waterborne diarrheal disease such as dysentery, cholera and typhoid probably are the most prominent examples, and affect mainly children in developing countries and it is attributable to unsafe water supply, sanitation and hygiene [3]. Every year, around 250 million people are infected with water-borne pathogens resulting in 10 to 20 million deaths world-wide. It has been estimated that 80% of all illness in developing countries is related to water and sanitation and 15% of all child deaths under the age of five years in developing countries result from diarrheal diseases [3]. The lack of clean drinking water and sanitation systems is a major public concern in Ghana, contributing to 70% of diseases in the country. Consequently, households without access to clean water are forced to use less reliable and unhygienic sources of water [4]. This is the reason why the quality of our food and water are monitored, personal hygiene and policies established in order to prevent contamination in the first place. Studies have shown that faecal indicator bacteria survive from a few hours up to several days in water, but may survive for days or months in sediments, where they may be protected from sunlight and predators [5]. Every year, millions of people die in developing countries from diseases such as dysentery, salmonellosis, shigellosis and typhoid due to inadequate safe drinking water and sanitation measures. The assessment of potable water supplies for coliform bacteria is very significant in evaluating the sanitary quality of drinking water because high levels of coliform counts suggest a contaminated source, inadequate treatment or post treatment deficiencies [6]. It has been shown that drinking water supplies have a long history of association with a wide spectrum of microbial infections [7]. For the past 20 years, Ejisu-Juaben Municipal has no pipe-borne water supply. Until 1984, Ghana Water Company limited (GWCL) was supplying water to some selected areas of the district with water from its head works at Barekese a suburb of Kumasi [8]. Currently, the municipality relies mainly on groundwater for its water supply needs and information on groundwater quality is inadequate. Studies have shown that groundwater contamination often correlates with areas of poor hygiene standards and sanitation [9; 10; 11]. Majority of the boreholes and hand-dug wells since being constructed have scarcely been maintained, rehabilitated or any major assessment carried out on the quality of water being pumped from it. Also professional consultation was not properly done because most of the boreholes and hand-dug wells are close to public utility areas, septic tanks, farmlands and piggeries which pose a threat to groundwater quality. The main objective of this study was to assess the quality of groundwater in the Ejisu-Juaben municipality of Ashanti Region for effective and efficient management so as to prevent diseases among the inhabitants living within the municipality.

MATERIALS AND METHODS

Study area

Ejisu-Juaben Municipal is one of the 27 administrative and political districts in the Ashanti Region of Ghana. It lies within latitude 1.15°N and 1.45°N and longitude 6.15°W and 7.00°W. It lies within the semi deciduous forest zone of Ghana, which does not differ much in appearance from the rain forest [12]. The study area is predominantly underlain by crystalline rocks. These rocks belong to the Birimian, Granites formation [13]. The mean annual rainfall is 1200mm with temperatures range between 20°C in August and 32°C in March [14]. The 2010 National Population Census put the population of the Municipality at 143,762 comprising 68,648 males and 75,114 females and the main occupation in the Municipality is farming.

Selection of boreholes and wells

Out of 84 settlements, the municipal has only five (5) urban centres namely: Ejisu, Juaben, Bonwire, Fumesua and Besease. These five towns account for 30.18% of the total population in the district with the municipal capital covering 9.2% [15]. Public boreholes and hand-dug wells were used for the study. All the boreholes in each urban community were used for the study with the exception of Ejisu where simple random sampling was used to select 3 out of the 4 boreholes. Simple random sampling was used to select 3 hand-dug wells from each urban community with the exception of Juaben where purposive sampling was used to select the only hand-dug well at the northern part of the town and random sampling used to select 2 out of the 4 hand-dug wells at the southern part of the town. A total of fifteen boreholes and fifteen hand-dug wells were sampled for the study. A GPS was used to geographically locate all sampling communities (Fig. 1).

