



## Assessment of Physico-Chemical Parameters and Trace Metals Contents of Some Selected Boreholes (Drinking Water Sources) in Lapai Metropolis, Niger State, Nigeria

Ibrahim<sup>1\*</sup> B.U., Muhammad<sup>2</sup> A.M., Muhammad<sup>2</sup> H.L. and Ntiense<sup>1</sup> E.H.

<sup>1</sup>Department of Biological Sciences, Ibrahim Badamasi Babangida University, Lapai, Nigeria

<sup>2</sup>Department of Chemistry, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria

### ABSTRACT

The safety and accessibility of drinking water are major concerns throughout the world. Health risks may arise from the consumption of water contaminated with infectious agents, toxic chemicals and radiological hazards. Improving access to safe drinking water can result to tangible improvements to health. This study was therefore embarked upon to assess physico-chemical parameters and trace metal contents in selected boreholes (Drinking water sources) in Lapai Metropolis, Niger State, Nigeria. The Physico-chemical parameters analyzed were found to be within the Nigerian Standard Drinking Water Quality (NSDWQ) and World Health Organization (WHO) standards for Turbidity, Dissolved oxygen, Temperature, Conductivity, Calcium hardness, Chloride, Iron, Chromium, Fluoride, Nitrate and Alkalinity, except for pH level, Total Dissolved Solids, Total hardness, Magnesium and Nitrite in Badegi quarters sampling site. The analysis carried out on the water samples for six months (March - August 2015) indicated that in Badegi sampling site, some of the values were above the standard set by NDSWQ and WHO. There is therefore the tendency of high potential health hazards to the inhabitants of that area, that uses the water source for drinking and other domestic purposes without treatment.

**Keywords:** Water, borehole, Physico-chemical Parameters, trace metals contents

### INTRODUCTION

Groundwater uses and applications are often related to its composition which is increasingly influenced by human activities, and by many other climatic factors including precipitation surface runoff groundwater flow and the characteristics of catchment area (Pierina *et al.*, 2012).

Water at most times contains impurities which are introduced by rock weathering, soil leaching, dissolution of aerosol from the atmosphere and several human activities including mining processing and the use of metal based materials (Ipinmoroti and Oshodi, 1993, Adeyeye, 1994, Asaolu, 1997).

According to the United Nations (UN) Water Initiative (2010), the safety and accessibility of drinking water are major concerns throughout the world. Health risks may rise from the consumption of water contaminated with infectious agents, toxic chemicals and radiological hazards. Therefore, access to safe

drinking water can result to tangible improvements in health.

The objectives of this study is to access the physico-chemical parameters and trace metals contents of some selected boreholes (Drinking Water Sources) in Lapai Metropolis, Niger State, Nigeria, so as to ascertain their purity and safety for domestic uses.

### METHODOLOGY

#### The Study Area

Lapai is a Local Government Area (LGA) in Niger State, Nigeria, adjoining the Federal Capital Territory. It's headquarter is in the town of Lapai located at Latitudes 9°03'North and longitudes 6°34'East. It is bounded on the west by Agaie LGA, to the north by Paikoro, to the east by Gurara LGA and to the south is

Received 23 November, 2018

Accepted 17 December, 2018

Address Correspondence to:

[iubaba@ibbu.edu.ng](mailto:iubaba@ibbu.edu.ng)

bordered by the River Niger parallel to the Kogi State. (Lapai LGA Report, 2009). It has a total land mass of about 3,051km<sup>2</sup> (1,178 sq

mi) and a population of 110,127 (Shittu *et al.*, 2008).

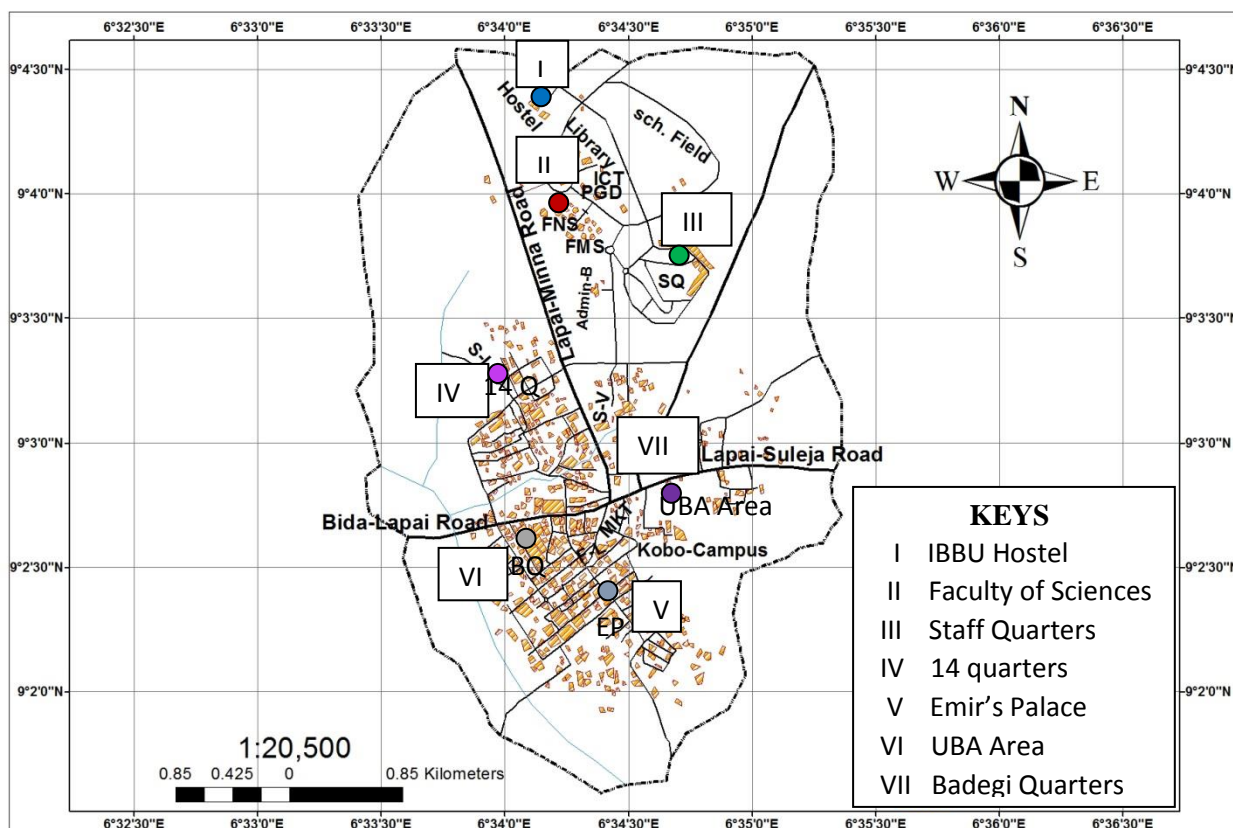


Fig. 1: Map of Lapai, Niger State showing the sampling sites

Source: Department of Geography, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria.

