Analysis of Groundwater Quality of Hand-Dug Wells in Peri-Urban Area of Obantoko, Abeokuta, Nigeria for Selected Physico-Chemical Parameters.

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ABSTRACT

To assess the groundwater quality in the Obantoko community, a peri-urban area in Abeokuta, Nigeria, twenty-five (25) hand-dug wells were selected and analyzed for important water quality parameters using standard procedures. Observed parameters were temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), hardness, alkalinity, chloride (Cl^-), sulfate (SO_4^{-2}), phosphate (PO_4^{3-}), nitrate (NO_3^-), and ammonia (NH_4^+). The results of water parameters analyzed showed elevated values of pH (7.7 – 9.5), electrical conductivity (110 – 490 µS/cm), temperature (27.7 – 28.3 ^oC), TSS (10 – 450 mg/l), phosphate (27.9 – 86.0 µg/l), nitrate (2.97- 40.68 mg/l) and ammonia (0.0 – 0.59 mg/l), higher than World Health Organization standards for drinking water. The potential health risks associated with these water parameters have been documented. The groundwater quality of these wells is thereby compromised and unfit for healthy consumption except when thoroughly treated.

(Keywords: hand-dug well, water parameters, groundwater, quality, standard, health risk)

INTRODUCTION

Obantoko is a peri-urban community located on the outskirts of the ancient city of Abeokuta in the Odeda Local Government Area, Ogun State (longitude 3^o 20’ E and latitude 7^o 93’ N). The residents depended absolutely on hand-dug wells for their water supply. During the wet season due to the poor drainage system of the community, runoff water from diverse sources finds itself emptied into these wells, thereby deteriorating the groundwater quality. This is usually evident in the rise in water levels of the wells; water becoming turbid and brownish in color, which could last for days before it clears.

Access to safe drinking water for every individual regardless of the economic and social status is one of the objectives of the World Health Organization (WHO) (Lefort, 2006). Large portions of the populace in developing countries die annually as a result of water borne diseases such as cholera, typhoid, hepatitis, diarrhea, etc. (WHO, 2008). Groundwater is a major water source for rural dwellers for both domestic and drinking purposes. However, groundwater resources through hand-dug wells may be contaminated by soil particles eroded during heavy downpours on which water-impairing substances like nitrates and phosphates are washed into the wells.

Adekunle *et al*. (2007) has established the contamination of wells sited close to dumping sites in southwest, Nigeria. Similarly, Ajayi *et al.* (2002) reported pollution of some well water resources in Warri, a coastal part of Nigeria.

Runoff from agricultural and human activities had been found to increase water pollution indices in Epie creek in Yenagoa, Bayelsa State (Izonfuo and Bariweni 2001). Whenever there’s a rainfall, varieties of contaminants from the atmosphere and land surfaces are deposited into surface and ground waters resulting in pollution (Strahler and Strahler, 1973).

Although most of the hand-dug wells in Obantoko are usually covered, they are not free from contaminations from runoff. Pollutants transported by surface runoff are deposited into these wells via available openings and percolation. Cases of water pollution by run-off have been reported by Inoue and Ebise (1999), Inanc *et al.* (1998), and Martin *et al*. (1998). Nitrate remains a major concern in groundwater contamination because of its high solubility and health implication (mostly on pregnant women and infants below six months in age).

Research also indicates that there is a potential for phosphorus to leach into groundwater through sandy soils with high phosphorus content (Citizens Pfiesteria Action Commission, 1997). The presence of nitrates and phosphates in groundwater may increase the microbial load of the water. The objective of this study is to assess the groundwater quality of some selected hand-dug wells in Obantoko, Abeokuta, Nigeria.

MATERIALS AND METHODS

The Study Area

Obantoko is one of the peri-urban areas of Abeokuta (Figure 1), an ancient city in the southwestern part of Nigeria. It is characterized by a hot humid climate (28^{o}C) with an average annual rainfall of 1.19m (Okeyode and Akani, 2009).

