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Pollution Trend in Selected Shallow Wells within Ogbomoso, South-Western Nigeria

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ABSTRACT

Water is one of most important gift nature has given to humanity. The importance of this gift of nature is such that without it man could hardly exist. However, the major source of water is groundwater which is mostly polluted by bacteria due to activities around the wells. The aim of the study is to access the level of pollution in shallow wells in Ogbomoso by bacteria. Groundwater samples were collected from ten (10) wells at different locations in Ogbomoso, Oyo State, Nigeria. The samples were taken to the laboratory for Physical and Microbial analysis. The parameters determined include pH, temperature, odour, Total Viable Count (TVC), Total Yeast Count (TYC), Total Mould Count (TMC) and isolation of organisms. Physical parameters in the samples indicated groundwater pollution were below the WHO limits for consumption and USEPA maximum contaminant level. The pH ranged from 5.46-6.65 indicating toxic pollution. In the same vein, odour, temperature and depth range from mild, 23.4-26.0 celsius and 6.3-24.5fts respectively. Organisms identified during isolation include salmonella spp, shigella spp and e.coli. TVC, TYC and TFC ranges between 9.6-57.3(cfu/ml), 4.1-30.0(cfu/ml) and 0-31.2(cfu/ml) respectively. It is concluded that the samples were polluted due to activities around the water source such as improper waste disposal and care for the water source in the environment. The microbial constituents of the entire samples are high and require treatment before domestic use. Borehole provisions, groundwater monitoring and effective nutrient management in the study area were recommended.

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Introduction

As population grows and urbanization increases, more water is required and greater demand is made on ground and surface water. The rate of urbanization in Nigeria is alarming and major cities areas are growing at rates between 10-15% Per annum (Yusuf, 2007). Human activities including soil fertility remediation, indiscriminate refuse and waste disposal, and the use of septic tank, soak away pits and pit latrine are on the increase. Ground water pollution has been attributed to the process of industrialization and urbanization that has progressively developed overtime without any regard for environmental consequence which eventually results in the deterioration of physical, chemical and biological properties of water (Isikwe *et al.*, 2011; Longe and Balogun, 2010).

In Nigeria, there is the challenge of lack of supply of pipe borne water hence many homes have shallow wells sited around the house at a distance from the septic tank. However, the scene remain the same in Ogbomoso as water supply is a serious problems which result to people travelling a long distance often by foot before water can be obtained for domestic purposes. The study found relationships between water quality parameters. Also, Bergstrom and Ritter (2001) affirmed that organic constituent leaches into groundwater. The seasonal effect of climate on fresh and groundwater quality was considered by Aizebeokhai (2011) which stated that freshwater resources including groundwater are vulnerable to climate change and variability. However, the scene remain the same in Ogbomoso as water supply is a serious problems which result to people travelling a long distance often on foot before water can be children roam the street in search of water, the ground water is an important natural resource that supplies millions of gallons of water for drinking, agriculture, industrial purposes and other uses.

The known surface bodies of water in the area are severely polluted by direct discharge of domestic and industrial waste, so that about 95% of the population of the area solely depends on ground water (shallow well) as their source of water. Thus harnessing and preserving clean and safe ground water become imperative (Olabisi *et al.*, 2007). However, in Ogbomoso community, studies relating to groundwater have be carried out such as Investigating Pollution of Groundwater from Atenda Abattoir Wastes, Ogbomoso, Nigeria by Adegbola *et al.* (2012), Assessment of the Groundwater Quality in Ogbomoso Township of Oyo State of Nigeria by Adetunde *et al.* (2011), and the Groundwater Potential Evaluation at Industrial Estate Ogbomoso, Southwestern Nigeria by Sunmonu *et al.* (2012) and very few on nitrate contaminations to mention but a few. These studies had been carried out effectively using direct research using physical and biological analyses on the effect of other sources of pollution. These present work will bridge the gap between all other sources of groundwater contaminant and the activities around the water source.

Description of Study Area

The study was carried out in Ogbomoso which is located in southwestern part of Nigeria (West Africa) along the guinea savannah belt of Nigeria but human activities such as exploitation are causing major changes. It is plodding into a Sudan savanna type of vegetation. The region is located in Geographical coordinates in decimal degrees (WGS84) Latitude:

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8.133, Longitude: 4.267 and her coordinates in degrees minutes seconds is (WGS84) Latitude: 8 08' 00", Longitude: 4 16' 00". The town comprises of North and South Local Government Area as shown in Figure 1. According to 2006 census figures, she has a population of 51,249 male, 49,566 female and a total of 100,815 people in her 18 square kilometers land area. Located in the North-Eastern part of Oyo State and is bounded in the north by Ogbomoso North LGA, in the south by Ogo-Oluwa LGA, in the east by Surulere LGA and in the west by Orire LGA. Her headquarters is situated at Sunsun/Arowomole, Ogbomoso (Adetunde *et al*., 2009).