### Sampling

A number of 84 water samples were collected from March-August 2015. Samples for determining physico-chemical and trace metals contents were collected in a 1 litre (1L) plastic container which were washed with neutral liquid soap and rinsed with distilled water prior to the day of water sampling. The final rinsing was done using the water sample to be collected. Water was collected and then sealed with corks and then transported to the Regional Water Quality Laboratory of the Upper River Basin Authority, Minna, Niger State in an ice box. These were kept in the refrigerator at 4°C prior to the analysis (Andrew *et al.*, 2005).

### Physico-chemical Analysis

The method used to analyse turbidity of water sample(s) was the APHA – 2130 B (i.e. Nephelometric Method), (APHA, 1995 and Hach *et al.*, 1985). The method used to analyse dissolved oxygen (APHA, 1995), pH (APHA 4500H<sup>+</sup>B), electrical conductivity and Total Dissolved Solids (APHA 2510B), and temperature (APHA 2550B) of water samples was the Electrometric method (APHA, 1995).

Chloride was analysed using the Argentometric Method (APHA 4500Cl<sup>-</sup>B), (APHA, 1995), Complexometric Method (APHA 2340C), (APHA, 1995), was used in analysing total hardness in water samples. Alkalinity was analysed in water sample using the Titration

method (APHA 2320B), (APHA, 1995). The EDTA Complexometric Method (APHA 3500-Ca D), (APHA, 1995) was used in determining Calcium determination and the Calculation Method (APHA 3500- Mg E), (APHA, 1995) for Magnesium determination.

The method used to analyse iron content in water sample(s) was the Colorimetric method (APHA 3500-Fe D), (APHA, 1995), Colorimetric method (APHA 3500-Cr<sup>+6</sup> D), (APHA, 1995) was used for chromium, APHA 4500 – F D SPADNS Method (APHA, 1995) was used to analyse fluoride in water samples. The Colorimetric method (APHA 4500NO<sub>3</sub><sup>-</sup> B), (APHA, 1995) was used to determine nitrate content in water samples while the method used to analyse nitrite content in water samples was the Colorimetric method (APHA 4500NO<sub>2</sub><sup>-</sup> B), (APHA, 1995).

## RESULTS

For Total dissolved solids (TDS), Table 1 showed that there were significant differences ( $P < 0.05$ ) amongst the stations with Badegi quarters (586.00mg/L) with the highest value and the least in 14 quarters (77.15mg/L), when compared to the Nigerian Standard Drinking Water Quality (NSDWQ) and World Health Organisation (WHO) standards the result of TDS were up to standard except for Badegi's value was more than the (NSDWQ) limit, but up to the WHO standard. The highest result of conductivity was recorded in Badegi quarters (875.58 $\mu$ s/cm) and the least was in 14 quarters (115.42 $\mu$ s/cm), therefore there was significant differences ( $P < 0.05$ ) in the stations. However, these values were below the Nigerian Standard Drinking Water Quality (NSDWQ) and the World Health Organisation (WHO) standards. Table 1 showed that there were significant differences ( $P < 0.05$ ) of Dissolved Oxygen (DO) in the stations. The highest result was in Emir's palace (7.31mg/L) and the least in UBA area (6.10mg/L). Thus, the values recorded all through the months did not exceed the NSDWQ and WHO standards.

The result on Table 1 for temperature showed that there was no significant difference ( $P > 0.05$ ) amongst the stations. The highest temperature was recorded in IBBU hostel (29.63°C) and the least in Faculty of Science (28.72°C). The values recorded were all of the NSDWQ and WHO standards. pH values in table 1 showed that there were significant

differences ( $P < 0.05$ ) amongst the stations with the highest value recorded at UBA area (7.17) and the least in Badegi quarters (5.47). Therefore all the values recorded were all up to the NSDWQ and WHO standards except in Badegi quarters (5.47). The turbidity (Table 1) showed that all the stations were statistically the same with Faculty of Science (1.51 NTU), as the highest recorded value and the least in Badegi quarters (1.02 NTU). All values of turbidity were in the permissible standard of NSDWQ and WHO.

Total hardness values in Table 1 showed that there were significant differences ( $P < 0.05$ ) in the stations. The highest value recorded in Badegi quarters (240.58 mg/L), and the least in 14 quarters (36.65 mg/L). However, all the values recorded were all up to the NSDWQ and WHO standards. Chlorine content in Table 1 showed that there were significant differences ( $P < 0.05$ ) in the stations, with the highest value recorded in Badegi quarters (49.92 mg/L) and the least in IBBU hostel (11.08 mg/L). The values recorded measured up to the standard of NSDWQ and WHO. Alkalinity content were significantly different ( $P < 0.05$ ) in the stations (Table 1), whereby the highest recorded value was in UBA area (53.00 mg/L) and the least in IBBU hostel (21.00 mg/L), the values in these stations were up to the standard of NSDWQ and WHO.

Chromium values on Table 1 showed that there were significant differences ( $P < 0.05$ ). The highest value was recorded in Badegi quarters (0.05 mg/L) and the least in IBBU hostel, IBBU staff quarters and 14 quarters. The values were within the acceptable standards of NSDWQ and WHO. Fluoride content on Table 1 were significantly difference ( $P < 0.05$ ) in the stations, in which the highest recorded value was in Badegi quarters (1.39 mg/L), and the least in 14 quarters (0.28 mg/L). All the values recorded were all up to the NSDWQ and WHO standards. The result of Iron content on Table 1 showed that there were significant differences ( $P < 0.05$ ) in the stations, with the highest recorded in Badegi quarters (0.30 mg/L) and the least in IBBU hostel (0.10 mg/L), the values recorded measured up to the standard of NSDWQ and WHO.

Calcium contents in the stations were significantly different ( $P < 0.05$ ) ( Table 1) in

which Badegi quarters (47.10 mg/L) had the highest value, and the least was 14 quarters (9.26 mg/L), the values in these stations were up to the standard of NSDWQ and WHO. The result on the values of magnesium content (Table 1) showed that there were significant differences ( $P < 0.05$ ) in the stations, where the highest value was recorded in Badegi quarters (28.05 mg/L), and the least in UBA area (3.06 mg/L). The values were acceptable when compared to the NSDWQ and WHO standard. For nitrate content, there were significant differences ( $P < 0.05$ ) in the stations (Table 1). The highest value was recorded in Badegi quarters (33.4 mg/L) and the least in 14 quarters (4.43 mg/L). All the values recorded were all up to the NSDWQ and WHO standards.

