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ANALYSIS OF GROUNDWATER QUALITY FOR THREE SELECTED COMMUNITIES IN THE GA EAST MUNICIPAL ASSEMBLY (GEMA) IN THE GREATER ACCRA REGION OF GHANA

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ABSTRACT

Groundwater constitutes a major source of water for most households in the selected communities under this study. Water sources for the analysis were drawn from hand dug wells and mechanical boreholes from Abokobi, Pantang and Kweiman all in the Ga East Municipality of the Greater Accra Region, Ghana in response to complaints from the inhabitants. A physicochemical analysis was conducted on the water samples drawn from the two sources (dug wells and mechanical boreholes) of water from these communities. Various physicochemical parameters were used. The result of the analysis indicated that the *pH* 5.4 – 5.6 of the three boreholes and three hand-dug wells were below the recommended levels set by the Ghana Water Company (GWC) and the 6.5 – 8.5 by the World Health Organization (WHO). Water drawn from boreholes and wells exhibited similar characteristics with water hardness levels ranging from moderately hard to hard; that is, 5.7 – 4.9. These two parameters could have been responsible for the rusting and the scale formation in the fittings which might have led to complaints from communities members. However, the remaining parameters were all found to be within the acceptable limits and posed no major health implications to the people.

KEY WORDS: Groundwater, rusting, scale formation, hand-dug wells, boreholes.

INTRODUCTION

Water is related to the issue of social development through its impacts on health. Good quality drinking water is thus essential for the well being of all people. The United Nations has declared that access to clean water is a basic human right. Without safe drinking water, humans, animals and plant life, cannot survive. This is because water related diseases are amongst the most common causes of illness and death, and the majority of people affected by them live in developing countries (WWAR, 2003:6). Unfortunately, most countries in the developing world get their drinking water supplies from underground sources. Most of the sources are contaminated with bacteria, viruses, heavy metals, nitrates, and salt. These enter into drinking water supply sources as a result of poor treatment and disposal of human and livestock waste, industrial discharges and overuse of limited water resources (Lee & Brodie, 1982). This has led to a large number of deaths and health problems from diarrhea, cholera and hepatitis B, and shortages of portable and safe drinking water. The current trend of increasing urbanization in many countries have compounded the difficulties in disposal of liquid and solid waste, and this has led to increased occurrence of water related diseases. Generally, areas that are replenished at a higher rate are generally more vulnerable to contamination than those replenished at a lower rate. Large fractures in bedrock also contribute to contamination by providing a pathway for the contaminants (Palaniappan, Gleick, Allen , Cohen, Christian-Smith, & Smith, 2010). In Bangladesh for example, high levels of natural Arsenic (As) which is having adverse human health impacts have been reported (Anawara, Akaib, Mostofac, Safiullahd, & Tareqd, 2002). Monitoring the quality of drinking groundwater is essential for environmental safety and as such analyzing physico-chemical properties including trace element content are crucial for public health (Kot, Baranowski, & Rybak, 2000). Ghana is no exception to this world water crisis which is affecting other countries in other parts of the world. The quality of groundwater resources in Ghana is generally good except for some cases of localized pollution and areas with high levels of trace metal elements.

In Ghana, majority of the communities depend on rivers, streams, lakes and underground water for their source of water supply and occasionally rain water. Many rural communities depend on these sources of water without any treatment or quality check. All natural waters contain many dissolved substances. Contaminants such as bacteria, viruses, heavy metals, nitrates and salts have polluted water supplies as a result of uncontrolled human activities and untreated industrial waste discharges (Singh & Moseley, 2003). Even if no anthropogenic sources of contamination exist there is the potential of natural levels of metals and other chemicals to be harmful to human health (Akpoveta, Okoh, & Osakwe, 2011). Site-specific characteristics such as soil type, depth of the aquifer, weather, season and the recharge rate can influence the probability and severity of contamination of groundwater. Any contamination that can percolate the soil and rocks has the potential to reach the groundwater beneath. Therefore, water from various source suffer from pollution from anthropogenic and natural sources and groundwater is not exceptional. The well known contaminants varies from organic to inorganic, living to non-living, heavy metals etc which all have some health effects on consumers of such sources of drinking water. The contaminants can be broadly grouped as physiochemical and bacteriological parameters.