Sample collection

Samples were collected in the early hours of the morning with sterilized plastic bottles. For boreholes, the mouth of the metal pipe was cleaned with alcohol and flamed. For the hand-dug wells, sterilized plastic container with rope was used to fetch water from wells. The bottles were rinsed with some of the water from the boreholes and hand-dug wells and then completely filled to capacity leaving no air space and immediately covered and sealed with masking tape. Distances of boreholes and hand-dug wells to unsanitary sites were measured with 100m or 330ft fibre glass measuring tape. Water samples were taken to the laboratory in cool box with ice and analyzed within 6 hours.

Laboratory analysis

Temperature, pH, total dissolved solids (TDS) and electrical conductivity (EC) of water samples were measured on site using Cyberscan PC 300 Waterproof Handheld pH/Conductivity/TDS/Temperature meter. Turbidity and colour of water samples were determined using nephelometric method and Lovibond® Nessleriser 2150 respectively. Total hardness and chloride in water samples were determined by complexometric titration using Ethylenediamminetetraacetic acid (EDTA) and Argentometric method respectively. The levels of sulphate and nitrate in water samples were determined by Hach DR/2400 Portable Spectrophotometer (HACH, USA) using Sulfa Ver 4 method and Cadmium Reduction method respectively. Fluoride levels were also determined by Hach DR/2000s spectrophotometer (HACH, USA). Standard methods were used to determine total coliform, faecal coliform and *E. coli* [16; 17].

Statistical analysis

Paired sample T-Test was used to analyze data using the SPSS (version 16) software for windows (SPSS Inc., Chicago, IL, USA) to examine the apparent differences and means of observed data between the different sampling location of the boreholes and hand-dug wells. Tables and graphs were obtained using the Microsoft Excel Programme (Microsoft Corporation, 2010). The statistical analyses were carried out at $P \leq 0.05$ level of significance.

RESULTS

Physicochemical parameters of water from boreholes and hand-dug wells

Water samples from boreholes and hand-dug wells at Juaben recorded highest mean temperatures while the mean lowest temperatures for boreholes and hand-dug wells were recorded at Besease and Bonwire respectively (Table 1 and 2). Even though mean temperature of borehole water samples was higher than hand-dug wells (Table 5), the difference was not statistically significant ($p=0.075$). Water samples from boreholes and hand-dug wells across different locations had pH values below the WHO recommended guideline value for drinking water (Table 1 and 2). Mean pH value of hand-dug wells was higher than boreholes (Table 5) but the difference was not statistically significant ($p=0.353$). TDS values of water samples from boreholes and hand-dug wells across different locations were within WHO recommended guideline value for drinking water (Table 1 and 2). Mean TDS value of hand-dug wells was lower than boreholes (Table 5) and the difference was not statistically significant ($p=0.187$). Water samples from boreholes and hand-dug wells across different locations had EC values within limits prescribed by WHO (Table 1 and 2). Mean EC value of boreholes was higher than hand-dug wells (Table 5) and the difference was not statistically significant ($p=0.187$). There was a positive correlation between TDS and EC which was highly significant. Total hardness values of water samples from boreholes and hand-dug wells across different locations were within WHO recommended guideline value for drinking water (Table 1 and 2). Mean value of total hardness for hand-dug wells was lower than boreholes (Table 5) and the difference was statistically significant ($p=0.001$). Water samples from boreholes and hand-dug wells across different locations had colour values within the WHO recommended guideline value for drinking water (Table 1 and 2). Mean value of colour for hand-dug wells was higher than boreholes (Table 5) and the difference was statistically significant ($p=0.001$). Turbidity values of water samples from boreholes across different locations were within WHO recommended guideline value for drinking water but some of the hand-dug wells had values above WHO limits (Table 1 and 2). Mean value of turbidity for hand-dug wells was higher than boreholes (Table 5) and the difference was statistically significant ($p=0.001$).

Table 1. Mean (± SD) and range values of physicochemical parameters analysed for borehole water in Ejisu-Juaben Municipality.