The result on Table 1 for nitrite content showed that there were significant differences ( $P < 0.05$ ) in the stations, the highest recorded was in Badegi quarters (0.21 mg/L) and the least in 14 Quarters (0.05 mg/L) and IBBU hostel (0.05 mg/L). With the exception of Badegi quarters, all other sampling station's values measured up to the NSDWQ and WHO standards.

Table 1: Physico - chemical parameters of selected borehole water from selected stations in Lapai Metropolis, Niger State, Nigeria.

S a m p l e	T D S	Conductivity	D O	Temp. °C	p H	Turbidity	Hardness	C	l	Alkalinity	Cr <sup>6+</sup>	F <sup>-</sup>	F e	C a <sup>+</sup>	M g <sup>+</sup>	Nitrate	Nitrite
IBBU Hostel	84.33 (±1.56) <sup>a</sup>	127.08 (±2.23) <sup>a</sup>	6.97 (±0.67) <sup>ab</sup>	29.63 (±1.93) <sup>a</sup>	6.95 (±0.60) <sup>cd</sup>	1.09 (±0.78) <sup>a</sup>	44.17 (±18.72) <sup>a</sup>	11.08 (±3.48) <sup>a</sup>	21.00 (±5.53) <sup>a</sup>	0.01 (±0.01) <sup>a</sup>	0.33 (±0.12) <sup>a</sup>	0.10 (±0.02) <sup>a</sup>	10.92 (±5.27) <sup>ab</sup>	4.76 (±5.61) <sup>b</sup>	5.59 (±2.06) <sup>d</sup>	0.05 (±0.05) <sup>d</sup>	
IBBU Staff Quarters	119.75 (±1.66) <sup>b</sup>	178.58 (±2.61) <sup>a</sup>	7.06 (±0.76) <sup>b</sup>	29.48 (±2.05) <sup>a</sup>	7.16 (±0.60) <sup>d</sup>	1.27 (±0.84) <sup>a</sup>	58.93 (±24.67) <sup>b</sup>	11.59 (±2.92) <sup>a</sup>	34.25 (±1.57) <sup>b</sup>	0.01 (±0.01) <sup>a</sup>	0.55 (±0.12) <sup>bc</sup>	0.16 (±0.05) <sup>b</sup>	12.60 (±4.03) <sup>b</sup>	6.45 (±0.31) <sup>c</sup>	8.39 (±3.74) <sup>ab</sup>	0.07 (±0.04) <sup>b</sup>	
Faculty of Sciences	139.75 (±21.05) <sup>b</sup>	208.08 (±31.08) <sup>b</sup>	7.05 (±1.08) <sup>b</sup>	28.72 (±1.48) <sup>a</sup>	7.07 (±0.87) <sup>d</sup>	1.51 (±1.00) <sup>a</sup>	69.38 (±10.16) <sup>bc</sup>	15.50 (±18.59) <sup>b</sup>	46.42 (±5.96) <sup>c</sup>	0.01 (±0.02) <sup>a</sup>	0.42 (±0.51) <sup>b</sup>	0.12 (±0.12) <sup>ab</sup>	16.15 (±2.40) <sup>bc</sup>	6.69 (±0.50) <sup>cd</sup>	8.65 (±1.46) <sup>b</sup>	0.06 (±0.08) <sup>ab</sup>	
14 Quarters	77.25 (±16.83) <sup>a</sup>	115.42 (±25.16) <sup>a</sup>	6.90 (±0.54) <sup>ab</sup>	29.58 (±2.08) <sup>a</sup>	6.53 (±0.44) <sup>bc</sup>	1.41 (±0.36) <sup>a</sup>	36.65 (±9.44) <sup>a</sup>	11.33 (±1.78) <sup>a</sup>	30.50 (±3.61) <sup>b</sup>	0.01 (±0.00) <sup>a</sup>	0.28 (±0.15) <sup>a</sup>	0.13 (±0.02) <sup>ab</sup>	9.29 (±2.76) <sup>a</sup>	3.16 (±2.02) <sup>a</sup>	4.43 (±0.82) <sup>d</sup>	0.05 (±0.04) <sup>d</sup>	
UBA Area	144.50 (±1.00) <sup>b</sup>	198.85 (±6.96) <sup>a</sup>	6.10 (±0.57) <sup>a</sup>	29.41 (±2.03) <sup>a</sup>	7.17 (±0.35) <sup>d</sup>	1.17 (±0.64) <sup>a</sup>	69.25 (±12.31) <sup>c</sup>	16.00 (±1.21) <sup>b</sup>	53.00 (±3.69) <sup>c</sup>	0.02 (±0.01) <sup>b</sup>	0.55 (±0.21) <sup>bc</sup>	0.21 (±0.02) <sup>c</sup>	20.30 (±3.04) <sup>c</sup>	3.06 (±0.50) <sup>a</sup>	14.26 (±3.08) <sup>c</sup>	0.09 (±0.05) <sup>b</sup>	
Emir's Palace	246.08 (±18.29) <sup>bc</sup>	337.46 (±8.51) <sup>c</sup>	7.31 (±0.70) <sup>c</sup>	29.33 (±2.21) <sup>a</sup>	6.21 (±0.29) <sup>b</sup>	1.18 (±0.60) <sup>a</sup>	92.13 (±31.44) <sup>d</sup>	24.42 (±3.80) <sup>c</sup>	44.58 (±6.96) <sup>bc</sup>	0.03 (±0.01) <sup>c</sup>	0.83 (±0.15) <sup>c</sup>	0.25 (±0.04) <sup>c</sup>	23.79 (±1.90) <sup>c</sup>	6.94 (±0.96) <sup>d</sup>	18.43 (±1.56) <sup>c</sup>	0.17 (±0.03) <sup>c</sup>	
Badegi Quarters	586.00 (±6.08) <sup>d</sup>	875.58 (±8.96) <sup>d</sup>	6.39 (±1.20) <sup>a</sup>	29.23 (±2.32) <sup>a</sup>	5.47 (±0.66) <sup>a</sup>	1.02 (±0.39) <sup>a</sup>	240.58 (±46.35) <sup>e</sup>	49.92 (±3.03) <sup>d</sup>	46.08 (±6.78) <sup>c</sup>	0.05 (±0.02) <sup>d</sup>	1.39 (±0.41) <sup>d</sup>	0.30 (±0.05) <sup>d</sup>	47.10 (±1.67) <sup>d</sup>	28.05 (±4.39) <sup>e</sup>	33.4 (±3.57) <sup>d</sup>	0.21 (±0.01) <sup>c</sup>	
NSDWQ 2007	5 0 0	1 0 0 0	0	0	6.5-8.5	5	1 5 0	2 5 0 0		0 . 0 5	1 . 5	0 . 3		2	0 5	0 0 . 2	
WHO 1999	1 0 0 0	1 0 0 0			6.5-8.5	5	1 5 0	2 5 0 0		0 . 0 5	1 . 5	0 . 3	7	5 5	0 5	0 3 . 0	

Values in parenthesis are standard deviation of means (S. D.).

