

Assessment of Drinking Water Quality in Selected Locations in Selected States of North Central Nigeria.

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Abstract: The pollution of freshwater resources is a global crises and unpolluted water is an indispensable need of human being. The investigation of drinking water quality in selected locations in selected States in north Central Nigeria was carried out using standard methods and the results revealed the pollution index of water samples from Plateau State is between 0.00 – 4.65 indicating the water is polluted with Mg, Hg, Cd and Cr with the values of 4.65, 1.67, 1.11 and 83.67 respectively. Other elements like Cu, Mn, Fe, Zn, As and Ni havetheir values less than one meaning the water is not polluted in respect to these elements. The organic constituents are within the Nigeria Industrial Standard for drinking water but the values of coliform are above the guideline value except for samples G, H, I and K. For samples from Nasarawa State the pollution index ranges from 0.00-54.63, the water was not polluted with Cu, Zn, Hg, Cd, As and Ni (values less than one) but polluted with Pb, Mg, Mn, Fe and Cr with the pollution index values of 14.79, 4.94, 1.50, 1.70 and 54.63 respectively. The organic constituents of the water is within the guideline limits but the coliform values were above the guideline values of 0 cfu/mL exception of sample E and F. For water samples from Abuja the pollution index ranges from 0.00- 66.53, with the values of Pb and Mn exceeding one (66.53 and 42.45) while others Cu, Mg, Fe, Zn, Hg, Cd, As, Cr and Ni are less than one. The organic constituents are within the guideline values but the values of coliform exceeded the limit. This research revealed the water need further treatment before it can be used for package portable water.

Keywords: Water, Pollution index, Organic and Microbiological.

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I. Introduction

Availability of drinking water in many developing countries has become critical and urgent problem to families and communities. This is a challenge of the 21st century both in term of management of the available water resources and the provision of access to drinking water and sanitation for the world population. The United Nation in 2002 recognized that access to water is an essential human right. Water is prime need of man and no living creature can survive without water (Babalola, 2007). Water is essential for life but good quality water is necessary to good health yet not many people have access to good drinking water. The implication of this problem results in many diseases which are prominent in the developing countries such as Asia, Africa and South America (mendie, 2005). It has been notice that provision of safe drinking water is index of development. Research evidence showed that in 2002 1.1 billion of the world population lacked access to improved drinking water, 2.6 billion lacked access to basic sanitation and 1.8 billion peoples die every year of water borne diseases of which 90% are children under 5 years mostly in the developing countries and 80% of the people without access to drinking water live in rural areas (Water Forum, 2003 and WHO, 2005). In most metropolitan cities in Nigeria pipe borne water is inadequate both in quality and quantity. Consequently water borne diseases such as cholera, typhoid and diarrhea are of epidemic proportion. It has been reported that over 80% of patient at University College Hospital Ibadan with typhoid are between 10-30 years with cases of mortality between 20-28% (Mendie, 2007). Typhoid fever remains a great socio-economic problem in the developing countries, other such as kidney and cardiovascular diseases including hypertension which were sometime uncommon are now rampant and all these have been attributed to unsafe drinking water. Poor water quality and sanitation have significant impact in children health and growth because water plays a key role in prevention of diseases (Oparaocha, Ireogbu and Obi, 2010).

Increase in human population has cause serious pressure in safe drinking water quality especially in the developing countries (Umeh, Okorie and Emessiani, 2005).The major sources of drinking water is the ground water which includes borehole, well etc and surface water which includes streams, rivers etc. Other treated form of water like the one from municipal or Government water board in each of the state are not sufficient due to increase in population and lack of constant supply as a result of inadequate chemicals for treatment and

