Assessment of bacteria pollution of shallow well water in Abeokuta, Southwestern Nigeria

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Abstract

The significance of good quality water to health has long been realized hence the development of water resources is a significant part of integrated community development policy. In this paper the analysis of bacteriological quality of shallow well water was undertaken. This is because shallow well is fast gaining prominence as an alternative source of potable water supply in Abeokuta. To this end, the city of Abeokuta was divided into four zones namely indigenous areas (I), Peri-urban areas (P), modern low density areas (MLD) and modern high density areas (MHD) and a total of 40 shallow wells over the entire study area were investigated. The pH, temperature and electrical conductivity were taken on the field to avoid interference by change of environment while the bacteriological analysis was carried out within 24 hours of sampling. The result of the bacteria count shows a minimum value of 20 col/100 ml at MHD-1 and a maximum value of 800 col/100 ml at I-8. Fifteen (15) of the wells also show presence of multiple bacteria. From the study, it was found that shallow well water in Abeokuta are highly contaminated with faecal bacteria and requires disinfection before use since all the wells test positive to the presence of faecal bacteria. [Life Science Journal. 2008; 5(1): 68 – 72] (ISSN: 1097 – 8135).

Keywords: bacteria pollution; shallow well; ground water; modern low density; modern high density; indigenous; peri-urban; Geographic Information System; Abeokuta; Nigeria

1 Introduction

The importance of potable water supply in poverty alleviation and socio-economic development cannot be overemphasized. In fact it has attracted increasing attention over the last decade and will still enjoy greater attention over the next decade. This is because access to water and adequate sanitation is a core objective of the Millennium Development Goals of reducing poverty by the year 2015. In Abeokuta metropolis, with a population of 605,461 (projected from 1991, Census at a growth rate of 3.5 percent) and a daily water demand of 120 million liters per day (MLD), the water supply from the Ogun State Water Corporation is inadequate in terms of quantity hence the need for alternative source of water supply. The new Abeokuta water scheme at Arakanga has a design capacity of 163 MLD but at present, it produces 80 MLD leaving a short fall of 40 MLD in the water demand of the city. In order to meet the daily water demand in Abeokuta, groundwater is being considered a better alternative to supply from public fountains. This is because groundwater is characterized by certain features that make it attractive as a source of potable water supply. Firstly, with adequate aquifer protection, groundwater has excellent microbial and chemical quality and it therefore requires minimal or no treatment[1]. Secondly, the capital cost of groundwater development when compared to surface water development is modest and groundwater lends itself to flexible development[2].

The groundwater in Abeokuta 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. The groundwater is tapped at shallow depths for domestic use through hand-dug wells. The wells terminate in the weathered crystalline rocks and if deep enough could sustain the dry season.

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The increases in the development of groundwater in Abeokuta due to increase in population is also accompanied by an increase in the provision of on-site sanitation systems. The above statement is premised on the fact that the city lacks a central Sewage treatment system. Therefore the provision of cesspools and septic tanks soakaway is considered a better choice of excreta disposal. As reported by Odai and Dugbantey[3], on-site sanitation facilities happen to be the choice of excreta disposal in communities where groundwater is used for domestic purposes. However, there is a growing concern that the use of on-site sanitation facilities may result in groundwater contamination and subsequent diseases outbreak and transmission. Besides, one gram of faecal material can contain 10 million viruses, 1 million bacterial, 1 million cysts, and a hundred eggs of worms[4]. Unfortunately millions of persons are unaware that there is link between faecal contamination and the occurrence of intestinal worms, diarrheic diseases, schistosomiasis, and skin troubles among others. Children are an easy target for these diseases which causes or account for the death of 600 of them per day[4]. In Ago-Odo, Ikereku, Ikija and Adedotun areas of Abeokuta, the outbreak of Cholera as a result of water scarcity between 28th of November and 12th December 2005 led to the death of 10 people most of which are children.

