2013, Scienceline Publication

Journal of Civil Engineering and Urbanism

Volume 3, Issue 1: 25-28 (2013) (Received: January 11, 2013; Accepted: January 20, 2013; Published: January 30, 2013) ISSN-2252-0430

Physicochemical Assessment of Groundwater Quality in Akure, Southwestern Nigeria

Duvbiama Omolara Atarhe and Egbuna Chukwuemeka Kingsley

University of Brighton, United Kingdom

*Corresponding author's E-mail: cke10@uni.brighton.ac.uk myangel.lara@yahoo.com

ORIGINAL ARTICLE

ABSTRACT: This paper investigates the physicochemical properties of 36 hand-dug wells in the North-western part of Akure, Nigeria. 36 hand-dug wells were analysed for some physicochemical parameters such as temperature, pH, electrical conductivity, redox potential (Eh), total dissolved solids, Ca, Mg, Na, K, HCO_3, Cl, SO_4, total alkalinity, total hardness and acidity. Results showed that all the wells except for wells 8 and 31 have their physicochemical parameters within the WHO guideline value. The high level of these physicochemical parameters in wells 8 and 31 could be attributed to geologic formation of these areas. Since most of the occupants of the area depend on these well water supplies for drinking and other domestic needs, it is recommended that any source of contamination should a minimum of thirty five meters away from any source of contamination.

Keywords: Physicochemical parameter, well, water quality, WHO, Assessment

INTRODUCTION

Water is necessary for household uses which include drinking and sanitation. It is also vital as a critical input into industry, for tourism and cultural purposes and for its role in sustaining the earth's ecosystem (Mark et al., 2002). Groundwater is an important source of water supply throughout the world and almost every living and non-living thing uses water for one thing or the other. In Nigeria, hand dug-wells constitute the largest source of groundwater (Tekwa et al., 2006; Long et al., 2010). Most groundwater in the South-western part of Nigeria is recharged by rainfall, percolation through thin layered soft rock, by percolation of surface water in relatively highly weathered and fractured rock and possibly by seepage from streams and rivers around the city (Olabisi, et al., 2007).

Ground water is less susceptible to bacterial pollution than surface water because the soil and rocks through which ground water flows screen out most of the bacteria. Bacteria, however, occasionally find their way into ground water, sometimes in dangerously high concentrations. The level of microorganisms in groundwater is fewer than surface water and this is due to its lengthy time of travel in the subsurface environment (Bendient et al., 1999; Fasunwon et al., 2008; Louis and Egbuna, 2012). Nevertheless, groundwater can still be polluted by surface runoff, feedlots, domestic sewage, as well as other sources of pollution (Gray, 2008; Fasunwon et al., 2008; Louis and Egbuna, 2012). Several organisations such as World Health Organisation (WHO), U.S Environmental Protection Agency (EPA) and EC directives have laid guideline values which are meant to protect the consumer's health by placing a limit value, in which a water parameter should not exceed.

In this study, the level of some physical and chemical water quality parameters in the wells located in the residential and metropolitan area of Akure, in the south-western part of Nigeria was assessed.

MATERIAL AND METHODS

Study Area: Akure

Akure is the capital of Ondo state, which is located in the South-western part of Nigeria. Akure lies on latitude 7^o 15′ North of the Equator and on longitude 5^o 15′ east of the Greenwich meridian. The study area which is the North-western part of Akure Metropolis is located on latitude N7^{o}15′ to N7^{o}19′and on longitude E005^o 08′ to E005^{o}13′. Topographically the area is made up of both highlands and lowlands. Most part of the North-western part of Akure Metropolis is mainly lowlands except for a few places especially towards the north eastern part of the map where we have highlands in form of conical hills and in some areas like Shagari village the topography is of a gentle slope.

Site selection

Akure is located in the equatorial zone, which has predominant climatic characteristics of being warm humid, with little seasonal variation like the other parts of the western states. Being in the equatorial tropical hinterland, two distinct seasons are experienced, they are wet season; characteristically wet and takes place between April to October and dry season**;** which is characteristically dry and takes place between November and March. Thirty six monitoring sites were visited within

To cite this paper: Duvbiama Omolara Atarhe and Egbuna Chukwuemeka Kingsley. 2013. Physicochemical Assessment Of Groundwater Quality In Akure, Southwestern Nigeria. *J. Civil Eng. Urban*, 3(1): 25-28.

Journal homepage: http://www.ojceu.ir/main/

a period of two weeks, in which groundwater samples are collected and analysed for the purpose of the research.

