COMPARATIVE ASSESSMENT OF RISK-TO-HEALTH OF DRINKING WATER SOURCES: A CASE STUDY OF IJEBU-ODE CITY OGUN SOUTHWESTERN NIGERIA

Adegbite Afeez Ayoade*

Lawal Oyebanji O

Oduyiga Oluwakemi O

Solesi A Obafemi**

ABSTRACT

The study was carried out to comparatively assess the 'risk-to-health' conditions of drinking water sources (boreholes and Public stand points) in Ijebu-Ode City, Ogun State Southwestern Nigeria. A total number of twenty (20) boreholes and twenty (20) stand points were selected from government residential area on one side of the city with the residents of high socio-economic status and the other side of the city with residents of low socio-economic status. The 'risk-to-health' conditions of the considered drinking water sources were assessed by combining the risk scores from the sanitary surveying with the number of e-coli counts from microbiological analysis. Then, Karl Pearson of correlation was used to determine the degree association between the risk scores and the E-coli counts confirmed. Out of the twenty (20) boreholes and twenty (20) water stand points; four (4) boreholes pose very high risks, four (4) pose high risks, six (6) pose low and no risk from six (6) boreholes while from the public pipe water stand posts, ten (10) pose very high risks, one (1) pose high risks and nine (9) water stand posts pose low

* Department of Water Resources Management and Sanitation

** Department of Pharmaceutical Techniques, Ogun State College of Health Technology, Ilese-Ijebu Nigeria

risks. The coefficient of positive correlation 0.676 indicated that the risk scores from the borehole drinking water sources resulted to the E-coli contamination and 0.806 positive high correlation between water stand posts and E-coli counts indicating that both water sources constitute 'risk-to- health' to the consumers of the water. However, the values showed that the public water stand points and water they supply constitute more risk –to –health than the boreholes and borehole water. There is need to embark on routine monitoring of water qualities from the drinking water sources, rehabilitation of the failed the sources, Then, there is need for compliance and enforcement of drinking water supply regulations and finally there is need for proper waste management and environmental sanitation around these drinking water sources.

Keywords: *E-coli, borehole, Correlation, Microbiology, Water Sources, Risk-to-health, Stand point*

1 Introduction

A reliable supply of clean wholesome water is highly essential in a bid to promoting healthy living amongst the inhabitants of any defined geological region (Mustapha and Adam, 1991). In the study area of Ijebu Ode, the sources of household drinking water are boreholes and public pipe borne water (tap water). Among the inhabitants, borehole water is most reliable and readily available while the water supply from the State Water Corporation is intermittent and endemic (Dada, 2009). The conditions of the public water supply can be a major setback in provision of household drinking water supply due to poor infrastructures, inadequate coverage of network and poor operational/ maintenance of supply scheme.

The drinking water supply issue highlighted above is supported by the report from Nigeria Federal Ministry of Water Resources (FMWR), that the existing Water Works for urban and semi-urban water supplies often have problems associated with their designs, operation and maintenance and lack of integrated management planning, supplying less water than they were designed for (FMWR, 2000).

This study focuses on the two household drinking water sources- boreholes (groundwater) and public stand points. The quality of water from the former sources (boreholes) can be satisfactory, but a poor site and management of boreholes and consumers poor hygiene habits can pose risk to

the quality which consequently affects the health of the consumers of the water. For instance, lack of observing maximum distances from source of contamination, poor environmental sanitation and waste management will eventually directly or indirectly contaminate the water and the consumers healthy being are jeopardized (Lawrence A. R et al, 2001) and (Lee M.D. and Bastemeijer T.F, 2000) and the latter (pipe borne water) having passed through several treatment stages therefore, is of high quality and poses no risk to health of the consumers.

The study area, Ijebu Ode is characterized as urban area with continued physical expansion virtually merging with neighboring settlements such as Mobalufon, Erinlu, Molipa, Oke Owa, Iwesi, Igbeba and Latogun (Mabogunje, A.L and Kates R. W, 2007). However, some part of city contained residential areas with people of low socio-economic status and poor housing conditions, while some part of the city consists of planned residential areas with people of high socio-economic status like Government Residential Areas and Government Housing Estates that are relatively new compared with other part of the city and the areas are well planned and with proper lay-out.

