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PHYSICO-CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF SELECTED BOREHOLE WELL WATER SAMPLES IN THE OMANJOR COMMUNITY IN THE ACCRA METROPOLIS, GHANA

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ABSTRACT

The quality and safety of groundwater normally changes slowly because more often the water is not directly exposed to pollution sources but can become contaminated as a result of improper drilling of wells and improper waste disposal procedures in the vicinity of the well. This study was to evaluate the physico-chemical and bacteriological quality of selected borehole well water samples in the Omanjor community, Accra Metropolis, Ghana. Samples of water for the investigations were collected in sterile bottles (200 ml). All the 5 selected borehole wells water had their water pumped into tanks and stored in overhead poly-tanks prior to fetching. Physico-chemical parameters were determined using standard instruments and methods whiles the presence of pathogenic bacteria were detected, isolated, and identified by the multiple tube/most probable number (MPN) method, culture, and biochemical testing. The ranges of mean values of the various physico-chemical parameters of the selected borehole water samples investigated were temperature (29-31^{o}C), pH (7.2-7.5), and dissolved oxygen (5.6-6.9 mg/l). Also turbidity and electrical conductivity mean values ranged from 1.3-2.2 neophelometric turbidity units (NTU), and 510.5-869 microSiemens per centimeter (µS/cm) respectively. All the physico-chemical parameters except conductivity values were within the permissible limits of the United States Environmental Protection Agency (EPA) and World Health Organization (WHO) standards. However, the mean MPN/100 ml values ranged 1-98. The most prominent bacteria isolated from the water samples were coliforms including species of *Citrobacter*, *Enterobacter*, and *Klebsiella*. Although no faecal coliforms were isolated from the selected borehole water samples investigated and also the 3 bacterial strains isolated and identified are still under debate as there should be used as indicators of feacal contamination of water bodies there is still the need for proper sanitary checks and regular maintenance to prevent future contamination of the borehole water in Omanjor community, Accra Metropolis, Ghana.

Keywords: Borehole water, physical, chemical, bacteriological analysis, enterobacteriaceae.

INTRODUCTION

Water is one of the most important necessities to all forms of life on this planet and beyond. Therefore adequate and safe water supply should be available to humans, plants, and animals in all parts of the world. According to the World Health Organization (WHO, 2008) every effort should be made to achieve a safe drinking water supply in every community of the

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world because it is known that improving access to safe drinking-water can result in significant benefits to health.

It has been estimated that the mortality of water associated diseases exceeds 5 million people per year around the world (Gleick, 2002). Of these, there are reports that more that 50% of these deaths are associated with microbial intestinal infections, particularly with cholera and typhoid more especially in developing countries including Ghana (Fenwick *et al.*, 2006). People affected by diarrhoeal infections or diseases are those with low immunity and also from homes with the lowest financial resources and poorest hygienic facilities. For example, in most Asian and African countries children (0-5 years) are the most affected by microbial diseases transmitted through water because people obtain their drinking water from surface and underground sources (Seas *et al.*, 2000). Both surface and ground water sources could become contaminated by biological and chemical pollutants arising from point and non-point sources (Roohul-Amin *et al.*, 2012). Therefore adequate water of good quality is essential for healthy lifestyle. The associations between sanitation, water, and health are well known for many diseases in humans and animals are transmitted through the consumption of contaminated water because of water shortages.

In Ghana and most other countries public drinking water supplies are required, by law, to be free from pathogens. However, private water systems are so vulnerable to contamination from bacterial and other pathogens, because most of them have no governmental oversight and are being managed by private owners. But it must be noted that if group of persons or a community rely on private wells or water systems, then it becomes their responsibility to ensure that the water is safe for consumption and other domestic uses. For the consumption of unwholesome water by humans and animals can result in the body being infected with many preventable infections or diseases. Waterborne infections are one of the greatest health challenges facing major governmental authorities worldwide especially in developing and underdeveloped countries including Ghana. Therefore there is the need for periodic assessment of the quality of our water sources in order to determine their level of pollution and their safety state for human consumption. The aim of the study was to evaluate the physico-chemical and bacteriological quality of selected borehole well water samples in the Omanjor community in the Accra Metropolis, Ghana.

