

# Assessment of groundwater quality of wells sited in close proximity to Waste Management Systems in Ahanta West District-Ghana

Braimah Seth and Bentil John

**Abstract**-The study investigated the physico-chemical and bacteriological qualities of water from wells sited in close proximity to waste management systems in the Ahanta West District. GPS was used to determine the geographical location of wells and waste management system. The physico-chemical and bacteriological parameters of samples of water taken from these wells were determined at the laboratory and compared with the WHO guideline values for drinking water.

Analysis of the results of the study revealed a total of 107 wells geographically located at Agona, Adjoa, Beahu, Apowa, Funko, Bokro and Ewusiejoe in the district. Out of the eight wells analysed, samples A, C and D were less than 20m from a waste management system, samples B and E located more than 20m but less than 50m and samples F, G and H located more than 100m from a waste management system.

The study also showed that, all the selected communities use well water for domestic purposes. 25% of the total inhabitants complained of skin itches after bathing and 7.5% experiences some form of stomach upset after drinking. The study further revealed that, pH of samples B, C, F, G and H were acidic. Samples A and D recorded high nitrate levels. More so, all the samples were positive to Total coliform count and faecal coliform affecting the quality of the water for human consumption. E.coli results were also positive for all the eight samples. It was concluded that water from these wells must be treated before usage.

**Index Terms:** Water quality, Wells, water consumption, Physico-chemical parameters, Waste Management Systems, geographical location, source of contamination.



## 1 INTRODUCTION

WATER, after air, is the most essential commodity to the survival of life. Human life depends to a large extent, on water. It is used for an array of activities; chief among these being for drinking, food preparation, as well as for sanitation purposes. In as much as safe drinking water is essential to health, a community lacking a good quality of this commodity will be saddled with a lot of health problems which could otherwise be avoided [10].

Accessibility and availability of safe drinking water is the key to sustainable development. Safe drinking water is essential to life and a satisfactory safe supply must be made available to consumers. Though Ghana has a large number of water resources, not all rural residents have

access to quality drinking water. The supply of piped water is inadequate in most communities in terms of quality and quantity of the water supplied. As a result of lack of quality potable water supply from the municipal sources, peri-urban communities have turned to other sources of water with questionable quality to satisfy their water needs.

The Millennium Development Goals: Target 7.C “Halve, by 2015 says that; the proportion without sustainable access to safe drinking water and basic sanitation”, this is focused on increasing access to an improved water source and improved sanitation. Yet even having access to an improved water source does not guarantee the water is quality, as it could lack proper treatment, become contaminated during transport or even during home storage [7]. Rural and Urban communities rely on water for most of their daily activities. Their source of water is of two origins; thus Surface water and Ground water. Surface water is found in lakes, rivers, streams, dams etc. which is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, evapotranspiration and ground water recharge. Groundwater lies under the surface of the land, where it travels through and fills openings in the rocks (aquifer) [5]. Over one billion people lack access to an improved water source and more than three million people, mostly children, die annually from water-related diseases [12].

Groundwater sources are being increasingly used as drinking water and other domestic chores yet, testing to know whether the water is of good quality is almost non-existent. Although, it is true that soils generally function to reduce the effect of microorganisms by a simple filtration mechanism, especially larger bacterial and protozoa, pollution of groundwater by microorganisms especially those located near waste management systems, such as pit latrines, septic tanks and landfills significantly do occur [8].

The rapid population growth of the district, as a result of the recent oil discovery, has massively increased the district's water demand far above the supply from Ghana Water Company Limited. The indigenes, therefore, rely on hand dug wells as their only source of water, regardless to their proximity to waste management systems.

It has been documented, and accepted as a standard that when on-site sanitation systems are sited less than 50 m away from wells and bore holes, the water from such wells will definitely be polluted [11].