Locally, Ogbomoso area experiences tropical rainfall which dominates most of southwestern part of Nigeria and the area has two distinct seasons, the wet season usually between March and October, and the dry season which falls between November and February every year. The annual rainfall for the study area is 1247mm, but the amount varies from 1016mm to 1524mm, and is almost entirely concentrated in the wet season. The geology of Ogbomoso comprises migmatic and granitic, calcareous and granulitic rocks (Olafisoye *et al*., 2012).

Areas are selected randomly across Ogbomoso town which includes Porte, Osaro, High School Area, Isale High School, Sabo garage and Stadium. Shallow and deep well are scattered around the areas.

Methodology

Water Samples Collection and Laboratory Analysis

The method adopted for this study includes, reconnaissance survey around ogbomoso town, survey of sanitary conditions before sample collection for laboratory analysis in physical and microbial tests of the groundwater samples. Ten (10) samples were collected from the main water well that supply the selected areas. The sampling was done in the month of febuary during the raining season although the effect of dilution may arise from precipitation during the season. It should the noted that samples were solely taken where popution were concentrated in ogbomoso town. During sampling, no particular spatial distance between samples was adospted as the well was randomly picked at Ogbomoso town. Sampling method is manual, 100mls containers were used to take the samples. All samples were collected in sterilized plastic bottle. This is done so as not to get additional pollution treat into the water sample which is not from the source.

Also, the sample containers were first rinsed thoroughly with the waters to be sampled. In addition, to ensure that no organisms were admitted into the bottle other than that which already exists in the water sample, the containers used to draw the water was also sterilized. Samples were securely covered and sealed in the Ice parked coolers, well labeled, sealed and transported to the laboratory within 2 hours of collection. Physical and chemical parameters tested for include Temperature, pH, Colour, Odour and Bacteriological, analysis was performed to determine Total Viable Count, Total Yeast Count, Total Mould Count and isolation of organism was done to know the type of harmful organisms present.

Results and Discussion

Preluding the actual disussion of results, it is important to put in the perspective of the conditions surrounding the ten (10) wells. The ten (10) wells at various sites collection serves as the source of water for the people in the environments. In addition, the activities around the environment warrant the purposes the wells serves, the principal use of the wells is domestic which ranges from washing, drinking and cooking etc. Various conditions surrounding the wells are presented in Table 1.

Table 1. Field Log Showing Well Conditions

Sample Label	Location of Sampling Point	Condition of the Well	Vol. of Sample taken (ml)	Depth of Water Level (ft)	Weather	Observation on Water Surface
1	Porte	Uncovered and with Rings	100	24.0	Humid	Oily and Cloudy
2	Osaro	Uncovered and without Ring	100	10.2	Humid	Oily and Cloudy
3	Osaro	Uncovered and without Ring	100	15.4	Humid	Oily, Nylons, Small Woods, Leaves, Soil particles.
4	Osaro	Covered and with Rings	100	6.3	Humid	Cloudy
5	High School Area	Covered and with Rings	100	15.4	Humid	Oily
6	Isale High School	Uncovered and with Rings	100	21.4	Humid	Oily
7	Isale High School	Covered and with Rings	100	18.5	Humid	Oily and Cloudy
8	Sabo Garage	Uncovered and without Rings	100	13.5	Humid	Oily, Nylons, Small Woods, Leaves, Soil particles.
9	Stadium Area	Covered and with Rings	100	24.5	Humid	Cloudy
10	Stadium Area	Covered and with Rings	100	20.4	Humid	Cloudy

Well 1, 2, 3, 6 and 8 are uncovered and for all the wells, fetching of water was being done by the inhabitants of the area and workshops using various types of water drawers, many of which were not hygienically kept. Moreover, the well 6-10 was located downstream south of Ogbomoso, Oyo State which makes it very receptive to surface runoff during precipitation. Also, the rate of water withdrawal was very high, making the well to be highly disturbed every day. Periodically, the wells are desilted so that it can continue to serve the hundreds of inhabitants. It should also be noted that the samples were collected in February, 2015 during the dry season when there would be low recharge to the groundwater aquifer through infiltration. Table 2.