MATERIALS AND METHODS

Sample Collection

Omanjor is a developing community near Swoutum in the Ga Central Municipality in the Greater Accra Region of Ghana. The community is a quarry environment where stone quarry are mined and many children are employed in the process according to the Ghana News Agency (GNA, 2014). Borehole well water is the major source of drinking water for domestic and other uses in the community. All the borehole wells in the community are privately owned and the water is usually sold on commercial purposes. A total of 5 borehole well water supply situated at different places in the community were selected and used for the study. The borehole well water had all been pumped and stored in overhead poly-tanks prior to the collection for the investigations. Samples of the water for the laboratory investigations were collected according to the American Public Health Association (APHA, 1998) sampling guidelines on the standard operating procedures for examination of water and wastewater. A total of 40 water samples from the 5 different borehole well sites were collected (i.e. 2 samples from each well a week). The samplings were done on Mondays and Thursday mornings (peak period) for 4 consecutive weeks. The water samples (200 ml) were collected

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aseptically into sterile bottles. Each collected borehole water sample was labelled with the temporal well's code number and transported in an ice chest containing ice cubes within 2-3 h to the Research Laboratory, Department of Microbiology, University of Ghana Medical School (UGMS) for the bacteriological analysis.

Physico-Chemical parameters of the selected borehole well water samples

The pH, turbidity, electrical conductivity (EC), and dissolved oxygen (DO) were determined by first switching on the respective meters and rinsing the probes with distilled water (H_2O) and immersing them into the borehole water samples followed by the reading. Temperatures of the selected borehole water samples were also accessed by using mercury-in-glass thermometer. All the above procedures were repeated three more times and the mean values recorded. The same process was performed at each borehole well site at each sampling time.

Bacteriological Analysis

In this investigation modification of the most probable number (MPN) method by Cheesbrough (2006) was used in the presumptive coliform testing of the selected borehole water samples. First double strength (i.e. twice the normal amount of broth powder) and single strength (contains the normal amount of broth powder as instructed by the manufacturer) MacConkey broths (MB: Oxoid Limited, Basingstoke, UK) were prepared according to the manufacturer's instructions. Then 50 ml of the double strength MB was poured into 10 bottles (200 ml) each (2 for each borehole well water samples), 10 ml into 10 set of universal bottles each with 10 ml of double strength MB, and another 10 set of universal bottle with 5 ml of the single strength MB using a pipette with tips. The setups were autoclaved at 121^{o}C for 15 min. After the broths have cooled to room temperature, 50 ml of borehole water samples were pipetted into each 50 ml of double strength MB, 10 ml of water samples into each 10 ml of double strength MB and 1 ml of samples into each 5 ml of single strength MB using a sterile syringe. The contents of each bottle were shaken vigorously to mix the water samples with the MB. Sterile Durham tubes were placed in the mixture in-vertically for the collection of gas. The universal bottles were labelled with the representative borehole water sample code and incubated at 37^{o}C for 24-48 h. After the overnight incubation the bottles were examined and counted for the production of both acid and gas. Acid production was shown by a change in the colour of the MB from purple to yellow and gas production by the collection of bubbles in the Durham tubes or displacement of the medium (Cheesbrough, 2006). The bottles that showed reactions after the incubation period were taken as indicative presumptive evidence of the presence of coliforms in the selected borehole water samples investigated. The MPN of coliforms in 100 ml of the selected borehole water samples from each well was estimated by the number of positive bottles and then compared with standard MPN Probability Tables. Controls were setup alongside strains of *E. coli* and sterile distilled H_2O. Samples of the borehole water were also inoculated onto Harlequin agar (HA; Lab M Limited, Topley House, UK) incubated at 37ºC for 24 h for the isolation of total coliforms and *E. coli* whiles for faecal coliforms the water samples were inoculated unto media-faecal coliform (m-FC; Acumedia, USA) and incubated at 44ºC for 24 h. The isolated bacterial strains obtained were identified based on the morphology, Gram staining reactions and different biochemical tests as described in Bergey's manual for determinative bacteriology (Holt *et al*., 1994).