Parameters	Temperature (˚C)	pH	Total dissolved solids (mg/l)	Electrical Conductivity (µS/cm)	Total hardness (mg/l $CaCO_3$)	Colour (HU)	Turbidity (NTU)
WHO limits		**6.5 – 8.5**	**1000**	**1500**	**500**	**15**	**5**
Towns							
Ejisu	**27.50±0.43** (27.00-28.10)	**4.71±0.39** (4.20-4.99)	**39.20±2.16** (36.30-41.30)	**78.40±4.32** (72.60-86.60)	**23.00±5.94** (12.00-29.00)	**6.67±2.50** (5.00-10.00)	**0.47±0.13** (0.30-0.57)
Juaben	**28.36±2.07** (26.30-31.20)	**4.74±0.56** (4.01-5.27)	**150.67±4.09** (141.00-155.00)	**301.33±8.19** (282.00-310.00)	**46.56±3.47** (42.00-50.00)	5.00	**0.34±0.11** (0.22-0.47)
Fumesua	**27.93±0.33** (27.50-28.30)	**4.53±0.63** (3.93-5.34)	**82.11±4.30** (75.90-89.00)	**164.22±8.61** (151.80-178.00)	**25.33±2.65** (22.00-28.00)	5.00	**0.62±0.13** (0.51-0.80)
Bonwire	**26.94±0.83** (25.90-28.00)	**4.34±0.37** (3.84-4.64)	**339.46±2.98** (335.00-343.50)	**678.91±5.95** (670.00-687.00)	**127.00±0.87** (126.00-128.00)	**6.11±2.20** (5.00-10.00)	**1.54±1.18** (0.41-2.98)
Besease	**26.93±0.63** (26.00-27.60)	**5.13±0.40** (4.63-5.55)	**62.29±3.94** (58.30-67.50)	**124.58±7.88** (116.60-135.00)	**36.11±1.90** (34.00-39.00)	5.00	**0.38±0.05** (0.32-0.42)

Table 2. Mean (± SD) and range values of physicochemical parameters analysed for hand-dug wells in Ejisu-Juaben Municipality.

Parameters	Temperature (˚C)	pH	Total dissolved solids (mg/l)	Electrical conductivity (µS/cm)	Total hardness (mg/l $CaCO_3$)	Colour (HU)	Turbidity (NTU)
WHO limits		**6.5 – 8.5**	**1000**	**1500**	**500**	**15**	**5**
Towns							
Ejisu	**27.19±0.24** (26.90 – 27.50)	**4.66±0.28** (4.06 – 5.10)	**116.67±3.58** (112.00 – 122.00)	**233.33±7.15** (224.00 – 244.00)	**18.89±2.26** (16.00 – 23.00)	**12.22±2.64** (10.00 – 15.00)	**7.79±2.94** (4.00 – 12.00)
Juaben	**27.28±0.21** (27.00 – 27.60)	**4.61±0.20** (4.40 – 4.89)	**75.27±2.89** (72.70 – 79.00)	**150.53±5.79** (145.40 – 158.00)	**33.22±3.03** (30.00 – 38.00)	**8.33±3.54** (5.00 – 15.00)	**1.32±0.49** (1.00 - 2.60)
Fumesua	**27.26±0.23** (27.00 – 27.60)	**5.03±0.59** (4.59 – 5.93)	**88.13±1.03** (86.70 – 90.00)	**176.27±2.05** (173.40 – 180.00)	**27.11±1.69** (25.00 – 30.00)	**6.67±2.50** (5.00 – 10.00)	**5.52±1.06** (4.78 – 6.98)
Bonwire	**27.02±0.09** (26.90 – 27.20)	**4.83±0.83** (3.64 – 6.30)	**220.37±0.96** (219.00 – 222.00)	**440.73±1.93** (438.00 – 444.00)	**118.11±1.62** (116.00 – 121.00)	**10.00**	**4.52±0.37** (4.10 – 4.98)
Besease	**27.27±0.19** (27.00 – 27.50)	**4.89±0.14** (4.75 – 5.20)	**100.01±3.86** (97.90 – 110.10)	**200.02±7.71** (195.80 – 220.20)	**36.78±2.22** (34.00 – 40.00)	**13.33±2.50** (10.00 – 15.00)	**6.18±1.38** (4.46 – 7.98)

