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# PHYSICO-CHEMICAL STATUS OF SOME BOREHOLE WATER SOURCE FROM THREE SENATORIAL AREAS (KADUNA, KAFANCHAN AND ZARIA) IN KADUNA STATE, NIGERIA

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# ABSTRACT

Thirty-six (36) water samples were randomly collected from different boreholes in three senatorial areas (Kaduna, Kafanchan and Zaria) in Kaduna state, Nigeria. They were analyzed for their physicochemical parameters which include pH, temperature, conductivity, Total dissolved Solids (TDS), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) using standard methods. The results revealed that pH ranged from (4.03 - 6.66) indicating that the water is slightly acidic, Temperature ( $^{0}$ C) (23.7 – 27.3), Electro- Conductivity (mS/cm) (0.05 – 1.44), Total Dissolved Solid (mg/L) (0.02 - 0.72), Chemical Oxygen Demand (mg/L) (9.36 – 21.12), Total Suspended Solid (mg/L) (0.01 -1.65), Dissolved Oxygen (mg/L) (0.30 – 2.70) and Biochemical Oxygen Demand (mg/L) (0.001 -0.009) . The values obtained from the physico-chemical parameters analysis were compared with the WHO and NIS standards for drinking water and the results showed that the values were within the acceptable range for drinking water except for some water samples which has COD that were higher in some sites due to anthropogenic factors.

Keywords: Physico-chemical parameters, Boreholes, NIS, W.H.O

#### **1.0. Introduction**

Water is the most abundant substance on the earth surface. Its unique properties make it the most important and abundant substance in the universe. It can occur as surface water in lakes, rain water and streams as well as groundwater in wells, boreholes and springs. Water plays vital role in human life. It is extremely essential for survival of all living organisms. Water is necessary for healthy living and must be available to consumers in sufficient quantity and at high quality (WHO, 2010). Groundwater is ultimate, most suitable fresh water resource with nearly balanced concentration of the salts for human consumption (Krishna *et al.*, 2012). Groundwater account for about 98% of the world fresh water and is distributed throughout the world. It provides a reasonable constant supply, which is not likely to dry up under natural condition and usually of high quality. Also, water is one of the basic needs for the survival of human beings. According to WHO (2007) about 1.1 billion people lack access to an improved drinking water supply. The majorities of the populations in developing countries are inadequately supplied with potable water and are thus bound to use water from sources like shallow wells and bore holes that have high potential of contamination and provide the unsafe water for domestic and drinking purposes (WHO, 2011).

In Nigeria alone, about 52% of the population lack access to safe drinking water (Orebiyi *et al.*, 2010). About 8.3 million residents in Lagos (62.6% of the state population) and some industries lack access to pipe borne water, thus depend solely on groundwater (shallow, hand dug wells and boreholes) for their domestic and industrial use (Majolagbe *et al.*, 2014). In most cities, towns and villages in Nigeria, valuable man-hours are spent on seeking and fetching water, often of doubtful quality from distant sources (Efe *et al.*, 2005). The quality of a water resource depends on the management of anthropogenic discharges as well as the natural physico-chemical characteristics of the catchments areas (Efe *et al.*, 2005; Saba and Baba, 2004).

According to Davis and De wiest (1966), drinking water standards are based on two main criteria, namely; the presence of objectionable tastes, odour and colour and; the presence of substances with adverse physiological effects. However, mineral enrichment from underlying rocks can change the chemistry of the groundwater, making it unsuitable for the consumption (Ako et al., 1990). In addition, water of poor physico-chemical quality may have adverse health effects, causing avoidable economic and human losses. Polluted water is potentially dangerous to health because of possible outbreaks of typical dysentery or cholera, epidemics and other water-borne diseases.

The aim of this study is to analysis the physico-chemical parameters of borehole water source in the three senatorial areas of Kaduna State. The results of this study is to provide the necessary data and information for Kaduna Government Environmental Agency in the monitoring of water sources, usage, anthropogenic origins of water pollutions if any and necessary palliative preventions in cases of water contaminations to its citizens.