Laboratory procedures

Physicochemical assessment: The study exercise was carried out using 36 hand-dug wells that were evenly distributed over the study area which is Akure Township. The wells were randomly selected and the distance of one well to the other, accessibility as well as cooperation of owners were put into consideration. The Hanna Comb field metre was used in the field to test the water for its pH, Total Dissolved Solid and Electrical Conductivity. The Global Positioning System was used to locate the wells on the topographical map by taking the longitude and latitude of the position of each well that was chosen. The flame photometer was used to determine the concentration of sodium, potassium and calcium, while titration technique was used to determine the concentration of total hardness, total alkalinity (TA), chloride, acidity (Ac) and bicarbonate. The concentration of sulphate was determined with colorimeter machine.

These laboratory tests were carried out in accordance with standard methods (APHA, AWWA, WEF, 2005). All instruments were calibrated prior to use.

While some of the physical and chemical analysis of water samples was carried out in the field, some others were carried in the geology laboratory of the Federal University of Technology, Akure.

All samples were initially calibrated using distilled water samples before the actual samples from the sites were analysed.

RESULTS AND DISCUSSION

The water table is seen to mimic the topography of the area. It was observed that most of the areas with high hills usually have low water depth when compared with lowland areas. The water table elevation ranged from 320m to 395.3m. 36 hand-dug wells were observed and the results of the physicochemical parameters that were measured from their water samples are shown in table 1, while their descriptive statistics which includes the average values, minimum values and maximum values are also shown in table 2.

The temperature of the wells ranged between 24.7^{o}C and 30.4^{o}C. This is the general ambient temperature of the area. Although no health-based limit was set by WHO for temperature, it is important that temperature of drinking water is within range because higher temperature improves the growth of microorganisms, thereby increasing the associated problems of corrosion, colour and odour (WHO, 2006). The pH value for the 36 wells ranged from 4.64 to 7.08, with most of them below the WHO maximum permissible concentration of 6.5-8.5 in groundwater. The acidity of the groundwater could be attributed to insufficiently cured cement mortar pipe linings. Since pH is one of the most significant operational water quality parameters (its range affects the workability of other parameters), cautious consideration should be made to control the pH. The Total Dissolved Solids of the ground water in ranges from 37mg/l to 767mg/l, with an average of 142mg/l (tables 1 and 2). All the wells except for well 31 have their values less than the WHO permissible limit of 600 mg/l. While no health-based guideline value was proposed to TDS, a TDS value greater than 600mg/l will make the water unpalatable and might also cause excessive scaling in water pipes, heater and boilers (WHO, 2011). The EC measured from the wells ranged from 40 µS/cm to1528 µS/cm, with an average of 284.6µS/cm (tables 1 and 2). The WHO guideline for the electrical conductivity is 1400 µS/cm and only well 31 exceeded this limt. The Eh (Redox potential) determines the dissolved ions of the ground water. The redox potential of the water samples of the hand- dug wells ranged from 374mV to 497mV, with an average of 432.2mV (tables 1 and 2).

Total hardness mainly depends on the amount of calcium or magnesium salt or both. The Total hardness of the samples that were tested ranged from 52mg/l $CaCO_3$ to 740mg/l $CaCO_3$. All the wells except for wells 31 and 8 had their hardness between 52mg/l to 263mg/l, while the total hardness of wells 31 and 8 is 612mg/l and 740mg/l respectively. According to WHO (2011), the taste threshold for the calcium ion is in the range of 100–300 mg/l, while the range of the calcium ions in the well is from 16.8 to 50.5mg/l, with an average of 27.3mg/l (tables 1 and 2). Also, the magnesium ion ranged from 0.5mg/l to 39.2mg/l. From the foregoing, it could be said that the water samples from the well soft, while wells 31 and 8 are very hard (tables 1 and 2). Alkalinity of water is its capacity to neutralize a strong acid and it is normally due to the presence of bicarbonate, carbonate and hydroxide compound of calcium, sodium and potassium. The Total alkalinity of the hand-dug wells ranged from 80mg/l $CaCO_3$ to 580mg/l $CaCO_3$, with an average of 183mg/l. The sodium ion concentration ranges from 8mg/l to 103mg/l, with an average of 31.57mg/l. Although, no health-based guideline value was placed for sodium, the average taste threshold value for sodium is 200mg/l (WHO, 2011). Therefore, all the wells are within the WHO guideline limit for sodium. The potassium ion concentration in the water samples taken from the thirty six hand-dug well ranges from 0.6mg/l to 52.8mg/l. Generally the value of potassium is very low compared to sodium ion concentration and they are well below the WHO guideline value of 300mg/l.