Abeokuta is located on basement complex of igneous and metamorphic origin (Jones and Hockey, 1964). The basement rocks are overlain by various sedimentary rocks. The metropolis covers a geographical area of 78.57 square kilometers with population of about six hundred thousand whose occupations are farming, trading, textile making (Adire), pottery, and fishing (Oyawoye, 1964). The land-use types in the city also reveals that large portion of undeveloped land parcels spaces between buildings are either cultivated or used as a dumpsite, and are typically littered with human and animal wastes as shown in Figure 2 (Gbadebo *et al*., 2010).

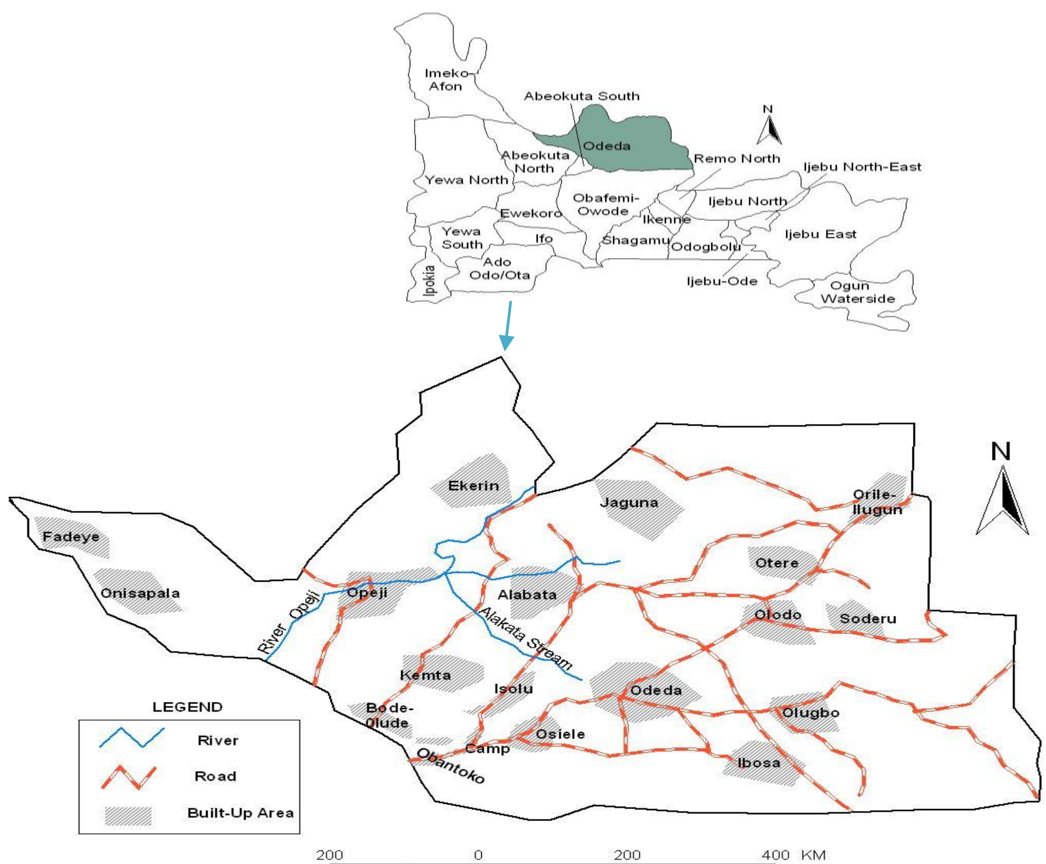

Figure 1: Map Showing the Study Area in Odeda Local Government (insert is Ogun state, Nigeria and Africa).

