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Physicochemical and Microbial Parameters of Water From Hand-Dug Wells From Nyamebekyere, A Surburb of Obuasi, Ghana

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ABSTRACT

Exploitation of groundwater through the construction of hand-dug wells is a major source of drinking water for majority of the populace of developing nations. The need to assess the quality of water from this source has now become imperative because of the health impacts on individuals. Ten groundwater samples were taken from different parts of Obuasi and analyzed for physicochemical parameters including pH, electrical conductivity, total dissolved solids, alkalinity, total hardness and coliform bacteria. Metals and anions analyzed were Ca, Mg, Fe, Zn, Pb, NO_3^-, NO_2^-, SO_4^{2-}, PO_4^{2-}, F^- and Cl^-. Bacteria analysed were total and fecal coliforms. The data showed variation of the investigated parameters in samples as follows: pH, 5.86-6.61; conductivity (EC), 29.89-310.97µS/cm; turbidity, 1.33-32.2 NTU; total suspended solids (TSS), b/d–26mg/L; total dissolved solids (TDS), 30.73-314.4mg/L; alkalinity, 8.0–90.37mg/L; total hardness, 9.06-104.0mg/L; calcium hardness, 4.0 – 73.09mg/L; magnesium hardness, 4.73-50.34mg/L; Ca, 1.6-29.27mg/L; Mg, 1.15-12.22mg/L; Fe, 0.011-0.31mg/L; Pb, 0.09-0.20mg/L; Zn, b/d - 0.21mg/L; F^-, b/d - 0.24mg/L; Cl^-, 1.67-25.7mg/L; NO_2^-, b/d; NO_3^-, b/d -10.99mg/L; SO_4^{2-}, b/d -14.10mg/L; PO_4^{3-}, b/d - 2.35mg/L; Total coliforms were 2-44CFU per 100mL and fecal coliforms were 0-16CFU per 100 ml in all the samples. The concentrations of most of the investigated physicochemical parameters in the groundwater were within the permissible limits of the World Health Organization drinking water quality guidelines but the Total and fecal coliforms make the water not potable.

Keywords: *Physiochemical, Fecal and Total Coliforms, Groundwater*.

1. INTRODUCTION

Access to safe drinking water is a problem facing a large proportion of the inhabitant of the developing nations [1,2]. Unfortunately, in many countries around the world, including Ghana, water has become a scarce commodity [3] as only a small proportion of the populace have access to treated water. Consequently, the inhabitants have resulted to the use of hand-dug wells as an alternative source of water supply. Hand-dug wells also provide cheap and low technology solution to the challenges of rural and urban water supply.

Alternative sources of water such as rainwater and ground water have become major sources of drinking water for people living in new settlements and some residents who do not have access to treated water in Ghana. The need to assess the quality of water from some of these alternative sources has become imperative because they have a direct effect on the health of individuals [4].

Shimizu *et al*. [5] have shown that bacteria contaminate well water depending on location. Thus, it is suspected that water from wells in unhygienic areas could be contaminated according to their proximity to sources of pollution. Contaminants such as bacteria, viruses, heavy metals, nitrates and salts have polluted water supplies as a result of inadequate treatment and disposal of waste from humans and livestock, industrial discharges, and over-utilisation of limited water resources [6].

Unfortunately the quality of groundwater depends on agricultural activities such as land clearing and fertilization and on industrial waste, acid precipitation etc. [7,8]. The quality of groundwater is constantly changing in response to daily, seasonal and climatic factors which means continuous assessment of water quality parameters is very important because changes in the quality of water has undesirable consequences in terms of its effects on people, plants and animals. Ground water quality which is one of the alternative sources of water is usually affected by mining and chemical use from agriculture. Chemicals can seep through soil and rocks down to contaminate well water. Use of water which is chemically or fecally polluted is very likely to result in water-borne diseases. The need to assess the quality of water from some of these alternative sources has become very necessary because they have a direct effect on the health of individuals.

Nyamebekyire was chosen because is a new and fast growing area which has not been connected with pipe water in the metropolis.