Sulphates in groundwater are caused by natural deposits of magnesium sulphate, calcium sulphate or sodium sulphate. The concentration of sulphate in the water samples tested ranged from 1.25mg/l to 17mg/l which is generally below the WHO permissible level of 250mg/l (WHO, 2011). The bicarbonate concentration in the water samples tested ranges from 73.2mg/l to 707.6mg/l, with wells 8 and 31 having the highest value of 658.8mg/l and 707.6mg/l respectively, thereby confirming the hardness of the well water from 8 and 31. Most bicarbonate ions in groundwater are derived from the carbon (IV) oxide in the atmosphere, carbon (IV) oxide in the soil and solution of carbonate rocks. Chloride in groundwater can be naturally occurring in deep aquifers or caused by pollution from sea water, brine, or industrial or domestic wastes. The range of the concentration of chloride ion in the water samples tested is from 19.53mg/l to 133.125mg/l which is generally below the maximum permissible level (WHO) of 250mg/l.

The values of the chemical constituents of the water samples collected from the hand-dug wells in the North western part of Akure Metropolis was plotted on the Piper's diagram and different hydrochemical facies were identified. The dominant cation facies was Calcium-sodium facies while the most dominant anion was bicarbonate-chloride–sulphate facies. The values of the chemical constituent were also plotted on Stiff's diagram and the most dominant cation was calcium ion while the most dominant anion was bicarbonate ion.

From the results of the laboratory analysis of the water samples and its comparison with WHO guideline value, it could be seen that except for the wells 8 and 31, all other wells have their physicochemical parameters within the WHO permissible value.

The reason for wells 8 and 31 exceeding the WHO guideline values could be attributed to the geologic formation of these areas, which are mainly crystalline basement complex rocks of granitic rocks and charnockites.

Table 1. Descriptive statistics for the physicochemical parameters for the hand-dug wells

Items	Na^+ mg/l	K^+ mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	HCO_3^- mg/l	SO_4^{2-} mg/l	Cl^- mg/l	EC	Eh	TDS	TH mg/l	TA mg/l	Ac mg/l
Mean	31.57	6.79	27.3	6.72	223	7.16	43.5	284.6	432.2	142	182.8	183	406
Minimum	2.5	0.6	16.8	0.5	73.2	1.25	19.5	78	374	39	52	60	180
Maximum	103	52.8	50.5	39.2	707.6	17	133.	1528	497	767	740	580	1000

*Ac = Acidity, TH = Total Hardness, TA = Total Alkalinity, EC = Electrical conductivity, Eh = Redox potential