Values are mean ± standard deviation, values followed by the same letter(s) along the column are not significantly different (P>0.05) tested by LSD.

Table 2: Physico - chemical parameters of borehole water in the months (March-August) in Lapai Metropolis, Niger State, Nigeria.

Sample	TDS	Conductivity	D	O	Temp. °C	pH	Turbidity	Hardness	Cl <sup>-</sup>	Alkalinity	Cr <sup>+</sup>	F <sup>-</sup>	Fe	Ca <sup>+</sup>	Mg <sup>+</sup>	Nitrate	Nitrite
March	186.21 (±18.77) <sup>a</sup>	277.93 (±27.97) <sup>a</sup>	6.26 (±0.57) <sup>a</sup>	31.75 (±0.98) <sup>c</sup>	6.98 (±0.71) <sup>b</sup>	1.84 (±0.53) <sup>b</sup>	106.29 (±8.57) <sup>c</sup>	20.01 (±1.10) <sup>b</sup>	56.29 (±5.44) <sup>b</sup>	0.03 (±0.02) <sup>c</sup>	0.62 (±0.45) <sup>a</sup>	0.21 (±0.09) <sup>c</sup>	21.26 (±2.01) <sup>c</sup>	12.98 (±0.98) <sup>c</sup>	14.56 (±1.27) <sup>b</sup>	0.13 (±0.06) <sup>bc</sup>	
April	188.36 (±18.18) <sup>a</sup>	281.43 (±27.57) <sup>a</sup>	6.23 (±0.67) <sup>a</sup>	30.44 (±0.71) <sup>a</sup>	6.99 (±0.76) <sup>b</sup>	1.86 (±0.44) <sup>b</sup>	102.64 (±8.81) <sup>c</sup>	22.14 (±1.03) <sup>b</sup>	96.43 (±4.71) <sup>c</sup>	0.03 (±0.01) <sup>c</sup>	0.67 (±0.46) <sup>a</sup>	0.21 (±0.10) <sup>c</sup>	23.67 (±2.71) <sup>c</sup>	10.54 (±0.42) <sup>bc</sup>	14.82 (±1.34) <sup>b</sup>	0.14 (±0.05) <sup>c</sup>	
May	185.43 (±18.40) <sup>a</sup>	276.71 (±27.33) <sup>a</sup>	6.34 (±0.69) <sup>a</sup>	30.02 (±1.88) <sup>b</sup>	7.00 (±0.71) <sup>b</sup>	1.78 (±0.64) <sup>b</sup>	85.93 (±7.86) <sup>bc</sup>	20.29 (±1.58) <sup>b</sup>	20.00 (±1.55) <sup>a</sup>	0.01 (±0.01) <sup>a</sup>	0.61 (±0.38) <sup>a</sup>	0.17 (±0.08) <sup>b</sup>	20.48 (±1.54) <sup>c</sup>	8.38 (±1.24) <sup>b</sup>	13.59 (±1.02) <sup>ab</sup>	0.11 (±0.07) <sup>bc</sup>	
June	188.00 (±17.00) <sup>a</sup>	281.21 (±26.76) <sup>a</sup>	7.65 (±0.57) <sup>b</sup>	30.76 (±1.76) <sup>a</sup>	6.74 (±0.69) <sup>b</sup>	0.76 (±0.32) <sup>a</sup>	71.50 (±7.90) <sup>b</sup>	17.50 (±1.08) <sup>a</sup>	17.79 (±7.70) <sup>a</sup>	0.01 (±0.01) <sup>a</sup>	0.51 (±0.43) <sup>a</sup>	0.14 (±0.08) <sup>a</sup>	16.96 (±1.18) <sup>b</sup>	4.84 (±0.19) <sup>a</sup>	10.03 (±1.25) <sup>a</sup>	0.06 (±0.01) <sup>a</sup>	
July	188.71 (±17.87) <sup>a</sup>	241.98 (±27.29) <sup>a</sup>	7.30 (±0.45) <sup>b</sup>	30.09 (±1.26) <sup>a</sup>	6.77 (±0.51) <sup>b</sup>	0.75 (±0.30) <sup>a</sup>	71.64 (±7.90) <sup>b</sup>	17.14 (±1.87) <sup>a</sup>	18.43 (±7.99) <sup>a</sup>	0.02 (±0.02) <sup>b</sup>	0.56 (±0.44) <sup>a</sup>	0.16 (±0.07) <sup>b</sup>	16.61 (±1.18) <sup>b</sup>	4.821 (±0.26) <sup>a</sup>	11.13 (±0.44) <sup>a</sup>	0.07 (±0.01) <sup>b</sup>	
August	182.93 (±17.70) <sup>a</sup>	273.29 (±26.71) <sup>a</sup>	7.47 (±0.69) <sup>b</sup>	30.70 (±0.10) <sup>a</sup>	5.76 (±0.77) <sup>a</sup>	0.61 (±0.37) <sup>a</sup>	50.23 (±4.77) <sup>a</sup>	16.00 (±1.66) <sup>a</sup>	11.50 (±8.65) <sup>a</sup>	0.02 (±0.02) <sup>b</sup>	0.55 (±0.35) <sup>a</sup>	0.16 (±0.07) <sup>b</sup>	11.89 (±0.81) <sup>a</sup>	6.07 (±0.97) <sup>ab</sup>	10.74 (±0.34) <sup>a</sup>	0.07 (±0.01) <sup>b</sup>	
NSDWQ 2007	500	1000	0	0	0	6.5-8.5	5	150	250	0	0.05	1.5	0.3	0	2	0	5
WHO 1999	1000	1000	0	0	0	6.5-8.5	5	150	250	0	0.05	1.5	0.3	7	5	5	0

Values in parenthesis are standard deviation of means (S. D.).