In recent times, there have been growing concerns about the quality of groundwater which shows signs of trace metals in the drinking water sources which have health effects. When groundwater contains high levels of trace metal concentrations, people in rural communities tend to use to contaminated surface water for household activities. The problem of high level of trace metals concentration is more rampant in the southern parts where large quantities of various rocks are found. As a result, this project is restricted to groundwater quality in three rural communities in the Ga East Municipal in the Greater Accra-Region.

Study Area

The Ga East Municipal Assembly (GEMA) is located at the northern part of Greater Accra Region. It is one of the ten (10) districts in the Greater Accra Region and covers a Land Area of 166 sq km. It is boarded on the west by the Ga West Municipal Assembly (GWMA), on the east by the Adenta Municipal Assembly (AdMA), the south by Accra Metropolitan Assembly (AMA) and on the north by the Akwapem South District Assembly.

The Ghana Statistical Service (GSS) projected population for GEMA for the year 2010 is 244,226. The growth of the population is mainly due to the influence of migration inflows. The 2000 population figure yields a density of 1,214 persons per sq km much higher than the national density of 79.3 and the regional density of 895.5 persons per sq. km. With a projected population of 244,226 in 2010, the estimated population density is 1,391 persons per sq. km. This indicates a great pressure of population on land and water resources. Potable water supply in the peri-urban areas of the Municipality has been a major challenge to the Assembly.

However, the Municipality has a land area consisting of gentle slopes interspersed with plains in the west. The Akwapem range rises steeply above the western end and lies generally at 375-420m north of Aburi and fall to 300m southward. This makes the area rich in ground water resources. Thus, the nature of drainage pattern has called for most households within GEMA to depend on hand dug wells and boreholes for their water supply.

MATERIALS AND METHODS

The Flame Atomic Absorption Spectrometry (FAAS) method was used to determine the trace metals in underground water. The FAAS method offers some important advantages principal among which is its sensitivity.

Sampling was done during the dry season within the two months interval from February to April, 2012. The water samples were taken at the water sources (wells and boreholes). In all, two (2) samples each, one (1) from a well and another one (1) from a borehole, were collected from the three communities within the GEMA. Analysis was conducted to determine turbidity, pH, Total Dissolved solids, Total Suspended Solids, Temperature, Calcium, Magnesium, Manganese, Total hardness, Total Iron and Chlorides. Acid digestion was done to digest the trace metals before the atomic absorption spectrometry to determine the levels (concentration) (http://www.ghanadistricts.com/pdfs/Ga_East_demo.chara pdf)

The analogue (Use full meaning for WPA) was used to determine the *pH* of the water samples. Before using the *pH* meter it was calibrated with buffer solutions with *pH* of 4 and 9.2. The *pH* meter was now raised with distilled water and about 50ml of the sample was measured and its pH read by immersing the electrodes in the sample. The procedure is repeated for the other four (4) samples. In the determination of metals in underground water, water samples were digested with concentrated nitric acid and made up to the original volume with distilled water in a conical flask. It was then read on standardized flame AAS. In these process is sample, 50ml of sample is measured into beakers and 50ml concentrated nitric acid added. Few drops of glass beads were added and placed on a hot place set at about 95°C. The samples were allowed to boil slowly until the volume is about 25ml. Turbidity was measured using HACH 2100AN turbidimeter. The cuvette was rinsed with distilled water and filled with samples into the instruments light cabinet and cover with light shield. After stabilization turbidity value was read and recorded. In addition, aliquots of HNO_3 were added to the samples and digested until a clear solution was formed. The samples were allowed to cool and made to the original volume using distilled water. The samples were then sent to the AAS for reading of the trace metals in solution.