2. METHODOLOGY

2.1. Study Area

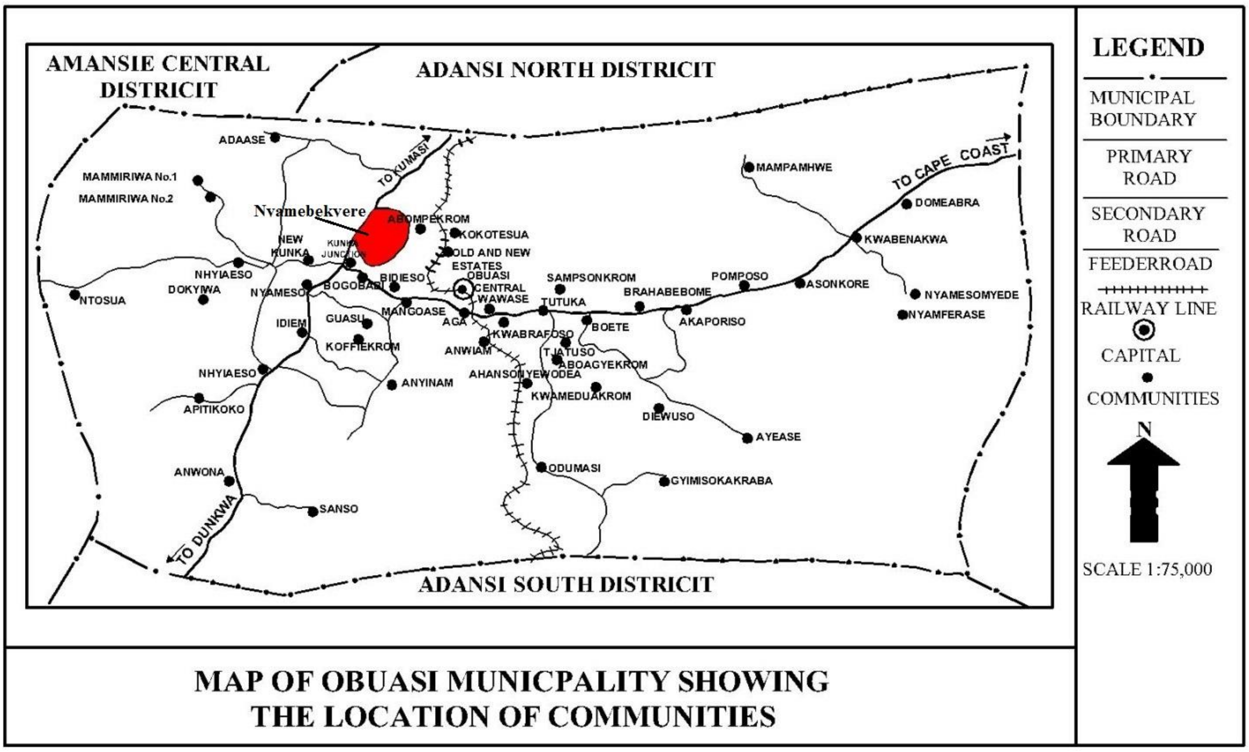

Figure 1: Map of Obuasi Municipality showing the location of Nyamebekyere (red spot). Source of map (OBUASI Municipal Assembly

Obuasi is the administrative capital town of the Obuasi municipal assembly. The Municipality is one of 27 districts of the Ashanti Region which was created as part of the government's effort to further decentralize governance. It was carved out of what was formerly Adansi West District Assembly on the strength of executive instruments (E. I.) 15 of December, 2003 and Legislative Instrument (L.I) 1795 of 17th March, 2007. The Municipality is located at the southern part of Ashanti Region between latitude 5.35N and 5.65N and longitude 6.35N and 6.90N. It covers a land area of 162.4 sqkm. There are 63 communities in the Municipality which share 30 electoral areas. Obuasi is where the famous Obuasi Gold Mines, now Anglo Gold Ashanti is located. The Municipality has an undulating topography and the climate is of the semi-equatorial type with a double rainfall pattern. Mean annual rainfall ranges between 125 mm and 175mm. Mean average annual temperature is 25.5^{o}C and relative humidity is 75 % - 80 % in the wet season. The population of the Municipality is estimated at 168,141 using the 2010 Housing and Population Census.

3. MATERIALS AND METHODS

3.1. Collection of water sample

Ten (10) samples were collected in pre-washed plastic containers from ten different hand-dug wells in various residences in Nyamebekyere in Obuasi. All the water samples were stored in a refrigerator until analysis. Test on samples for bacteria was conducted within 6 hours of sampling while the physicochemical parameters were done within 14 days.

3.2. Analysis of water samples

Water samples were analysed for physicochemical parameters. The pH was measured using a portable Yokogawa pH meter calibrated with buffers 7 and 9. Parameters like Chloride, Total Hardness, Nitrite, Nitrate, Sulphate and phosphate were analyzed using the standard methods described by American Public Health Association [9] and American Environmental Protection Agency. The pH, TSS, TDS, conductivity, and turbidity were determined on site. Calibrated EUTEC CON 2700 meter was used to measure the conductivity and total dissolved solids in the water. Total suspended solid was measured with HACH DR 2800 photometer; and turbidity with a Hach 2100 P turbidimeter. Alkalinity and total hardness were determined by titrimetric method whereas fluoride, chloride, sulphate, phosphate, nitrite and nitrate were determined by the ion chromatography on DIONEX ICS 3000. VARIAN SpectrAA 220 was used to determine iron, zinc, and lead. Total and fecal coliform were also determined on water samples.