From the health point of view, the most important characteristic of good quality water is obviously an absence of pathogenic organisms[5]. By convention, water contamination is considered to be the introduction or release into water organisms or toxic substances that render it unfit for human consumption or domestic use[6]. Meanwhile, water bodies polluted by faecal discharge from man and other animals may transport a variety of human pathogens. These microbial agents include pathogenic bacteria, viruses, protozoa and several more complex multicellular organisms that can cause gastro-intestinal illness. Other organisms are opportunistic in nature infecting susceptible individual through body contact with contaminated film or by inhalation of poor quality water droplets in aerosols of various origin[7]. The most common water borne bacterial pathogen detected in contaminated drinking water supplies in the USA during 1961 – 1983 were *Shigella*, *Salmonella*, *Camphilobacter*, toxigenic *Escherichia coli* (*E. coli*), *vibrio* and *yersina*[8]. Others include *mycobacterium*, *pasteurella*, *leptospira* and *legionella*, *klebsiella* (Table 1).

Since *E. coli* first became recognized as the most appropriate bacteriological indicator of water pollution by human excrement, the most probable number (M.P.N) of coliform group has been universally used as an indicator[9]. But for small household supplies such as wells and springs the WHO suggests that a zero *E. coli* count and not more than 10 coliforms per 100 ml are appropriate standards[5]. The zero *E. coli* count standard lay down by WHO is attainable; for example, there were no *E. coli* in 13,000 samples taken in London in 1964 – 1965[10]. However, these standards are too high for general applicability in tropical developing countries. Therefore by determining the level of bacteria pollution and identifying the bacteria present in the shallow wells water of Abeokuta, an attempt has been made to predict the health hazards associated with the use of such waters.

Table 1. Bacteria and associated diseases

Bacteria organism	Diseases
Camphilobacter	Gastroenteritis
Pathogenic *E. coli*	Gastroenteritis
Pathogenic *Klebsiella* spp.	Respiratory infection
Salmonella typhi	Typhoid fever
Other *Salmonella*	Food poisoning
Shigella spp.	Bacillary dysentery
Vibrio cholerae	Cholera
Vibrio vulnificus	Septicaemias
Other *Vibrios*	Diarrhoea
Yersinia spp.	Yersiniasis

Source from International Journal of Tropical Science[11].

2 Materials and Methods

2.1 Study area

The study area Abeokuta is located in the sub-humid tropical region of Southwestern Nigeria (Latitudes 7º 5′ N to 7º 20′ N and Longitudes 3º 17′ E to 3º 27′). The city enjoys a tropical climate with distinct wet and dry seasons with dry period of about 130 days[12]. The mean annual rainfall and temperature are about 1,270 mm and 28 ºC respectively while the estimated mean annual potential evaporation is 1,100 mm. The city is underlain by crystalline pre-Cambrian Basement complex of igneous and metamorphic origin noted for their rather poor groundwater bearing properties[13]. The city is drained mainly by River Ogun which passes through and divides the city into two, and the drainage pattern is dendritic. The study area which covers a geographical area of 1,256 square kilometers has a population of about 605, 461 and comprise of Abeokuta South, Abeokuta North, parts of Odeda and Obafemi-Owode Local Governments of Ogun State of Nigeria. The main occupation of the indigenes is