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Statistical Analysis

The data obtained from the physico-chemical and MPN/100 parameters investigated were entered into a data base and analyzed for variance using *Statistical Package for Social Sciences (SPSS)* and was tested at a level ($p < 0.05$) for significance. Also the mean values of all the parameters were compared with the water quality recommendations of the United States Environmental Protection Agency (EPA, 2006) and WHO (1996).

RESULTS

Physico-chemical and bacteriological quality of the selected borehole water samples

The physical, chemical nature, and pathogenic content have characteristic effects on the quality and taste of water for drinking, bathing, swimming, and other domestic uses. Results of the various physico-chemical parameters of the selected borehole water samples are presented in Table 1. From the Table, ranges of the mean values of the various physico-chemical parameters of the selected borehole water samples investigated were temperature (29-31^{o}C), pH (7.2-7.5), and DO (5.6-6.9 mg/l). Also turbidity and EC values ranged from 1.3-2.2 neophelometric turbidity units (NTU), and 510.5-869 microSiemens per centimeter (µS/cm) respectively. However, there was no significant statistical difference ($p \geq 0.05$) between the various physico-chemical parameters investigated from the 5 selected borehole water samples from the Omanjor community, Accra Metropolis, Ghana.

The presumptive mean coliform count (MPN/100 ml) measured by the multiple tube fermentation technique of bacterial enumeration from the selected borehole water samples are presented in Table 2. Mean MPN/100 ml values ranged 1-98 with the highest mean values found in borehole water sample coded 3 in the present study (Table 2). Bacterial strains isolated and identified in the selected borehole water samples from Omanjor, Accra Metropolis, Ghana were species of *Citrobacter*, *Enterobacter*, and *Klebsiella*.

DISCUSSION

In Ghana like most developing countries due to the scarcity and unavailability of pipe-borne or safe water in most communities many people are inclined to dig or drill wells with overhead poly-tanks as an alternative sources of water supply for drinking, other domestic uses, and at times for commercial purposes. But it must be noted that the spread of infections through the faecal contamination of water sources particularly in most developing and underdeveloped countries are a common phenomenon (Idowu *et al*., 2011). The mean pH, turbidity, DO, and temperature values (Table 1) were all within the EPA (2006) and WHO (1996) permissible range of 6.5-8.5, 1-5 NTU, > 2.0 mg/l, and < 40^{o}C for water for drinking purposes. However, for the EC the mean values obtained in this study ranged from 510.5-882.5 µS/cm were above the recommended EPA standard (2006) range of 1-300 µS/cm for water for drinking. EC is a measure of the capacity of water to conduct electrical current which often is directly related to the concentration of salts dissolved in the water and also known as total dissolved solids (TDS). Salts in water can dissolve into positively and negatively charged ions which can conduct electricity. The source of increased levels of conductivity of the borehole water samples investigated may be due to an abundance of dissolved salts and minerals from rain water run-off, or other discharges as proposed by Roohul-Amin *et al*. (2012). A previous study on the chemical analysis of drinking water from some communities in the Brong-Ahafo Region, Ghana found EC within the ranges of 35-1216 μS/cm (Akoto & Adiyiah, 2007). EC values ranging from 706-976 μS/cm have also been reported in drinking water samples in Kohdasht City, Iran (Jafri *et al*., 2008).

