Quality Assessment of Water Reservoirs in Federal Polytechnic Damaturu

By

Lawan Bello, Oyenike Badirat O., Abubakar El-Shaq and Ibrahim Adamu Godowoli

Correspondence address: bellolawan70@gmail.com
Department of Science Laboratory Technology
School of Science and Technology,
The Federal Polytechnic Damaturu, Yobe State.

Abstract

One of the most basic necessities for all living things is water. For a variety of daily tasks, including drinking, washing, taking baths, and cooking, humans require water. The water becomes unfit for drinking and other uses if its quality is poor. Water quality is typically defined in terms of its physical, chemical, and biological properties. Finding water that is suitable for consumption, agriculture, and industrial use becomes imperative. The actions of every living thing depend on water, which is one of the essential elements of the biotic environment. Water must be handled carefully to preserve its purity in order to be suitable for both home and commercial use. The purpose of this research project is to offer potential remedies for water The investigation of the six samples, which came from different parts of Yobe State, revealed that the majority of the samples' physical and chemical characteristics did not match the values recommended by the World Health Organization. The results of the bacteriological parameters indicated that the water samples were contaminated because they were below the permitted limits. Any water source should be purified before being consumed and used for other household purposes

Keywords: *Bubayero Hall water reservoir, Elkenemi Hall water reservoir, Maryam Abacha Hall water reservoir, Ngazargamu Hall water reservoir, Students Mosque. Zik Hall water reservoir*

I. Introduction

The quality of drinking water is a powerful environmental determinant of health (WHO, 2010). Water plays an indispensable role in sustenance of life and it is a key pillar of health determinant, since 80% of diseases in developing countries are due to lack of good quality water (Cheesbrough, 2006). Drinking water quality management has been a key pillar of primary prevention for over one and half centuries and it continues to be the foundation for the prevention and control of water borne diseases (WHO, 2010). Contaminated water is a global public health threat placing people at risk of a host of diarrheal and other illness as well as chemical intoxication (Okonko *et al.,* 2009). The major risk to human health is faecal contamination of water supplies.

Population pose a great pressure on provision of safe drinking water especially in developing countries (Okonko *et al.,* 2009). Consequently, water borne diseases such as cholera and typhoid often have their outbreak especially during dry season (Banu *et al.,* 2010). High prevalence of diarrheal among children and infants can be due to the use of unsafe water and unhygienic practice (Oladipo, 2002). Thus, many infectious diseases are transmitted by water through faecal oral contamination. Diseases due to drinking of contaminated water leads to the death of five million children annually and make 1/6 of the world population sick (Shittu, Olaitan, and Amusa, 2008). Also, water may contain toxic inorganic chemicals which may cause either acute or chronic health effect. Acute effects include nausea, lung irritation, skin rash, vomiting and dizziness, sometime death usually occurred. Chronic effect, like cancer, birth defects, organs damage, disorder of the nervous system and damage to the immune system are usually more common (Erah, Akujieze, and Oteze, 2002).

Inorganic chemicals like lead may produce adverse health effect which include interference with red blood cell chemistry, delay in normal physical and mental development in babies and young children, slit deficit in attention span, hearing and learning abilities of children and slight increase in blood pressure in some adults. Also, presence of chromium in drinking water had been shown to result in chronic toxic effect (including liver and kidney damage, internal haemorrhage and respiratory disorders) in animal and human by ingestion. Although, the sources of metal contaminants of the underground water are uncertain, it may likely be due to natural process and anthropogenic activities (Erah, Akujieze, and Oteze, 2002). In addition, rural water also has excessive amount of nitrite from microbial action on agricultural fertilizer, when ingested nitrite compete for oxygen in the blood (Oladipo, Onyenike, and Adebiyi, 2009). Water is an essential need for human existence, and its importance for individual health and the well-being of a nation cannot be underestimated. Notwithstanding, many people in developing countries do not have access to safe and clean drinking water, or to adequate amounts of water for basic hygiene (WHO and UNICEF, 2010). In many developing countries, there are lots of public health concerns related to the challenge of poor water quality and the risk of water-borne diseases (UNICEF/WHO, 2012). Most water sources in developing countries are polluted by both organic and chemical pollutants (Haylamicheal and Moges, 2012). Rapid urbanization, especially in developing countries like Nigeria, has affected the availability and quality of groundwater due to waste and effluent disposal practice, especially in urban areas (Makwe and Chup, 2013). Pollution is caused when a change in the physical, chemical or biological condition in the environment harmfully affects quality of human life, other animals and plants (Esemikose and Akoji, 2014). Agricultural practices, industrialization and discharge of sewage into water bodies are among the factors responsible for water pollution. Pollution easily arises when population growth outmatches availability of potable water due to inadequate urban planning processes (Oluyemi *et al.,* 2010).

Water is one of the indispensable resources for the continued existence of all living things including man and adequate supply of fresh and clean drinking water is a basic need for all human beings (Edema, Atayese, and Bankole, 2011). In nature, all water contains impurities; as water flows in streams, accumulates in lakes and filters through layers of soil and rock in the ground, it dissolves or absorbs substances it come in contact with, which may be harmful or harmless (Ogamba, 2004). One of the major and critical problems in most developing countries today is the provision of an adequate and safe drinking water to its populace.

Drinking water that is safe and aesthetically acceptable is a matter of high priority to Standard Organization of Nigeria (SON), National Agency for Foods and Drugs Administration and Control (NAFDAC) and other regulatory agencies in Nigeria and is expected to meet the Nigerian Industrial Standard (NIS). Furthermore, drinking water that is fit for human consumption is expected to meet the World Health Organization (WHO) standard and be free from physical and chemical substances as well as microorganisms in an amount that can be hazardous to health. It is a known fact that no single method of purification can eliminate 100 % contaminants from drinking water. However, water can be and should be made safe for consumption within acceptable limits (Danloye, 2004).

II. Methodology

water Sampling: the water samples was collected in sterilized plastic containers from six different locations.

Physiochemical analysis. Analysis of parameters from water samples were carried out using Hannah instrument (HI 9813-6). For pH, conductivity and total dissolved solids (TDS). Dissolved oxygen and temperature were determined using dissolved oxygen meter (DOH-SDi).

Elemental analysis (Digestion process): Analysis of parameters from water samples were carried out using atomic absorption spectrophotometer (AAS) (PinAAcle 900H). For chromium, copper, cadmium, lead, zinc. 10ml of water sample was poured into a digestive tube. 10ml of nitric acid was added water sample and was heated inside the digestor (foss) tecator 2006) machine at 250^{o}C. It was covered to dilate the odor which will pass through a pipe as waste. After heated for 10minutes, it was removed from the machine and was allowed to cool for 5minutes. It was poured into a sample bottle of 60ml and was diluted with distilled water.

III. Results and Discussion

The result obtained from the quality assessment of water reservoirs in Federal Polytechnic Damaturu were carried out using: physiochemical and elemental analyses.

Physico-chemical parameters determined were; dissolve oxygen (DO), total dissolved solid (TDS), conductivity, temperature, and pH in Table using Hannah instrument (HI 9813-6) and dissolved oxygen meter (DOH-SDI). The elemental parameters determined were; calcium, magnesium, cadmium, iron, lead, and zinc using Atomic Absorption spectroscopy (AAS). Pin AAcle 900H. The results are presented in tables below based on the physical, chemical and biological properties of the water samples collected in different locations. The results were presented in the sequence below:

Table1 of Physico-chemical analysis

Sample ID	TDS (ppm)	DO mg/L	pH	Temp. ºC	E. C × 1000 µS/cm
A BHR	105	3.6	7.0	23.8	140
B HER	103	1.6	6.6	22.8	130
C MHR	102	3.0	6.5	23.0	130
D NHR	101	3.0	6.4	23.0	130
E SMR	101	4.1	6.4	24.3	130
F ZHR	104	5.6	6.5	24.1	140

Key: Bubayero Hall Reservoir (BHR), Elkenemi Hall Reservoir **(**EHR), Maryam Abacha Hall Reservoir (MHR), Ngazargamu Hall Reservoir (NHR), Students Mosque Reservoir (SMR), Zik Hall Reservoir (ZHR).