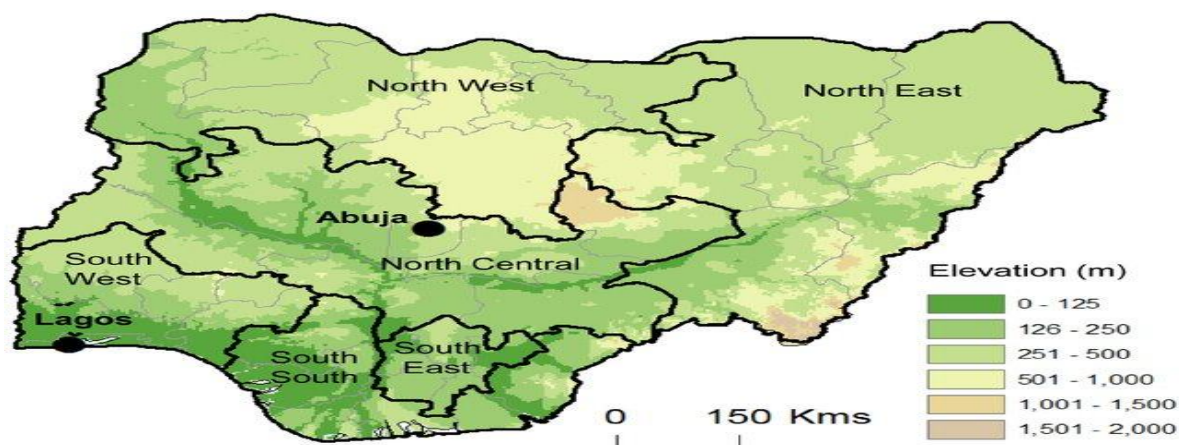
maintenance work has also made the provision of boreholes to be one of the most reliable source of drinking water in Nigeria.

II. Material And Method

All reagents used for this research are of analytical grade obtained from Merck Scientific unless stated otherwise.

Study Area

Samples were collected in some selected locations in north central Nigeria; this is made up of six states which are located at the central part of the country. The occupation of this part of the nation is mostly farming and with only few industries but with many solid minerals and this opened room for so many illegal mining around the North central states. This region is made up of Nasarawa, Benue, Plateau, Niger, Kogi, Kwara and Abuja (FCT). But for the purpose of this research samples were collected in some selected Locations across Nasarawa state, Southern senatorial zone of Plateau State, selected locations in Abuja. Most of the ethnics groups in this country are located in this region. The map of Nigeria indicating the North central states is shown below. Abuja being the headquarter of the country has attracted much populations' which majority resides in these neighboring state which formed the North central states.



SAMPLE COLLECTION AND PREPARATION.

Water samples from these selected locations were collected to determine the quality. A total of twenty five samples across various locations of the research were collected. The water sample collected into a plastic bottle washed previously with 2M HNO₃ and rinsed severally with deionized water. This is to remove the possibility of any contamination from the same bottles. The treatment required by samples after sampling before storage depends on the nature of analysis to be carried out. For example samples requiring elemental analysis such as alkaline earth and trace metals, concentrated HNO₃ acid of analytical grade was added to the samples making the pH less than 2. This addition stabilizes the samples and maintains the oxidation state of the elements and prevent precipitation. (Egereonu, Anuo and Egereonu, 2012).

(i) pH, Electrical Conductivity and Total dissolved solids (TDS)

A digital pH meter from Hach US was used to determine the pH of all the water samples, after calibration of the pH meter with pH buffer 4 and 7 solution as recommended by standard methods for the examination of water and wastewater (Ademoroti, 1996). While the electrical conductivity and total dissolved solids were determine using a digital conductivity meter (Sprite). These three physical parameters (pH, Electrical conductivity and Total dissolved solids) were all determined in situ, that is at the sample collection sites.

(ii) Total Hardness

50cm³ of the water samples were transferred into a beaker and 1cm³ buffer solution of ammonia was added. Three drops of Eriochrome Back T indicator was also added, and the solution was swirled properly. 0.01M EDTA solution was used as a titrant until the colour change from wine red to blue with bluish tinge remaining. Then the total hardness of the water sample was calculated.

$$\text{Total Hardness} = \frac{\text{vol. of titrant} \times 100}{\text{Vol. of sample (cm}^3\text{)}}$$

(iii) SULPHATE, NITRATE, FREE CHLORINE, FLUORIDE AND NITRITE

Sulphate, Nitrate, Free Chlorine, Fluoride and Nitrite were all determined spectrophotometrically using Hanna 83200 Multiparameter Bench top Photometer from Hanna instruments US. For sulphate determination, the water sample was developed using Hanna reagent HI 93751-0 added to 10mL of the water sample and after 5 minutes of the reaction the concentration was read from the photometer in mg/L.

For Nitrate, Free Chlorine, Fluoride and Nitrite appropriate reagents were added to develop the treated sample per instrument manufacturer manual and method for determination of each parameter were selected and the various concentrations were read from the Photometer in mg/L.