#### 2.0. Material and Methods

#### 2.1. Sampling Area

Water samples were collected from selected borehole in rural and urban areas of the three senatorial areas in Kaduna State during the dry season in 2015. Seventy - Two ground water samples were sampled in all the selected sampling areas. Upon collection of the ground water samples, physico-chemical parameters such as Temperature, pH, Electro-Conductivity (EC),

Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS) and Dissolved Oxygen (DO) were determined using the various appropriate analytical methods below.

The sample containers were washed with 20 % analytical grade nitric acid and rigorously rinsed with distilled deionized water. Prior to sampling, it was further rinsed with the actual sample. Collected samples were preserved by chemical adjustment of the pH < 2, by acidifying with 5 cm<sup>3</sup> of analytical grade nitric acid. This reduces precipitation and sorption losses to the container walls. After which the samples were stored under ice on transit and then refrigerated after arriving the laboratory at a temperature of (4°C) prior to analysis.

# 2.2. Determination of TDS, pH, temperature and electrical conductivity.

These parameters were determined using the HACH complete water laboratory model 44600 and Nahita pH meter model 903 instrument. Water samples of 100 cm<sup>3</sup> were collected in 250 cm<sup>3</sup>pyrex beaker and the probe of meter dipped into the container. TDS, pH, Temperature and electrical conductivity were determined and recorded. This was repeated for all the water samples in all the sampled locations.

# 2.3. Determination of COD

Drinking water samples,  $50 \text{cm}^3$  was collected and transferred to a  $250 \text{cm}^3$  beaker containing 10 cm<sup>3</sup> of 0.01M KMnO<sub>4</sub> and 2 cm<sup>3</sup> of 25% H<sub>2</sub>SO<sub>4</sub> already mixed. The solution was refluxed using a reflux condenser for one hour and allowed to cool at room temperature. Then 1% Ammonium Oxalate (NH<sub>4</sub>)<sub>2</sub>C<sub>2</sub>O<sub>4</sub>.H<sub>2</sub>O was carefully prepared and added drop-wise to the solution until colourless solution was observed. The solution obtained was then titrated with 0.01M KMnO<sub>4</sub> until a pink solution was observed. The COD calculations after laboratory analysis of the water samples was as follows:

$$COD(mg/L) = (B - A) \times M \times 16000 \div Volume of the water sample$$

Where A is titre value of sample, B is titre value of blank, M = Molarity of  $KMnO_4$  and 16000 (Constant).

#### 2.4. Determination of TSS

Determination of total suspended solids was carried out using gravimetric methods.  $10 \text{ cm}^3$  of the water samples were measured into a pre-weight evaporating dish, which was then dried in an oven at temperature of  $103 - 105^{\circ}$ C for two and half hours. The dish was transferred into the desiccator and allow to cool at room temperature. The total solids was represented by the increased in the weight of the evaporating dish (Onwughara *et al.*, 2013).

Total solids  $(mg/L) = [(w_2-w_1) mg x 1000] / mL$  of the sample used.

Where  $w_1$  = initial weight of evaporating dish.

 $w_2$ = final weight of evaporating dish + residue.

The total solids were easily obtained by simple calculation i.e

Total suspended solids = total solids – total dissolved solids.

# 2.5. Determination of Dissolved Oxygen (DO)

2cm<sup>3</sup> each of manganese sulphate solution followed by alkaline iodide oxide reagent were added to the water samples. The bottles were stoppered without trapping any air bubbles and mixed up by inverting the bottles several times. The precipitate formed were allowed to settle to at least the lower half of the bottle leaving a clear supernatant above. The stoppers were

carefully removed. About  $1 \text{ cm}^3$  of concentrated  $H_2SO_4$  was added allowing the acid to run down the neck of the bottle. The bottles were again stoppered and mixed up by inverting the bottles several times until there was a uniform yellow colour in the bottle. About 200cm<sup>3</sup> of the mixture was then titrated with sodium thio-sulphate adding 1-2ml of freshly prepared starch as an indicator (Onwughara *et al.*, 2013).