Table2: Elemental analysis

SAMPLE ID	PARAMETERS	1^{ST}	2^{ND}	3^{RD}	MEAN	SD	MEAN±SD
BHR	CALCIUM	0.936	0.965	0.985	0.962	0.0248	0.962±0.0248
HER	CALCIUM	0.779	0.752	0.775	0.769	0.0144	0.769±0.0144
MHR	CALCIUM	0.768	0.792	0.792	0.784	0.0136	0.784±0.0136
NHR	CALCIUM	0.698	0.677	0.679	0.685	0.0116	0.685±0.0116
SMR	CALCIUM	0.716	0.714	0.728	0.719	0.0074	0.719±0.0074
ZHR	CALCIUM	0.824	0.850	0.833	0.835	0.0133	0.835±0.0133

Key: Bubayero Hall Reservoir (BHR), Elkenemi Hall Reservoir **(**EHR), Maryam Abacha Hall Reservoir (MHR), Ngazargamu Hall Reservoir (NHR), Students Mosque Reservoir (SMR), Zik Hall Reservoir (ZHR)

Table3: Elemental analysis

SAMPLE ID	PARAMETERS	1^{ST}	2ND	3^{RD}	MEAN	SD	MEAN±SD
BHR	ZINC	0.038	0.036	0.038	0.038	0.0012	0.038±0.0012
HER	ZINC	0.032	0.033	0.032	0.032	0.0008	0.032±0.0008
MHR	ZINC	0.040	0.039	0.037	0.039	0.0014	0.039±0.0014
NHR	ZINC	0.039	0.038	0.034	0.037	0.0026	0.037±0.0026
SMR	ZINC	0.040	0.042	0.040	0.040	0.0010	0.040±0.0010
ZHR	ZINC	0.040	0.038	0.038	0.039	0.0011	0.039±0.0011

Key: Bubayero Hall Reservoir (BHR), Elkenemi Hall Reservoir **(**EHR), Maryam Abacha Hall Reservoir (MHR), Ngazargamu Hall Reservoir (NHR), Students Mosque Reservoir (SMR), Zik Hall Reservoir (ZHR)

Table4: Elemental analysis

SAMPLE ID	PARAMETERS	1ST	2ND	3RD	MEAN	SD	MEAN± SD
BHR	LEAD	0.073	0.046	0.070	0.073	0.0147	0.073±0.0147
HER	LEAD	0.077	0.048	0.106	0.077	0.0288	0.077±0.0288
MHR	LEAD	0.075	0.063	0.071	0.070	0.0062	0.070±0.0062
NHR	LEAD	0.047	0.102	0.068	0.072	0.0278	0.072±0.0278
SMR	LEAD	0.063	0.080	0.084	0.075	0.0111	0.075±0.0111
ZHR	LEAD	0.071	0.062	0.075	0.070	0.0070	0.070±0.0070

Key: Bubayero Hall Reservoir (BHR), Elkenemi Hall Reservoir **(**EHR), Maryam Abacha Hall Reservoir (MHR), Ngazargamu Hall Reservoir (NHR), Students Mosque Reservoir (SMR), Zik Hall Reservoir (ZHR)

Table 5: Elemental analysis

SAMPLE ID	PARAMETERS	1ST	2ND	3RD	MEAM	SD	MEAN±SD
BHR	CADMIUM	0.023	0.023	0.023	0.023	0.0003	0.023±0.0003
HER	CADMIUM	0.021	0.019	0.020	0.020	0.0005	0.020±0.0005
MHR	CADMIUM	0.018	0.021	0.019	0.019	0.0014	0.019±0.0014
NHR	CADMIUM	0.018	0.020	0.020	0.019	0.0012	0.019±0.0012
SMR	CADMIUM	0.019	0.019	0.019	0.019	0.0002	0.019±0.0002
ZHR	CADMIUM	0.019	0.019	0.019	0.019	0.0005	0.019±0.019

Key: Bubayero Hall Reservoir (BHR), Elkenemi Hall Reservoir **(**EHR), Maryam Abacha Hall Reservoir (MHR), Ngazargamu Hall Reservoir (NHR), Students Mosque Reservoir (SMR), Zik Hall Reservoir (ZHR)

Table 6: Elemental analysis

SAMPLE ID	PARAMETERS	1ST	2ND	3RD	MEAN	SD	MEAN±SD
BHR	IRON	0.254	0.214	0.209	0.226	0.0249	0.226±0.0249
HER	IRON	0.195	0.184	0.198	0.192	0.0073	0.192±0.0073
MHR	IRON	0.233	0.232	0.226	0.230	0.0036	0.230±0.0036
NHR	IRON	0.190	0.183	0.186	0.186	0.0037	0.186±0.0037
SMR	IRON	0.174	0.169	0.173	0.172	0.0027	0.172±0.0027
ZHR	IRON	0.167	0.174	0.172	0.171	0.0036	0.171±0.0036