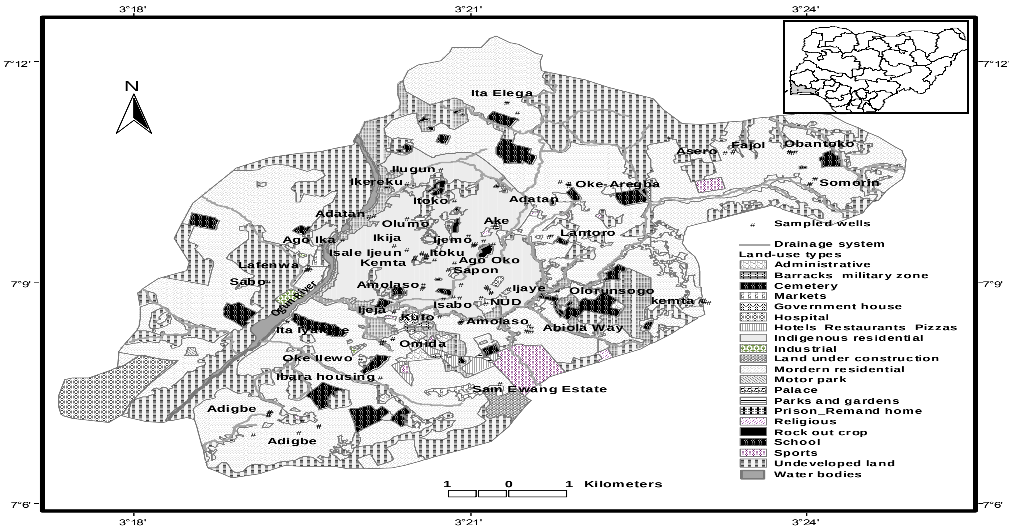

Figure 2: the Land-use map of Abeokuta Metropolis (basement complex terrain section of the study area. Inset location in Nigeria) (Source: Gbadebo et al., 2010).

Sample Collections and Analysis

Water samples were collected randomly from 25 hand-dug wells in Obantoko, Abeokuta. Samples were collected during the rainy in 2008. The water samples were subjected to various laboratory analyses using standard procedures (APHA, 1989). The below listed parameters were determined: temperature, pH, electrical conductivity, total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), hardness, alkalinity, chloride, sulfate, phosphate, nitrate, and ammonia. Temperature, pH, EC, TDS were determined by probe methods, TSS was analyzed gravimetrically while TS was measures by addition of TSS and TDS. Alkalinity, chloride and hardness were determined titrimetrically while sulfate, phosphate, nitrate, and ammonia were measured via colorimetric methods. Data are presented in Table 1.

RESULTS AND DISCUSSIONS

Table 1 shows the values of various physico-chemical parameters determined from the sampled hand-dug wells. Water temperature shows no variation in all the wells sampled, with values generally greater than 27^{o}C. The Commission of European Community (1988) maximum standard for temperature for drinking water is 25^{o}C. The temperature results obtained from the sampled groundwater was greater than this standard. Temperature has been known to have effects on other parameters like dissolved oxygen and also toxicity of metals (Awofolu *et al.,* 2007).

Th pH of the hand-dug wells anged from 7.7-9.5. WHO pH standard for drinking water is 6.5-8.5 (WHO, 1993). Most of the pH values obtained from this study were higher than this standard. The alkaline nature of the well water could alter the toxicity of other pollutants. For instance, ammonia is more toxic in high pH water (i.e., pH>8.5) than at low pH water (Wilcock *et al.* 1995). pH may also affect the solubility and bioavailability of other substances (heavy metals) in water (EPA, 2003).

Electrical conductivity (EC) is a measure of total salt content in water (Morrison *et al.,* 2001). It's a determination of levels of inorganic constituents in water (Awofolu *et al.,* 2007). In drinking water, WHO standard for EC is 250μS/cm (WHO, 2003). About 76% of the well samples have their EC values greater than this permissible standard. High EC in water may result into adverse ecological effects on aquatic biota (Fried, 1991).

The total dissolved solids (TDS) values obtained from this study were less than 500 mg/l, the WHO standard for drinking water (WHO, 1993). TDS is a measure of total inorganic and organic substances dissolved in water (ANZECC, 2000). TDS concentration in natural water is generally less than 65 mg/l (Garrison Investigative Board, 1977).

Table 1: Physico-Chemical Parameters of the Hand-Dug Wells from Obantoko, Abeokuta.