# **2.6. Determination of BOD**

The method involve filling the samples to overflowing, in an airtight bottle of specified size and incubating it at specified temperature for five days. Dissolved oxygen was measure initially prior to incubation and also after the incubation. The BOD was computed between initial and final DO, because the initial DO was determined shortly after the dilution was added, all oxygen uptake occurring after this measurement was included in BOD measurement.

One cubic centimeter  $(1\text{cm}^3)$  of MgSO<sub>4</sub>, CaCl<sub>2</sub>, phosphate buffer, Fecl<sub>3</sub> were added, to 1 liter of water. The solution was shaken thoroughly to saturate the dissolve oxygen. The solution was used to dilute samples. One hundred cubic centimeter  $(100\text{cm}^3)$  of the samples were measured into different one litre flask and were made up to (1L) mark with the distilled water previously prepared.

The dilution sample water was then poured into the BOD bottle and subsequently incubated at  $20^{\circ}$ C (680F) for five days, at the end of the five days the remaining DO was measured (Onwughara *et al.*, 2013).

 $BOD5 = (DO_1 - DO_5) X D.F$ 

 $BOD_5$  - BOD at 5days

 $DO_1$  - DO at day 1

 $DO_5$  - DO at day 5

D.F - Dilution factor = volume of the bottle / volume of the sample.

#### 2.7 Statistical Analyses

Relevant statistical packages (Microsoft Excel 2011 Statistical Tool Pack) were used to analyze the data obtained and their levels of significance. One-way analysis of variance (ANOVA), mean and standard deviation were some of the analyses carried out in this study.

#### **3.0. Results and Discussion**

All physic-chemical parameters from the borehole water sources were evaluated using the regulatory standard that was shown below. The results of the physicochemical parameters for the borehole underground water samples obtained from Zaria, Kaduna and Kafanchan senatorial districts are shown in Tables 1 - 3.