Key: Bubayero Hall Reservoir (BHR), Elkenemi Hall Reservoir **(**EHR), Maryam Abacha Hall Reservoir (MHR), Ngazargamu Hall Reservoir (NHR), Students Mosque Reservoir (SMR), Zik Hall Reservoir (ZHR)

Table 7: Elemental analysis

SAMPLE ID	PARAMETERS	1ST	2ND	3RD	MEAN	SD	MEAN±SD
BHR	MAGNESIUM	1.474	1.495	1.519	1.496	0.0222	1.496±0.0222
HER	MAGNESIUM	1.238	1.233	1.245	1.239	0.0062	1.239±0.0062
MHR	MAGNESIUM	1.271	1.281	1.286	1.279	0.0074	1.279±0.0074
NHR	MAGNESIUM	1.099	1.094	1.099	1.098	0.0029	1.098±0.0029
SMR	MAGNESIUM	0.992	0.986	0.992	0.990	0.0036	0.990±0.0036
ZHR	MAGNESIUM	0.926	0.920	0.927	0.925	0.0038	0.925±0.0038

Key: Bubayero Hall Reservoir (BHR), Elkenemi Hall Reservoir **(**EHR), Maryam Abacha Hall Reservoir (MHR), Ngazargamu Hall Reservoir (NHR), Students Mosque Reservoir (SMR), Zik Hall Reservoir (ZHR).

The physico-chemical, elemental and microbial parameters were compared with the World Health Organization (WHO, 2005) standard in order to assess the quality of water from six different locations in federal polytechnic Damaturu. Physical parameters determined revealed that, the values for the total dissolved solids were within the WHO acceptable value of 105 mg/L, for all the six samples. However, water containing more than 500 mg/L total dissolved solids is not considered desirable for water supplies for drinking purposes. Electrical conductivity which is a measurement of water electrical current is directly related to the concentration of dissolved ions in the water, the value falls within the limit of WHO standard. The temperature of the samples falls within the range of 2.4^{o}c may be the outcome this of the nature of the climatic condition of the State. The pH range of (6.00-8.5) were obtained in all the six samples. Threshold for DO is 6.0 mg/L for drinking water and should be more than 5 mg/L for agricultural purposes. Very low DO may result in anaerobic conditions that cause bad odors. The result shows a DO level that is normal and acceptable for drinking. The elemental parameters such as magnesium, calcium, cadmium, lead, zinc and iron are above the SON standard Mg 1.496- 0.925mg/L, Ca 0.962- 0.835mg/L, Pd 0.073- 0.070mg/L, Cd 0.023- 0.019mg/L, Fe 0.226- 0.171mg/L, which will likely lead to health problem such as kidney, cancer, affect mental development, toxic to the central and peripheral nervous system. While Zn is within the SON standard Zn 0.038- 0.039mg/L.

Izah and Ineyougha, (2015) review of the microbial quality of potable water in Nigeria, their study found out that the microbial load often exceeds the WHO and FAO Food and Agricultural Organization (FAO) allowable limit of 1.0 x102cfu/ml for potable water and SON maximum permissible level of 10cfu/ml for total coliform.

Conductivity

Conductivity is a measure of the ability of water to pass an electrical current. Because dissolved salts and other inorganic chemicals conduct electrical current, conductivity increases as salinity increases. Organic compounds like oil do not conduct electrical current very well and therefore have a low conductivity when in water. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity.

The unit for measuring conductivity in water is the microsiemen per centimeter (µs/cm). The conductivity of pure water is in the range 0.5 to 3 µs/cm. Lake and river water in the U.S. is much higher, generally ranging from 50 to 1500 µs/cm.

Temperature

Usually, there is no growth above 55°C, and a temperature of over 60°C has a bactericidal effect. Thus, the WHO recommends that water be heated and stored at 60°C. In the U.S., we usually use the Fahrenheit scale to measure temperature - where water freezes at 32 degrees and boils at 212 degrees; however, scientists usually use the Centigrade (or Celsius) scale - where water freezes at 0 degrees and boils at 100 degrees.

The best temperature for drinking water is room temperature (20°C / 68°F) for maximum flavour, or chilled cold (6°C / 43°F) for maximum refreshment.

pH

pH is a measure of how acidic/basic water is. The range goes from 0 to 14, with 7 being neutral. pH of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water.