Table 2. Physical Characteristics of Ground Water Samples Analysed

Samples	pH	Odour	Temperature	Depth of Water Level
1	6.10	Mild	24.90	24
2	5.57	Mild	25.40	10.2
3	6.12	Mild	24.30	15.4
4	5.90	Mild	26.00	6.3
5	5.46	Mild	24.60	15.4
6	6.40	Mild	23.40	21.4
7	5.80	Mild	24.60	18.5
8	6.65	Mild	25.70	13.5
9	6.06	Mild	24.50	24.5
10	6.20	Mild	23.60	20.4

** Temperature is in Celcius

* Depth of Water Level is in ft

shows the physical characteristics of the groundwater samples analysed. In the same vein, bacteriological characteristics of the ground water analysed samples is hallmark of Table 3.

Table 3. Bacteriological characteristics of the groundwater samples analysed per ml

Samples	Total Viable Count (cfu/ml)	Total Mould Count (cfu/ml)	Total Yeast Count (cfu/ml)
1	9.6	13.7	10.2
2	47.2	31.2	30.0
3	12.0	2.0	4.1
4	11.2	4.0	12.4
5	24.8	2.0	19.6
6	24.8	0.0	11.4
7	49.8	1.9	4.9
8	34.0	0.0	13.9
9	57.3	0.4	12.2
10	35.2	3.5	9.0

All Values in the table x 10^6

Samples were collected at the site early in the morning using sterile containers bottles and was immediately transported to the Laboratory for microbial/Bacteriological analyses

During the study, the weather in which the samples were taken from was constant as shown in Table 1.

Physical and Bacteriological Analyses of the Samples

From the result, pH of groundwater samples ranges from a minimum of 5.46 in sample 5 to a maximum of 6.65 in sample 8 (Figure 2 and Table 2) which were found to be within the permissible limits of WHO,USEPA,NSDWQ, IS and CDWQ standards. The pH signifies the presence of calcium carbonate (calcareous) which is one of the geological structures of Ogbomoso is (Olafisoye *et al*., 2012). Field research indicates that drinking water with a pH lower than 6 can impair broiler performance. Temperature of samples study ranges between 23.4 – 26.0 celsius, sample six (6) with minimal temperature while sample four (4) with maximum temperature. Temperature ranges according to the depth of various wells and weather condition with sample six (6) and four (4) having depth of 21.4ft and 6.3ft as shown Table 2. The presence of odour in water is one of the basic elements that makes unfit for consumption.

The activities around water source such as washing, deficating, refuse dumps, pit latrines causes and influence the odour present in the water. When nitrogenous organic matter is destroyed by microbiological activity, ammonia is produced. Some nitrifying bacteria convert ammonia into nitrites and then into nitrates which leads to the cause of water. The water sample analysed indicates mild odour as shown in Table 2. Highest value of Total Viable Count (TVC) with 57.3 x 10^6 cfu/ml was found in sample 9. Also, the sample with highest Total Yeast Count (TYC) 19.6 x 10^6 cfu/ml and 30.0 x 10^6 cfu/ml (Table 3) was also detected in sample 5 and 2 respectively while lowest value (4.1 x 10^6 cfu/ ml) was detected in sample 3.

Table 4. Comparing Physical and Bacteriological Characteristics with Standards

Parameters	WHO	USEPA	NSDWQ	IS	UK	CDWQ	Present Report
Temperature	24.5 – 39.7		Ambient			≤15	24.90-26.90
pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5		6.5-8.5	5.57-6.65
Odour	U		U	U	A	I	mild
TVC	1		1		0		9.6-57.3
TYC					0		0.0-31.2
TMC					0		4.1-30.0

Values for TVC,TYC and TMC in the table x 1000000

U-Unobjectionable, Nd- No Data, A-Acceptable, I-Inoffensive

Sources: WHO - World Health Organisation (1993,2008)

USEPA- United State Environmental protection Agency(2012) Standard(1993)

All in MCL (Maximum Contaminant Level and Health Based). All units in mg/L except T in degree Celsius

According to World Health Organization (WHO) recommendations there should not be a single microbial growth per m/L of drinking water, therefore all sample contain higher coliform count.

Also, the Total Mould Count (TMC) detected in all samples is above the guidelines provided by the World Health Organization (WHO) with the exception of sample 6 and 8 with no trace of mould count, therefore all the samples are considered unsafe for drinking except sample 6 and 8 with no traces of mould as shown in Table 3. In addition, 31.2 x 10^6 cfu/ml value of mould occurred in sample 2 with the highest value of mould count.