Sampled wells (s/n)	pH	T (°C)	TDS (mg/l)	TSS (mg/l)	TS (mg/l)	EC (µS/cm)	PO_4^{3-} (µg/l)	NH_4^+ (mg/l)	SO_4^{2-} (mg/l)	NO_3^- (mg/l)	Cl^- (mg/l)	Hardness (mg/l)	Alkalinity (mg/l)
1	7.8	28.0	270	280	550	530	30.0	0.03	197.5	13.32	90	210	160
2	8.4	28.2	240	270	510	460	28.2	0.15	115.0	28.41	-	-	-
3	8.8	27.9	50	10	60	110	27.9	0.0	5.0	25.01	18	80	80
4	8.9	28.0	160	260	420	330	40.0	0.59	120.5	28.23	50	113	40
5	7.7	28.0	140	200	340	280	28.0	0.0	195.0	10.38	40	113	120
6	8.8	28.0	170	360	530	340	46.0	0.0	155.0	30.42	56	72	80
7	9.3	27.9	170	260	420	350	36.0	0.01	155.0	21.69	46	112	40
8	8.6	27.5	70	-	-	140	54.0	0.0	207.5	6.15	-	-	-
9	8.9	27.9	250	330	580	490	64.0	0.47	340.0	6.72	64	168	120
10	9.1	28.1	170	270	540	350	28.0	0.0	145.0	25.68	44	76	80
11	9.4	27.8	170	350	520	330	40.0	0.19	115.0	23.4	58	136	40
12	8.9	27.9	160	360	520	330	30.0	0.0	120.0	30.18	56	108	40
13	8.6	27.8	250	-	-	520	44.0	0.01	275.0	3.6	-	-	-
14	9.1	28.1	140	380	520	-	66.0	0.01	225.0	15.09	26	144	80
15	7.6	28.1	160	-	-	330	42.0	0.0	115.0	14.52	-	-	-
16	7.6	28.2	70	290	360	140	30.0	0.0	2.5	2.97	30	48	120
17	8.3	27.9	170	400	570	340	68.0	0.02	240.0	15.99	26	40	120
18	9.0	27.7	50	380	430	110	44.0	0.0	37.5	10.26	28	12	120
19	9.5	27.7	130	330	460	280	36.0	0.0	52.5	25.74	158	80	80
20	9.2	28.2	230	450	680	490	40.0	0.0	130.0	40.68	74	176	40
21	8.6	27.7	250	280	530	490	56.0	0.0	207.5	17.04	-	140	-
22	8.7	28.2	170	240	410	350	86.0	0.27	100.0	9.27	40	100	80
23	8.1	28.3	200	190	390	420	58.0	0.29	225.0	27.84	48	84	80
24	7.3	28.0	130	200	330	270	50.0	0.38	22.5	4.38	102	124	80
25	8.9	28.1	100	440	540	210	80.0	0.35	130.0	4.77	-	108	-

TDS levels have been found to be higher in regions of Palaeozoic and Mesozoic sedimentary rock, ranging from 195 to 1100 mg/l (Garrison Investigative Board, 1977) because of the presence of carbonates, chlorides, calcium, magnesium and sulfates (Rainwater and Thatcher, 1960). According to TDS panels of tasters, the palatability of these hand-dug wells could be rated excellent being less than 300 mg/l (Bruvold and Ongerth, 1969). There's no health effect of TDS but when greater than 500 mg/l could results into corrosions (USEPA, 1998).

The total suspended solids (TSS) of the well samples ranged between 10-450 mg/l. This value was absolutely high when compared to Robert (1978) TSS standard for aquatic life in fresh water habitat given as 25-80 mg/l. The influx of run-off into these hand-dug wells might have responsible for this high TSS values. High TSS in these wells could be dangerous to human health when the water is consumed without filtering. TSS has tendency to shield harmful microorganisms. Total solids (TS) are the sum of TDS and TSS. The highest value of TS in this study was 680 mg/l, which was below the WHO standard given as 1000 mg/l (WHO, 1993).

The well water samples were moderately alkaline and buffered against sudden pH change, with alkalinity values varied between 40 mg/l and 120 mg/l. Nevertheless, this is within the WHO limit of 200 mg/l for drinking water. Run-off has been reported by Phiri *et al.* (2005) to increase water alkalinity. For protection of aquatic life the buffering capacity should be at least 20 mg/l (www.kywater.org/ww/ramp/rmfe.htm).

Temporary loss of buffering capacity can permit pH levels to drop to level that could be harmful to life in the water. Drop in pH of drinking water could be harmful for consumption because metal dissolves more in low pH water.