Water has a neutral pH of 7, which indicates that it is Neither Acidic or Basic. The scale ranges from 0 (very acidic) to 14 (very basic). It is normal for water to have a range of between 6.5 and 8.5 on the scale. pH in water may fluctuate with differing environmental factors.

Dissolved Oxygen

Dissolved oxygen (DO) is the amount of oxygen that is present in water. Water bodies receive oxygen from the atmosphere and from aquatic plants. Running water, such as that of a swift moving stream, dissolves more oxygen than the still water of a pond or lake.

Healthy water should generally have dissolved oxygen concentrations above 6.5-8 mg/L and between about 80-120 %.

Total Dissolved solid (TDS)

Total dissolved solids (TDS) are the amount of organic and inorganic materials, such as metals, minerals, salts, and ions, dissolved in a particular volume of water; TDS are essentially a measure of anything dissolved in water that is not an H2O molecule. Water with high TDS is completely safe to drink. However, some substances such as lead, or copper can lead to health hazards. Cooking- Though high TDS doesn't affect health, it can alter the taste of your food. Cleaning- High TDS in water leaves ugly spots on your utensils.

Generally, the TDS level is between 50-150 is considered as the most suitable and acceptable. If the TDS level is about 1000 PPM, it is unsafe and unfit for human consumption.

Calcium

One of the main reasons for the abundance of calcium in water is it natural occurrence in the earth's crust. Calcium is also a constituent of coral. Rivers generally contain 1-2 ppm calcium, but in lime Areas Rivers may contains calcium concentrations as high as 100 ppm. In general, hard water does not pose a threat to human health. Calcium and magnesium are the two minerals most commonly found in hard water. Neither of these minerals are harmful to humans.

The general rule of thumb is to drink clean water, with hardness being somewhere in the middle of soft and hard, 60 mg/L to 120 mg/L. Some also advise to not go beyond 170 mg/L, which indicates very high levels of calcium and magnesium.

Cadmium

Cd is an extremely toxic heavy metal, even in low concentrations. It leaches into the soil through water and further bio-accumulates in organisms and ecosystems; in addition, Cd has a long biological half-life in the human body, ranging from 10 to 33 years. The long-term exposure to Cd induces renal damage.

Cadmium is regulated as a primary drinking water standard and the MCL is 0.005 mg/L (5 ppb). Cadmium has been linked to kidney disorders, bronchitis, and anemia. Low level exposure to cadmium decreases bone density and disrupts bone composition. Rapidly growing bones are the most sensitive to these effects, so children are at an increased risk. Cadmium does not easily leave our bodies and tends to build up in the kidney.

Lead

Lead can cause serious health problems if too much enters your body from drinking water or other sources. It can cause damage to the brain and kidneys, and can interfere with the production of red blood cells that carry oxygen to all parts of your body.

Although children are at increased risk of the effects of lead poisoning, exposure via drinking contaminated water can also result in illness in adults. Even if you are experiencing these symptoms, it does not always mean you have lead poisoning. Symptoms in adults can include: high blood pressure.

Zinc

Zinc is a natural element found in rocks deep underground, air, soil, and water. Zinc is found in the environment as zinc compounds joined to other elements like chloride, oxygen and sulfur. Zinc is used to produce metals, batteries, and pennies.

EPA has stated that drinking water should contain no more than 5 mg of zinc per liter of water (5 mg/L or 5 ppm) because of taste. Furthermore, any release of more than 1,000 pounds (or in some cases 5,000 pounds) of zinc or its compounds into the environment (i.e., water, soil, or air) must be reported to EPA. At the levels normally found in drinking water, zinc is not a health hazard. At extremely high concentrations (675 mg/l and above), zinc can act as an intestinal irritant, causing nausea and vomiting. However, there is a wide safety margin between these levels and the amount found in drinking water.

Magnesium

There is also some evidence that calcium and magnesium in drinking water may help protect against gastric, colon, rectal cancer, and pancreatic cancer, and that magnesium may help protect against esophageal and ovarian cancer. Hard water may also serve a protective role against atherosclerosis in children and teens.

Iron

Iron can be a troublesome chemical in water supplies. Making up at least 5 percent of the earth's crust, iron is one of the earth's most plentiful resources. Rainwater as it infiltrates the soil and underlying geologic formations dissolves iron, causing it to seep into aquifers that serve as sources of groundwater or wells. Although present in drinking water, iron is seldom found at concentrations greater than 10 milligrams per liter (mg/L) or 10 parts per million. However, as little as 0.3 mg/l can cause water to turn a reddish brown color.