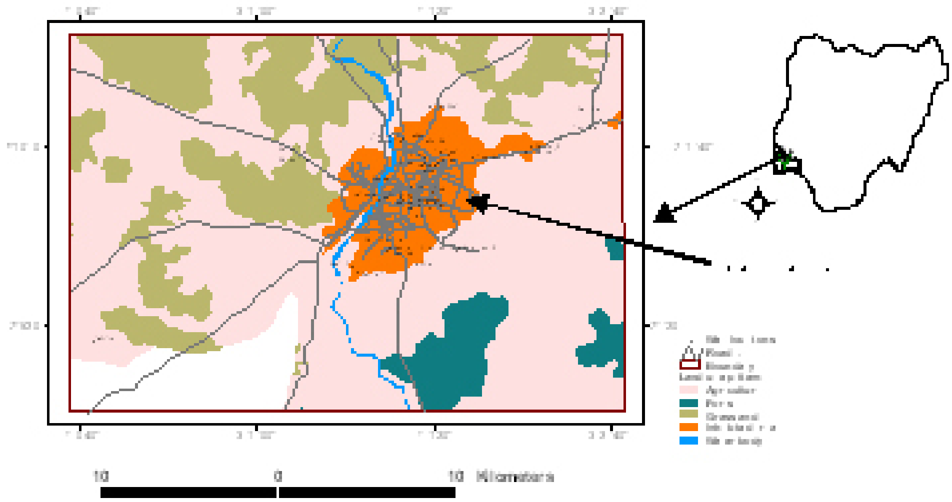

Figure 1. Map of study area showing sample points and land use pattern (Inset Map of Nigeria showing geographical location of study area).

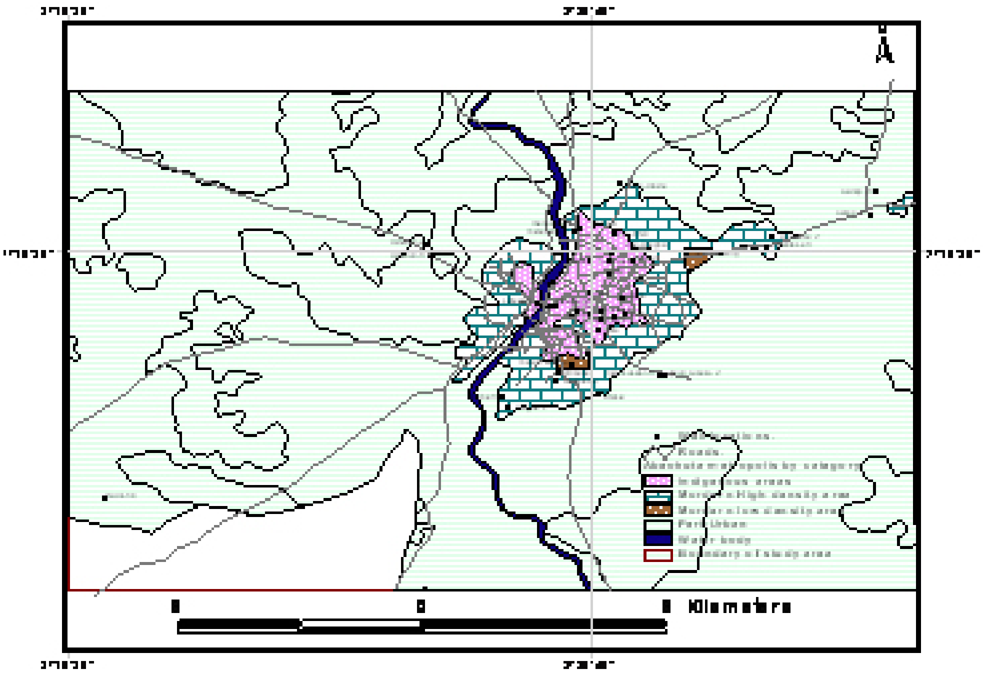

Figure 2. Map of study area showing Abeokuta metropolis by categories.

farming, local textile making (Adire) trading, pottery and fishing (Figures 1 and 2).

2.2 Survey of sanitary conditions

Visual inspection of the selected wells and sanitary systems of the immediate environment of the wells was conducted. Distance between the various sanitary systems and the wells were measured. Their related positions were also noted.

2.3 Sampling of water

The samples were collected, stored and transported in sterilized crystal bottles for bacteriological analysis while the pH, temperature and electrical conductivity were measured at the field. Samples were collected by the use of hand pumps fitted on the shallow wells. The spout of hand-pumps were cleaned and sterilized before sampling with flame to prevent contamination of samples. A total of 40 samples were collected from shallow wells with static water level ranging from 1.2 m to 11.1 m (Table 2). Sampling was done in December 2005.

2.4 Water sample analysis

The analysis of water sample was carried out within twenty four hours of collection. The bacteria count and identified bacteria were analyzed for in the samples. Because of their small size, observation with the naked eye is impossible and in the case of the simpler micro organism, their physical features do not provide identification. Nutrient agar medium was used to obtain plate count of living bacteria (viable cell count). The procedure involves mixing 1ml of water sample with liquefied agar at 40 ºC in a Petri dish. The agar sets to a jelly, thus fixing the bacteria cell in position. The plate is then incubated under appropriate condition (24 hours at 37 ºC for bacteria organism from animal or man)[14].

At the end of the incubation, the individual bacteria will have produced colonies visible to the naked eye and the number of colonies is assumed to be a function of the viable cells in the original sample. Detection of coliform was achieved using a lactose medium (MacConkey Broth) inoculated with serial dilution of the sample. The appearance of acid and gas after 24 hours at 37 ºC was taken as positive indication of the presence of coliform bacteria; results were expressed as number of colonies per 100 ml. As a confirmation for bacteria, tubes were subculture appropriately in fresh medium for 24 hours at 44 ºC under which conditions such bacteria as appropriate will grow.

3 Results and Discussion

The summary of the results of the measured parameters in the study area is presented in Table 2 and Figure 3. The concentration of bacteria in a sample of water is usually expressed as the number of colonies per 100 ml (col/10 0ml). The results indicated that shallow wells in Abeokuta metropolis has high bacteria pollution and non of the sampled well give a result that falls within the permissible level for drinking water quality given by the WHO. All sampled well test positive to bacteria count with the lowest result of 20 col/100 ml occurring at MLD-1, while the highest result of 800 col/100 ml was obtained at I-5. A single bacteria type (Table 2) was obtained at MLD-1 while I-5 which has the highest number of bacteria count also shows the highest concentration of identified bacteria (EC + PA + SAL). All the wells in the indigenous areas and the Peri-Urban areas of the metropolis where majority of the research work was carried out indicated high bacteria pollution with results ranging from 100 to 800 except P7, P8, and P9 which has 80 col/100 ml, 40 col/100 ml and 90 col/100 ml respectively. All the wells in the MLD and MHD areas show the presence of single bacteria except MHD-3 which shows the presence of EC and PA. The high bacteria pollution observed in the study may be attributed to both the shallow depth at which water is tapped, settlement pattern and land use practices. The location of wells also does not take water quality into cognizance. Wells are often located too close to sanitation systems and almost all the well used bailer as mode of collection (Table 3).

The bacteria pollution of shallow wells in Abeokuta is anthropogenic in origin. The high human concentration in Abeokuta metropolis enhances the use of pit latrines and septic soak away which are often located too close to the wells in most households (Table 3). In addition to this, free ranging domestic animals and other domestic solid wastes which are dumped around the house are possible sources of bacteria pollution of the shallow wells. Besides, there is tendency for higher rate of infiltration of precipitated water during the rainy season.

High level of faecal bacteria in water samples indicate the possible presence of pathogenic (disease causing) organisms. From the result of the bacteria identification carried out, it is evident that diseases such as cholera, typhoid fever, bacteria dysentery, infectious hepatitis and food poisoning can possibly result from the consumption of the water. Eye, ear, nose and throat infections can also spread from contact with the water. The presence of these bacteria indicates that the sanitary conditions of shallow wells in Abeokuta most especially the indigenous and peri-urban areas are very poor.

4 Conclusion

Integration of GIS in modelling distribution variability of bacteria as an indicator of shallow well water pollution has demonstrated its usefulness as a tool in predicting the state of groundwater at any point. This tool could be employed to protect the groundwater resources.