**Author Braimah .S, is currently working as Lecturer at Takoradi Polytechnic Institute, Department of Civil Engineering, Ghana. E-mail: Seth.braimah@tpoly.edu.gh**

**Co-author Bentil.J, is currently working as senior Lecturer at Takoradi Polytechnic Institute, Department of Civil Engineering, Ghana. E-mail:John.bentil@tpoly.edu.gh**

## **2 MATERIAL AND METHODS**

### **2.1 Background of Study Area**

Ahanta West District is located at the southernmost point of Ghana with Agona Nkwanta as its capital. It has a total land area of 591 km<sup>2</sup> but the study area lies between latitude (004°45'-004°54'N) and longitude (002°00'-001°47'W) as shown in **fig.1**. It shares boundaries with Nzema East Municipal to the west, Tarkwa-Nsuaem Municipal & Mpohor District on the north, Sekondi-Takoradi Metropolitan Assembly to the east and the Gulf of Guinea to the south.

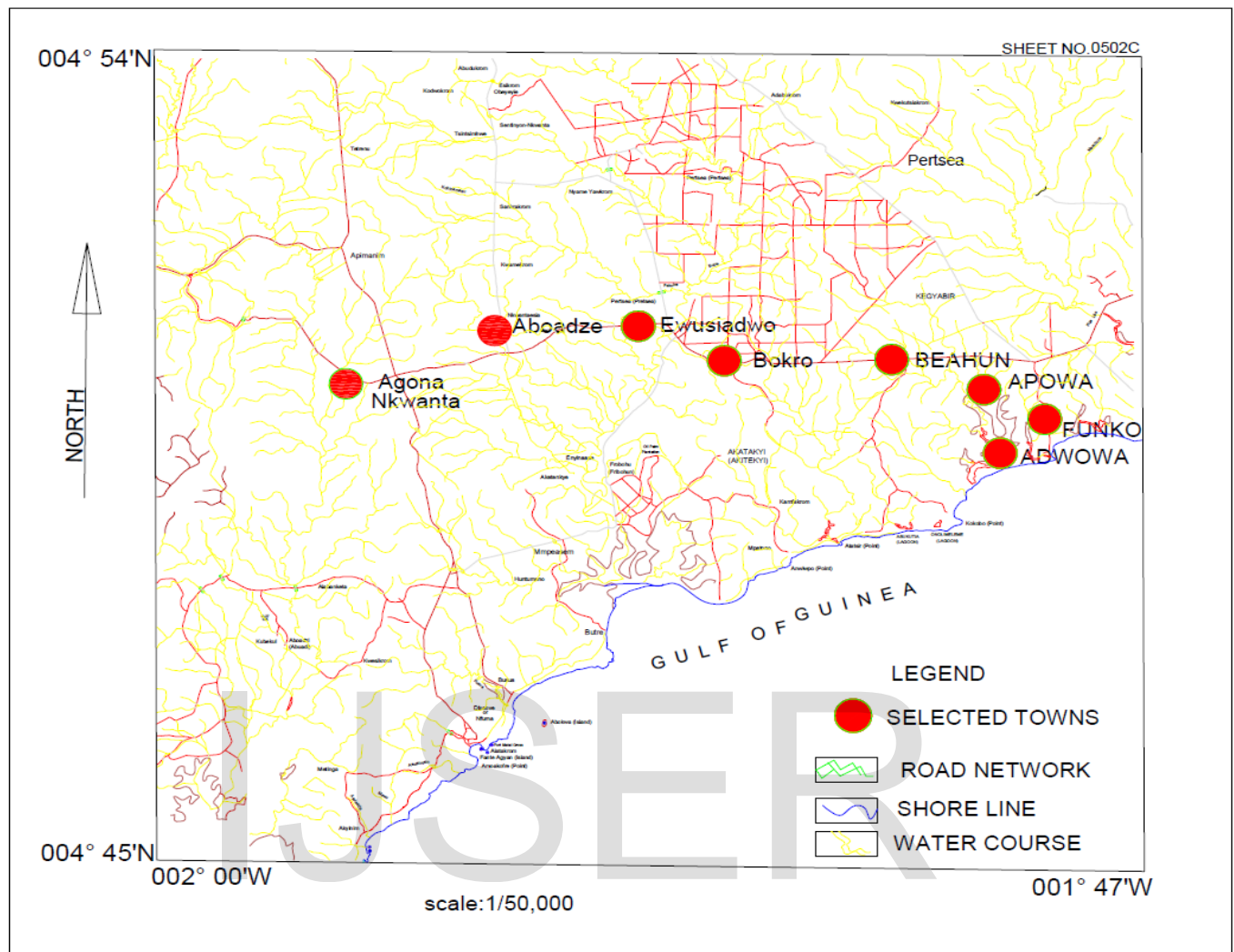
The district has a highest mean temperature of 34°C, which is recorded between March and April, while the lowest mean temperature of 20°C is experienced in August. It experiences a double maxima rainfall of over 1700 millimeters. The relative humidity is very high in the raining season and low in the dry season. The population of the district in the year 2000 and 2010 was 95,140 and 106,215 respectively given a population rise of 11,075. The District has a population density of 180.0 persons per square kilometer [8].

The population of the district constitutes about 4.5% and 0.43% of the total population of Western Region and Ghana respectively. There are 26,095 households in the district [4].

The Geology of district is underlain by Precambrian upper Birimian rock series containing minerals deposits such as gold, diamond and manganese.

Substantial clay deposits which could be developed for ceramics can also be found in parts of the district, notably around the Beahu area [3].

The district has about 147 boreholes, 16 hand-dug wells fitted with pumps as well as over 500 unprotected wells. The total population served with water is 73329, constituting 58% of the population [4].



**Figure 1.**The map of Ahanta West District showing the selected towns.

## 2.2 DATA COLLECTION

### 2.2.1 Observation and interviews

An observation of the catchment area was carried to identify groundwater sources in close proximity to waste management systems (less than 50m) and that far from waste management system (above 50m) as well as any potential source contamination.

At each randomly selected groundwater source, five (5) regular users were interviewed. Interviewees were questioned on the water use of, perception on water quality and any illness experienced upon usage.

### **2.2.2 GPS survey**

A hand held Garmin GPS map 62s was used to determine the geographical position of groundwater sources and waste management systems within the study area.

### **2.2.3 Sampling Techniques**

Groundwater samples were the main experimental materials. Five (5) groundwater sources close to waste management systems and three (3) far away from waste management systems were randomly selected to represent the study area. The selection was based on groundwater sources with frequent users. Groundwater sources were randomly selected and labeled as **A,B,C,D,E,F,G** and **H** from Agona, Aboadze, Adwoa, Beahun, Apowa, Funko, Bokro and Ewusiejoe respectively, to represent the district. Samples were drawn and carefully poured into clean plastic containers that were rinsed with distilled water. The sample containers were labeled and tightly covered to avoid spillage and any possible contamination during transportation to the Physicochemical and Bacteriological laboratory at Ghana Water Company Limited-Takoradi. The physical, chemical and microbial characteristics of the samples were determined using the [12] guidelines as well as the Ghana Water Company Limited standards.

The physical parameters measured were; turbidity, temperature and colour while the chemical parameters included; pH, Alkalinity, Total Hardness, Total dissolved solids, Conductivity, Phosphate, Nitrate and Chloride. Bacteriological analyses also included; Total coliform, E-coli and faecal coliform.