4. RESULTS

The results of the physicochemical parameters of water samples from the hand-dug wells of Nyamebekyire have been given in the Tables 1 and 3. Total and Fecal Coliforms are given in table 2. The appearance of the water sample was colourless and clearly shows no odour. The parameters of the water quality such as pH and conductivity have a significant effect on it. They also influence physiology of organisms in water and may contribute to metal forms in water.

Table 1: **Physicochemical Parameters**

Sample Code	pH	Conductivity (µS/cm)	Turbidity (NTU)	TSS (mg/L)	TDS (mg/L)	F^- (mg/L)	Cl^- (mg/L)	NO_2^- (mg/L)	NO_3^- (mg/L)	PO_4^{3-} (mg/L)	SO_4^{2-} (mg/L)
N 3	6.25	29.89	2.38	2	30.73	b/d	3.72	b/d	0.89	b/d	b/d
N 6	6.14	177.87	7.32	4	181.03	b/d	25.76	b/d	10.99	b/d	3.85
N 12	6.29	244.37	32.2	21	248.8	b/d	4.83	b/d	3.36	0.24	5.34
N 30	6.49	58.19	11.47	8	57.59	b/d	1.67	b/d	2.09	b/d	0.394
N 31	6.33	310.97	1.55	b/d	314.4	0.24	10.20	b/d	1.37	2.35	14.109
N 34	5.86	31.16	23.35	26	31.29	b/d	2.85	b/d	1.08	b/d	2.078
N 42	6.24	63.69	3.33	1	64.04	b/d	2.14	b/d	0.90	b/d	0.937
N 45	6.27	41.10	1.33	b/d	43.06	b/d	1.82	b/d	3.99	b/d	b/d
N 59	6.61	152.07	1.72	b/d	153.2	b/d	2.45	b/d	1.65	b/d	1.920
N 60	6.61	193.13	2.16	b/d	197.6	b/d	7.95	b/d	b/d	b/d	9.490
WHO	6.5-8.5	1000	5	1000	1000	1.5	250	3	50	40	250

Abbreviations: b/d, below detection limit

Table 2: Results of total and fecal coliforms

Sample Code	Total Coliform (CFU)	Fecal Coliform (CFU)
N 3	16	11
N 6	6	4
N 12	2	0
N 30	25	13
N 31	25	0
N 34	9	4
N 42	14	5
N 45	33	0
N 59	10	9
N 60	44	16
WHO	0	0

Table 3: Results of Total Hardness, Calcium Hardness, Magnesium Hardness, Calcium and Magnesium Ion Concentrations, Total Alkalinity and Trace Metals (Fe, Zn and Pb) Concentration

Sample Code	Total Hardness (mg/L)	Ca Hardness (mg/L)	Mg Hardness (mg/L)	Ca^{2+} ion (mg/L)	Mg^{2+} ion (mg/L)	Total Alkalinity (mg/L)	Fe (mg/L)	Zn (mg/L)	Pb (mg/L)
N 3	12.082	7.350	4.732	2.943	1.149	8.006	0.173	0.136	0.122
N 6	44.30	23.157	21.143	9.273	5.134	11.609	0.189	0.215	0.119
N 12	100.283	55.679	44.604	22.298	10.831	12.110	0.316	0.142	0.105
N 30	24.164	15.707	8.457	6.290	2.053	20.017	0.180	0.004	0.126
N 31	104.008	53.665	50.343	21.491	12.225	15.273	0.155	b/d	0.203
N 34	9.061	4.027	5.034	1.612	1.222	10.308	0.063	0.051	0.128
N 42	31.514	18.425	13.089	7.378	3.178	27.323	0.013	0.034	0.090
N 45	17.720	11.075	6.645	4.435	1.613	19.616	0.011	0.029	0.100
N 59	72.493	54.672	17.821	21.895	4.327	71.661	0.013	0.011	0.126
N 60	91.926	73.098	18.828	29.274	4.572	90.377	0.044	0.031	0.112
WHO	500	-	-	75-200	50-150	200	0.3	-	10

5. DISCUSSION

From table 1, the pH values obtained were in the range of 5.86-6.61 as against the World Health Organization (WHO) guideline range of 6.5-8.5. Only three samples were within this range. The rest (N 3, N 6, N 12, N 31, N 34, N 42, and N 45) which formed seventy percent were below the range and were mildly acidic. At extremely high or low pH levels (for example 9.6 or 4.5), the water becomes unsuitable for most organisms. Low pH values in drinking water could result from flow of acidic water which drains from mines into streams and from ground pollutants in the Obuasi mining environment which could eventually find its way to underground water. Most aquatic organisms adapt to a specific pH level and may die if the pH of the water changes even slightly because pH could change the water chemistry.