Table 2. Results of the physicochemical assessment of the hand dug wells

S/N	Na^+ mg/l	K^+ mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	HCO_3^- mg/l	SO_4^{2-} mg/l	Cl^- mg/l	EC	Eh	TDS	TH mg/l	TA mg/l	Ac mg/l
1	17	1.6	21.87	1.01	122	1.5	19.53	105	437	52	72	100	300
2	44	4.4	45.42	3.66	170.8	1.75	62.13	321	434	160	176	140	400
3	18	0.9	16.82	0.58	97.6	10.5	28.4	98	412	49	52	80	300
4	32	7.8	18.5	6.66	170.8	6.5	28.4	223	427	111	160	140	280
5	30	4.2	16.82	7.84	219.6	5.5	21.3	227	404	113	176	180	280
6	14	3.6	21.87	0.55	122	2.25	21.3	78	433	39	64	100	300
7	14	6.2	20.19	1.03	97.6	1.75	39.05	92	497	46	68	80	180
8	96	5.6	28.6	39.2	658.8	12	133.13	1175	410	587	740	540	600
9	25	8.8	23.55	4.52	268.4	10.25	37.28	141	433	70	136	220	280
10	2.5	8.5	31.96	4.46	390.4	16.5	40.83	203	452	101	156	320	400
11	13	7	28.6	0.5	146.4	3.25	26.63	87	431	43	80	120	280
12	13	3	20.18	1.5	219.6	2	24.85	96	452	48	76	180	440
13	13	17.9	23.55	5.22	146.4	4.75	35.5	163	422	82	148	120	300
14	8	16.2	38.7	6.52	439.2	5.25	28.4	192	429	96	208	360	220
15	27	0.6	35.32	5.84	97.6	5.75	69.23	234	450	118	188	80	340
16	13	7	26.9	4.02	292.8	2.25	31.95	136	399	68	136	240	500
17	15	7.1	16.82	4.8	195.2	2.5	24.85	129	429	64	124	160	440
18	12	4.2	20.19	3.6	97.6	3	46.15	104	446	52	112	80	340
19	39	4.9	47.1	14.2	585.6	11.75	33.73	376	423	188	360	480	500
20	21	5.2	23.55	2.41	195.2	5	24.85	167	445	83	100	160	440
21	45	4.2	26.91	6.36	195.2	1.25	44.38	247	455	114	176	160	580
22	34	7.2	28.6	5.42	195.2	6.75	40.83	212	435	106	164	160	360
23	40	4.6	20.19	6.42	122	15.5	53.25	261	461	130	160	100	420
24	53	3.7	23.6	7.33	170.8	3	67.45	373	451	187	184	140	360
25	64	12	45.42	6.99	97.6	6.5	81.65	543	448	271	233	80	440
26	37	5.8	28.6	4.94	73.2	9.5	42.6	225	431	128	156	60	480
27	12	2.4	20.19	2.2	97.6	9.25	26.3	84	439	42	88	80	380
28	34	2.3	25.23	10.6	219.6	8.75	35.5	314	413	157	244	180	180
29	41	1.2	20.19	4.31	97.6	5.25	30.18	213	429	106	124	80	480
30	25	7.6	50.46	18.9	488	14.75	42.6	576	374	288	448	400	940
31	103	52.8	35.32	30.7	707.6	12.75	122.48	1528	417	767	612	580	1000
32	53	3.2	33.64	7.26	146.4	17	78.1	734	422	368	208	120	500
33	70	5.7	26.91	1.68	97.6	9.5	28.4	106	400	53	96	80	520
34	20	2.8	25.23	2.63	146.4	11.5	31.97	130	436	65	108	120	220
35	25	1.7	23.55	6.16	170.8	10.25	28.4	232	440	116	164	140	280
36	14	2.4	21.87	1.72	268.4	2.25	37.28	121	444	60	84	220	340

CONCLUSIONS

This study assessed the physical and chemical quality of groundwater in Akure, south-western part of Nigeria, in order to determine whether the water meets the recommended drinking water physical and chemical quality standards as set out in several drinking water related regulations and directives.

The following conclusions were drawn from the study; results showed that all the wells except for wells 8 and 31 have their parameters below or within the WHO guideline values.

From these results, it could almost be concluded that all these wells are suitable for drinking except for wells 8 and 31, since the hydrogen ions, calcium and magnesium ions concentration exist at level suitable for drinking. Nevertheless, public awareness and education on health risk related with the consumption of untreated water and the indiscriminate location of wells is necessary.

REFERENCES

Bendient, P.B., Rifat, H.S. and Newell, C.J.(1999). *Groundwater Contamination: Transport and Remediation*, 2nd edition. Prentice Hall Publications.

Fasunwon, O., Olowofela, J., Akinyemi, O., Fasunwon, B. and Akintokun, O.(2008). Contaminants Evaluation as Water Quality Indicator in Ago-Iwoye, South-western, Nigeria. *African Physical Review (2008) 2:0012*

Gray, N.F. (2008). Drinking Water Quality: Problems and Solutions. Cambridge University Press, Cambridge UK.

Longe, E.O., Omole, D.O., Adewumi, I.K. and Ogbiye, A.S. (2010). Water resources use, abuse and regulations in Nigeria. *Journal of Sustainable Development in Africa*. 12(2).

Louis, I.A. and Egbuna, C.K. (2012). Assessment of Ground-water in the South-East of England. *J. Cvil Eng. Urban* 2(6): 00-00

Mark, W.R., Ximing Cai and Sarah A.C. (2002): World Water and Food to 2025: Dealing with Scaraty. *International Food Policy Research Institute*, NW, Washington, DC, USA

Olabisi, E.O., Awonusi, A.J. and Adebayo, O.J. (2007). Assessment of bacteria pollution of shallow well water in Abeokuta, Southwestern Nigeria. *Life Science Journal. 2008; 5(1): 68 – 72.*

Tekwa, I. J., Abba, M. U. and Ray, H. H. (2006). An Assessment of Dug-well Water Quality and Use in Mubi, Nigeria**.** *Journal of Sustainable Development in Agriculture and Environment* Vol. 2(1).

WHO (2006). Guidelines for Drinking-water Quality. third edition. WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland.http://www.who.int/water_sanitation_health/dwq/gdwq3rd_add1.pdf (accessed 10/01/2013)

WHO (2011). Guidelines for Drinking-water Quality. fourth edition. WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland.