African Scientist Vol. 18, No. 3, September 30, 2017
Printed in Nigeria

1595-6881/2016 $10.00 + 0.00

http://www.niseb.org/afs

AFS 2017039/18308

Evaluation of the Extent of Consumption, Contamination and Management of Groundwater Resource in Isiohor, Ovia North East, Edo State, Nigeria

*S. Odiana, C. Madubuike and D.I. Olorunfemi

Department of Environmental Management & Toxicology, University of Benin, Benin City
*Corresponding author E-mail: odiana09@yahoo.com

(Received August 21, 2017; Accepted in revised form September 11, 2017)

ABSTRACT: Groundwater consumption is increasing due to high susceptibility of contamination of other sources. In this study, the consumption, contamination and management of groundwater resource in Isiohor quarters in Edo State were evaluated. A total of 300 questionnaires were randomly administered and laboratory analysis was carried out to determine the physicochemical parameters of the water samples collected. The results obtained showed that 94.7% of the respondents depend on groundwater as against 5.3% that use harvested rainwater. 251(93.6%) of the respondents use at least 50 L of water daily for major domestic activities; 29% use rainwater as an alternative to borehole water and only 18.0% use 25 L of water daily during scarcity. Laboratory analysis revealed that Fe and SO_4 exceeded SON permissible limits in both water sources while the harvested rain water were acidic and were not within the SON permissible range. The findings showed that groundwater consumption was high with poor management. The need for public awareness on efficient water consumption cannot be overemphasised.

Keywords: Groundwater, Consumption, Heavy metals, Management, Respondents

Introduction

Water is an essential resource that sustains life on earth. It is needed for most human activities and plays a major role in human settlement. Available water sources to man include groundwater, rainwater and surface water. Water can make or man the economy and life style of a nation or group of people. The advent of technological advancement has made the quest for water for domestic, industrial and agricultural consumption to drift from mere search for surface water (flowing or stagnant pools) to prospecting for steady reliable subsurface/ground water from boreholes (Ezomo and Ifedili, 2005, 2007). It is one of the most essential needs of humans and the most abundant natural resources on the surface of the earth (Oyinloye and Jegede, 2004). However, pure water needed for human consumption does not always occur in nature due to the presence of dissolved or suspended impurities in most natural water bodies (Goldface, 1999). The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life (Oluduru and Aderiye, 2007).
Groundwater is the largest reservoir of drinking water and due to natural filtration it is less contaminated as compared to surface water (Aiyesanmi *et al*., 2004). Water in its original sources can be contaminated by domestic, industrial or agricultural waste. It is essential for supporting livelihood, safeguarding public health, providing food security, ensuring environmental sustainability, promoting industrial and economic development, improving living standards and achieving sustainable development (Falkenmark, 2015; Kumar *et al*., 2015; Mayzelle *et al*., 2015).

Materials and Methods

Study Area: The study was carried out in Isiohor, Ovia North East Local Government Area, Edo State, Nigeria. It has a tropical climate, characterised by two distinct seasons, the wet and dry seasons. It lies in the thick equatorial rainforest zone which experiences heavy rainfall. It lies within latitudes 6°10'and 6°30'N and longitude 5°30'and 5°45'E.

Questionnaire: The information for this research was obtained through the distribution of structured questionnaires, observations and extraction of relevant information from published reports. Questionnaires were designed in such a way that it is relevant to the evaluation of consumption and management of groundwater in the study area. These questionnaires were administered to 300 persons using simple random technique.

Laboratory Analysis: Water samples were collected in a clean container and taken to the laboratory for determination of the physicochemical parameters. Heavy metals were determined using method described by Nouri *et al.* (2006) while APHA (2002) method was used to determine the physical and chemical parameters.

Data Analysis: The data obtained were analyzed using descriptive method such as frequency distribution tables and graphs. Chi – Squared Test was also utilized to test significant difference at 95% and 99% confidence levels ($P<0.001$ and $P<0.05$). Computer software Statistical Package for Social Scientists (SPSS) version 16.0 and Microsoft Excel 2007 were used for the statistical analysis.

Results

The results obtained from questionnaires administered on respondents show that 13.7% had no formal education, 0.7% had First School Leaving Certificate, 21.7% had Ordinary Level Certificate, 16.7% had NCE/Diploma, 26% had 1st degree or equivalent while 21.3% had higher degrees (Fig. 1).

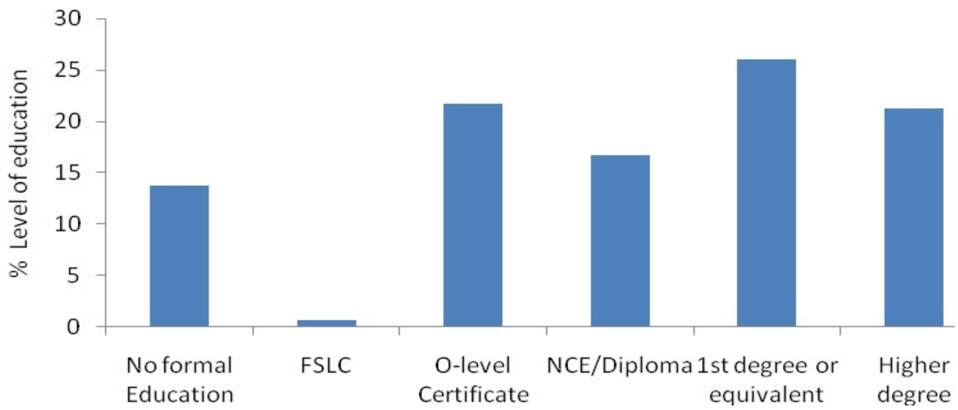

Fig. 1: Level of education of respondents.

The number of respondents per water tank of 2000/2500 litre capacity reveals that 0.7% respondents are between 1-3 persons/tank, 7.7% between 4-7 persons/tank, 57.3% between 8 -10 persons/tank, while 34.3% were above 10 persons/tank (Fig. 2).

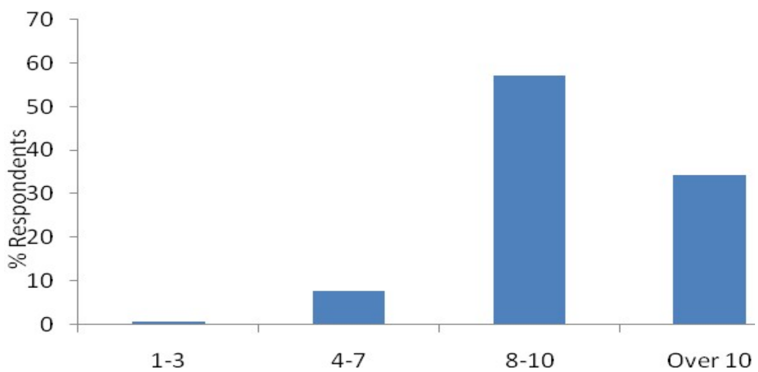

Fig. 2: Number of persons per tank.

Fig. 3 shows the rate at which respondents filled their tanks if borehole and harvested rainwater were the sources of water in their homes. 47.0% respondents had both borehole and harvested rainwater filled tanks once a week, 52.0% twice a week while 1.0% had their tanks filled once a month.

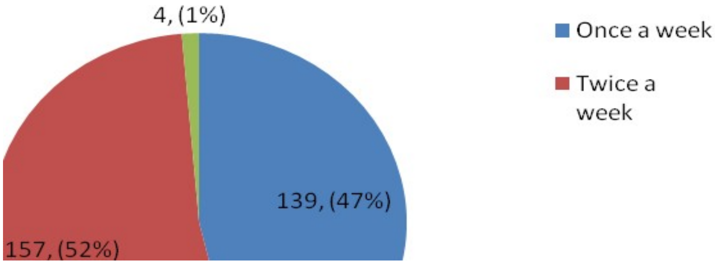

Fig. 3: Rate at which respondents filled their tanks if borehole and harvested rainwater were the sources of water in their homes.

Respondents' responses on the use of rainwater as an alternative or supplement to groundwater is shown in Fig. 4. Twenty-nine per cent (29%) responded in the affirmative while 71% were negative.

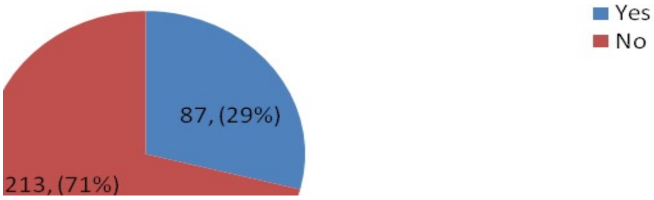

Fig. 4: The use of rainwater as an alternative to borehole.

Analysis of the quantity of water respondents used daily for major domestic activities like cooking and bathing as shown in Fig. 5 reveals that 1.7% used 25 litres, 14.7% used 38 litres, 47.3% used 50 litres while 36.3% of the respondents used 75 litres.

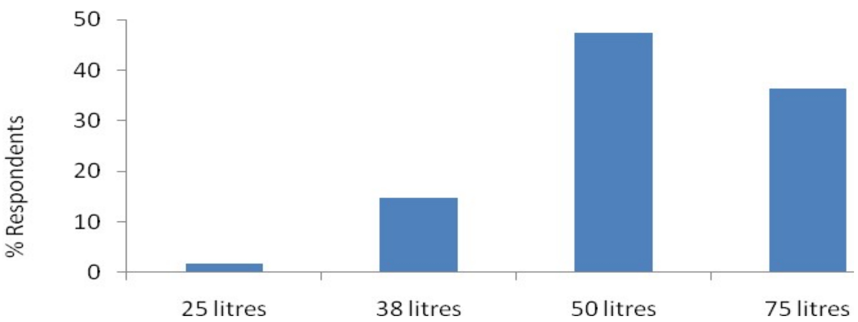

Fig. 5: Quantity of water respondents used daily for cooking and bathing.

Respondents' views on the use of 25 litres of water daily in case of scarcity as shown in Fig. 6 reveals that 18% of the respondents agreed while 82% responded negatively.

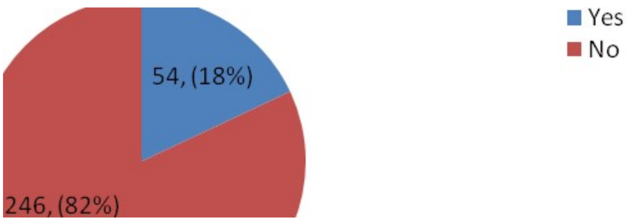

Fig. 6: Response on the use 25 litres of water daily in case of scarcity.

Table 1 shows the results obtained from the physicochemical analysis of borehole and rain water samples collected in the study area. Fe and SO_4^{2-} exceeded SON (2007) permissible limits (0.3 and 100 mg/l respectively). The pH of the water samples obtained from the boreholes were slightly alkaline; on the contrary all the harvested rain water were acidic and were not within the permissible range set by SON (2007).

Table 1: Physicochemical parameters of borehole and rainwater

Water Sample	pH	Parameters (mgL^{-1})						
		TDS	SO_4	Cl	Fe	Zn	Mn	Cu
Harvested Rain Water (Station 1)	5.14	167.0	150.1	250.4	0.67	0.539	0.031	0.100
Harvested Rain Water (Station 2)	6.20	150.0	140.9	190.6	0.59	0.30	0.011	0.091
Harvested Rain Water (Station 3)	5.33	170.0	139.5	210.6	0.69	0.219	0.040	0.093
Borehole Water Station 4	8.05	120.7	165.8	130.5	0.905	0.617	0.0102	0.085
Borehole Water Station 5	7.95	118.5	105.0	123.4	0.863	0.805	0.0113	0.077
SON 2007 (mgL^{-1})	**6.5-8.5**	**500**	**100**	**250**	**0.3**	**3.0**	**0.02**	**1.0**

Discussion

Isiohor being a growing urban area, their educational level is quite moderate. Most of the people are learned; only 41 (13.7%) had no formal education. Gbadegesin and Olorunfemi (2007) opined that literacy level has some implications on quantity and quality characteristics of water used by households as well as the management of the existing water sources. In this study, respondents with higher level of education had higher water consumption tendencies than the less educated individuals. This observation agrees with the findings of Anyashola *et al.* (2010) and Aho *et al* (2016) who stated that an increase in an individual's level of education is likely to increase water demand by 4.85 litres. Ifabiyi (2011) also indicated that literacy level has influence on domestic water use. The influence could be due to the fact those who are educated are more likely to have more modernized style of living as a result of the use of new machinery for washing and cleaning, and having frequent faucets inside and outside bathrooms and kitchens to facilitate cleaning activities (Almotirin and Falah, 2010). The variance could also be because those with higher levels of education seem to be more sensitive to the health implication of water consumed; as such they are likely to use more water for sanitary purposes (Fotue and Sikod, 2012). In addition, educated people in contrast to the less educated individuals are more aware of the importance of frequent bathing in controlling microbes.

Most of the inhabitants in the study area depend on groundwater as against those that used harvested rainwater. This observation is consistence with the studies of Ezekiel and Dominic (2015), Aho, *et al* (2016), Makwe and Ahmad (2017) who reported that more people depend on groundwater than other sources like rainwater. Similarly, Bakari *et al.,* (2014) reported that out of the nation's population of about 168 million, more than half depend directly on this natural resource for their daily water needs. This preference for groundwater source is found to influence domestic water use (Ogunbode and Ifabiyi, 2014).

The results of this study revealed that groundwater is the major source of water in the study area as such its consumption was very high. The over dependence on groundwater by the people is however majorly due to cultural perception that other sources like rainwater are not fit for human consumption. Nwankwoala (2011) opined that groundwater is widely used because of its high quality. Menon, (1998) reported that the reliable supply of groundwater, uniform quality and temperature, relative turbidity and pollution free, minimal evaporation losses and low cost of development are attributes making groundwater more attractive compared to other sources. In addition, population and economic growth have led to the ever more growing demand on the groundwater resources.

In this study, 296 (98.6%) of the respondents had family sizes greater than 5 or 275(91.6%) had at least eight (8) persons per tank. This is attributed to the fact that most households in Nigeria especially in the rural and growing urban areas are large because of the kinship structure and the extended family system practised in Nigeria. This observation is similar to results obtained by Keshavarzi *et al*., (2006), Ayanshola *et al,* (2010); Makwe and Ahmad (2017) in which 70% of the total number of their respondents had 8 to 11 members in their households. Family size has implication for quantity of water consumed which meant that more water would be fetched for household purposes.

The study area is characterised with unsustainable consumption of water particularly groundwater. It was found that 251(93.6%) respondents used at least 50 litres of water daily for major domestic activities like cooking and bathing. UNDP (2008) cited in Mohammed (2016) opined that the water need per person per day is 50 litres (13.2 gallons) which include 5 litre for drinking, 20 litres for sanitation and hygiene, 15 litres for bathing and 10 litres for preparing food. The World Health Organization (WHO) defines basic access to potable water as the availability of drinking water at least 20 litres per day per person, a distance of not more than 1 km from the source to the house and a maximum time taken to collect round trip of 30 minutes (Mohammed, 2016). In

Gwagwalada, Nigeria, Makwe and Ahmad (2017) reported that 61% of the respondents used 100-200 litres of water per day for an entire household, about 38% used more than 200 litres per day. Ezekiel and Dominic (2015) showed that about 80% of the households consume 100-200 litres per day. The findings of this study implied that groundwater is over-extracted or used unsustainably.

This study has also revealed poor management of groundwater resources in the study area because 83.3% respondents with average number of eight (8) persons per tank of 2000 or 2500 litres that depend on borehole water as their only source of water filled their tanks at least twice a week. It was also found that 98.6% respondents who depend on borehole and harvested rainwater filled their tanks at least once a week. Only 1.3% respondents could fill their water tanks once a month. This showed unsustainable consumption of groundwater in the study area. It was found that only 29% respondents use rainwater as an alternative to borehole water. This shows the extent to which the inhabitants prefer groundwater to other alternatives like rainwater (which is readily available particularly during raining season). The study area is located in the tropical rainforest region of the country where rain falls almost throughout the year. If the people would use rainwater for similar domestic activities as they do to groundwater resources, the rate of extraction of the ground water resource would reduce and become sustainable. This would also help to control problems associated with over extraction of groundwater, ground subsidence and salt water intrusion.

The pH of all the harvested rain water were acidic and were outside the permissible range set by SON (2007). The acidic pH of rainwater occurs as a result of dissolution of CO_2 as well as the presence of acidic species (NO_3^- and SO_4^{2-}) in the atmosphere (Agbede *et al*., 2015). Prolonged intake of water with low pH may predispose one to the risk of acidosis, which may lead to cancer or cardiovascular damage including the constriction of blood vessels and reduction in oxygen supply even at mild levels (Ogundipe and Obinna, 2008) cited in Anyawu and Nwigwe (2015). Also, metal corrosion or solubility problem occur when pH of water happens to be more acidic (Onwughara *et al,* 2013; Agbede *et al*., 2015). In borehole water samples, pH was slightly alkaline but was within SON (2007) permissible limit of 6.5 to 8.5.

In this study, SO_4^{2-} was above acceptable limit of 100mg/l set by SON (2007). Excess sulphate in water can cause noticeable taste and laxative effect (Anyawu and Nwigwe 2015). Other parametres (TDS and Cl) were within SON (2007) permissible limits of 500mg/l and 250mg/l respectively. The concentrations of heavy metals revealed that copper and zinc in all the water samples were within SON (2007) permissible limit; however, the concentration of iron in both rainwater and borehole water were above acceptable limit of SON. A similar finding of high iron concentration in borehole water was reported by Anake *et al*. (2014). In this study, manganese was above regulatory limit in rainwater samples from stations 1 and 3 with 0.31 and 0.040 mg/l respectively. Mn in drinking water is associated with neurological damage (Chennaiah *et al,* 2014). Rainwater had higher concentrations of the heavy metals examined than borehole water. These metals, at higher concentrations could cause adverse health effects or illness (Valavanidis and Vlachogianni, 2010)**.** Zinc toxicity leads to diarrhea (Osibanjo and Majolagbe, 2012), manganese may hamper the intellectual development of the child (Buschmann *et al.,* 2008). Iron has been associated with genetic and metabolic diseases and repeated blood transfusions (Fraga and Oteiza, 2002) and copper toxicity is related to several health concerns, including stomach cramps, nausea, vomiting, diarrhea, cancer, liver damage and kidney disease (EPA, 2013 cited in Anake *et al,* 2014) .

In conclusion, the work inferred that there was heavy dependence on groundwater in the study area with little or no effort to manage this resource. The fact that there was minimal contamination of the different water sources in the study area, rainwater may not be used as alternative or supplement to groundwater in the study area because of its low pH and relatively higher concentrations of the heavy metals examined. There should be effective public awareness conducted towards water management to broaden the mind of the inhabitants on proper water management and consumption. Rainwater should be harvested and used for at least non potable uses so as to supplement groundwater. It can even be treated and consumed.

References

Agbede TO, Ayedun H, Umar BF: Major and trace elements in rain water collected from industrial and non-industrial areas of Ogun State, Nigeria. J Chem Soc Nigeria 40(1): 19-23. 2015.

Aho MI, Akpen GD, Ivue P: Determinants of residential per capita water demand of makurdi metropolis. Nigerian J Technol 35(2): 424 – 431. 2016.

Aiyesanmi, AF, Ipinmoroti KO, Oguntimehin II: Impact of automobile workshop on groundwater quality in Akure Metropolis J Chem Soc Nigeria (Supplement to 2004 Proceeding) pp. 420–426. 2004.

Almotirin, FA, Falah MW: The influence of water and sewage networks on residential water consumption. Int J Water Resour Environ Eng 4(2):103-106. 2010.

American Public Health Association APHA: Standard Method for Examination of water and waste water, 20th edition, American Public Health Association, Washington D.C. p. 86. 2002.

Anake WU, Benson NU, Akinsiku AA, Ehi-Eromosele CO, Adeniyi IO: Assessment of trace metals in drinking water and groundwater sources in Ota, Nigeria. Int J Sci Res Publ 4(5):1-4. 2014.

Anyanwu ED, Nwigwe NC: Assessment of bottled water quality using physico-chemical indicators. Appl Sci Res J 3(1):1-12. 2015.

Anyashola AM, Sule BF, Salami AM: Modelling of residential water demand at household level in Ilorin, Nigeria. J. Res Inform Civ Eng 7(1):59-67. 2010.

American Public Health Association APHA: Standard Methods for the Examination of Water and Wastewater, 20th ed. American Water Works Association, Water Pollution Control Federation, Washington, USA. 1998.

Bakari A, Akunna J, Jefferies C: Towards sustainable groundwater management in the south-western part of the Chad Basin, Nigeria: A Stakeholder Perspective. Br J Appl Sci Technol 4(25):3726-3729. 2014.

Buschmann J, Berg M, Stengel C, Winkel L, Sampson ML, Trang PTK, Viet PH: Contamination of drinking water resources in the Mekong Delta floodplains: Arsenic and other trace metals pose serious health risks to population. Environ Int 34(6), 756–764. 2008

Chennaiah JB, Rasheed MA, Patil DJ: Concentration of heavy metals in drinking water with emphasis on human health. Int J Pl An Env Sci 4(2): 205-214. 2014.

Ezekiel A, Dominic AA: Sources, demand and problems of domestic water in Nassarawa Eggon Town, Nigeria Pollut 1(1): 55-65. 2015.

Ezomo FO, Ifedili SO: Vertical Electrical Sounding (VES) as a useful instrument for investigating aquifers existence in Eguare – Egoro, Edo State, Nigeria. J Nigeria Assoc Math Phys 11(1): 597-604. 2007.

Ezomo FO, Ifedili SO: Drilling as a useful tool for water bearing formation investigation in Uhiele, Ekpoma. J Appl Sci 9(3):6579-6588. 2005.

Falkenmark M: Adapting to climate change: towards societal water insecurity in dry-climate countries. Int J Water Resour Dev 25(2): 123–136. 2015.

Fotue LAT, Sikod F: Determinants of the households choice of drinking water source in Cameroun. J Sustain Dev in Afr 7(3):86 – 97. 2012.

Fraga CG, Oteiza PI: Iron toxicity and antioxidant nutrients. Toxicol 180(1): 23-32. 2002.

Gbadegesin N, Olorunfemi F: *Assessment of Rural Water Supply Management in Selected Rural Areas of Oyo State, Nigeria*. ATPS Working Paper Series No. 49. African Technology Policy Studies Network. Nairobi, Kenya.64p. 2007.

Goldface DR: *Water Laws and Water Law Administration*. National Water Resources Institute, Kaduna, Nigeria, pp. 56-57. 1999.

Ifabiyi IP: Willingness to pay for water at household level in Ilorin, Kwara State, Nigeria. Global J Human-Soc Sci 11(2): 14 – 24. 2011.

Keshavarzi AR, Sharifzadeh M, Kamga HAA, Amin S, Keshtkar SH, Bamda A: Rural domestic water consumption behaviour: A case study in Ramjerd Area, Fars Province, Iran. Iran Water Resour (40) 1173-1178. 2006.

Kumar P, Bansod BKS, Debnath SK, Thakur PK, Ghashyam C: Index-based groundwater vulnerability mapping models using hydrogeological settings: a critical evaluation. Environmental Impact Assess Rev 51:38–49. 2015.

Makwe E, Ahmad HA: 2017: Gender inequality in household water provision: consequences on women and children in Gwagwalada Area Council, Federal Capital Territory, Nigeria. Confluence J Environ Stud 11(1): 117- 131.

Mayzelle MM, Viers JH, Medellin-Azuara J, Harter T: Economic feasibility of irrigated agricultural land use buffers to reduce groundwater nitrate in rural drinking water sources. Water 7(1): 12–37. 2015.

Menon S: *Groundwater Management: Need for Sustainable Approach*. Proceedings of the Seminar on Artificial Recharge of Groundwater, December, 1998, Central Groundwater Board, Ministry of Water Resources, New Delhi, www.wikipedia.org.

Mohammed SS: An Analysis of the Domestic Water Demand and Supply in Ilorin Metropolis, Kwara State. A Dissertation Submitted to the School of Postgraduate Studies Ahmadu Bello University Zaria. 2016.

Nouri J, Mahvi AH, Babaei AA, Jahed GR, Ahmadpour E: Investigation of heavy metals in groundwater. Int J Phys Sci 9(3):377- 384. 2006.

Nwankwoala HO: An integrated approach to sustainable groundwater development and management in Nigeria. J Geol Mining Res 3(5):123-130. 2011.

Ogunbode TO, Ifabiyi PI: Determinants of domestic water consumption in a growing urban centre in Osun State, Nigeria. Afr J Environ Sci Technol 8 (4): 247- 255. 2014.

Oluduro AO, Adewoye BI: Efficiency of *Moringa oleifera* seed extract on the microflora of surface and ground water. J Plant Sci 6: 453-438. 2007.

Onwughara NI, Ajiwe VIE, Nnabuenyi HO: Physicochemical studies of water from selected boreholes in Umuahia North Local Government Area in Abia State, Nigeria. Int J Pure Appl Biosci 1 (3): 34-44. 2013.

Osibanjo O, Majolagbe AO: Physicochemical quality assessment of groundwater based on land use in Lagos City, Southwest, Nigeria. Chem J 2(2): 79-86.

Oyinloye AO, Jegede GO: Geophysical survey, geochemical and microbiology investigation of ground well water in Ado-Ekiti, North South Western Nigeria. Global J Geol Sci 2(2): 235-242. 2004.

Standards Organisation of Nigeria: Nigerian standard for drinking water quality. Nigerian Industrial Standard (NIS 554). Standards Organisation of Nigeria (SON), Abuja, Nigeria. pp. 14 – 17. 2007.

Valavanidis A, Vlachogianni T: Metal Pollution in Ecosystem, Ecotoxicology Studies and Risk Assessment in the Marine Environment. https://www.researchgate.net/.../236623174. 15p. 2010.