The electrical conductivity (EC) (Table 1) values ranged from 29.89–310.97µS/cm while WHO guideline value of 1000µS/cm. All the wells were within the guideline value. Total dissolved solids (TDS) values ranged from 30.73-314.4mg/L. 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 to a large extent at TDS concentrations higher than about 1000 mg/L. The presence of high TDS may also be objectionable to consumers, owing to excessive scaling in water pipes, heaters, boilers and household appliances [10].

Table 1, showed turbidity values ranged from 1.33NTU to 32.2NTU from well sites N 45 and N 12 respectively as against a WHO guideline value of 5 NTU. Six wells were within the guideline value, while four (N 6, N 12, N 30, N 34) were outside the range. Turbidity in some groundwater sources result from unreactive or still clay or chalk particles or the precipitation of non-soluble reduced iron and other oxides when water is pumped from anaerobic waters [10]. Excessive turbidity in water causes problems with water purification processes such as flocculation and filtration and this could lead to increase in cost of treatment.TSS values were from below detection, (b/d) to 26mg/L against WHO permissible value of 1000mg/L. Turbidity and total suspended solids could be related in a way in that the underlying common characteristic property of the two parameters is clarity.

Alkalinity concentration values ranged from 8mg/L to 90mg/L in wells 3 and 60 respectively while WHO permissible level was 200mg/L. The water was safe with this parameter.

Calcium and magnesium concentrations ranged from 1.61mg/L to 29.27mg/L and 1.15mg/L to 12.22mg/L respectively.

Zinc ranged from below detection limit (b/d) to 0.215mg/L while lead was from 0.09mg/L to 0.20mg/L. Iron ranged from 0.011 to 0.31mg/L. WHO guideline value for iron is 0.3mg/L. At levels above 0.3 mg/l, iron stains laundry and plumbing fixtures. There is usually no noticeable taste at iron concentrations below 0.3 mg/L although turbidity and colour may develop [10].

Fluoride concentrations were between below detection (0.001mg/L) and 0.24mg/L while the WHO value was 1.5mg/L. Most of the wells (9) sampled were below 0.001mg/L. Fluoride in drinking water is generally bioavailable. This water poses no risk since fluoride levels were far below WHO guideline values.

Chloride concentrations ranged from 1.67 to 25.76mg/L whereas WHO guideline was 250mg/L. This implies that the water was domestically safe to use in terms of chloride concentration. High concentrations of chloride give a salty taste to water.

Nitrate however ranged from below detection limit (b/d) to 10.99mg/L. Therefore they were lower than WHO values for nitrite and nitrate of 3mg/L and 50mg/L respectively.

Phosphate concentrations were between below detection limit and 2.35mg/L as against a WHO guideline value of 40mg/L. This water was suitable for domestic use.

Sulphate concentrations ranged from below detection limit (b/d) to 14.109 ppm. In general, the average daily intake of sulphates from drinking-water, air and food is approximately 500 mg, food being the major source. Taste impairment varies with the nature of the associated cation; taste thresholds have been found to range from 250 mg/l for sodium sulphate to 1000 mg/l for calcium sulphate. It is generally considered that taste impairment is minimal at levels below 250 mg/l [10].

Total coliform counts ranged from 2 to 44CFU (colony forming units) per 100mL sample while the fecal coliform counts were between 0 and 16CFU per 100mL.WHO stipulates that for water to merit potability quality, it must have zero (0) coliform (fecal and total) count. For Total coliforms all the wells had some amount of counts. However, for fecal coliforms there were three wells (N 12, N 31 and N 45) had zero counts . This shows the extent of danger or health risk associated with water from of these wells. Fecal coliform refers to coliform organisms which grow at 44^{o}C and ferment lactose to produce acid and gas. In practice, some organisms with these characteristics may not be of fecal origin and the term “thermo tolerant coliform” is, therefore, more correct and is becoming more commonly used.

6. CONCLUSION

In this study, the concentrations of the investigated physicochemical parameters in the water from hand dug wells from Nyamebekyere in the Obuasi Metropolis in the Ashanti region of Ghana were within WHO guide line values.

However, the quality of groundwater supplied by the wells was not satisfactory with fecal indicator bacteria above WHO limits. The groundwater studied, according to WHO standards is not potable since Total coliforms were present. However the water can be used for domestic purposes when it is treated.

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