For Ca^{2+}, a calcium standard was prepared from $CaCO_3$ and HNO_3 to calibrate the AAS. A blank solution was also used to zero the machine, a nitrous oxide and acetylene flame was set to read for Ca^{2+} at a wave length of 239.9nm. With Mg^{2+}, a magnesium standard solution was prepared from an Mg metal strip and nitric acid to calibrate the AAS. A fade solution was prepared to zero the machine. Air acetylene flame was then used to read for Mg^{2+} at a wavelength of 202.6nm. With respect to Mn^{2+}, a Manganese metal strip and nitric acid were used to prepare the standard for calibration and a blank solution was used to zero the AAS. Air-acetylene flame was then used to read for the Mn^{2+} at a wavelength of 403.1nm. Finally, for Fe, an iron metal strip and Hydrochloric acid were used to prepare the standard for calibration. A blank was also prepared to zero the AAS. Air- acetylene flame was used to read for Fe at a wavelength of 372.0nm.

RESULT AND DISCUSSION

The results, which gave similar physical and chemical characteristics of samples of water from wells and boreholes from three communities, are shown in Table 1 below. The results indicate that ground-waters in the selected communities are within the pH range of 4.9 – 5.7. This shows that the groundwater are mildly acidic, and are most probably derived from carbonic acid due to the dissolution of atmospheric CO_2, or CO_2 generated in the soil zone as a result soil oxidation of organic matter (13). The turbidity of the three water samples from the three communities is 0.2NTU. This is far below the recommended standard of 5NTU set by the GWC. This is expected of groundwater. Hence, it is safe for domestic use and does not pose any health problems to the communities. However, the true colour measured for the water samples were all below the 5HU. That is, below the standard of 15 HU set by the GWC's standard.

With regard to TDS, the three water samples from the communities range between 210 – 384 mgL (ppm). All three samples fell below the permissible levels of 1000mg/L set by the GWC. The relatively higher water samples values for Pantang and Abokobi (381 and 384 respectively) might be attributed to the locational and structural difference of the underlying rock types.

TABLE 1: Results of the physico-chemical characteristics of the water samples from wells and boreholes from the Study Communities.

Parameter	Community			Test Units	Method Code
	Abokobi	Pantang	Kweiman		
pH	5.7	5.4	4.9	-	
True color	<5	<5	<5	Plat cobalt Unit	2120 B
Turbidity	0.2	0.2	0.2	NTU	2120 B
TDS	381	334	210	Mg/L(ppm)	2130 B
TSS	<1	<1	<1	Mg/L(ppm)	2540 D
TD	69	97	<5	Mg CaCo3/L	2510 B
Conductivity	61.1	58.6	38.3	Ms/m	2540 D
Alkalinity	223	26	2	Mg CaCo3/L	2340 B
Ca	11.8	17.7	4.2	Mg/L (ppm)	2320 D
Mg	9.7	12.8	2.9	Mg/L (ppm)	3111 D
Na	60	53	51	Mg/L (ppm)	-
K	19	6.2	1.3	Mg/L (ppm)	3500-Na D
Cl	146.9	128	111.9	Mg/L (ppm)	3500-K D
Fe	<0.1	<0.1	<0.1	Mg/L (ppm)	3111 B
Mn	0.02	<0.02	0.03	Mg/L (ppm)	3111 B
cu	0.07	<0.02	<0.09	Mg/L (ppm)	3111 B
PO4	<0.02	0.02	<0.02	Mg/L (ppm)	4500 N02 B
SO	37	41	2	Mg/L (ppm)	4500-S04 E
S	13.3	16.9	13.3	Mg/L (ppm)	4500 S02 B
Zn	0.96	<0.05	0.12	Mg/L(ppm)	3111 B
Cr	<0.01	<0.01	<0.01	Mg/L(ppm)	3111 B
Ni	<0.02	<0.02	<0.02	Mg/L(ppm)	3111 B
As	<0.002	<0.002	<0.002	Mg/L(ppm)	3111 B
Pb	<0.01	<0.01	<0.01	Mg/L(ppm)	3111 B
N	<0.05	<0.05	<0.05	Mg/L(ppm)	4500-N03 E
Al	0.03	0.04	0.04	Mg/L(ppm)	3111 B
Cd	<0.002	<0.002	<0.002	Ug/L (ppm)	3114 B