ID No	Location of sample	Temperature	pН	Conductivity	TDS	COD
		(0°C)		(mS/cm)	(g/L)	(mg/L)
BH 01	WUSASA- ZA	26.1±0.02	5.01±0.22	0.45±0.10	$0.22 \pm 0.05$	17.23±1.99
BH 02	KOFA DOKA- ZA	26.7±0.62	5.02±0.21	0.58±0.23	0.29±0.12	12.16±3.08
BH 03	KONGO- ZA	27.1±1.02	5.78±0.55	1.00±0.65	0.50±0.33	13.41±1.83
BH 04	SABO GARI- ZA	27.3±1.22	$4.03 \pm 1.20$	0.12±0.23	$0.06 \pm 0.11$	$21.12 \pm 5.88$
BH 05	EMANTO- ZA	$26.9 \pm 0.82$	6.19±0.96	$1.44{\pm}1.09$	$0.72 \pm 0.55$	$18.56 \pm 3.32$
BH 06	SAMARU- ZA	27.2±1.12	6.21±0.98	1.15±0.80	$0.53 \pm 0.36$	$15.30 \pm 0.06$
BH 07	DUTSE- ZA	26.8±0.72	$6.24{\pm}1.01$	$0.42\pm0.07$	$0.56 \pm 0.39$	$17.20 \pm 1.96$
BH 08	BASSAWA- ZA	27.1±1.02	$4.04{\pm}1.19$	0.52±0.19	$0.20 \pm 0.03$	$12.10 \pm 3.14$
BH 09	CHIKA- ZA	27.2±1.12	$5.68 \pm 0.45$	0.10±0.25	0.28±0.11	$13.40{\pm}1.84$
BH 10	GRACELAND- ZA	26.1±0.02	5.02±0.21	1.24±0.89	0.51±0.34	$18.56 \pm 3.32$
BH 11	TUDUN WADA- ZA	26.2±0.12	5.41±0.18	0.52±0.17	0.06±0.11	12.11±3.13
BH 12	U/GODO- KD	27.1±1.02	5.44±0.21	1.14±0.79	$0.08 \pm 0.09$	12.12±3.12
BH 13	NARAYI – KD	25.9±0.18	4.82±0.41	0.48±0.13	0.24±0.07	$16.64 \pm 1.40$
BH 14	TELEVISION- KD	25.6±0.48	5.13±0.10	0.09±0.26	0.04±0.13	11.52±3.72
BH 15	GONIGORA- KD	25.4±0.68	5.26±0.03	0.05±0.30	0.02±0.15	16.41±1.17
BH 16	C/ MARKET-KD	25.2±0.88	5.78±0.55	0.46±0.11	0.23±0.06	13.41±1.83
BH 17	MANDO-KD	25.2±0.88	4.05±1.18	0.09±0.26	0.02±0.15	$17.40 \pm 2.16$
BH 18	H/ DAMANI- KD	23.7±2.38	4.44±0.79	0.05±0.30	$0.02 \pm 0.15$	20.40±5.16
BH 19	KAWO- KD	25.4±0.68	4.44±0.79	0.05±0.30	$0.02 \pm 0.15$	16.60±1.36
BH 20	MALALI- KD	25.3±0.78	$4.05 \pm 1.18$	0.09±0.26	$0.02 \pm 0.15$	$11.52 \pm 3.72$
BH 21	TUDUNWADA- KD	25.4±0.68	$5.78 \pm 0.55$	$0.42 \pm 0.07$	$0.22 \pm 0.05$	$13.40{\pm}1.84$
BH 22	KAKURI- KD	25.2±0.88	5.26±0.03	0.41±0.06	$0.02 \pm 0.15$	$13.40{\pm}1.84$
BH 23	HAYAN BAKIN-	25.2±0.88	$5.26 \pm 0.03$	0.16±0.19	$0.02 \pm 0.15$	$13.22 \pm 2.02$
	KD					
BH 24	SABO- KD	25.3±0.78	5.50±0.27	0.34±0.01	0.02±0.15	$13.44 \pm 1.80$
BH 25	ADWANI I- KF	25.0±1.08	5.38±0.15	0.13±0.22	$0.08 \pm 0.09$	21.12±5.88
BH 26	U/RIMI	26.7±0.62	6.66±1.43	0.06±0.29	$0.57 \pm 0.40$	14.72±0.52
BH 27	GARAJI ROAD- KF	26.3±0.22	5.88±0.65	0.18±0.17	0.06±0.11	$17.92 \pm 2.68$
BH 28	KATSIT- KF	26.1±0.02	4.87±0.36	0.06±0.29	0.03±0.14	$13.44{\pm}1.80$
BH 29	MADAKIA- KF	26.1±0.02	5.14±0.09	0.15±0.02	$0.08 \pm 0.09$	15.36±0.12
BH 30	TAKAU – KF	26.3±0.22	5.23±0.00	0.06±0.29	0.03±0.14	9.36±5.88
BH 31	ADWANI II- KF	26.4±0.32	5.14±0.09	0.18±0.17	$0.08 \pm 0.09$	15.36±0.12
BH 32	KANIKON – KF	26.4±0.32	4.87±0.36	0.06±0.29	$0.08 \pm 0.09$	$13.44 \pm 1.80$
BH 33	FASAN – KF	26.1±0.02	5.88±0.65	0.08±0.27	0.03±0.14	14.72±0.52
BH 34	LOKO- KF	26.2±0.12	5.11±0.12	0.07±0.28	0.06±0.11	21.12±5.88
BH 35	U/FARI –KF	26.3±0.22	5.23±0.00	0.06±0.29	0.07±0.10	$17.92 \pm 2.68$
BH 36	U/BAKI –KF	26.4±0.32	5.14±0.09	0.16±0.19	0.05±0.12	$13.44 \pm 1.80$
	MEAN±STD	26.08±0.80	5.23±0.64	0.35±0.39	0.17±0.20	15.24±3.02

Table 1: The result of physicochemical parameters in the borehole water samples from three senatorial (Zaria, Kaduna and Kafanchan) during dry season.