(iv) Cu, Mg, Mn, Fe, Zn, Cr and Ni

The determinations of these metals (Cu, Mg, Mn, Fe, Zn and Ni) were carried out using Hanna Multiparameter Bench top Photometer. 10mL each of the sample were measured into the cuvette and one pillow each of the corresponding reagents for each of these metals were added to developed the treated sample and the concentration of each metal were determined by selecting method corresponding to each of the element after the calibration of the instrument. The spectrophotometer work according to the principles of Beer Lambert law after obtaining a calibration curve for the standard the absorbance of the sample are taken and the concentration for each element is obtained from the curve. The reading is done digitally.

(v) Pb, Hg, Cd and As

The standard solution of each element under investigation was aspirated into a nebulizer burner assembly and the corresponding absorbance readings obtained from the digital readout of the Atomic Absorption Spectrophotometer (AAS) at the wavelength of the element under investigation. This was followed by aspiration of the water sample and the absorbance reading obtained from digital readout. The concentration of each of this element in the water sample was obtained by extrapolation from the standard curve. The elements determined included Lead, Mercury, Cadmium and Arsenic.

(vi) CHLORIDE

Chloride determination: To 50mL of the sample was five drops of a phenolphthalein indicator solution added and neutralized with 0.1N sulphuric acid to the colourless side of the phenolphthalein. 1mL of Potassium chromate indicator solution was added before titration with standard Silver Nitrate solution to the pinkish-yellow endpoint. A reagent blank titration was carried out in parallel to the sample titration. Chloride quantity was calculated as follows.

$$\text{Chloride mg/L} = \frac{(A-B) \times N \times 35460}{V}$$

A = Silver Nitrate solution in mL for sample titration

B = Silver Nitrate solution used for blank titration in mL

N = Normality of the Silver Nitrate solution

V = Sample volume in mL

(vii) TURBIDITY

Turbidity determination: A two part calibrated turbidity tube was used with calibrations from 5 – 25 turbidity units. The joined tubes were held over a white paper while slowly pouring the water sample into the tube until the black cross at the bottom was no longer visible. At this point the reading was taken from the side of the tube as the turbidity value of the water sample.

(viii) Microbiological.

All chemicals and reagents used were prepared according to manufacturer's specifications. The culture media used were sterilized using an autoclave at 121^oc for 15 minutes, while petri-dishes, pipettes and other glass wares were sterilized in a hot air oven at 160^oc for one hour. The standard plate count method was used for the analysis. In this method serial doubling dilutions of the respective water samples were made as follows. A row of sterile bottles containing 90ml of peptone water labeled 1-5, was set up for each water sample. Ten (10ml) volume of each test sample was added to the first bottles on each row containing 90ml of diluents to give 1:10 dilution. This was thoroughly mixed and 10ml volume was transferred from the first bottle on the same row to the second bottle and for the respective sample (1:10, 1:100, 1:1000, 1:10,000 and 1:100,000). Thereafter, 0.1ml of each diluted sample was inoculated in duplicates onto already sterile solidified nutrient and MacConkey agar using a fresh sterile 1ml pipette for each dilution. Using sterile glass spreader

, the inoculum was spread on the surface of the solid agar medium. The inoculated plates were incubated, some at 37⁰cfor 24hrs for the growth of faecal coliforms while some plates were incubated at 22⁰c for 24hrs for saprophytic coliforms. The viable organisms were counted using the electronic colony counter after incubation. The colony forming unit (cfu/ml) was calculated for each sample from the lowest concentration that showed viable growth (Oparaocha, Iroegbu and Obi, 2010)

(ix) ORGANIC CONSTITUENTS.

The organic constituents which include 2-Chlorophenol, 2, 4- Dichlorophenol, 2,4,6- trichlorophenol, Trihalomethane, Pesticides, Polyaromatic hydrocarbon, Detergent, Total organic carbon, Mineral oil and Radionuclide were determined using America Public Health Association method (APHA 6410) exception of Mineral oil APHA 64200 ,Total organic Carbon AOAC 972.43 and Polyaromatic hydrocarbon which was EPA 550.

III. Results And Discussion

The results of this research are presented in four different tables, physicochemical, elemental, organic and microbiological for each of the study area. Furthermore the degree of pollution was also computed by calculation of pollution index using the formula (ci(av)/li) where ci(av)= average concentration of the metal and li is the limit from Nigeria Industrial Standard for drinking water quality NIS 977: 2017 which is also presented in bar chart.

Table1.Physicochemical Properties of the water Samples (mg/L) from Plateau South Senatorial Zone.