TDS- Total Dissolved Solids; **TSS**-Total Suspended Solids, **TD**- Total hardness, **Ca** - Calcium, **Mg** - Magnesium, **Na** - Sodium, **Fe** - Iron, **Mn** - Manganese, **Pb** - Lead, **Zn** - Zinc, **Cr** - Chromium, **Ni** - Nickel, **As** - Arsenic, **Cd**-Cadmium, **K** - Potassium, $\mathbf{SO_4^{2-}}$ - Sulphate, **Cl** - Chloride, $\mathbf{NO_3}$ - Nitrate, **Al** - Aluminium, **Cu** – Copper, $\mathbf{SiO_2}$ – Silica, $\mathbf{PO_4}$ -Phosphate

According to Langmuir (1997), Hounslow (1995) and WHO (2006), water with hardness in the range 0 – 61mg/L, 61 – 120mg/L, 121 – 180mg/L and >180mg/L are regarded as soft, moderately hard, hard and very hard respectively. Therefore, in Table 1, a TD of 97mg/L for Pantang and 69mg/L for Abokoki fall within the 61 – 120mg/L, that is considered to be moderately hard, whiles the TD of Kweiman was recorded as <5mg/L, which also is within 0 – 60mg/L noted to be for soft water. Therefore, variations do exist in the TD of water within the three communities found in the Ga East Municipal Assembly.

Concentration of Manganese ions (Mn^{2+}) ranges between 0.02 - .03mg/I. This fell below the recommended standards set for 0.1ml by GWC and WHO guidelines. These concentrations do not pose any health risk to the selected communities. Even though iron is essential to the human body and its intake through drinking water forms an insignificant portion of the body requirement (Freeze and Cherry, 1979), the maximum permissible concentration of 0.3mg/I in drinking water is primarily for reasons of taste and avoidance of staining sinks (Wolfe, 1960). The concentrations of calcium ions (Ca^{2+}) and magnesium ions (Mg^{2+}) in water samples of the three communities range between 4 – 20mg/I and 17 – 24.3mg/I respectively were all found to be below the GWC standards. Both Ca^{2+} and Mg^{2+} are essential for human health (WHO, 2006), and are major contributors to the hardness of water especially with the samples from Pantang and Abokobi.

Other major ions present were Na^{2+}, $C1^{-}$, and SO_42^{-} with recommended permissible limits ranging between 76.58–94.75mg/I, 118-146mg /me and 2–4 mg /me respectively. All these concentrations were below standard recommended levels of GWC's values of 250mg/L for

$C1^{-}$, 200mg/I for Na^{2+} and 250mg/I for SO_42^{-}. According to Freeze and Cherry (1979), intake by humans of water with concentrations of these ions above the recommended limits is generally not harmful. However, when Na^{2+} exceeds the recommended limit of 200mg/I, the water becomes salty. Whereas a maximum chloride concentration permissible in drinking water is 250mg/I primarily because of taste. But SO_42^{-} concentration in drinking water must not exceed the 250mg/I else the water will taste bitter. Higher concentrations of SO_42^{-} can cause laxative effect.

CONCLUSION

In conclusion, the physico-chemical analysis revealed the quality or nature of groundwater available to the three communities and to the GEMA jurisdiction area in general. The study, again, revealed that majority of physical characteristics of the sample water have no health complications except above the permissible limits. Thus, the experimental results obtained show a relatively higher pH levels in Pantang and Abokobi. The higher pH levels showed that the water samples were slightly acidic and might be responsible for the corrosion of pipe fittings. The indication from moderately hard to hard of ground water sources of the communities could be attributed to the presence of salts such as Ca++ and mg++ or other carbonate compounds present in the water. All the other physico-chemical characteristics were within the acceptable limits set by GWC and WHO. It is recommended that the pH of the groundwater in the communities be raised to an acceptable level because almost all the other parameters depend on the pH value. Finally, there should be regular physico-chemical analysis of the groundwater sources of the three communities as well as analysis in other parts of GEMA.

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