FUOYE Journal of Pure and Applied Sciences

Available online at www.fuoye.edu.ng

ASSESSMENT OF HEAVY METAL STATUS IN DOMESTIC WATER SOURCES IN JALINGO, TARABA STATE, NIGERIA

Kanu M. O.[1*], Gabriel E. C.[2]
[1,2]Department of Physics, Taraba State University, Jalingo, Nigeria.

Received: 5 November, 2015
Accepted: 15 July, 2016

Keywords:
Heavy metal, Domestic water, Atomic Absorption Spectrometer, WHO
Corresponding author: maxiexpress007@gmail.com
(+2347030795112)

Abstract

The study investigates the quality of domestic water sources in Jalingo Metropolis. To this end, 22 water samples were collected from bore holes (14), hand dug wells (6) and surface water (2) and analyzed for physiochemical parameters and some heavy metals. The physiochemical parameters were measured using standard methods while the heavy metals were analyzed using Air-acetylene Flame Atomic Absorption Spectrometer (220 FS BUCK Scientific model). Results showed that the concentration of these heavy metals were within the World Health Organization (WHO) maximum permissible limit. The result indicated that the water sources are recommended for domestic purposes, however, if indiscriminate sinking of bore holes and dumping of refuse and other anthropogenic emissions are not checked there is likelihood of increased concentration of these metals in the future.

1.0 Introduction

Water is a common chemical that is essential for the survival of all known forms of life. It is used in vast quantities for drinking purposes and even in greater quantities for washing, bleaching, dyeing, cooling, raising steam to drive engines and turbines to generate electricity and in other industrial processes too numerous to mention. Due to industrialization and urbanization, there is high urban migration causing population overshoot in these cities. This results in high demand for water amongst other necessities of life. Although surface water such as lakes, rivers, streams and springs are easily accessible, in most cases, they are not usually available all-year-round as they dry –up during the dry season. There is great need for people to drill boreholes and dig wells for ground water which are thought to be of better quality [1]. The quality of water are indirectly and adversely affected by some human activities such as accidental or unauthorized release of chemical substances, discharge of untreated effluents, leaching of noxious liquids from solid wastes deposits, surface run-off, untreated sewage acidic rain etc. The above mentioned human activities all contribute to the heavy metals input in water bodies. In natural aquatic ecosystem, heavy metals occur in low concentrations mainly due to weathering of soils and bedrocks [2]. The natural aquatic ecosystems are mostly found in rural areas. In urban areas, however, there has been an unprecedented increase in the level of these metals due to anthropogenic activities. The occurrence of such metals in excess of natural concentrations is toxic and has become an increasing problem to both environmentalist and health practitioners. Unlike most organic pollutants, heavy metals are persistent in the environment as they are not easily degraded through either biological or chemical means. The accumulation of various metal pollutants into the aquatic environment could damage the quality of the ecosystem, rendering it unsuitable for its intended uses and posing serious health threat to the immediate population. In view of the health threat/hazard associated with increased heavy metal concentration, many studies have been undertaken to assess the level of heavy metal in aquatic and terrestrial habitat [2-6]. There is little or no information on the status of heavy metals in available domestic water sources in Jalingo, hence this study. The study is further necessitated by the fact that as a fast growing capital city in Nigeria, there is high demand for potable water in every household. The absence of access to potable water has led to the proliferation of boreholes and hand dug wells in the city without considering the presence or absence of dumpsites, pit toilets etc. close to the boreholes. In this work we hope to close the information gap and therefore provide data on the status or quality of domestic water sources in Jalingo. The results will be compared with quality standards and guidelines set by the World Health Organization (WHO) in order to determine the health risks or otherwise to the inhabitants of the City [9].

2.0 Materials and methods

2.1 Study Area

The study area, Jalingo is the Capital of Taraba State, Nigeria, and is located between latitude 8°50´ and 8° 55´ N and between longitude 11° 17´ and 11° 26´ E (Figure 1). The State has a tropical wet and dry climate; dry season lasts for a minimum of five months (November to March) while the wet season spans from April to October. It has an annual rainfall of about 8000 mm and a total population of over 2, 2944, 800 (NPC, 2006).