However, in the area with low socio-economic status, the physical setting and the improper provision of urbanization infrastructures might have negative impacts on these household drinking water sources. For instance, the widespread uses of on-site disposal system (via septic tanks, cesspits, or pit latrines) are common practices in the study area. In some instances, having damaged septic tanks with the wastewater flowing freely on the environment may end up into the groundwater systems as a results of infiltration/percolation or the run-off entering into the water supply distribution network through the damaged water- conveying pipes. Therefore, the water from the sources get contaminated, thereby posing health risk to the consumers.

In the light of the above, assessment of drinking water sources was carried out to determine the potential hazards of contamination from on-site sanitation in Ijebu-Ode city, Southwestern Nigeria. The assessment is due to the fact that the use of septic tanks and latrines are very common in the study area that has high population density with inadequate space for on-site disposal of effluent. In this kind of situation, the drinking water sources within the vicinity can

easily get contaminated as results of non maintenance of standard distance limit to on- site sanitation disposal systems (Lawrence et al, 2001) and (Adetunji and Odetokun, 2011)

The study then considered both the functioning boreholes and public pipe borne water sources, if the drinking water from these sources poses risk-to-health to the inhabitants as results of their locations and the environmental conditions around these drinking water sources.

1.1 Objectives of the study

(a) To carry out sanitary survey of the sources (borehole and stand points) and compare the level of risks facing the inhabitants;

(b) To carry out microbiological testing on the water samples collected from these water sources;

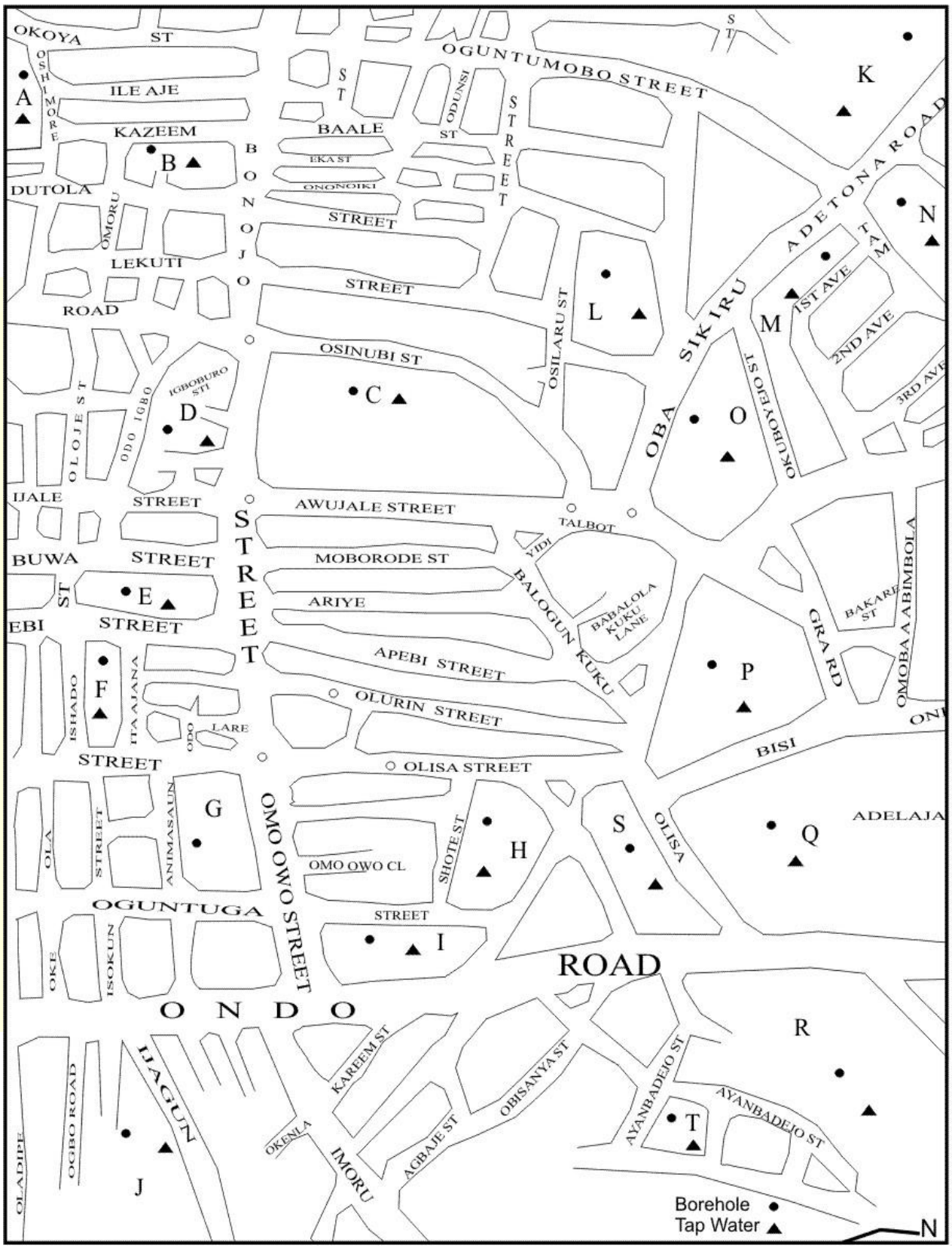
(c) To determine the 'risk-to-health' conditions of these drinking water sources.