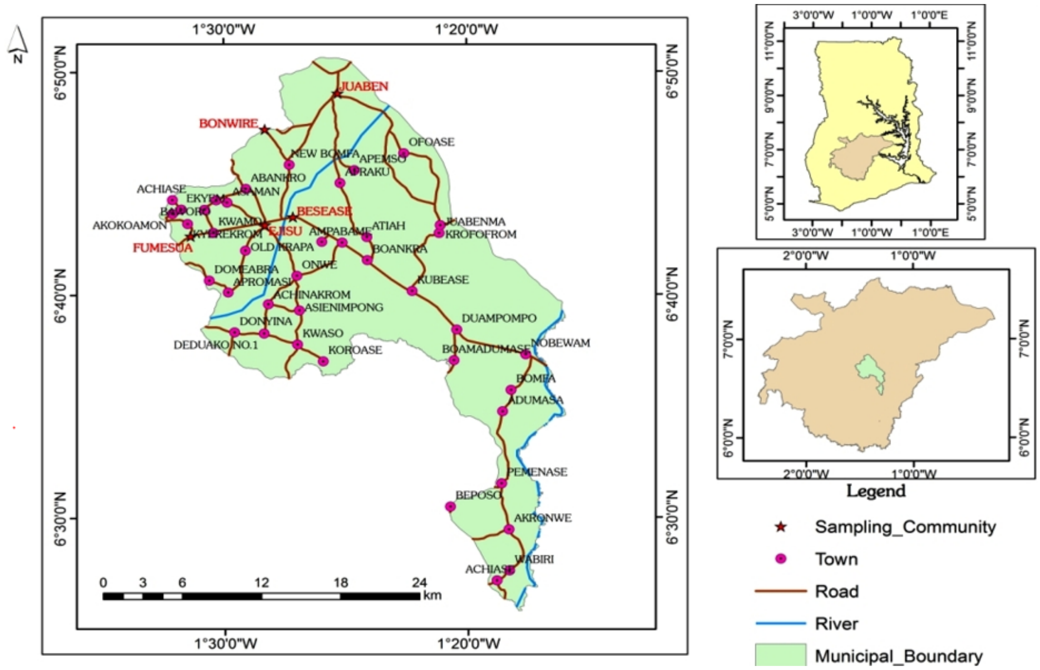

Fig. 1. Map of the Ejisu Juaben area showing the sampling communities (in red print) with an insert of Ghana's map showing Ashanti region in relation to the rest of the country.

Anions levels in water samples analyzed in boreholes and hand-dug wells

Sulphate, nitrate, chloride and fluoride levels in water samples across all the different sampling locations for boreholes and hand-dug wells were within WHO recommended values of 250, 50, 250 and 1.5 mg/l respectively for drinking water (Figure 2 and 3). Mean values of sulphate and nitrate levels analyzed in water samples from all the hand-dug wells were higher than boreholes and statistically significant ($p=0.001$, $p=0.007$) but mean values of chloride and fluoride levels were not statistically significant ($p=0.263$, $p=0.705$) (Table 5).

Microbiological analysis of water samples from boreholes and hand-dug wells

Total coliform count of water samples from boreholes across different locations were within WHO recommended guideline value (0 CFU $100ml^{-1}$) for drinking water with the exception of two boreholes at Juaben and one borehole each at Ejisu and Besease respectively. All the hand-dug wells had values above WHO limits (Table 3 and 4). Mean value of total coliform count for hand-dug wells was higher than boreholes (Table 5) and the difference was statistically significant ($p=0.001$). Faecal coliform and *E. coli* count of water samples from boreholes across different