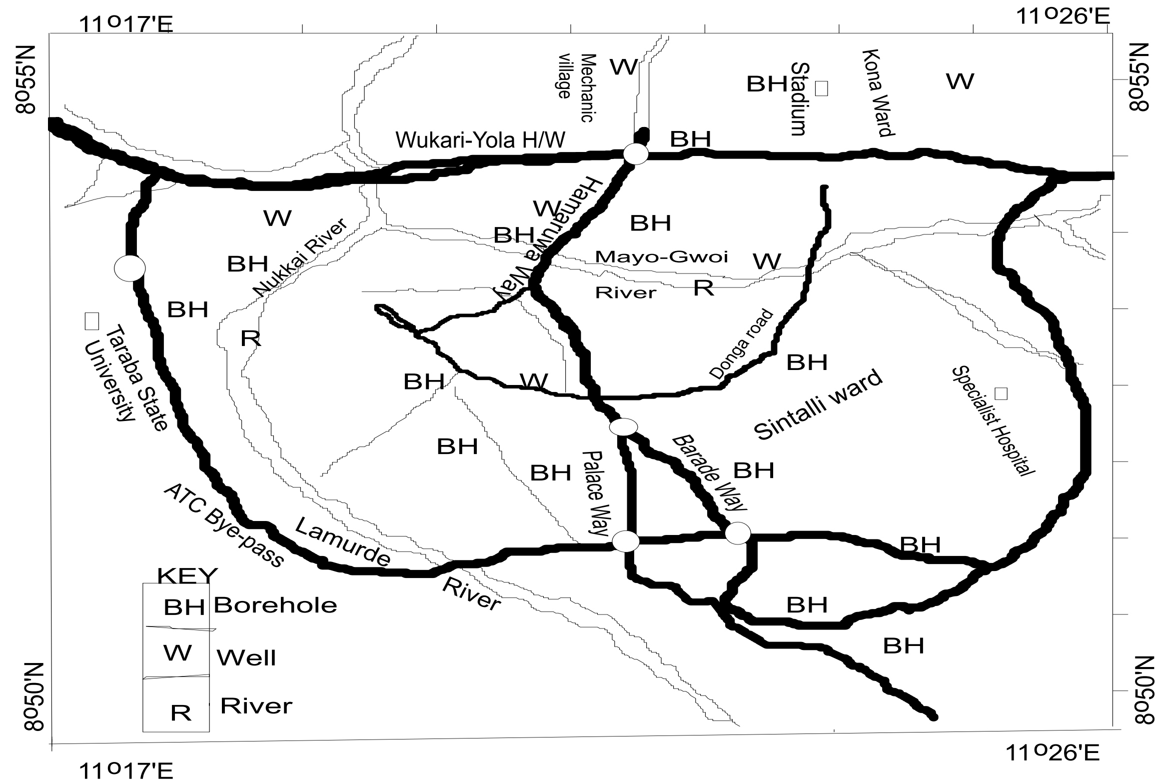


Figure 1: Map of Study Area in Jalingo Town, Taraba, Nigeria, showing water Sampling Points

2.2 Sample Collection and Analysis

A total of total of 22 water samples were collected from functional bore holes (14), hand dug wells (6) and surface water -rivers (2) (Surface water sources). Nukkai River and Mayo-Gwoi River are the two main rivers that flow across different areas of the Jalingo town. A lot of agricultural activities take place by the river sides during the dry seasons. The water samples were collected in 1 litre plastic bottles. The plastic containers used were first rinsed with distilled water prior to sample collection.

The samples were carefully labeled after each sampling and transported to the laboratory where they were stored in a refrigerator prior to analysis. For the analysis of the total concentration of heavy metals, samples were digested with a mixture of concentrated Hydrochloric acid and Nitric acid in the ratio 3:1 in a microwave digestion oven. The heavy metals content was analyzed using an Air-acetylene Flame Atomic Absorption Spectrometer (220 FS, BUCK Scientific Model). The following heavy metals were analyzed: cadmium, copper, iron, lead and zinc. In addition to the heavy metals,

physiochemical parameters such as pH, electrical conductivity (EC) and total dissolved solids (EDS) were analyzed using standard laboratory methods [8].