2 Brief description of the study area

The study was conducted in Ijebu-Ode, Ijebu-Ode Local Government Area (LGA) of Ogun State Southwestern Nigeria. The area can be located between latitudes 60 47'N and 60 52'N and between longitudes 30 53'E and 30 59'E. Ijebu-Ode is an ancient city, which is centrally located in relation to other human settlements around it.

Generally, Ijebu-Ode's climatic condition is of alternate wet (April to October) and dry seasons from (November to March). The mean annual rainfall is between 1523 mm and 2340 mm, while the temperature ranges between 25^0C and 32^0C with the average annual temperature of about 27^0C. The alternate season of wet and dry is responsible for fluctuation in the volume of surface water bodies, such as rivers and streams in Ijebu-Ode (Ogunnowo, 2004).

Figure 1: Map of Study Area



Source: Author Fieldwork, 2012

3.0 Materials and Methods

The study was carried out during the dry seasons between the months of November 2011 –March, 2012. Twenty (20) boreholes (BH) and Twenty (20) public stand points (PT) were selected across the city using cluster sampling techniques, selecting available borehole and stand points from the same vicinity. Ten (10) BH and Ten (10) PT were selected from Government Residential Areas/Housing Estates (GRA) and royal palace areas on the right side of the study area, which consists of low density area, this is planned to accommodate high income people (the elites and the noble men (Fagbohun and Oke, 2011) (see figure1above), while Ten (10) BH and Ten (10) PT were selected from other residential part of the city, high densely populated that accommodated low-income group of people (Fagbohun and Oke, 2011), with blocked or failed drainage systems on the left side of the map of the study area (see figure 1). Then, sanitary inspection was carried out on each of the drinking water sources and water samples were collected, transported to the College Pharmaceutical laboratory for microbiological analysis only. The boreholes and stand points water collected were labeled alphabetically (the subscript number one (1) attached to boreholes and number two (2) attached to stand points water) for identification and comparison. The data collection and analysis involved the following stages as follows:

3.1 Sanitary Surveying (inspection) of the drinking water sources

Sanitary surveying is an inspection technique that records such visible problems, enabling fieldworkers to assess the likely quality of the water, relative to other sources (Smith M and Shaw R, 1999) The sanitary surveying is a field survey (the on-site inspection of the water sources) provides a direct method of identifying all the hazards that are potential and actual causes of contamination of the water sources. The exercise is a simple and rapid means of assessing and identifying hazards associated with drinking water source (WHO, 2006). The standard sanitary inspection forms developed by Lloyd, 1990; Lloyd and Suyati, 1989) in collaboration with WHO, were used tso collect the data, the itemized questions, that requires YES or NO answers. A 'Yes' answer indicates a sanitary-risk factor. The total risk score is equal to the sum of all questions with a yes answers. The results are interpreted as thus: 7–10 Very high; 4–6 Intermediate; 1–3 Low risk; 0 No observed risk (WHO, 2006).

3.2 Microbiological Analyses of the Water Samples

Detection and enumeration of coliform organisms, thermotolerant coliform organisms, and presumptive Escherichia coli from the waters samples were carried out using Standard Methods (APHA, AWWA, WEF, 1998). Escherichia coli is considered for the study because it is the most suitable index of faecal contamination. *Escherichia coli* occurs in high numbers in human and animal faeces, sewage and water subject to recent faecal pollution (WHO, 2008). The results interpreted as thus: 0 (in conformity with WHO guidelines-No risk), 1-10 (Low risk), 10-100 (Intermediate risk), 100-1000 (High risk) and > (1000 Very high risk) (WHO, 2008).