The results revealed that inhabitants of Abeokuta who consume water drawn from shallow wells without treatment stands the risk of bacteria pollution in drinking water as concentration of bacteria exceeds the WHO

Table 2. Results of laboratory analysis of the water samples

S/N	Location	Latitude	Longtitude	Bacteria count	Identified bacteria	Temperature (°C)	pH	Electrical conductivity (µs/cm)	Static water level
I-1	Isabo	7.148	3.349	100	EC	26	8.29	507	2.60
I-2	Igbein	7.149	3.345	400	EC + PA	23	8.12	847	4.80
I-3	Igbore	7.150	3.341	300	EC	26	7.80	1005	1.80
I-4	Ijeun Lukosi	7.148	3.353	600	EC + PA	26	7.99	742	2.94
I-5	Oke-Sokori	7.152	3.333	800	EC + PA + SAL	27	8.08	866	2.58
I-6	Elega	7.181	3.346	400	EC	25	8.12	499	2.05
I-7	Oke-Efon	7.179	3.353	400	KL + EC	25	8.19	642	4.20
I-8	Adatan	7.169	3.359	200	EC + PA	26	8.05	1128	5.20
I-9	Oke-Aregba	7.173	3.365	600	PA	26	8.03	273	2.55
I-10	Itoku	7.157	3.345	100	EC	26	8.35	1039	1.60
I-11	Iberekodo	7.180	3.341	400	EC	27	8.15	672	1.64
I-12	Iberekodo	7.180	3.340	500	EC + PA	27	7.96	737	1.67
I-13	Ago-Ika	7.161	3.332	400	EC + PM	26	8.42	746	1.20
I-14	Lafenwa	7.153	3.327	400	EC + PM	27	8.18	495	1.85
I-15	Ake	7.164	3.351	400	EC + PM	25	7.98	923	3.35
I-16	Ijaye	7.149	3.357	200	EC	26	7.50	1101	8.30
I-17	Ilogbo	7.155	3.356	200	EC	26	7.20	1035	5.10
I-18	Oke-Bode	7.150	3.349	400	EC	26	7.20	881	4.27
I-19	Itoko	7.169	3.345	200	EC	26	7.30	1251	5.10
I-20	Oke-Ejigbo	7.169	3.351	100	EC	27	6.20	776	7.20
I-21	Totoro	7.152	3.333	600	EC + SAL	27	8.03	768	2.18
I-22	Keesi	7.172	3.352	600	EC + SAL	25	8.00	705	2.30
P-1	Bode-Olude	7.197	3.355	600	EC + PM	26	8.02	264	3.65
P-2	Oloke	7.119	3.347	400	EC + PA	26	7.95	457	2.75
P-3	Obantoko 1	7.174	3.403	400	EC + PM	26	8.10	368	2.41
P-4	Obantoko 2	7.178	3.341	500	EC	26	6.40	987	3.30
P-5	Ijeun Lukosi 1	7.126	3.368	200	EC	27	6.40	102	6.20
P-6	Ijeun Lukosi	7.126	3.370	100	EC	27	6.50	1661	11.10
P-7	Camp-1	7.195	3.439	80	EC	27	6.70	248	10.36
P-8	Camp-2	7.186	3.438	40	EC	27	6.20	385	6.95
P-9	Adehun-1	7.171	3.293	90	EC	27	7.40	477	5.00
P-10	Adehun-2	7.174	3.291	100	EC	26	7.30	822	1.80
P-11	Ita Oshin	7.081	3.185	200	EC	25	8.30	583	1.70
MLD-1	Ibara Housing	7.130	3.339	20	EC	25	7.98	488	2.46
MLD-2	Asero Housing	7.171	3.376	300	EC	26	7.78	322	8.42
MHD-1	Adigbe 2	7.114	3.318	60	PA	26	8.09	211	3.68
MHD-2	Kuto	7.1142	3.399	40	EC	27	8.34	311	3.14
MHD-3	Onikolobo	7.125	3.333	400	EC + PA	25	7.92	261	4.28
MHD-4	Onikoko	7.127	3.334	200	PA	26	.16	376	2.40
MHD-5	Adigbe	7.118	3.316	300	EC	27	8.05	220	1.57

EC: *Escherichia coli*; PA: *Pseudomonas aeruginosa*; PM: *Proteus mirabilis*; SAL: *Salmonella* species; KL: *Klebsiella pneumonia*