Values followed by the same letter(s) along the column are not significantly different (P>0.05) tested by LSD.

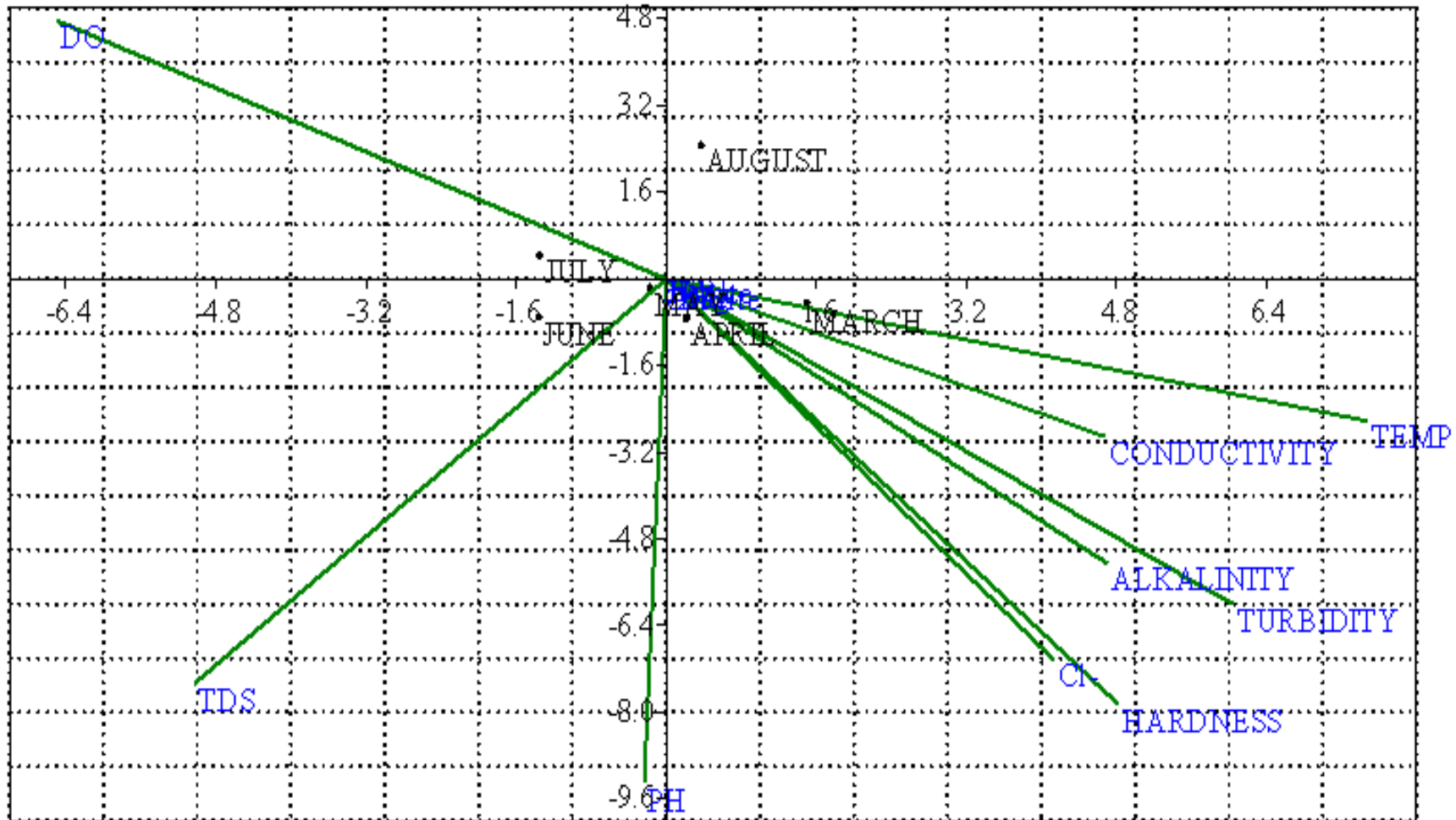


Figure 2: Canonic Correspondence Analysis (CCA) showing the relationship between physico-chemical parameters and months of selected boreholes in Lapai Metropolis, Niger State, Nigeria

Table 3: Physico-chemical parameters of selected boreholes in the Dry and Rainy seasons in Lapai Metropolis, Niger State, Nigeria.

Sample	TDS	Conductivity	D O	Temp.	p H	Turbidity	Hardness	C l	Alkalinity	C r	F l	F e	C a	M g	Nitrate	Nitrite
Dry Season	106.66(±17.00) <sup>a</sup>	278.69(±26.23) <sup>a</sup>	6.28(±0.63) <sup>a</sup>	30.40(±2.20) <sup>b</sup>	6.99(±0.71) <sup>b</sup>	1.82(±0.53) <sup>b</sup>	98.29(±7.85) <sup>b</sup>	20.81(±1.88) <sup>b</sup>	57.57(±5.39) <sup>b</sup>	0.02(±0.01) <sup>a</sup>	0.64(±0.42) <sup>b</sup>	0.20(±0.09) <sup>b</sup>	21.80(±1.65) <sup>b</sup>	10.63(±0.31) <sup>b</sup>	14.31(±1.94) <sup>b</sup>	0.12(±0.01) <sup>b</sup>
Rainy Season	106.55(±17.18) <sup>a</sup>	265.49(±26.52) <sup>a</sup>	7.47(±0.58) <sup>b</sup>	28.52(±1.26) <sup>b</sup>	6.42(±0.80) <sup>a</sup>	0.70(±0.33) <sup>a</sup>	64.46(±8.38) <sup>a</sup>	16.88(±1.20) <sup>b</sup>	15.90(±0.53) <sup>a</sup>	0.02(±0.01) <sup>a</sup>	0.54(±0.40) <sup>a</sup>	0.15(±0.07) <sup>a</sup>	15.15(±1.20) <sup>b</sup>	5.24(±0.63) <sup>b</sup>	10.61(±1.46) <sup>a</sup>	0.07(±0.02) <sup>a</sup>

Values in parenthesis are standard deviation of means (S. D.).

Values follow by the same letter(s) along the column are not significantly different (P>0.05) tested by LSD.

Table 4: ANOVA showing the Physico-chemical Parameters at different sampling stations in Lapai Metropolis, Niger State, Nigeria with respect to months and seasons.