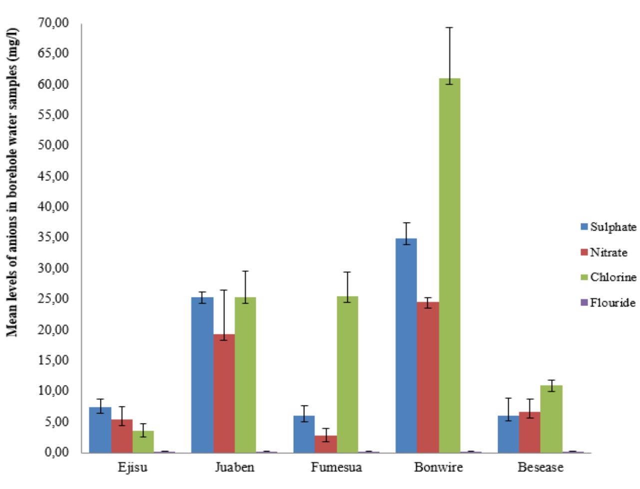

Fig. 2. Mean (± SD) values of anions analysed for boreholes in Ejisu-Juaben Municipality.

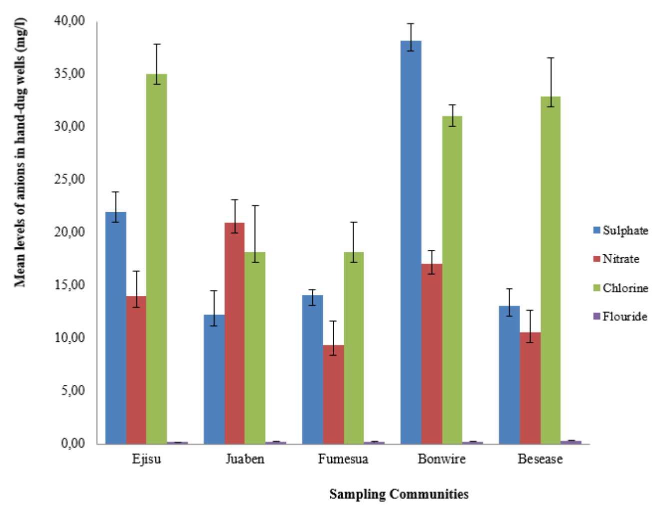

Fig. 3. Mean (± SD) values of anions analysed for hand-dug wells in Ejisu-Juaben Municipality.

locations were within WHO recommended guideline value (0 CFU 100ml^{-1}) for drinking water with the exception of one borehole at Besease which recorded mean values of 4.13x10^4 and 3.07x10^4 CFU 100ml^{-1} respectively for faecal coliforms and *E. coli*. With the exception of all hand-dug wells at Fumesua, selected hand-dug wells had faecal coliform counts above WHO limits (Table 1 and 2). Mean value of faecal coliform count for hand-dug wells was higher than boreholes (Table 5) and the difference was statistically significant (p=0.014). With the exception of selected hand-dug wells at Fumesua, all the selected hand-dug wells had *E. coli* counts above WHO recommended value of 0 (Table 1 and 2). The mean value of *E. coli* count for hand-dug wells was higher than boreholes (Table 5) and the difference was statistically significant (p=0.001).

Table 3: Mean counts of coliforms in water from boreholes in Ejisu Juaben Municipality.

Microbes	Total Coliforms (CFU 100ml^{-1})	Faecal coliforms (CFU 100ml^{-1})	*E. coli* (CFU 100ml^{-1})
WHO Limits	**0**	**0**	**0**
Towns			
Ejisu	***2.08x10^4**	**0.00** 0.00	**0.00** 0.00
Juaben	**3.06x10^4** (3.00x10^4 – 3.10x10^4)	**0.00** 0.00	**0.00** 0.00
Fumesua	**0.00** 0.00	**0.00** 0.00	**0.00** 0.00
Bonwire	**0.00** 0.00	**0.00** 0.00	**0.00** 0.00
Besease	***9.37x10^5**	***4.13x10^4**	***3.07x10^4**

*mean coliform count of one borehole

Table 4: Mean counts of coliforms in water from hand-dug wells in Ejisu Juaben Municipality.