Water hardness is usually due to the presence of multivalent metal ions, which come from minerals dissolved in the water. Water hardness standard for drinking water is 10-500 mg/l $CaCO_3$ (Marier *et al*., 1979). Tyson and Harrison (1990) classified hardness in drinking water in terms of its calcium carbonate concentration as follows: soft, 0 -60 mg/l; medium hard, 61 to 120 mg/l; hard, 121 to 180 mg/l; and very hard, 181 mg/l and above. Based on this classification, three of the sampled hand-dug wells have hardness that could be described as soft (12-48 mg/l), eleven as medium (72-113 mg/l), six as hard (124-176 mg/l) while only one is very hard (210 mg/l). No health effect has been associated with hardness in drinking water. However, Dzik (1989) has reported an inverse relationship between water hardness and cardiovascular disease.

Chloride concentration in these well water samples ranged from 18-158 mg/l, these values were below the WHO standard of 250 mg/l for drinking water. Department of National Health and Welfare, Canada (1978) reported that chloride in surface and groundwater may result from both natural and anthropogenic sources such as run-off containing salts, the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas. Chloride is not harmful to human at low concentration but could alter the taste of water at concentration above 250 mg/l (Hauser, 2001).

Sulfate is a non-toxic anion that is present in natural water, but ailment like catharsis, dehydration and gastrointestinal irritation have been linked with it when concentration is above 500 mg/l (Bertram and Balance, 1996). By and large, the concentrations of sulfate obtained from this study varied between 5.0 - 340 mg/l and fell within WHO limits of 250 mg/l.

The range of ammonia (in the form of ammonium nitrate) in this study was 0.00-0.59 mg/l. With the exception of well number 4, the concentration of ammonia was less than 0.50 mg/l. However, over half of the well sampled had zero value of ammonia. WHO standard for ammonia for drinking water is 0.5 mg/l (WHO, 1993). In uncontaminated surface or groundwater, the value of ammonia is usually less than 0.1 mg/l (Wilcock *et al*., 1995). About 20 % of the sampled wells in this study have ammonia values greater than this value (0.1 mg/l). Ammonia is toxic to aquatic organisms (Richardson, 1997). The toxicity however depends mainly on pH and temperature (Wilcock *et al.,* 1995).

The phosphate range of the well water samples was 12-86 μg/l. More than one-third of the well samples had their phosphate values higher than Ministry of the Environment and Energy, Canada (1994) permissible limit of 30 μg/l normally found in natural water. The major concern of phosphate in water is eutrophication (Environmental Manual for Poultry Practice, 2003). Phosphate is toxic to animals and humans at extremely high levels and could cause digestive problems (D'Amelio, 2007).

The nitrate level of about 68 % of the well water samples was greater than WHO standard of 10 mg/l for drinking water (WHO, 2003). Nitrate is harmful when it is above this concentration as it causes methemoglobinemia in infants less than six months. Other ailments associated with high nitrate concentration are diarrhea and respiratory diseases (Ward *et al.,* 2005). In an unpolluted river nitrate is usually less than 1.0 mg/l (Meybeck, 1982). The observed high nitrate from this study might have resulted from lawn fertilizer run-off, leaking septic tanks and cesspools, manure from farm livestock, animal wastes and discharges from car exhausts (USEPA, 1986; Knepp and Arkin, 1973). A high nitrate value had been reported in wells close to poultry farm in Oyo state (Ajayi *et al*., 2002). Similarly, high value of nitrate (124 mg/l) had been observed in a groundwater in parts of southwestern Nigeria (Malomo *et al*., 1990).

CONCLUSION

The values of parameters such as temperature, EC, phosphate and nitrate are higher than WHO standards are major threats to the groundwater quality in the study area. Similar observation has been reported by Orebiyi *et al*. (2010) who studies the pollution hazards of shallow wells in Abeokuta and environs. High values of nitrate, TSS, phosphate and EC were generally observed. Drinking these well waters is dangerous to human health, although, WHO has no standards for some of the measured parameters. There is need for proper erosion management in Obantoko to cushion the effect of runoff, which introduces these pollutants into the wells. Nitrate remains a major issue in all the wells sampled because of its high values, which are above the permissible limit for drinking water, for this reason, poses a potential health-risk for infants and pregnant women.

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