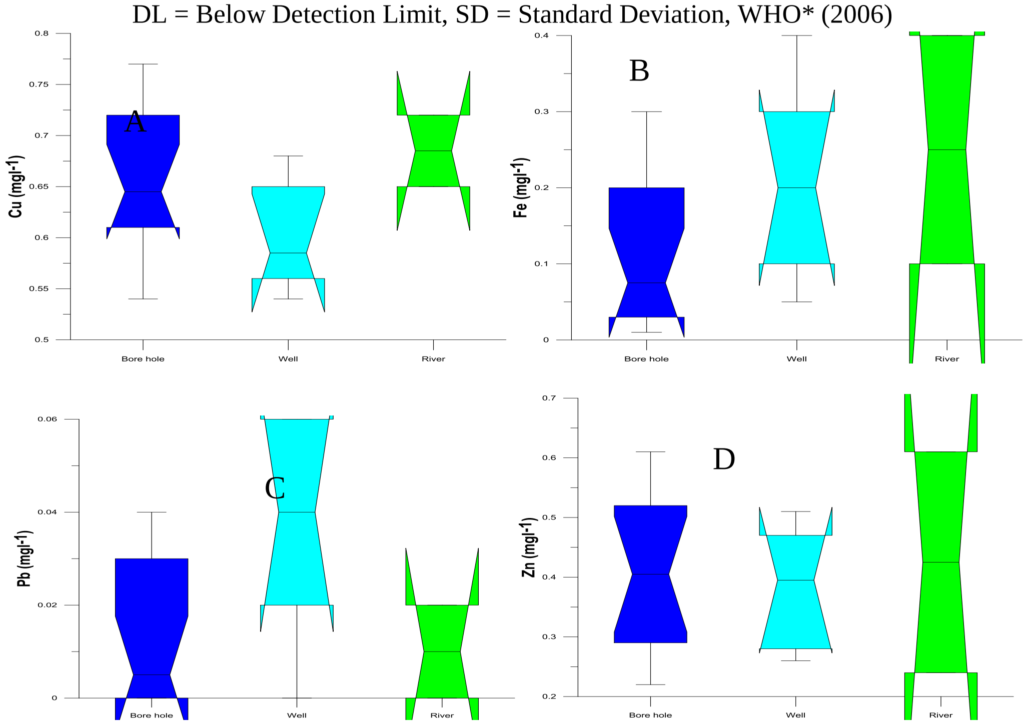
3.0 Results and discussion

The results of the concentration of heavy metals and physiochemical parameters determined are presented in Table 1. The concentration of Cu in mgl^{-1} varied from 0.54 to 0.77 with a mean value of 0.64 ± 0.07 (Table 1). The mean value of Cu concentration falls within the WHO permissible limit of 1.00 mgl^{-1}. Copper is an essential substance to human life, but at high concentration it can be harmful, causing irritation of nose, mouth and eyes, nausea, vomiting, diarrhea etc. the low level of Cu in these water sources implies that the water is suitable for human use in terms of Cu concentration.

Table 1: Results of Heavy Metals and Physiochemical Parameters in water samples from Jalingo town in Nigeria.

LOCATIONS	SOURCE	Cu (mg/l)	Fe (mg/l)	Pb (mg/l)	Zn (mg/l)	pH	EC (µS/cm)	TDS (mg/l)
High court premises	Bore hole	0.72	0.03	0.01	0.34	7	145	16
Sabon-Gari Ward	Bore hole	0.54	0.1	0.04	0.22	6.7	25	18
Sabon – Layi Ward	Bore hole	0.77	0.3	BDL	0.24	6.65	45	2
Jolly Nyame Street	Bore hole	0.64	0.04	BDL	0.53	6.5	125	26
Federal Medical Centre	Bore hole	0.6	0.1	0.04	0.61	7.1	400	22
Ubandoma Street	Bore hole	0.72	0.3	0.04	0.52	6.7	130	36
Water Board	Bore hole	0.65	0.02	BDL	0.24	7	90	40
ATC	Bore hole	0.62	0.03	BDL	0.33	6.7	40	84
Investment Quarters	Bore hole	0.54	0.3	BDL	0.43	6.7	165	76
Nukkai Ward	Bore hole	0.66	0.2	BDL	0.52	6.9	250	66
Road Block	Bore hole	0.67	0.03	0.03	0.38	6.5	110	144
Stadium	Bore hole	0.62	0.05	BDL	0.29	6.3	190	84
Green Beach	Bore hole	0.73	0.1	0.01	0.47	7	300	144
Donga Road	Bore hole	0.61	0.01	0.03	0.46	6.2	30	28
Magami Ward	Well	0.68	0.3	0.02	0.26	6.3	110	44
Mayo Gwoi ward	Well	0.65	0.2	0.02	0.51	7.1	145	50
Abuja Phase II	Well	0.59	0.4	0.06	0.47	6.1	180	32
Mayo Dassa Ward	Well	0.58	0.2	BDL	0.28	7.1	225	52
Nukkai Ward	Well	0.54	0.1	0.06	0.44	7.1	325	64
Mile six	Well	0.56	0.05	0.06	0.35	5.6	185	48
Nukkai River	River	0.72	0.1	0.02	0.61	8	250	90
Mayo-Gwoi River	River	0.65	0.4	BDL	0.24	8.1	360	120
Mean ± SD		0.64± 0.07	0.15 ±0.13	0.02 ± 0.02	0.40± 0.13	6.79 ± 0.56	173.86 ±106.41	58.45 ±39.66
Min- Max		0.54 - 0.77	0.01-0.14	BDL-0.06	0.22-0.61	5.6 - 8.1	25.00-400.00	2.00-144.00
WHO* Limit		1	0.3	0.05	5	6.5-8.5	500	1000