Microbes	T. Coliforms (CFU 100ml^{-1})	F. Coliforms (CFU 100ml^{-1})	*E. coli* (CFU 100ml^{-1})
WHO limits	**0**	**0**	**0**
Towns			
Ejisu	**5.39×10^5** (2.40×10^5 - 9.30×10^5)	**5.82×10^4** (4.00×10^4 - 9.20×10^4)	**3.07×10^4** (3.00×10^4 - 3.30×10^4)
Juaben	**9.48×10^5** (2.00×10^5 - 2.50×10^6)	**3.24×10^5** (2.00×10^4 - 2.30×10^6)	***9.10×10^4**
Fumesua	**2.03×10^5** (8.50×10^4 - 4.50×10^5)	**0.00**	**0.00**
Bonwire	**3.38×10^5** (4.00×10^4 - 9.60×10^5)	***2.37×10^5**	***3.07×10^4**
Besease	**4.32×10^5** (4.00×10^5 - 4.60×10^5)	**2.11×10^5** (9.00×10^4 - 3.20×10$^{5)}$	**4.09 x 10^4** (4.00 x 10^4 - 4.50 x 10^4)

*mean coliform count of one hand-dug well

Table 5. Mean and range values of physicochemical and microbiological parameters of water from boreholes and hand-dug wells in Ejisu-Juaben Municipality.

Parameter	Minimum		Maximum		Mean		WHO Guideline value
	BH	HDW	BH	HDW	BH	HDW	
Temperature (°C)	25.90	26.90	31.20	27.60	27.53	27.20	-
pH (pH unit)	3.84	3.64	5.55	6.30	4.69	4.80	6.5-8.5
Total dissolved solids (mg/l)	36.30	72.70	343.50	222.00	134.74	120.09	1000
Electrical Conductivity (µS/cm2)	72.60	145.40	687.00	444.00	269.49	240.18	1500
Total hardness (mg/l CaCO3)	12.00	16.00	128.00	121.00	^{a}51.60	^{a}46.82	500
Colour (HU)	5.00	5.00	10.00	15.00	^{a}5.56	^{a}10.11	15
Turbidity (NTU)	0.22	1.00	2.98	12.00	^{a}0.67	^{a}5.07	5
Sulphate (mg/l)	2.00	10.00	38.00	40.00	^{a}13.89	^{a}19.93	250
Nitrate (mg/l)	1.70	7.00	28.30	24.50	^{a}11.76	^{a}14.40	50
Chloride (mg/l)	1.00	14.00	68.50	38.00	23.27	27.10	250
Fluorine (mg/l)	0.16	0.15	0.25	0.33	0.21	0.22	1.5
Total coliforms (CFU/100 ml)	0	2.40x10^4	9.50x10^5	2.50x10^6	^{a}7.32x10^4	^{a}4.90x10^5	0
Faecal coliforms (CFU/100ml)	0	0	4.30x10^4	2.30x10^6	^{a}2.75x10^3	^{a}1.34x10^5	0
***E. coli* (CFU/100ml)**	0	0	3.20x10^4	9.30x10^4	^{a}2.04x10^3	^{a}2.24x10^4	0

BH refers to borehole, HDW refers to hand-dug well, ^{a} statistically significant means (0.05).