3.3 Risk Analysis Assessment

This is done by combining the sanitary inspection score and the microbiological analysis results For the purposes of risk analysis, the results of *E.* coli counts and sanitary inspection are combined in a "risk-to-health" matrix, which gave an indication of the potential risk to health posed by the considered drinking water sources (FMWR, World Health Organization and UNICEF 2010)

3.4 Data Analysis

Tables and Microsoft Excel was employed to compare the level of risk from the two different sources. The Karl Pearson's coefficient of correlation, r^2 analysis was employed between the risk scores and detection of E-coli from the two sources. The coefficient of correlation , r^2, is useful because it is widely used method of measuring the degree of relationship between two variables (Kothari, 2004) and (Sowole and Adegbite, 2012). The presence / detection of E-coli from the water samples were correlated with the risk scores obtained from the sanitary assessment of these water sources to determine degree of association.

4.0 Results and Discussion

Table 1 *Risk scores for the water sources and E-coli count from the water samples*

	Boreholes$_1$		**Public Stand Points$_2$**	
	Risk Scores	**E-coli/cfu**	**Risk Scores**	**E-coli/cfu**

A	7	2	9	3
B	2	0	8	3
C	2	1	6	3
D	2	0	7	2
E	4	0	5	1
F	4	0	6	1
G	5	1	5	1
H	6	1	7	1
1	3	1	4	0
J	7	2	9	3
K	1	0	4	1
L	0	0	3	0
M	1	0	2	0
N	0	0	2	0
O	0	0	1	0
P	1	0	1	0
Q	0	0	1	0
R	0	0	2	0
S	1	0	1	0
T	0	0	2	0
Mean Values	2.3	0.4	4.25	0.95

The table 1 above displayed the sanitary survey results from twenty (20) selected boreholes and twenty (20) stand points and number of E—coli detected from microbiological analysis of water samples from these drinking water sources. Maximum risk scores of 7 were recorded from boreholes at locations A and J (see the map of the study area) indicating that these boreholes pose very high risk to the inhabitants consuming water from these sources. The risk scores of boreholes located at E, F, G and H indicated the consumers of water from the sources face intermediate risks. However, the risk scores from other boreholes at other locations indicated that these drinking water sources pose low risk to no risk to the consumers. Similarly, risk scores of 9, 8, 7, (very high risk) obtained from the stand points located at locations A, J, B, D and H respectively then risk scores of 6, 5, 4 (intermediate risk) were recorded at C, F, E, G, I and K respectively.

However, two (2cfu/100ml) E-coli counts confirmed from the boreholes at location A and J, then 1 from locations C, G, H and I while three (3cfu/100ml) E-coli counts confirmed at locations A, B, C and J, two (2) at location D and One (1cfu/100ml) at locations E, F, G, H and K.

Table 2*: Mean Values for the Risk Scores and E-coli contamination for the water sources*

	Risk Score	E-coli (cfu/100ml)
Boreholes	2	0.4
Public stand points	4	1

The table 2 above shows the means values of risk scores (2) for the boreholes and (4) for the stand points indicating that the stand points in the study area pose more risk to the health of the consumers of the water from these sources than that of boreholes. The results of E-coli confirmed from the water samples support the risk scores because, on average 0.4cfu/100ml E-coli recorded for the water samples collected from the boreholes considered for the study while 1cfu/100ml recorded for the water samples from the stand points

Table 3*: Risk-to-Health Analysis for the borehole water sources**

Sanitary Inspection Score/No of Boreholes	**Boreholes**			
	E-coli Count cfu/100ml			
	0	1-10	11-100	>1000
0 (6)	L, N, O, Q,R, T			
1-3 (8)	B, D, K,M, P, S	C,I,		
4-6 (4)	E, F,	G, H		
7-10 (2)	A, J			

Table 4*: Risk-to-Health Analysis for the stand point water sources**

Sanitary Inspection	**Public Stand Points**

Score/No of Stand Points	E-coli Count cfu/100ml			
	0	1-10	11-100	>1000
0 (0)				
1-3 (9)	L ,M, N, O, P, Q,R, S T,			
4-6 (6)	I,	C, E,F, G, K		
7-10 (5)		A, B, D, H, J		