## **3 RESULTS AND DISCUSSIONS**

### **3.1 Observation and Interview**

A total of 107 wells were identified within the selected communities. It revealed that Forty eight (48) of the wells were closer to waste management systems whilst fifty nine (59) were far. Observational results revealed that, well water was drawn normally using various containers with varying degrees of hygiene; thus some appeared very dirty, others looked relatively clean. It also showed that, the wells A, B and C had filthy surroundings compare to the rest. All the eight (8) wells were constructed with concrete ring pipes. Out of the eight (8) wells sampled, B and C

were uncovered, D and E were covered with wooden lid, F was covered with a metal plate and the remaining (A, G, and H) were covered with concrete slab. Wells A, B and C were close to Dumpsites with distances 20m, 50m, and 20m respectively. Well D was sited less than 20m away from a pit latrine and a septic tank while sample E was sited less than 50m away from a public toilet. The remaining wells F, G and H were sited more than 100m away from waste management systems as shown in **Table 1 and fig.3**. The study revealed that, all the selected communities: Agona, Beahu, Apowa, Funko, Bokro and Ewusiejoe use water from wells. 80% use the well water for washing, cooking and bathing. 25% experiences skin itch after bathing. 7.5% drink from the wells and experienced some form of stomach upset.

### 3.2 Physicochemical and Bacteriological Analysis

The results of the physico-chemical and bacteriological parameters have been presented in **Table 1**, however, the values are placed alongside Ghana Standard Board values and WHO guideline values.

**Table1: Shows the distance between wells and possible source of contamination.**

Samples	Potential hazard	Distance from source of contamination
A	Dumpsite	< 20m
B	Dumpsite	< 50m
C	Dumpsite	< 20m
D	Pit latrine and Septic tank	< 20m
E	Public toilet	< 50m
F	<b>D</b>	>100m
G	<b>D</b>	>100m
H	<b>D</b>	>100m

Source: Field data (GPS data computation) 2016. [ **D** - far from source of contamination]