DISCUSSION

Physicochemical parameters of boreholes and hand-dug wells

The relatively low sampling temperature could be attributed to the fact that most of the samples were collected very early in the morning. Usually, cool water is more palatable for drinking though high water temperatures enhance the growth of micro-organisms and hence affect taste and odour [18]. Groundwater having high temperature can dissolve more minerals from the rocks it is in therefore increase its electrical conductivity [19]. In the study area, pH of all groundwater samples analyzed from boreholes and hand-dug wells was found to be far below the acceptable limit of 6.5-8.5 pH units as recommended by the WHO. [8] recorded a similarly low pH value (6.6) in the study area. Studies have shown that if the geology of the aquifer containing the groundwater has few carbonate rocks (sandstone, granite and gneisses), the groundwater tends to be acidic [20]. The study area is predominantly underlain by crystalline rocks which belong to the Birimian, Granites formation [13] and therefore the low pH could be attributed to the geology of the study area. The groundwater sources in the municipality had low pH values which are considered too acidic for human consumption and can cause health problems such as acidosis [21]. It may also corrode reactive metal fixtures. The results for TDS and EC are not different from [22] who also recorded high TDS and EC values in borehole than hand-dug wells at Achiase and Wabiri within the same municipality. Electrical conductivity (EC) of water is a direct function of its total dissolved salts [23]. Hence it is an index to represent the total concentration of soluble salts in water [24]. The dissolutions of cations and anions in the host-rock by groundwater in the course of its movement accounts for the higher concentration of total dissolved solid (TDS) [9]. According to [25], all the samples from boreholes and hand-dug wells were non-saline. Studies have shown that calcium and magnesium accompanied by their sulphates, chlorides and carbonates naturally contribute to temporary and permanent hardness [26]. Hardness can affect the taste and lathering ability of water when used for washing. Exceeding the guideline value will cause poor lathering with soap and skin irritation [27]. Colour and turbidity are important factors for describing water quality. They affect the acceptability of water by the consumers [28]. High turbidity in some hand-dug wells indicates the existence of suspended and colloidal matter such as silt, clays and fibrous particles suchlike asbestos minerals [29]. This could be attributed to the presence of colloidal matter such as clay and silt, leaching of organic matter and domestic waste, and the disturbance associated with the drawing of water with the receptacles as most of the hand-dug wells were not cemented as the same observed by [25] in India. High turbidity of drinking water is of great concern because there are chances for the disease causing organisms to be enclosed in turbidity causing particles and as a result lead to health hazards [30].

Anions in boreholes and hand-dug wells

The levels of anions in individual boreholes and hand-dug wells at the various locations vary due to different soil type, water chemistry and different human activities around the water source [21]. The traces of sulphate in the water sample might have resulted from improper disposal of refuse and sewage in the area and also runoff from farmlands [31]. Most of the hand-dug wells were very close to public refuse dumps, piggery, soakaways and toilets facilities. Sulphate content in drinking water above 400mg/l causes bitter taste and may also cause gastro-intestine irritation and catharsis [30]. Water with high sulphates levels can cause laxative effect and gastro intestinal irritation [21]. The water samples from boreholes and hand-dug wells in the study area fell within the stipulated range by WHO of 50mg/l. The result is not different from findings by [22] who also recorded high nitrate values in hand-dug wells than boreholes at Achiase and Wabiri within the same municipality. Some traces of nitrate detected in the water samples might have originated from waste dump sites in the area and the use of artificial fertilizer for farming which probably leached and percolated into the soil and polluted the groundwater [32]. High concentration of nitrates in drinking water can cause methemoglobinemia (cyanosis) in infants, which is a disease characterized by blood changes [25]. Chloride levels in all the selected boreholes and hand-dug wells were low and within WHO limits. Human excreta and leachate from landfills [33], septic tanks and pit latrines [34] adds a significant amount of chlorides to groundwater. Chloride in water may react with sodium to form sodium chloride and can impact a salty taste in the water. Fluoride concentration in both borehole and hand-dug well samples was below the guideline value of 1.5 mg/l as prescribed by WHO guideline value for drinking water. Fluoride can get into drinking water through discharge from fertilizer or aluminium factories. Most fluoride that enters the body is found in drinking water [35]. Fluoride is regarded as a vital element though health problems may possibly arise from either deficiency or excess intake [36]. Chronic exposure to excessive consumption of fluoride may cause increased likelihood of bone fractures in adults which may lead to pain and tenderness.