The highest value found in sample 2 is linked to improper care of the ground water source and its location. The well is located near a mechanic workshop and a dump hill. Due to these, activities around the well get contaminated through infiltration as the well recharges. The total moulds and yeasts in the water samples analysed ranges from 0 x 10^6 cfu/ml to 31.2 x 10^6 cfu/ml and 4.1 x 10^6 cfu/ml to 30.0 x 10^6cfu/ml respectively. The boxplot of the TVC, TYC and TMC below indicates the outliers of each sample (Figure 2) while Figure 3 compares the bacteriological characteristics of each sampled groundwater.

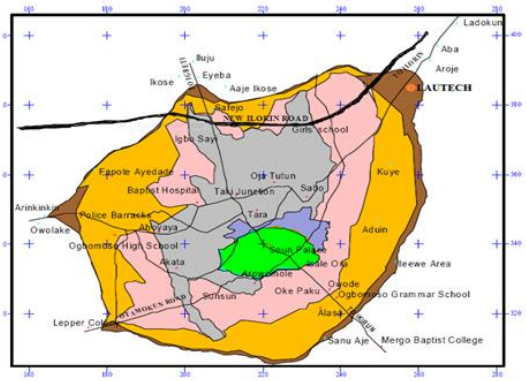

Figure 1. Map of Ogbomoso Town

Source: Modified from Adeboyejo et al. (2007)

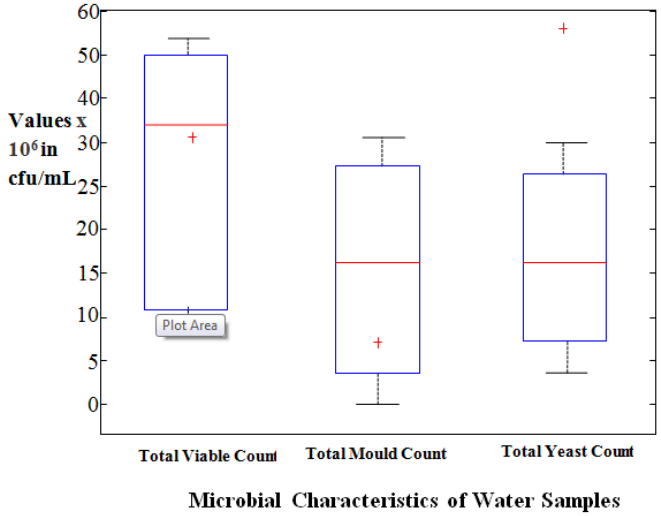

Figure 2. Boxplot for TVC, TFC and TCC of each Samples

Table 5. Correlation Matrix of the Microbial Characteristics of the Samples

Correlation Coefficient (r_s)	TVC	TMC	TYC
TVC	1.000		
TMC	0.112**	1.000	
TYC	0.253	0.717*	1.000

The alpha value used for this study is 0.05
* Correlation is significant at the 0.05 level (2-Tail)
** Correlation is significant at the 0.01 level (2-Tail)

Table 6. Correlation Matrix of the Physical Characteristics of the Samples

Correlation Coefficient (r_s)	Ph	Temperature	Depth
Ph	1.000		
Temperature	0.180**	1.000	
Depth	0.298	-0.694*	1.000

** Temperature is in Celsius
* Depth of Water Level is in ft
* Correlation is significant at the 0.05 level (2-Tail)
** Correlation is significant at the 0.01 level (2-Tail)

Table 7. Characteristics and Description of Identified Organism

Samples	Isolate Code	Cultural Characteristics	Cellular Characteristics	Probable Identification
1	1.1	Creamy and shiny colony	Gram negative, rod shaped and motile	*Salmonella spp*
	1.2	Pink colony	Gram negative short rod	*E.coli*
	1.3	Small round and creamy colony	Gram negative rod -shaped, non motile	*Shigella spp*
2	2.1	Creamy and shiny colony	Gram negative and motile	*Salmonella spp*
	2.2	Creamy rod colony	Gram negative rod and non motile	*Shigella spp*
	2.3	Pink colony	Gram negative	*E. coli*
3	3.1	Creamy round Colony	Gram negative, rod non- motile	*Shigella spp*
	3.2	Pink colony round shaped	Gram negative rod	*E.coli*
	3.3	Creamy and shiny	Gram negative rod	*Salmonella Spp*
4	4.1	Creamy and shiny colony	Gram negative rod	*Salmonella spp*
5	Nil	Nil	Nil	Nil
6	6.1	Pink round colony	Gram negative rod	*E.coli*
	6.2	Creamy and shiny colony	Gram negative rod	*Salmonella spp*
7	7.1	Creamy and shiny colony	Gram negative rod shaped	*Salmonella spp*
	8.1	Creamy and round colony	Gram negative rod	*Shigella spp*
8	8.2	Shiny and creamy colony	Gram negative rod	*Salmonella spp*
9	9.1	Creamy and shiny colony	Gram negative rod shaped	*Salmonella spp*
10	Nil	Nil	Nil	Nil