*Adapted from WHO, 2006/FMWR, 2010

Table 5*: The categories of Risk-to-Health*

Risk-to-Health Categories			
No Risk	Low Risk (low Priority)	High risk (high priority)	Very high risk (urgent action)

The 'risk –to- health' matrices (table 3 and 4) above showing the sanitary risk inspection results cross-checked with the microbiological data (E-coli confirmed). From the matrices, it can be observed that, boreholes considered for the study, six (6) constitute no risk to the health of inhabitants (consumers) (L, N, O, Q, R and T), another six (6) constitute low risk (B, D, K, M, P and S), then four (4) constitute high risk (E, F, C and I) and last four (4) constitute a very high risk (A, J, G, H). However, the 'risk-to health' matrix for the tap water sources shows that nine (9) public stand points at L, M, N, O, P, Q, R, S and T constitute low risk to the health of the inhabitants, one (1) stand point at I constitute high risk and the remaining stand points at C, E, F, G, K, A, B, D, H and J constitute a very high risk.

The presence of thermotolerant coliform organisms and confirmed Escherichia coli from water samples collected from these drinking water sources is supported by the work of Adekoyeni O and Salako S (2010). In addition to these, in the RADWQ survey by UNICEF/WHO in Nigeria, some numbers of drinking water sources used for the survey confirmed some low level thermotolerant coliform. However, from the results, borehole drinking sources recorded low level of contamination from thermotolerant coliform (E-coli) 0.4cfu/100ml compared with public tap (0.95cfu/100ml) and the risk-to-health is minimal. Though, the levels of thermotolerant coliform (E-coli) contamination correlate with risk scores of boreholes (2) and Tap water (4) as consequent feacal contamination potential is high in pubic taps than the boreholes. It should be

noted that the locations, environmental and infrastructural conditions of these drinking water sources are factors responsible for the detection of E-coli in some water samples and the risks scores from the sanitary assessment and this is supported by the report of Foster S, Lawrence. A & Morri, B (2007). They believed that, in most developing cities population growth precedes the development of infrastructure to handle wastewater. This tends to lead to widespread contamination of groundwater by domestic and industrial effluents. Furthermore, conditions of the public water tap pipes on the left side of map are not satisfactory, as a result of the ages of the pipes and the pipes are exposed and some of them run through drainage channels. These resulted in exposing the stand points/pipes networking to high risk from contamination at stand points A, B, C, D, F, H and J and consequently detections of E-coli from the water samples obtained from these stand points.

The calculation of coefficient of determination r^2 with Microsoft excel between the risk the borehole drinking sources water exposed to and the number of E-coli detected indicated a value of 0.676 a positive correlation that is relatively low to correlation between that of stand points and the E-coli of value of 0.806 indicating a positive high correlation. The correlation values indicated the detection of the E-coli in the water samples from these drinking water sources is as results of their physical conditions and the environmental conditions of the water sources. The results indicated that both the boreholes and stand points constitute 'risk-to- health' to the consumers of the water and the inhabitants. However, the values showed that the stand points and water they supply constitute more risk –to –health than the boreholes and borehole water.

Table 6*: comparison of the categories of Risk-to-Health between the drinking water sources*

	Risk Categories	Boreholes	Stand points
A	Very High risk	A, J, G, H (4)	A, B, D, H, J, O, E, F, G, K (10)
B	High risk	E, F, C,H (4)	I (1)
C	Low risk	B, D, K, M, P, S (6)	L, M, N, O, P, Q, R, S, T (9)
D	No risk	L, N, O, Q, R, T (6)	-
	Total	20	20

Furthermore, the table 6 above also indicated that ten (10) public taps pose very high risk to health of the consumers and required urgent action while four (4) of the boreholes do, one (1) of

the survey stand points constitute high risk and four (4) of boreholes and nine (9) of the stand points pose low risk compare to boreholes that pose six (6).

On the other hand, by comparing the two drinking water sources from the Governmental residential areas/Government Housing estate (on the right hand side of the map) and other residences in the city (on the left side of map) (see figure one and table1), both boreholes and stand points from the government residential area/housing estate pose low risk-to-health to the consumers compared with the drinking water sources from densely populated part of the city.