DL = Below Detection Limit, SD = Standard Deviation, WHO* (2006)



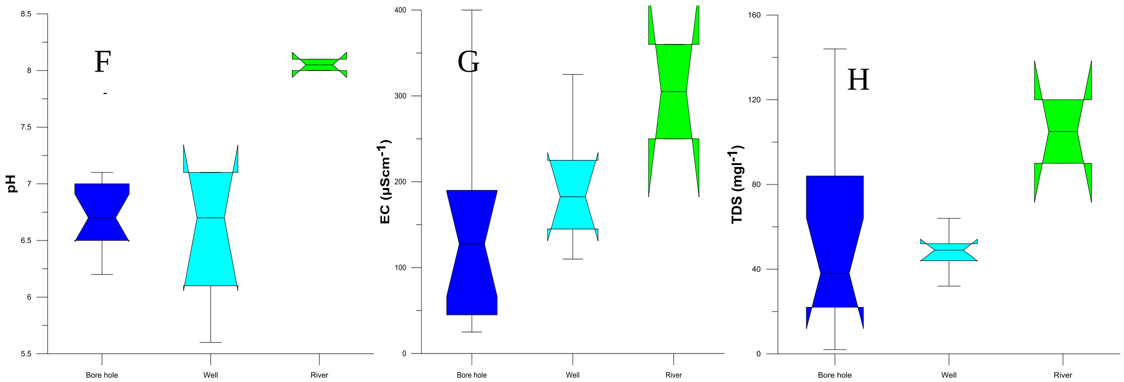


Figure 2: Comparison of Measured Parameters between Sources of water from Jalingo town, Nigeria

The concentration of Cu did not vary much between the different water sources (boreholes, well and river) as shown in Table 2 and Figure 2A, however, river water is seen to have the highest Cu concentration. One way analysis of variance (ANOVA) test indicates that the difference in the mean values of Cu among the water sources are not great enough to exclude the possibility that the differences is due to random sampling variability, hence there is no statistically significant differences (α = 0.05, P = 0.187) between the sources.

Table 2: Summary Statistics of Measured Parameters in the Water Sources in Jalingo, Nigeria

		Cu (mg/l)	Fe (mg/l)	Pb (mg/l)	Zn (mg/l)	pH	EDS (µS cm^{-1})	TDS (mg/l)
	Min – Max	0.54 - 0.77	0.01 - 0.30	BDL - 0.04	0.22 - 0.61	6.20 - 7.10	25.00 - 400.00	2.00 - 144.00
Bore holes	Mean ± SD	0.65 ± 0.07	0.12 ± 0.11	0.01 ± 0.02	0.40 ± 0.13	6.71± 0.27	146.07 ± 109.55	56.14 ± 45.58
	Min – Max	0.54 - 0.69	0.05 - 0.40	BDL - 0.06	0.26 - 0.51	5.60 - 7.10	110.00 - 325.00	32.00 - 64.00
Well	Mean ± SD	0.60 ± 0.05	0.21 ± 0.13	0.04 ± 0.03	0.39 ± 0.10	6.55 ± 0.64	195.00 ± 74.63	48.33 ± 10.46
	Min – Max	0.65 - 0.72	0.10 - 0.40	BDL - 0.02	0.24 - 0.61	8.00-8.10	250.00 - 360.00	90.00 - 120.00
River	Mean ± SD	0.69 ± 0.50	0.25 ± 0.21	0.01 ± 0.01	0.43 ± 0.26	8.05 ± 0.07	305.00 ± 77.78	105.00 ± 21.21