Key: ZA - Zaria, KD - Kaduna, KF-Kafanchan

BH01 – BH36: Borehole Sample of dry season

ID No	Location of sample	TSS	DO	BOD
	<b>F</b>	mg/L	mg/L	mg/L
BH 01	WUSASA- ZA	0.0715	0.60	0.001
BH 02	KOFA DOKA-ZA	0.0785	0.00	0.001
BH 03	KONGO- ZA	0.0703	1 40	0.001
BH 04	SABO GARI- ZA	0.0922	2 40	0.004
BH 05	EMANTO- ZA	0.0755	1 70	0.003
BH 06	SAMARU- ZA	0.6131	1.70	0.005
BH 07	DUTSE- ZA	0.1854	1.00	0.005
BH 08	BASSAWA-ZA	0.2350	1.00	0.001
BH 09	CHIKA- ZA	1 0810	1.10	0.001
BH 10	GRACELAND- ZA	1 2823	2.10	0.005
BH 11	TUDUN WADA-	1 1080	2.30	0.007
211 11	ZA	1.1000	2.30	0.007
BH 12	U/GODO- KD	0.1913	0.70	0.003
BH 13	NARAYI – KD	0.0680	0.50	0.002
BH 14	TELEVISION- KD	0.0464	0.30	0.003
BH 15	GONIGORA- KD	0.1800	0.80	0.004
BH 16	C/ MARKET-KD	1.6500	1.30	0.002
BH 17	MANDO-KD	0.0606	1.20	0.005
BH 18	H/ DAMANI- KD	1.1630	1.80	0.005
BH 19	KAWO- KD	1.3300	1.10	0.002
BH 20	MALALI- KD	1.1940	2.70	0.009
BH 21	TUDUNWADA- KD	23000	1.40	0.005
BH 22	KAKURI- KD	1.1601	1.80	0.003
BH 23	HAYAN BAKIN- KD	0.0755	1.00	0.006
BH 24	SABO- KD	2.0890	2.20	0.007
BH 25	ADWANI I- KF	1.3450	1.60	0.004
BH 26	U/RIMI	0.0109	1.20	0.003
BH 27	GARAJI ROAD- KF	0.6500	0.90	0.002
BH 28	KATSIT- KF	0.0147	1.00	0.004
BH 29	MADAKIA- KF	0.0212	1.80	0.006
BH 30	TAKAU – KF	0.0098	1.00	0.005
BH 31	ADWANI II- KF	0.9700	1.50	0.005
BH 32	KANIKON – KF	0.3730	1.20	0.003
BH 33	FASAN – KF	0.5350	1.60	0.004
BH 34	LOKO- KF	1.4712	1.30	0.005
BH 35	U/FARI –KF	1.2815	1.00	0.008
BH 36	U/BAKI –KF	1.3501	1.60	0.005
	MEAN±STD			

 Table 2: The result of physicochemical parameters in the borehole water samples from three senatorial (Zaria, Kaduna and Kafanchan) during dry season.

**Key:** ZA - Zaria, KD – Kaduna, KF-Kafanchan **BH01 – BH36:** Borehole Sample of dry season

Table 3: Comparison of observed values of the physicochemical parameters of boreholes water in the three senatorial district (Zaria, Kaduna and Kafanchan) of Kaduna State during dry season with Nigeria and World health Organisation (WHO) standards

	Units	NIS (2007)	WHO (2011)	MINIMUM	MAXIMUM	MEAN
Temperature	°C	25	30-35	23.7	27.3	25.5
рН		6.8-8.5	6.5-9.2	4.03	6.66	5.15
Conductivity	mS/cm	250	250	0.05	1.44	0.75
TDS	mg/L	500	500	0.02	0.72	0.37
COD	mg/L	10	10	9.36	21.12	16.32
TSS	mg/L		30	0.01	1.65	0.82
DO	mg/L		7.5	0.30	2.70	1.5
BOD	mg/L		6-9	0.001	0.009	0.005

The result obtained from the water analysis carried out was represented in Tables 1 and 2. The pH results as shown in Table 1 showed that all the water samples were acidic. The maximum pH was recorded as 6.66 at sampling location U/Rimi in Kaduna Senatorial Area and the minimum was 4.03 at Sabo Gari in Zaria Senatorial Area. When compared with the standard values of WHO and NIS, the water samples were below the stated permissible limit and thus not satisfactorily for consumption. The low values as recorded in the samples may be as a result of anthropogenic factors and as such could attack geological materials and leach toxic materials. This may pose a risk for consumption due to metallic toxicity as Cornish et al., (1999) reported that acidity in water favours the concentration of heavy metals. pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. It is considered as an important ecological factor and provides an important piece factor information on many types of geochemical equilibrium or solubility calculation (Shyamala et al., 2008). The pH of a body of water is affected by several factors. One of the most important factors is the bedrock and soil composition through which the water moves, both in its bed and as groundwater. Some rock types such as limestone can, to an extent, neutralize the acid while others, such as granite, have virtually no effect on pH (Oram, 2014).