Iron is mainly present in water in two forms: either the soluble ferrous iron or the insoluble ferric iron. Water containing ferrous iron is clear and colorless because the iron is completely dissolved. When exposed to air in the pressure tank or atmosphere, the water turns cloudy and a reddish brown substance begins to form. This sediment is the oxidized or ferric form of iron that will not dissolve in water.

IV. Conclusion

In conclusion, the study's parameters are higher than those of potable drinking and household water, making them unfit for consumption.

V. Recommendations

1- Periodic water testing and regular reporting of results to appropriate authorities are necessary. Bacteriological examination should be part of the study.

2- The government ought to furnish facilities and logistics for any follow-up studies. The establishment should supply sufficient laboratory equipment for any research endeavors.

3- To make water safe to drink, residents should boil and filter the water they fetch from the reservoirs.

References

Banu N, Menakuru H (2010) Enumeration of Microbial Contamination in School Water. A Public Health Challenge. Health 2(6): 582-588. doi: 10.4236/health.2010.26086.

Cheesbrough M (2006). District laboratory Practice in Tropical Countries. Part 2. Cambridge University Press. pp. 143-157.

Danloye SA (2004) Quality parameters of water, NAFDAC Laboratory Experience. IPAN News.

Erah PO, Akujieze CN, Oteze GE (2002). A quality of ground water in Benin City: A baseline study on inorganic chemicals and microbial contaminants of health importance in boreholes and open wells. Trop. J. Pharm. Res. 1(2): 75-82.

Esemikose, E. E. and Akoji I. G. (2014). Microbiological and Physicochemical Studies on Water Pollution of Ogane-Aji Rive Journal of Science & Multidisciplinary Research (2):41-46.

Haylamicheal I.D. and Moges A. (2012). Assessing Water Quality of Rural Water Supply Schemes as a measure of Service delivery sustainability: A Case Study of Wondo Genet District, Southern Ethiopia, African Journal of Environmental Science and Technology, 6(5):229 –236.

Makwe, E. and Chup, C.D. (2013). Seasonal variation in physico-chemical properties of groundwater around Karu abattoir. Ethiopian journal of environmental studies and management, vol. 6 (5):489-497.

Ogamba AS (2004) drinking water, how safe? Professionalism IPAN news.

Okonko I.O, Ogunjobi A.A, Kolawale O.O, Babatunde S, Oluwole I, Ogunnusi TA, Adejoyi OD, Fajobi EA (2009). Comparative Studies and Microbial Risk Assessment of a Water Samples Used for Processing Frozen Sea foods in Ijora- Olopa, Lagos State, Nigeria. EJEAFChe. 8(6): 408-415.

Oladipo C, Onyenike IC, Adebiyi AO (2009) Microbiological analysis of some vended Sachet water in Ogbomoso, Nigeria. Afr. J. Food Sci. 3(12):406-412.

Oluyemi, E. A., Adekunle, A. S., Adenuga, A. A. and Makinde, W. O. (2010) Physico chemical properties and heavy metal content of water sources in Ife North Local Government Area of Osun State, Nigeria African Journal of Environmental Science and Technology, 4(10):691-697.

Edema MO, Atayese AO, Bankole MO (2011) water syndrome: Bacteriological quality of drinking water in Nigeria. Afr J food Agricult Nutr 11 (1): 4595-4609.

Shittu OB, Olaitan JO, Amusa TS (2008) Physico-Chemical and Bacteriological Analysis of Water Used for Drinking and Swimming Purpose. Afr. J. Biochem. Res. 11:285-290.

UNICEF/WHO (2012), "Progress on drinking water and sanitation: 2012 update. WHO/UNICEF Joint Monitoring Programme for water supply and sanitation". UNICEF, New York. http://www.wssinfo.org/fileadmin/user'supload/resources/jmpreport 2012.

WHO and UNICEF (2010). Rapid assessment of drinking-water quality in the Federal Republic of Nigeria: country report of the pilot project implementation in 2004-2005 / WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland. Page viii.

World Health Organization (WHO) (2010). Guidelines for Drinking-water Quality. Recommendation, Geneva, p: 1-6. Retrieve from http://www.who.int/water_sanitation_health/WHS_ WWD2010_guidelines_2010_6_en.