	D f	T D S	Conductivity	D O	Temp. °C	p H	Turbidity	Hardness	C l	Alkalinity	C r	F l	F e	C a	M g	Nitrate	Nitrite
Factor	8 3	8531.22 <sup>ns</sup>	2194.21	2.18*	1.14 <sup>ns</sup>	4.77 <sup>ns</sup>	0.35*	583.05*	2352.16*	150.04*	0.00 <sup>ns</sup>	1.78*	0.27*	230.24*	928.13*	1229.67*	0.05 <sup>ns</sup>
S t a t i o n	6	59.69 <sup>ns</sup>	52.02 <sup>ns</sup>	3.13*	0.28 <sup>ns</sup>	14.37*	0.74*	28.25*	41.73 <sup>ns</sup>	0.72*	16.76*	31.13*	20.99*	12.89*	30.90*	38.29*	23.43*
M o n t h	5	0.00 <sup>ns</sup>	0.04 <sup>ns</sup>	16.47*	26.21 <sup>ns</sup>	6.65*	26.28*	1.21*	0.37*	18.45*	2.60	0.26 <sup>ns</sup>	1.71*	1.05*	1.87*	0.56 <sup>ns</sup>	3.28 <sup>ns</sup>
S e a s o n	1	0.00 <sup>ns</sup>	0.05*	81.31*	23.37*	11.76*	135.00*	4.77*	1.68*	27.92*	0.01	1.11 <sup>ns</sup>	6.29*	4.11*	7.57*	2.74*	14.63*
Season x Station	6	2387.83*	85194.21 <sup>ns</sup>	2.18*	1.14 <sup>ns</sup>	4.77*	0.36*	5893.50*	2352.16*	150.04*	0.00 <sup>ns</sup>	1.78*	0.07*	230.24*	928.13*	1229.67*	23.43*
Season x Month	5	68.65 <sup>ns</sup>	3175.01 <sup>ns</sup>	6.17*	42.32*	3.21 <sup>ns</sup>	5.31*	636.61*	75.89 <sup>ns</sup>	1558.53*	0.00 <sup>ns</sup>	0.05 <sup>ns</sup>	0.01*	246.88*	154.44*	61.42*	0.02 <sup>ns</sup>
Season x Station X Month	3 0	0.30 <sup>ns</sup>	3657.32 <sup>ns</sup>	29.91*	74.86*	6.74*	26.30*	2431.82*	324.50*	3658.33*	0.00 <sup>ns</sup>	0.19*	0.04*	928.94*	7.57*	286.42*	0.07 <sup>ns</sup>
E r r o r	8 2	217.35	126.13	0.16	6.42	0.83	1.86	132.94	67.46	162.31	0.02	0.31	0.01	36.29	20.04	86.43	0.01

\* means there is significant difference (P<0.05).

ns - means no significant difference (P>0.05).



The result on Table 2 for Total dissolved solids (TDS) showed that there were no significant differences ( $P > 0.05$ ) between the months in which the highest TDS was recorded in July (188.71mg/L) and the least was recorded in August (182.93mg/L). However, these values were below the Nigerian Standard Drinking Water Quality (NSDWQ) and the World Health Organization (WHO) standards. The result for conductivity of water samples showed that there was no significant differences ( $P > 0.05$ ) between the months in which the highest conductivity was recorded in April (281.43 $\mu$ s/cm) and the least was recorded in July (241.98 $\mu$ s/cm), when compared to the Nigerian Standard Drinking Water Quality (NSDWQ) and the World Health Organization (WHO) standards the conductivity were below.

The Dissolved Oxygen (DO) showed that there were significant differences ( $P < 0.05$ ) amongst the months with the highest DO recorded was in June (7.65mg/L) and the least recorded was in April (6.23mg/L). The values of DO were up to NSDWQ and WHO standards. The result of temperature on Table 2 showed that there were significant differences ( $P < 0.05$ ) amongst the months with the highest temperature recorded in March (32.75°C) and the least temperature was recorded in July (28.09°C). The values recorded were all of the NSDWQ and WHO standards. The result for pH (Table 2) showed that there were significant differences ( $P < 0.05$ ) between months with the highest recorded in May (7.00) and the least in August (5.76). All values of pH were in the permissible standard of NSDWQ and WHO.

The turbidity on Table 2 showed that there was significant difference ( $P < 0.05$ ) between months with the highest turbidity in April (1.86NTU) and the least in August (0.61NTU), the values recorded all through the months did not exceed the NSDWQ and WHO standards. For water hardness, there were significant differences ( $P < 0.05$ ) amongst the months. The highest hardness was recorded in March (106.29mg/L) and the least in August (50.2mg/L), therefore all the values recorded were all up to the NSDWQ and WHO standards. Chlorine values showed that there were significant difference ( $P < 0.05$ ) amongst the months with the highest chlorine content recorded in April (22.14mg/L), and the least in August (16.00mg/L), the values recorded

measured up to the standard of NSDWQ and WHO.

The result for alkalinity indicated that there were significant differences ( $P < 0.05$ ) amongst the months with April (96.43mg/L) having the highest value and August (11.50mg/L) having the least. Thus, the values are acceptable when compared to the NSDWQ and WHO standard. Table 2 showed that Chromium content amongst the months showed significant differences ( $P < 0.05$ ), in which March and April with values (0.03mg/L) were the highest recorded, while May and June with values (0.01mg/L) respectively had the least recorded value, thereby making Chromium contents in these months up to the standard of NSDWQ and WHO. The highest fluoride content recorded in April (0.67mg/L) and the least in June (0.51 mg/L) (Table 2). The values though within the acceptable standards of NSDWQ and WHO showed no significant differences.

The calcium content (Table 2) showed that there were significant differences ( $P < 0.05$ ) amongst the months. The highest calcium content was recorded in April (23.67 mg/L) while the least was in August (11.89 mg/L). The values in these months were within the acceptable standard of NSDWQ and WHO. The magnesium value on Table 2, showed significant differences ( $P < 0.05$ ) amongst the months. The highest was recorded in March (12.98mg/L) and the least in July (4.82 mg/L). The values were below the NSDWQ and WHO acceptable standards.

Nitrate values (Table 2) showed that there were significant differences ( $P < 0.05$ ) amongst the months with April (14.82mg/L) having the highest value, and the least in June (10.03mg/L). The Nitrite value on Table 2 showed that there were significant differences ( $P < 0.05$ ) amongst the months, with the month of April (0.14mg/L) having the highest value and June (0.06mg/L) with the least. However, the values in these months were within the acceptable standard of NSDWQ and WHO.