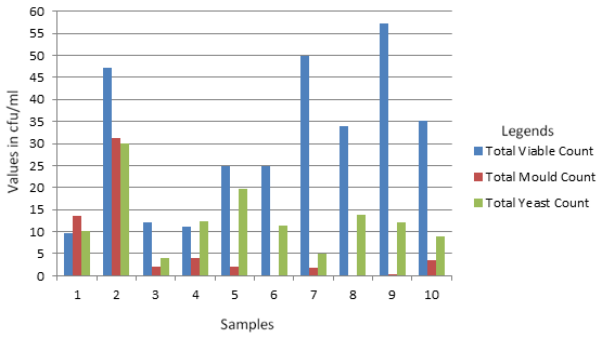

Figure 3: Comparing the Microbial Characteristics of each Sampled Groundwater

There are many reasons that are attributed to increase the level of total viable count, total mould and yeast count in drinking water around the study area. Sewage, leaching of the organic matters and use of unsterile drawers are good source for the growth of microbes. The highest value of total viable count detected in samples taken from site location may be due to the improper disposal of sewage. Furthermore, inadequate water treatment also gives reason for the survival of microbes. Organisms identified in the samples 1, 2, 3, 4, 6, 7, 8 and 9 are Salmonella, E.coli and Shigella, Salmonella, Shigella and E.coli, Shigella, E.coli and Salmonella, Salmonella, E.coli and Salmonella, Salmonella, Shigella and Salmonella, and Salmonella respectively while no organisms were identified in sample 5 and 10 as shown in Table 7.

Statistical Analysis and Correlations

The Spearman Correlation (a non parametric) is used for the statistical analysis. For this study, SPSS is used for the analyses and correlation is significant at the 0.05 level (2-Tailed).

H_o: *p≥0.05 [Null Hypotheses]*

H_A: *p≤0.05 [Alternative Hypotheses]*

From the above (Table 5 and 6), there exist a strong positive correlation between TMC and TYC, which was statistically significant $r_s(13) = 0.717$, a strong negative correlation also exist between Temperature and Depth $r_s(13) = -0.694$.

There is weak positive relationship between TYC and TVC $r_s(13) = 0.253$, weak positive relationship also exists between Depth and pH $r_s(13) = 0.298$. Inaddition, very weak positive relationship also exist between pH and temperature $r_s(13) = 0.180$.

Furthermore, very weak positive correlation exists between TMC and TVC $r_s(13) = 0.112$. However, very weak negative correlation and weak negative correlation was not found in the result. Therefore we accept the Ho for them.

The bacterial contamination was highly concentrated at all sites. Among total samples tested for at different location showed that TVC, TYC, TMC count are above the permissible limits as per WHO (2004). According to World Health Organisation (2005), TVC, TMC, TYC should be zero in the water which is used for drinking purposes. Furthermore, the result shown at Table 3 indicates gross pollution of ground water.

Conclusion and Recommendations

From the study, the following conclusions and recommendations were made:

(i) Moreover, the climate and hydrology of Ogbomoso also affects the concentrations of some parameters due to precipitation thereby causing dilution. In addition to this, the value of some physical parameters can be affected by the season as there is more aeration during the rainy season of February, 2015.

(ii) The study found strong correlation between parameters e.g. TMC and TYC while relationship between some e.g. Temperature and Depth is strong negative correlation. Thus, there is relationship between weather condition and the trace elements of groundwater pollution.

(iii) The study from identification, isolation, biochemical test and frequency distribution of the bacteria isolated from the water samples such as salmonella spp, shigella spp and e.coli are responsible for chronic diseases and should be avoided in water for consumption purposes.

(iv) Top level of hand dug wells should be elevated at most 3fts above the ground level as most of the wells from the study areas have the same top level with ground level which will enhance easy contamination of the wells.

(v) Constant research on groundwater quality in Ogbomoso metropolis is essential. This will help to monitor changes in groundwater chemistry so as to safeguard not only the health of the inhabitants of the farm, the people of Ogbomoso but will also help in protecting the ecosystem.

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