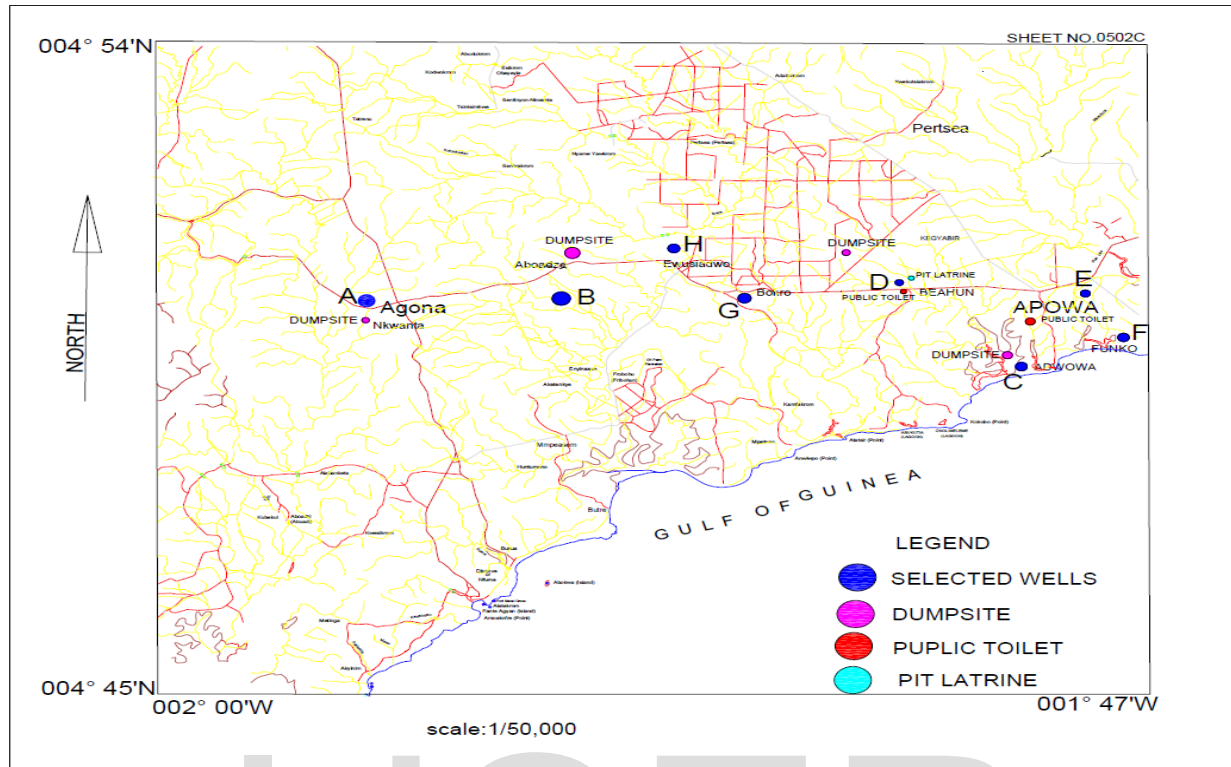


Figure3.Shows geographical locations of selected wells and possible sources of contamination.

PARAMETERS	WHO Guideline Value	GSA Standard	Sample Results							
			A	B	C	D	E	F	G	H
Temperature °C	-	-	27.1	27.0	27.0	26.5	26.8	26.9	27.0	27.1
pH	6.5-8.5	6.5-8.5	7.1	6.2	6.3	6.9	6.5	4.6	4.5	5.8
Colour (HU)	15	15	30	125	18	25	15	10	18	10
Turbidity (NTU)	5.0	5.0	1.66	2.94	4.39	1.29	1.18	0.70	3.29	9.05
Conductivity (µS/cm)	-	-	1687	343	459	1699	2308	460	1329	454
Total Dissolved Solids (mg/l)	1000	1000	843	171	229	849	1154	230	664	227
Total Alkalinity (mg/l)	-	400	280	58	75	170	210	8	90	33
Total Hardness (mg/l)	500	500	450	96	128	350	200	100	380	41
Nitrate (mg/l)	10	10	10.8	2.90	2.40	14.80	4.70	3.60	1.40	0.10
Phosphate (mg/l)	2.5	2.5	1.85	0.63	0.41	0.58	1.26	0.64	0.42	0.75
Chloride (mg/l)	250	250	294	47	73	394	579	126	439	107
Total Coliform (MPN/100)	0	0	Pre(+)	Pre(+)	Pre(+)	+	+	+	+	+
Faecal Coliform (cfu/ml)	0	0	13	10	0	0	0	0	0	0
E. Coli (cfu/ml)	0	0	TNTC	TNTC	TNTC	100	TNTC	20	40	TNTC

**Table 2: The Results of Physicochemical and Bacteriological Test**

*Source: GWCL (2016)*

*NB: TNTC means too numerous to count*

### 3.2.1 Physico-chemical parameters

The pH values of the results revealed that, samples B, C, F, G and H were below the WHO guideline for potable water. Whereas samples A, D, E were within the acceptable limits 6.5-8.5 stipulated for drinking and domestic purposes [12]. However samples B, C, F, G and H, are acidic. Acidity increases the capacity of the water to react with geological materials and leach toxic trace metals into the water making it adversely harmful for human consumption. The moderate acidity of samples B, C, F, G and H suggests that they were susceptible to some degree of trace metal pollution, acidic water consumption may lead to stomach upsets. Water



temperature ranged from 26.1 to 27.1 °C. These values are within the temperature ranges of raw water although there is no standard by WHO and GSA.

Color values for samples A, B, C, D, and G ranged from 18 to 125(HU) grossly above the accepted standard of 15 HU stipulated by WHO. This may be attributed to high dissolve organic matter in the water and its susceptibility to surface run-off. Color is also strongly influenced by the presence of iron and other metals, either as natural impurities or as corrosion products. Samples E, F and H met the acceptable standards and can be deemed fit for human consumption.

Turbidity value for sample H was recorded as 9.05NTU which was highly above the acceptable limit recommended by WHO. Samples A, B, C, D, E, F and G recorded turbidity values ranged from 0.70NTU to 4.39NTU within the stipulated limit (0-5 NTU) of WHO. Higher turbidity water is often caused by possible micro-biological contamination which creates difficulty in water disinfection [1].