Parameters/Sites	A	B	C	D	E	F	G	H	I	J	K	L	NIS
Color(TCU)	1.00	5.00	1.00	2.00	1.00	1.00	5.00	1.00	5.00	1.00	1.00	13.00	3.00
pH	6.00	6.63	4.41	7.44	5.93	5.50	7.52	7.50	3.95	3.99	7.70	8.02	6.5-8.5
Chloride(mg/l)	30.00	85.00	50.00	38.00	75.00	80.00	22.00	18.00	50.00	55.00	32.00	120.00	100.00
Fluoride(mg/l)	0.10	0.56	0.93	0.10	0.50	0.50	0.80	0.18	1.20	0.18	0.80	0.36	1.00
Hardness(mg/l)	11.00	340.00	140.00	33.00	152.00	155.00	15.00	20.00	2050.00	2000.00	95.00	32.00	100.00
Sulphate (mg/l)	5.00	35.00	10.00	0.50	75.00	70.00	10.00	30.00	75.00	75.00	20.00	43.00	100.00
H ₂ S(mg/l)	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.01
Turbidity (NTU)	2.00	4.50	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.50	5.00
Nitrate (mg/l)	5.60	5.00	123.60	0.00	132.80	132.80	2.30	3.90	69.50	132.80	8.20	5.22	10.00
Nitrite (mg/l)	0.00	11.00	0.00	0.02	0.01	0.01	0.10	0.00	0.01	0.01	32.00	0.24	0.02
TDS (mg/l)	5.00	834.00	702.00	8.00	413.00	417.00	273.00	166.00	512.00	505.00	153.00	396.00	500.00
Conductivity (vs/cm)	13.00	485.00	1156.00	17.00	622.00	632.00	25.00	10.00	778.00	775.00	280.00	474.00	1000.00
Free Chlorine (mg/L)	0.01	0.24	0.01	0.22	0.03	0.04	0.00	0.03	0.01	0.00	0.00	0.04	0.20

Table 2: Metals concentration of water samples from Plateau South Senatorial Zone (mg/L)

Parameter/Sites	A	B	C	D	E	F	G	H	I	J	K	L	NIS
Pb	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Cu	0.00	0.00	0.00	0.00	0.12	0.20	0.02	0.00	0.00	0.00	0.00	0.05	1.00
Mg	0.00	0.08	1.05	0.08	28.12	28.20	0.01	0.10	22.71	22.66	8.43	0.15	2.00
Mn	0.00	0.60	0.10	0.20	0.04	0.04	0.03	0.01	0.05	0.01	0.03	0.18	0.10
Fe	0.00	0.26	0.02	0.00	0.15	0.15	0.01	0.00	0.10	0.03	0.00	0.17	0.30
Zn	0.02	0.00	0.00	0.00	0.10	0.12	0.09	0.05	1.85	0.10	0.04	0.05	5.00
Hg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.001
Cd	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.03	0.003
As	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01
Cr	0.00	0.00	0.00	0.02	10.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Ni	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01

Table 3 Organic constituent of water samples from Plateau South Senatorial Zone (mg/L)

Parameter/Site	A	B	C	D	E	F	G	H	I	J	K	L	NIS
2-chlorodiphenol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
2,4- dichlorophenol	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.04
2,4,6-trichlorophenol	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02
Trihalomethane	0.00	0.00	0.001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.001
Phenol compounds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.001	0.001
Pesticides	0.00	0.00	0.00	0.00	0.0001	0.00	0.00	0.0001	0.00	0.0002	0.00	0.00	0.0005
PAH	0.00	0.003	0.00	0.001	0.00	0.00	0.002	0.00	0.002	0.00	0.00	0.001	0.007
Detergent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Total organic carbon	0.00	0.68	0.00	1.20	0.00	0.00	0.10	0.00	0.10	0.00	0.00	0.05	5.00
Radionuclide (Bq/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.10
Mineral Oil	0.00	0.00	0.00	0.001	0.001	0.00	0.00	0.001	0.001	0.001	0.00	0.001	0.003

Table 4 Result of microbiological status of water samples from Plateau South Senatorial Zone (Cfu/mL)

Parameter/Sites	A	B	C	D	E	F	G	H	I	J	K	L	NIS
Clostridium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfringenes													
E.Coli	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feecal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Streptococci													
Pseudomonas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
aeruginosa													
Coliform	20.00	15.00	2.00	7.00	3.00	2.00	0.00	0.00	0.00	4.00	0.00	3.00	0.00
Yeast/Mold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5 Physicochemical Properties of the water Samples (mg/L) from Nasarawa State.