The concentration of iron in the water samples ranged from 0.01 to 0.40 mgl^{-1} with a mean value of 0.15 ±0.13 mgl^{-1} (Table 1). Assessment of the contribution of individual sources to the total concentration of iron show that the highest contribution comes from the river water (Table 2). Figure 2B shows that though river water has the highest concentration of Fe, the variation of Fe between the different water sources is not much. The results of one way ANOVA test performed using Sigma Stat 2.03 statistical software confirmed that there is no significant difference in Fe concentration between the different water sources. The mean Fe contents in the sampled water sources indicate that Fe is below WHO maximum permissible limit of 0.3 mgl^{-1}. However, the samples from Mayo –Gwoi River and Abuja Phase II (well) had values of 0.4 mgl^{-1} which is above the permissible limit. High concentration of Fe generally causes inky flavor, bitter and stringent taste, and discoloration or stain of cloths etc. These two samples are therefore not recommended for domestic usage. The content of lead in the Jalingo water sources ranged from BDL to 0.06 mgl^{-1}. The mean value of 0.02 ± 0.02 mgl^{-1} falls within the permissible limit of 0.05 mgl^{-1} set by WHO. The contents of lead in borehole well and river water sources are summarized in Table 2 and Figure 2C with well water having the highest concentration of Pb. Although the concentration of lead in about nine (9) samples were below detection limit, two samples from well water samples (located in Nukkai Bridge and mile six areas) had values of 0.06 mgl^{-1} which is above the permissible limit are therefore unsafe for domestic purposes. Human exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. According to Lantech (2011), high levels of exposure may result in the toxic biochemical effects in humans which in turn cause problems in the synthesis of haemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive systems, and chronic damage to the nervous system.

There was no significant difference observed in the Zinc levels of the different water sources. The concentration of Zn varied between 0.22 and 0.61mgl^{-1} with the highest value obtained in the Nukkai river sample. The descriptive statistics of the various sources are clearly separated in Table 2 and comparison of the contents of Zn in these sources of water are displayed in Figure 2D. The mean value of 0.40 ± 0.13 mgl^{-1} falls within the WHO permissible limit of 3.00 mgl^{-1} for drinking water, implying that the water has no caustic taste and therefore good for consumption and other domestic uses. Zinc is an essential element in plant and human nutrient in normal concentration. However, in excess concentration, it can cause impairment of growth and development. Generally, Copper has the highest concentration followed by Zinc and Iron, with Lead having the lowest concentration. This result is summarized in the box plot shown in Figure 3. Heavy metal contamination in surface and sub surface of water bodies are usually derived from either lithogenic (that is from parent rocks) sources or anthropogenic sources. The anthropogenic sources of heavy metals may include emissions from automobile exhaust, heavy machineries, power plants etc., fertilizer application to soil surface which are subsequently leached to water subsurface or through erosion to the water surface, leaching from leachates or refuse dumps, sewage sludge, contamination in rain and dry atmospheric fallout etc.

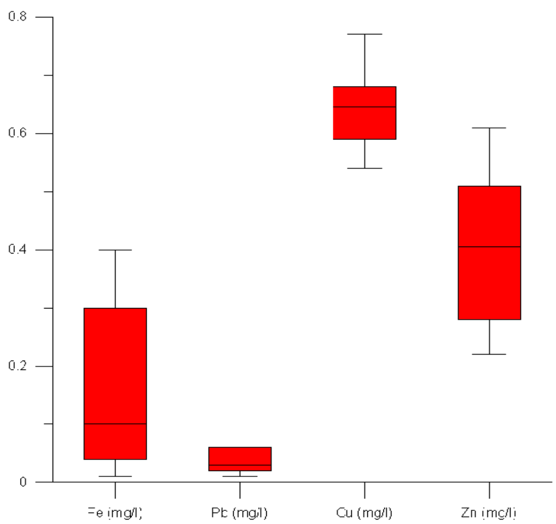


Fig. 3: Box plot comparing the concentration of heavy metals in Jalingo water samples

3.1 Physiochemical Parameters

The mean pH value obtained from the water sources analyzed was 6.79 ± 0.56. This satisfies the WHO standard of 6.0 – 8.5. Although slightly acidic value of 5.6 was obtained in one of the well water sample, neutral values (7.00) were recorded in three samples from bore holes. Highest pH values were obtained in the river water samples (Figure 2E). The level of pH in solution reflects the solvent power of water, thereby indicating its possible chemical reactions on substances [2]. Continuous consumption of water having a pH outside the WHO recommended range may in the long run lead to mineral deficiencies. Non-health effects are aesthetic because acidic water tends to be more corrosive to plumbing.