Conductivity has no stipulated limit, samples A, D, E and G had conductivity values exceeding 1000 ( $\mu\text{s}/\text{cm}$ ) while samples B, C, F and H ranged from (300 to 500  $\mu\text{s}/\text{cm}$ ). This is an indication that there are a lot of ions present in the samples and it can be attributed to proximity of the wells to the sea. It can therefore be said that there is some level of intrusion of the sea water into the wells thereby increasing the levels of ions.

Total Dissolved Solids values for WHO and GSA as shown in **Table 2**, revealed sample E (1154mg/l) to be exceeding the recommended limits. However samples A, B, C, D, F, G and H recorded values ranged from 150 to 850mg/l within the permissible limit (0-1000 mg/l) for WHO and GSA.

The total alkalinity for all the eight samples analyzed were within the permissible limits of WHO and the GSA standards for potable water. The Total hardness value deemed acceptable by WHO must not exceed 500mg/l. The test results as shown in **Table 1** indicate clearly that all the eight (8) samples recorded acceptable values of total hardness. This shows that water from these wells are fit to be used for washing and other domestic purposes.

The test results revealed that samples B, C, E, F, G and H recorded nitrate values ranged from 0.10 to 4.7mg/l within the acceptable limits (0-10 mg/l) of WHO. However samples A and D recorded an unaccepted value of 10.80 and 14.80mg/l respectively. These high nitrate values

recorded from samples A and D indicate leachates contamination from waste management systems, thus closeness to a refuse dumpsite and pit latrine respectively. This is adversely hazardous to health (Rivett et al., 2008). Which can be harmful to human when not controlled. Phosphate concentration ranged from (0.40mg/l to 1.86mg/l) within the WHO and GSA guideline values of (0-2.5 mg/l).

WHO acceptable limit for chloride is 250mg/l. The results of the samples analyzed as shown in Table 1, indicates samples A, D, E and G chloride values to be above the acceptable limit and therefore not fit for consumption. High chloride values can be attributed to septic system effluent, storm water runoff, brine water and saltwater intrusion. However, samples B, C, F and H are within the acceptable values and are recommended for consumption as far as chloride level is concerned.

### **3.2.2 Bacteriological Analysis**

The results obtained for microbial analysis as shown in Table 1 indicate that, all eight samples A, B, C, D, E, F, G and H tested positive to total Coliform, indicating the presence of bacteria which imply these water sources pose a serious health risk to consumers. Samples A and B recorded 13 and 10 counts for faecal coliform bacteria respectively. The presence of faecal coliform bacteria in sample A and B indicates proximity of well to waste management systems. For water to be considered as no risk to human health, the faecal coliforms counts/100ml should be zero [12]. The remaining samples C, D, E, F, G and H recorded 0 count for faecal coliform bacteria.

However, all the eight samples analysed contain ranged numbers of E-Coli bacteria. Samples A, B, C and E recorded uncountable E-Coli bacteria. Sample D recorded 100 counts for E-Coli bacteria; sample F recorded 20 counts and sample G recorded 40 counts E-Coli bacteria. The outrageous numbers of E-coli bacteria in all samples analysed indicate without doubt that the wells are polluted by human excreta from the waste management systems. The results suggest that the general sanitary qualities of the water source, as indicated by total coliforms counts, E-Coli and faecal coliforms were unacceptable.

## **4 Conclusion**

The study sought to assess the physical, chemical, and bacteriological quality of water from wells sited in close proximity to waste management. It revealed that Forty eight (48) wells were

closer to waste management systems while fifty nine (59) were far. It also revealed that samples A, B and C were at various level of sanitary risk of contamination. The common risks identified were unhygienic conditions of the area, poor material covering and the distance between waste management system and wells are less than 50m. 25% of the total inhabitants experience skin itches after bathing and 7.5% experiences some form of stomach upset after drinking.