Electrical conductivity (EC) is a measure of water capacity to convey electric current. It is an important parameters that helps in determining the amount of total dissolved salts (Dahiya and Kaur, 1999). Low EC values were observed at almost all the sampling points with reference to WHO and NIS standards, indicating the presence of low amount of dissolved inorganic substances in ionized form.

Temperature is an important biologically significant factor, which plays an important role in the metabolic activities of the organism. The temperature ranged from 23.7 °C - 27.3 °C during the study period. These values are all within the WHO/NIS permissible limits. The temperature values as observed in the work may be due to location of the boreholes. (Okoye and Okoye, 2008) reported that Cool waters are generally more potable for drinking purposes, because high water temperature enhances the growth of micro-organisms and hence, taste, odour, colour and corrosion problem may increase. Metal corrosion problem are also associated with high temperature especially when the pH of the water happens to be more acidic. High temperature is known to exert a major influence on the biological activity

and growth of aquatic organism, fish, insect, zooplankton and other aquatic species decreases until finally there are a few, some compounds are more toxic to aquatic life, the rate of chemical reaction increases. High temperature increases the level of dissolved oxygen and this encourages the microbial breakdown of organic matter, a process which requires dissolved oxygen (USEPA, 2005).

The total suspended solids value for the surface water sample ranged from 0.01 - 1.65 mg/L for the three Senatorial Areas. These values are all below the WHO standard of 500 mg/L (WHO, 2005) for total suspended solids in underground water. The TDS values show that there are low presence of dissolved substances such as metals ions in the sampled water (Abdullahi *et al.*, 2011). High concentration of total solids in river can lower water quality and cause water balance problem for individual organism, it reduces the clarity of water thus decreasing the amount of sunlight able to penetrate the water thereby decreasing the rate of photosynthesis. While low concentration limits the growth of aquatic life.

The DO and Biochemical Oxygen Demand results after five days (BOD5) were found within the range of 0.30 - 2.70 mg/L and 0.001 - 0.009 mg/L, respectively. The values are within the recommended limit for DO and BOD in drinking water (WHO, 1971). This suggests that the water from the whole area is less polluted by organic matter and they could support aquatic life. The highest DO value (2.70 mg/l) obtained for the borehole water may be due to aeration process during water treatment (Oluyemi *et al.*, 2010). The DO is an important water quality parameter and has special significance for aquatic organisms in natural waters (Willock *et al.*, 1981).

The TDS water samples results ranged from 0.02 - 0.72 mg/L. Low TDS values were observed in all the water samples as they were within the permissible limits as recommended by the regulatory agents above. Total dissolve solid (TDS) values are generally below 250mg/L and this also correlate with the low conductivity value observed above as the TDS results show that there are low presence of dissolved inorganic salts in the sampled water.

Water containing more than 500 mg/l of TDS is not considered desirable for drinking water supplies, but in unavoidable cases 1500 mg/l is also allowed (Shrinivasa Rao and Venkateswaralu, 2000), highly mineralized water may be used where better quality water is not available (Jain, 2002).

#### 4. Conclusion

From the results obtained, this study concludes that water samples across the three senatorial zones of Kaduna are not polluted and are suitable for agricultural uses. The concentration of some of the heavy metals present were within the WHO and EU recommended safe limits, therefore they are suitable for drinking purposes. It is recommended that the enforcement of public health laws and regularities of the area should be monitored by Federal Government and Kaduna State Government to protect the environment. Follow-up studies to monitor the bioaccumulation of contaminants are recommended in order to evaluate the health risks.

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