5 Conclusions

The study concluded that the risks recorded at the drinking water sources (boreholes and stand points) indicated that the sources are exposed to contamination either from the localized environment or through aquifer pathways and the contamination is confirmed with detection of E-coil from the water samples obtained from some of drinking water sources. The study confirmed that, the drinking water sources from the densely populated area with poor urban settlings are exposing to more risks because of the physical condition and poor environmental sanitation of the area compared with the drinking water sources in the government residential area/housing estate. Therefore, various risk-to-health categories are posed by these drinking water sources to the inhabitants on long run. The government should embark on routine monitoring of water qualities from the water sources and there should rehabilitation of the failed drinking water source. Then, there is need for compliance and enforcement of drinking water supply regulations and finally there is need for public health talk, education and campaign awareness for the inhabitants on drinking of contaminated water, the need for waste management and environmental sanitation around the drinking water sources.

6 References

[1] O Adekoyeni and S Salako: Microbiological, Physicochemical and Mineral Quality Of Borehole Water In Ijebu Land, Ogun State, Nigeria (2012) *International Journal of Science and Advanced Technology* Volume 2 No 1 January 2012

[2] V.O Adetunji and I. A Odetokun,: Groundwater contamination in Agbowo community, Ibadan Nigeria: Impact of septic tanks distances to wells Malaysian Journal of Microbiology, Vol 7(3) 2011, pp. 159-166 (2011)

[3] APHA, AWWA, WEF: Standard Methods for the Examination of Water and Wastewaters, 20th Edition. American Public Health Association, Washington, DC. (1998)

[4] C. A. Dada: Towards a successful packaged water regulation in Nigeria, Scientific Research and Essay Vol.4 (9), pp. 921-928 (2009) <http://www.academicjournals.org/sre>

[5] P.O Fagbohun and G.O. Oke (2011) Urban Planning and Design: Concept Publication Limited Lagos

[6] S. Foster, A. Lawrence. & B. Morri: Groundwater in Urban Development Assessing Management Needs and Formulating Policy Strategies: World Bank Technical Paper No. 390 (2007)

[7] FMWR/WHO/UNICEF: Rapid Assessment of Drinking Water Quality in The Federal Republic Of Nigeria Country Report Of The Pilot Project Implementation In 2004-2005 (2010)

[8] A.R Lawrence, D M J Macdonald, A G Howard, M H Barrett, S Pedley, K.M Ahmed and M. Nabubega: Guidelines for Assessing d risk to groundwater from on-site sanitation: British Geological survey, UK, (2001)

[9] M.D. Lee and T.F. Bastemeijer: Drinking Water Source Protection A review of environmental factors affecting community water supplies Occasional Paper 15 (2000)

[10] B Lloyd: Diagnostic surveillance for risk assessment, protection and improvement of drinking water sources in Indonesia : Working meeting on drinking water source protection, 30 June - 1 July, 1990. The Hague, The Netherlands, IRC International Water and Sanitation Centre (1990)

[11] B Lloyd and S Suyati:'A pilot rural water surveillance project in Indonesia'. In : Waterlines, vol.7, No.3, p.10-13. (1989)

[12] C.R Kothari: Research Methodology: Methods and Techniques: New Age Publishers (2004)

[13] A L Mabogunje and R.W Kates: Sustainable Development in Ijebu-Ode, Nigeria: The Role of Social Capital, Participation, and Science and Technology (2004)

[14] S Mustapha and E. A Adam: Discussion on Water Problems in Nigeria: Focus on Bauchi State. National Water Research Institute. (1991)

[15] C.O Ogunowo : A Concise Geography of Ijebu-Ode region; Fotak Publishers, Ijebu-Ode (2004)

[16] M. Smith and R Shaw: Sanitary Surveying WEDC Loughborough University Leicestershire (1999) < www.lboro.ac.uk/departments/cv/wedc/>

[17] A.R Sowole and A.A Adegbite: Correlation Analysis between the Prevalence of Schistosoma Haematobuim and Water Conditions: A Case Study among the School Pupils in Southwestern Nigeria (2012) http://www.arpapress.com/Volumes/Vol13Issue1/IJRRAS_13_1_17.pdf

[18] Standard Methods for the Examination of Water and Wastewater 20th edition, American Public Health Association, American Water Works Association, Water Environment Federation. Washington, DC. (1998)

[19] WHO (World Health Organization): Guidelines for Drinking-Water Quality: Incorporating First Addendum. Vol. 1, Recommendations, Third Edition. WHO, Geneva, Switzerland. (2008)
< www.who.int/water_sanitation_health/dwq/gdwq3rev/en/index.html>