The mean values of MPN/100 ml of the selected borehole water samples investigated were within different categories of the WHO (1996) guidelines for drinking purposes. Comparing the results of the present study with WHO (1996) recommendations it can be observed that borehole water samples from wells coded 1 and 2 were within category C, with the mean MPN/100 ml values of 17 and 13 respectively (Table 2). These values are unacceptable according to WHO (1996) guidelines which implies that the private owners of these boreholes must look for and correct the structural faults and if possible do a thoroughly maintenance of pumps that pumps the water from the wells to the overhead poly-tanks and also disinfect the equipments. Borehole water samples coded 3 had the highest mean MPN/100 ml count value of 98 (Table 2) which was within category D of the WHO (1996) recommendations for water human consumption. This therefore implies that the water sample is grossly polluted: look for an alternative source(s), or carry out necessary repairs and disinfect the equipments. Borehole water samples coded wells 4 and 5 had a mean MPN/100 ml count values of 1 each. This value is within category B of the WHO (1996) guidelines which also implies that the water is acceptable for consumption, but regular sanitary checks are needed.

A build-up of sediment in water storage systems can serve as sources of the supply of suitable nutrients on which bacteria and other microbes can grow and multiply (Pesewu *et al*., 2014). The coliforms or bacteria isolated from the selected borehole water samples from Omanjor, Accra, Metropolis, Ghana included species of *Citrobacter*, *Enterobacter*, and *Klebsiella*. But it is known that the presence of enteric coliforms especially *E. coli* makes water samples unsuitable for human consumption (WHO, 1996). However, it must be noted that other members of the coliform group particularly species of *Enterobacter*, *Citrobacter*, and *Klebsiella* can be free-living in nature especially in the soil. Therefore the presence of these bacteria in water samples does not necessarily give evidence that the water sources are faecally contaminated as proposed by the Australian Government, National Health and Medical Research Council (NHMRC, 2003). A previous study on the bacteriological quality of water stored ordinary in household poly-tanks in Accra, Ghana found faecal coliforms and *E. coli* (Pesewu *et al*., 2014). Also in a similar related investigation, *E. coli*, *Klebsiella* sp. and *Salmonella typhi* were isolated from well water samples in Sagamu, Nigeria (Idowu *et al*., 2011). The differences in the isolation of the various bacterial pathogens in this and other studies might be due to the differences in the sources of contamination of the water samples used.

CONCLUSIONS

From the study all the physico-chemical parameters except EC of the selected borehole water samples in Omanjor community, Accra Metropolis, Ghana were within the US EPA and WHO recommended standards. The bacterial strains isolated and identified including species of *Citrobacter*, *Enterobacter*, and *Klebsiella* are still under debate as whether they should be used as indicator bacteria for faecal contamination of water sources or not in most scientific areas. Although no faecal coliforms were isolated from the water samples investigated. There is still the need for proper sanitary checks and regular maintenance to prevent future contamination of the borehole water in Omanjor, Accra Metropolis, Ghana.

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DECLARATION OF INTEREST: None

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Table 1. Mean values of the various physico-chemical parameters of the 5 selected borehole water samples investigated.

	Wells	Mean	p-value
Temperature (°C)	1	30.5±0.6	.063
	2	29.0±0.5	
	3	30.0±1.0	
	4	30.0±0.5	
	5	31.0±0.6	
pH	1	7.5±0.1	.467
	2	7.4±0.2	
	3	7.4±0.3	
	4	7.3±0.4	
	5	7.2±0.2	
Dissolved Oxygen (mg/l)	1	6.5±0.6	.372
	2	6.5±0.9	
	3	6.9±0.7	
	4	5.6±1.0	
	5	6.3±0.9	
Conductivity (µS/cm)*	1	510.5±196.1	.100
	2	869.0±354.6	
	3	882.5±361.5	
	4	569.5±41.9	
	5	526.0±42.3	
Turbidity (NTU)*	1	2.2±0.6	.320
	2	1.3±0.6	
	3	1.8±1.0	
	4	2.1±0.9	
	5	1.4±0.3	

*µS/cm, -microSiemens percentimeter
*NTU, - neophelometric turbidity units

Table 2. Mean values of the MPN/100 ml of the 5 selected borehole water samples.

Well	MPN/100 ml
1	17
2	13
3	98
4	1
5	1