The study revealed that, pH of samples B, C, F, G and H were acidic. However, samples A, D and E were consumable. The results also showed turbidity of sample H to be unacceptable. Samples A, B, C, D, and G had an unacceptable colour. Sample A and D recorded high nitrate levels and all samples recorded higher conductivity. Sample E also recorded higher level of total dissolved solids. The results also showed that, all the samples were positive to Total coliform count. Faecal coliform result of samples A and B were in close proximity to waste management systems, affecting the quality of the water which is alarming to the health of consumers. Also E.coli results were positive for all the eight samples. It can therefore be concluded that water from these wells cannot be used without any form of treatment.

## **5 Recommendations**

The government should enact laws to prevent people from siting wells close to waste management systems.

Further analysis should be carried out in a larger scope to raise timely awareness and intervention to the pollution of groundwater by waste management systems since the use of groundwater is on the rise.

Waste management systems such as pit latrines and septic tanks should well designed and constructed to reduce the rate of seepage of leachates into groundwater.

The District Assembly should design sanitation programmes and propagate these through public education in the community to curtail the use of polluted well water.

## **Acknowledgment**

Our profound gratitude goes to Mr. Evans Akot-Adzei, Mr. Forson Aganu, Mr. Stanley Koppoe and Miss Veronica Afram all of Ghana Water Company – Western Region, Ghana for their assistance during the laboratory analysis. We also appreciate the effort of Darius Wobil and Alex Terkper.

## References

- [1] DWAF (1998). Quality of Domestic Water Supplies. Assessment Guide, 2nd edn. Department of Water Affairs of Forestry, Department of Health and Water Research Commission, Pretoria, South Africa.
- [2] Rivett, M.O, Buss, S.R, Morgan, P, Smith, J.W and Bernet, C.D, (2008). Nitrate Attenuation in Groundwater: A Review of Biological Controlling Process. Water Resources 2008 Oct; 42(16):4215-32.
- [3] Ahanta West District, (2007). Human Development Report. Vulnerability and the attainment of the MDGs at the local level.
- [4] Ahanta West District, (2015). District Composite Budget Document: [www.ghanadistricts.com](http://www.ghanadistricts.com) [Accessed 15 May 2016].
- [5] ARGOSS, (2001). Guidelines for assessing the risk to groundwater from on-site sanitation, BGS Commissioned Report CR/01/142, ARGOSS, Wallingford, UK.
- [6] Bain, R. E. S, Gundry S.W, Wright J. A, Hong Yang, Pedley S and Bartram J.K (2012). Accounting for water quality in monitoring access to safe drinking water as part of the millennium Development Goals: lessons from five countries. Bulletin of the World Health Organization.
- [7] Bouman D.N, and Wikke W, (2010). Smart disinfection solutions: examples of small scale disinfection products for safe drinking water. Amsterdam: KIT Publishers.
- .
- [8] Ukon, E, C, Abaraogu, U. J, (2013). Comparative Analysis of Water Quality From Hand Dug Wells And Bored Holes In Uyo, Akwa Ibom State, Nigeria.
- [9] Ghana Statistical Service (2010). National Population and Housing Census, 2000, Provisional Results. Ghana Publishing Corporation, Accra
- [10] Miller (Jnr), G.T. (1997). Environmental Science. Working with the Earth. 6th edn. Wadsworth Publishing Company, USA.
- [11] Obiri-Danso. K, Adjei, B, Stanley K.N, and Jones K, (2009). African Journal of Environmental Science and Technology Vol. 3 (1), pp. 059-066.
- [12] WHO, (2006). Technical Interventions. In WHO, Guidelines for Drinking Water Quality 2nd Edition- Volume 3 - Surveillance and control of community supplies (pp. 84-128). Geneva: World Health Organization ISBN 92 4 154503 8.