Microbiological quality of boreholes and hand-dug wells

With the exception of Fumesua and Bonwire, total coliforms were recorded from one borehole from Ejisu, two from Juaben and one from Besease. At Ejisu, the borehole was close to a piggery, septic tank and refuse dump. At Juaben, the two boreholes were close to pit latrines and refuse dumps. At Besease, the borehole was close to a cemetery and pit latrine. There is a possibility of leachates contamination and this might account for the presence of coliform bacteria in water samples because studies have made known that pit latrines and soakage pits can spread their influence on groundwater quality up to 10 m or more as groundwater movement is either lateral or vertical [37]. Studies done earlier by [11], and [38] also recorded high microbial counts in boreholes outside WHO guideline. Boreholes water samples from Fumesua and Bonwire recorded zero counts for total coliform, faecal coliforms and *E.coli*. This agrees with [39] that boreholes as low cost technology substitute for developing countries are usually considered as good sources of drinking water when properly constructed and maintained.

The presence of total coliform (TC), faecal coliforms (FC) and *E.coli* detected in most hand-dug well water samples suggests faecal contamination by human and animal faeces in groundwater system. Three possible reasons may account for the presence of total coliform, faecal coliforms and *E.coli* in samples from hand-dug well water: (1) distance from sanitary sites (pit latrine, refuse tip, septic tanks and piggery) and depth of hand-dug well, (2) sanitary conditions around the hand-dug wells and (3) contamination during fetching with public fetcher. It was observed that 60% of the hand-dug wells used for the studies were close (less than 15m) to sanitary sites such as pit latrines, soakaways and dumping sites. All the hand-dug wells had their inners walls fissured with the exception of Fumesua which had concrete ring pipes cemented to the bottom. This may account for no faecal coliform and *E.coli* in samples from Fumesua. The depth of the hand-dug wells could explain contamination levels. All the hand-dug wells studied were shallow and ranged approximately from 1.65 m – 7.8 m in depth. The shallowest hand-dug well was located at Juaben which also recorded the highest number of coliform bacteria in samples. The deepest was located at Fumesua which recorded the lowest total coliform and zero counts for faecal coliforms and *E.coli* respectively in samples. Studies have also shown that ground water sourced from deep wells are usually of good bacteriological quality because vertical percolation of the water through soil results in the removal of much of the microbial and organic population, by direct contrast, waters from shallow wells are obviously polluted [40]. Moreover total and faecal coliform contamination may be due to environmental factors especially human activities around the hand-dug well. Most of the wells did not have cover slabs and aprons exposing them to the dust and insects and waste water. It was also observed that domestic animals normally visit the hand-dug wells because of the wastewater and dirty water to drink and generally contaminate with their faeces in the process. According to [41], the nearness of domestic and grazing animals to sources of water have been made known to play a role in the severity of faecal contamination of water sources. All the hand-dug wells had no windlass and public fetcher with varying degree of hygiene is used to draw water from hand-dug wells. It was observed that after drawing the water, the fetcher is left in the waste water and dirty water that had been spilt around the hand-dug well. This practice also introduces dirty water into the hand-dug well. Results for total and faecal coliforms are similar to [11] which recorded levels above WHO guideline value in some hand-dug wells in some peri-urban communities in Kumasi. Also results from Fumesua also support [21] which recorded no faecal coliforms and *E.coli* in some hand-dug wells in Kumasi below the WHO guideline value.

CONCLUSION

The study has shown that generally physiochemical parameters of groundwater from selected boreholes and hand-dug wells were within acceptable WHO limits for drinking and domestic activities with the exception of pH which was low (out of recommended range) for all boreholes and hand-dug wells. The microbial quality of water in one borehole at Ejisu, two boreholes at Juaben and one borehole at Besease were unacceptable and require treatment before use. Water from all the hand-dug wells is of poor microbial quality and unsuitable for human consumption without treatment.

RECOMMENDATION

Tapping of shallow aquifers for domestic purposes should stop due to their vulnerability to pollution. Subsequent boreholes and hand-dug wells should tap water from deeper aquifers that are less prone to contamination. Future boreholes and or hand-dug wells should be located far away from dumpsites, pit-latrines and soakaway and the use of existing boreholes and hand-dug wells very close to unlined dumpsites, pit-latrines, piggeries and soakaways should be discontinued.

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