Canonical Correspondence Analysis (CCA) showed that the physico-chemical parameters like temperature, conductivity, turbidity, alkalinity, hardness and chloride were positively associated in the months of March, April, May and August while pH, Total dissolved solids (TDS) and Dissolved Oxygen

(DO) were negatively associated in the months of June and July (Figure 2).

Table 3 showed that with the exception of Total Dissolved Solids, Conductivity and Chromium values, there was significant differences ( $P < 0.05$ ) between Dry and Rainy season physico-chemical parameters values. The highest values of most of the parameters examined were obtained in the dry season except for Dissolved Oxygen (DO) with the highest mean values of  $7.47 \pm 0.58$  in the Rainy Season. However, all the values were within the acceptable standard of NSDWQ and WHO.

The statistical analysis on the ANOVA table showed that station, month, season, season X station, season X month and season X station X month of dissolved oxygen, hardness, turbidity, alkalinity, iron, calcium, magnesium have significant difference ( $P < 0.05$ ), including total dissolved solid of season X station, conductivity of season, temperature of season, season x month and season x station x month, pH of station, month, season, season x station and season x station x month, chloride of month, season, season x station and chromium of station, season x station x month, fluoride of station, season x station and season x station x month, nitrate of season, season x month, season x station x month, station and season x station and nitrite of station, season x station and season, but there were no significant difference ( $P > 0.05$ ) in the others.

## DISCUSSION

The study of the physico-chemical analysis of selected borehole water in Lapai Metropolis, Niger State, Nigeria from March - August, 2015 reveals that all the sampling sites had pH level falling within the W.H.O recommended range value of 6.5–8.5 (WHO, 1999; NSDWQ, 2007), except in Badegi quarters (5.47) which is below the recommended range set by WHO. This could be attributed to acid rain, industrial waste, mining, sewage, waste dumping through leaching into the soil which ultimately increases the soil acidity and consequently the pH is lowered as observed by (FAO/WHO, 1997). The result from the rainy and dry season also fell within the W.H.O. and NSDWQ recommended range value of 6.5–8.5 (WHO, 1999; NSDWQ, 2007). Even though

pH has no direct effect on human health, its indirect action on physiological process cannot be over emphasized (Adekunle *et al.*, 2004; NSDWQ, 2007).

For Conductivity, measurements were conducted in the water samples based on sampling sites, season and months, this reveals that all the values were within the W.H.O. and NSDWQ recommended standard of  $1000 \mu\text{s}/\text{cm}$  (WHO, 1999; NSDWQ, 2007). However, the high conductivity level at the sampling sites could be linked to sewage materials, leaching of inorganic contaminants as observed by Harrison, (1992). Although there is no disease or disorder associated with conductivity of drinking water (NSDWQ, 2007).

The turbidity level in all the sample sites, months and season determined showed that they are within the recommended levels of 5NTU (WHO, 1999; NSDWQ, 2007). Higher turbidity in water could be due to Suspended materials, bacteria, plankton and dissolved organic and inorganic substance and higher turbidity is associated with Surface water sources as observed by Reza and Gordeep, (2009). Water turbidity is very important because high turbidity is often associated with higher level of disease causing microorganism, such as bacteria and other parasites (Shittu *et al.*, 2008).

Based on classification of water conducted by Roxanne and Tom, (2012) in terms of softness and hardness in the following order of mg/l. 0 – 60 soft, 60 – 120 moderately soft, and 121 – 180 moderately hard and above 180 is hard. It can be deduced that almost all the water samples analyzed in the dry and rainy seasons and months are moderately soft except for the month of August (50.23mg/L), while that of IBBU Hostel, IBBU Staff Quarters and 14 Quarters are soft, that of Faculty of Science, Emir's Palace and UBA area (Lapai - Suleja road) are moderately soft and that of Badegi quarters (Lapai - Bida road) is hard but safe for drinking and other domestic purposes. However, the hardness could be removed by simple boiling, addition of chemicals e.g. washing soda, sodium hydroxide, and ion exchange method.

The alkalinity levels were assessed in the water samples and the results indicates that majority of the sampling sites have alkalinity

levels below the W.H.O. and NSDWQ recommended standard (WHO, 1999; NSDWQ, 2007). The Alkalinity value in water provides an idea of natural mineral salts present in the water. The main species that contribute to alkalinity includes bicarbonates, hydroxides, phosphates and borates (USGS, 1998).

It can be observed that water analysed in all the months, seasons and in all the sampling sites had total dissolved solid levels below WHO maximum contaminant levels of 1000mg/l (Wetzel, 2001) and (NSDWQ, 2007) except in Badegi quarters (586.00mg/L). The higher total dissolved solid reduce water clarity, which could contribute to the decrease in photosynthetic activities and might lead to an increase in water temperature as observed by (NRCC, 2011). The principal constituents of total dissolved solids (TDS) are usually calcium, magnesium, sodium and potassium cation, carbonate, hydrogen carbonate, chloride, sulphate and nitrate anion (WHO, 1996). The presence of TDS in water may affect its taste (WHO, 1996). It has been reported that drinking water with extremely low concentration of TDS may be unacceptable because of its flat insipid taste (WHO, 1996).

Also, fluoride content of all water samples fell within the standard limit of NSDWQ (1.5mg/l). Cool waters are generally potable for drinking purposes, because high water temperature enhances growth of microorganisms and hence, taste, colour, odour and corrosion problem may increase (Okoye and Okoye, 2008).

For Chromium, it can be seen that all the samples were within the safe limit recommended by (WHO, 1999; NSDWQ, 2007). This may originate from corrosion of brass fitting of certain types of submersible pumps used in groundwater wells as reported by (FAO/WHO, 1997).  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  are among the general elements essential for human health and metabolism, and should be available in normal drinking water (Kolo *et al.*, 2009). The calcium and magnesium were up to the WHO and NSDWQ standard, in exception of Badegi Quarters (28.05mg/l) which had magnesium higher than the NSDWQ standard.

The Canonical Correspondence indicated that most of the physical parameters are related to one another shows that higher Conductivity is related to higher Total Dissolved Solids and hardness which rise as a result of the presence of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  ions respectively. Chloride is within the standard of NSDWQ and WHO and also within the range as reported by Obi and Okocha, (2007). Trace metals which includes iron, nitrate, chromium were up to the NSDWQ and WHO standards except for nitrite in Badegi Quarters (0.21mg/L) which was above the WHO and NSDWQ standards which can result to Methemoglobinemia disease.

### Conclusion

Most of the observables physical parameters are within the W.H.O and NSDWQ safe limit and the levels of trace metals were also found to be within the recommended levels set by W.H.O and NSDWQ with exception of nitrite in Badegi quarters.