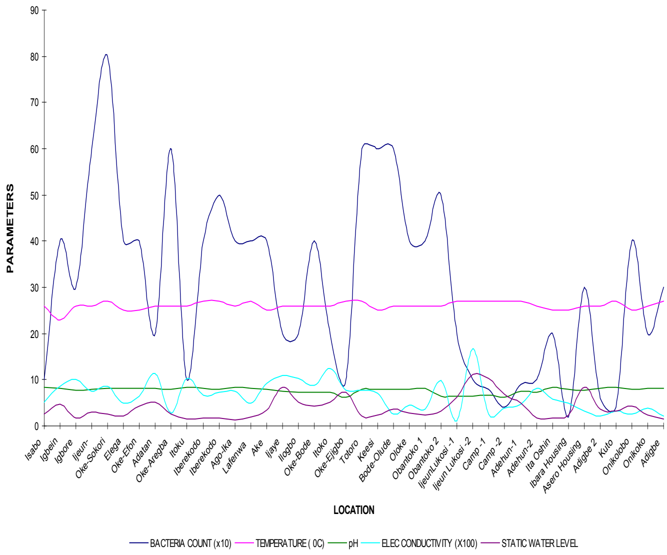

Figure 3. Graph of parameters measured against sampled well locations

Table 3. Well Characteristics (Collection method is bailer)

S/N	well wall construction method	Distance to sanitary system	Orientation of sanitary system to well
I-1	Cement lining, covered		Down slope
I-2	Unlined, covered	8.2	Level
I-3	Unlined, covered	5.6	Down slope
I-4	Unlined, uncovered	17	Up slope
I-5	Concrete ring lining, covered	19.6	Up slope
I-6	Unlined, uncovered	3.6	Level
I-7	Cement lining, uncovered	8.6	Down slope
I-8	Concrete ring lining, covered	16.4	Down slope
I-9	Concrete ring lining, covered	10.5	Level
I-10	Cement lining	7.9	Up stream
I-11	Concrete ring lining, partly covered	17.7	Down slope
I-12	Unlined, uncovered	12.7	Down slope
I-13	Concrete ring lining, uncovered	27	Up slope
I-14	Concrete ring lining, uncovered	26	Up slope
I-15	Unlined, covered	16.8	Up slope
I-16	Concrete ring lining, covered	8	Down slope
I-17	Cement lining	14	Level
I-18	Concrete ring lining, covered	17	Level
I-19	Unlined, uncovered	8.9	Up slope
I-20	Concrete ring lining, uncovered	12.5	Up slope
I-21	Unlined, uncovered	10.78	Up slope
I-22	Unlined, partly covered	12.6	Up slope
P-1	Concrete ring lining, covered	21.5	Level
P-2	Concrete ring lining, covered	5.2	Level
P-3	Concrete ring lining, covered	18	Level
P-4	Concrete ring lining, uncovered	14	Down slope
P-5	Concrete ring lining, covered	47	Down slope
P-6	Concrete ring lining, covered	8.7	Level
P-7	Concrete ring lining, covered	12.5	Down slope
P-8	Concrete ring lining, covered	28.7	Down slope
P-9	Concrete ring lining, covered	22	Down slope
P-10	Concrete ring lining, covered	12	Level
P-11	Concrete ring lining, covered	15	Up slope
MLD-1	Cement lining, covered	12.6	Down slope
MLD-2	Concrete ring lining, covered	11.9	Down slope
MHD-1	Concrete ring lining, covered	17.7	Down slope
MHD-2	Concrete ring lining, covered	12.9	Down slope
MHD-3	Concrete ring lining, covered	17	Up slope
MHD-4	Concrete ring lining, covered	25	Up slope
MHD-5	Concrete ring lining, covered	28.5	Level

recommended limit. However, education and awareness on health risk associated with the consumption of untreated water and the indiscriminate location of wells is necessary. Change assessment studies should also be conducted to evaluate the trend of the groundwater pollution over time.

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