Electrical conductivity indicates the presence of the dissolved solids and contaminants especially electrolytes in a substance [2]. In this study, the mean value of 173.86 µScm^{-1} is well below the WHO desirable limit of 500 µScm^{-1}. However, values close to this standard were obtained in some samples. The variation of electrical conductivity between the water sources are in the following order: borehole < well < river (Figure 2F).

Total dissolved solids (TDS) in the Jalingo domestic water sources varied between 2.00 and 144.00 mgl^{-1} with a mean value of 58.45 ± 39.66 mgl^{-1}. The concentration of TDS is highly variable in the borehole water (Table 2, Figure 2G). Although the highest value occurs in the borehole water, the river shows a general higher concentration. This result showed that the amounts of TDS in the sampled water sources are below the WHO standard of 1000 mgl^{-1}. The implication of this result is that the water sources are suitable for laundering purposes since the TDS increase hardness of water.

4.0 Conclusion

The analysis of the concentration of some heavy metals: Copper (Cu), Iron (Fe), Lead (Pb) and Zinc (Zn) in domestic water sources in Jalingo Metropolis has been carried out. Results revealed that the contents of these metals are within WHO permissible limit for drinking water and therefore safe for domestic purposes. The only exceptions to this recommendation are two hand dug wells located in Mile Six and Nukkai bridge with lead contents exceeding the recommended limit. Therefore standard treatment is recommended in these water sources. If indiscriminate sinking of bore holes and dumping of refuse and other anthropogenic emissions are not checked there is likelihood of increased concentration of these metals in the future. Hence, water resources management strategy should be put in place and regular monitoring and analysis of Jalingo water sources should be introduced in order to check pollution levels.

References

[1] Adeyeye, P. U and Abulude, F. O(2004) Analytical assessment of some surface and ground

water resources in Ile-Ife, Nigeria, *J. Chem. Soc. Nig. 29 (2), pp 98-103.*

[2] Sabo, A., Gani, A. M. and Ibrahim, A. Q (2013) Pollution status of heavy metals in water and bottom sediments of river Delimi in Jos, Nigeria, *American Journal of Environmental Protection, 1(3), pp 47-53.*

[3] Akan, J.C., Abdulrahman, F.I., Sodipo, O. A., Ochanya, A. E and Askira, Y. K. (2010) Heavy Metals in Sediments from River Ngada, Maiduguri Metropolis, Borno State, Nigeria, *Journal of* of heavy metal contents in the surface water of Oke-Afa Canal, Isolo Lagos, Nigeria. *Archives of Applied Science Research 4(6), pp 2322 – 2326*.

[6] Jeje, J. O and Oladepo, K. T (2014) Assessment of heavy metals of boreholes and hand dug wells in Ife North Local Government area of Osun State, Nigeria, *International Journal of Science and Technology, 3(4): 209-214.*

[7] National Population Commission (NPC) (2006) Population and Housing Census of the Federal Republic of Nigeria, Taraba State Priority Tables, Volume 1.

[8] American Public Health Association (APHA) (1998) Standard methods for examination of water and waste water, 20th Ed. American Public Health

Environmental Chemistry and Excotology, 2(9), pp 131-140

[4] Njar, G. N., Iwara, A. I., Offiong, R. A and Deekor, T. D (2012) Assessment of heavy metal status of boreholes in Calabar South Local Government Area, Cross River State, Nigeria. *Ethiopian Journal of Environmental Studies and Management, 5(1), pp 86-91.*

[5] Yahaya, A., Adegbe, A. A and Emurotu, J. E (2012) Assessment
Association Inc, New York. American Water Work Association (AWWA).

[9] World Health Organization (WHO) (2006): Guide lines for drinking water quality. Vol. 2 Recommendations, World Health Organization, Geneva, pp. 130.

[10] Lanntech (2011): Heavy Metals. http://www.lanntech.com/processes/heavy/heavy-metals/heavy-metals.htm