### Recommendations

Water should be boiled before use so as to remove the temporary hardness. The recycling and proper disposal of domestic and industrial waste should be practiced. Relevant agencies should make concerted effort to control, regulate and educate the community on indiscriminate waste disposal from inhabitants within the study area and also regular analysis should be carried out to ensure drinking water quality. Further research should be carried out to assess the level of some other parameters. The replacement of home plumbing components made from brass should be done regularly.

### REFERENCES

- Addo, K. K., Mensah, G. I., Bekoe, M., Bonsu, C. and Akyen, M. L. (2009). Bacteriological quality of sachet water produced and sold in Teshie-Nungua, Suburbs of Accra, Ghana. *Africa Journal of Food Agriculture and Nutritional Development* 9(4):1019-1030.
- Adekunle, L. V., Sridhar, M. K. C., Ajayi, A. A., Oluwade, P. A. and Olawuyi, J. F. (2004). Assessment of the health and socio-economic implication of sachet water in Ibadan, Nigeria. *African Journal of Biomedical Research*, 7(1):5-8.

- Adeyeye, E. I. (1994). Determination of Heavy Metals in Illisha African Associated Water, Soil Sediments from Fish Ponds, *International Journal of Environmental Study*, 45; 231-240.
- American Public Health Association (APHA) (1995). *Standard Methods For Examination of Water and Wastewater*. United Book Press, Inc., Baltimore, Maryland. 19<sup>th</sup> Edition.
- Andrew, D. E., Lenore, S. C., Eugene, W. R. and Arnold, E. G. (2005). *Standards Methods for the Examination of Water and Wastewater* APHA Washington DC. 20001-3710.
- Asaolu, S. S., Ipinmoroti, O., Adeeyinwo, C. E. and Olaofe, O. (1997). Interrelationship Of Heavy Metals Concentration In Water, Sediment And Fish Samples From Ondo State Coastal Area, Nigeria, *Africa Science* 1:55-61.
- Central Intelligence Agency (CIA) (2008). The World Factbook. Retrieved 20, December, 2008.
- FAO/WHO (1997). Food Agricultural Organisation. s Expert committee food additives World Health Organization, Geneva. WHO Technical Report series (FAO) Rome 1(2)20-26.
- Gleick, P. H.(1993).Water in Crisis: A Guide to the World's Freshwater resources. Oxford University Press. p13, Table 2.1 "Water reserves the earth".
- Hach, C. C., Vonous, R. D. and Heer, J. M. (1985). Understanding Turbidity Measurement. Hach co., Tech. Info. Ser. Booklet 11, Loveland, Colo.
- Harison, R. M. (1992). Understanding out Environmental Chemistry and Pollution. Cambridge University press 2<sup>nd</sup> ed. 46-49pp.
- Ipinmoroti, K. O. and Oshodi, A., (1993). Determination of Trace Metals of Fish, Associated Water and Soil Sediments from Fish Ponds. *Discovery Innovate*, 5:135-138.
- Kolo, B., Dibal, J. M. and Ndakawa, I. I., (2009).Elemental analysis of Tap and Borehole Water in Maiduguri, Semi-Arid Region, Nigeria. *European Journal of Applied Sciences*, 1(2): 26-29.
- Lapai, LGA and town (2009). Wikipedia, the free encyclopedia, navigation search "Map of LGA". NIPOST. Retrieved 2009-10-20.
- NRCC (2011). National Research Council of Canada. Effect of Sodium And Potassium in the Canadian Environment. NO. 150154. Associate Committee on Scientific Criteria for Environmental Quality Ottawa.
- NSDWQ (2007). Nigerian Industrial Standard: Nigerian Standard for Drinking Water Quality. NIS 554:2007.
- Obi, C. N. and Okocha, C. O., (2007). Microbial and Physicochemical Analysis of Selected Borehole Water in World Bank Housing Estate, Umuahia, Abia State, Nigeria. *Journal of Engineering and Applied Sciences*. 2(5): 920-929.
- Okoye, C. O. and Okoye, A. C., (2008).Urban Domestic Solid Waste Management. Nimo: Rex Charles and Patrick Limited Akwa. pp 5-7.
- Olowe, O. A., Ojurongbe, O., Opaleye, O. O., Adedosu, O. T., Oluwe, R. A. and Eniola, K. I. T. (2005). Bacteriological Quality of Water Samples in Oshogbo Metropolis. *African Journal of Clinical Experimental Microbiology* 6(3):219-222.
- Onemano, J. I. and Otun, J. A. (2008). Problems of Water quality standard and monitoring in Nigeria. Paper presented at the 29<sup>th</sup> WEDC International Conference at Abuja Sheraton Hotel and Tower, Nigeria on 22-26 September 2003.
- Pierina, L., Daniela, C., Antonio, L., Giuseppe, P., Vito, F. U. and Pasquale, A. N., (2012). Source apportionment of Groundwater Pollutants in Apulian Agricultural sites using Multivariate Statistical Analyses: Case study of Foggia province. *Chemistry Central Journal* 6(2), 1186-1752.
- Reza, J. and Gordeep, S. (2009).Pre and Post Monsoon Variation of heavy Metals Concentration of Ground Water Of Angul Talcher Region of Orisse, India *Natural and Science*7(6).52-56.

- Roxanne, J. and Tom, S. (2012). *Drinking Water quality testing and interpreting your Results Revised Ed.*
- Shittu, O. B., Olaitan, J. O. and Amusan, T. S. (2008). Physicochemical and Bacteriological Analysis used for Drinking and Swimming in Abeokuta, Nigeria. *African Journal of Biomedical Research* 11, 285-290.
- UNEP (1995). *Water Vapour in the Climate System, Special Report (AGU).*
- United States Geological Survey, Denver, C. O. (USGS) (1998). *Ground Water and surface Water: A Single Resource. Circular 1139.*
- UN Water Initiative (2010). *UN Water Global Annual Assessment of Sanitation and Drinking Water (2010 Report), Implemented by World Health Organization. Geneva: United Nations.*
- Wetzel, R. G. (2001). *Limnology lake and River Ecosystem 3<sup>rd</sup> ed. Academic Press New York 1006p*
- World Health Organization (WHO) (1996). *Total dissolved solid in drinking water. Guideline for drinking water quality. 2:0-1.*
- W.H.O. (1999) World Health Organization. *Guidelines for drinking water quality (WHO), Geneva, pp 160-220.*
- W.H.O. (2007). *World Health Organisation: Global Burden of Diseases, Geneva: World Health Organisation.*