Parameter/sites	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Color (TCU)	5.00	13.00	1.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	13.00	12.00	12.00	11.00
pH	6.50	8.52	9.15	8.14	7.49	3.73	7.11	7.35	5.91	6.00	6.55	8.52	4.25	6.56	6.76
Chloride(mg/l)	25.00	140.00	140.00	18.00	18.00	18.00	20.00	28.00	30.00	25.00	30.00	100	55.00	50.00	58.00
Fluoride(mg/l)	1.50	0.13	0.28	0.10	0.10	0.15	0.12	0.75	0.12	0.12	0.20	0.33	0.36	0.28	0.57
Hardness(mg/l)	15.00	30.00	34.00	110.00	400.00	145.00	148.00	1500	80.00	285	98.00	24.00	60.00	58.00	117
Sulphate (mg/l)	12.00	43.00	48.00	40.00	100.00	100.00	55.00	100.00	10.00	100	65.00	67.00	75.00	100	15.00
H ₂ S(mg/l)	0.02	0.01	0.03	0.00	0.00	0.02	0.00	0.02	0.01	0.01	0.00	0.00	0.02	0.00	0.02
Turbidity (NTU)	2.00	2.00	1.00	2.00	2.00	4.00	3.00	5.00	5.00	5.00	3.00	2.00	2.00	2.00	1.50
Nitrate (mg/l)	15.30	21.50	13.20	16.00	11.10	42.20	58.30	138.20	1.10	14.10	1.10	15.90	126.50	26.50	3.90
Nitrite (mg/l)	3.00	0.05	0.22	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.10	0.00	0.00	0.00
TDS (mg/l)	44.00	92.00	155.00	140.00	200.00	460.00	1178	550	217.00	508	230	122	388	201	289
Conductivity (µs/cm)	93.00	183.00	360.00	241.00	333.00	678.00	1357	920	359	728	344	244	275	156	554
Free Chlorine (mg/l)	0.01	0.08	0.26	0.06	0.57	0.06	0.50	0.06	0.03	0.08	0.06	0.02	0.21	0.22	0.03

Table 6 Metals concentration of water samples from Nasarawa State (mg/L)

Parameter/sites	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Pb	0.00	0.009	0.01	0.16	0.26	0.31	0.39	0.45	0.23	0.28	0.26	0.01	0.00	0.00	0.01
Cu	0.50	0.012	0.004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.006	0.00	0.00	0.08
Mg	0.55	0.34	0.28	8.25	10.15	68.00	16.37	18.57	5.35	13.62	6.17	0.56	0.00	0.00	0.12
Mn	0.10	0.11	0.16	0.01	0.00	0.04	0.08	0.03	0.10	0.04	0.01	0.17	0.80	0.50	0.10
Fe	0.15	0.32	0.34	0.82	1.31	0.63	1.07	0.25	0.17	0.92	0.72	0.36	0.28	0.25	0.06
Zn	0.10	0.08	0.08	0.17	0.12	0.12	0.10	0.10	0.16	0.18	0.12	0.17	0.38	0.001	1.05
Hg	0.00	0.00	0.002	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cd	0.001	0.00	0.004	0.00	0.001	0.00	0.001	0.001	0.002	0.002	0.001	0.00	0.001	0.00	0.002
As	0.00	0.007	0.002	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.003	0.001	0.00	0.00
Cr	0.00	6.05	0.004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.12	0.005	0.005	0.01
Ni	0.00	0.00	0.001	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01

Table 7 Organic constituent of water samples from Nasarawa State (mg/L)

Parameter/sites	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
2-chlorodiphenol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4- dichlorophenol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4,6-trichlorophenol	0.01	0.00	0.002	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.01	0.001
Trihalomethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Phenol compounds	0.00	0.00	0.001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.001
Pesticides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.002	0.00	0.004	0.002	0.002	0.002	0.002	0.003	0.002	0.002	0.00	0.00	0.00	0.00	0.003
Detergent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total organic carbon	0.15	0.00	0.03	0.12	0.12	0.12	0.12	0.12	0.10	0.10	0.15	0.00	0.55	0.55	0.003
Radionucleide (Bq/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mineral oil	0.00	0.00	0.001	0.001	0.001	0.001	0.001	0.001	0.00	0.001	0.00	0.00	0.00	0.00	0.001

Table 8 Result of microbiological status of water samples from Nasarawa State (Cfu/mL)

Parameters/sites	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Clostridium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfringenes															
E.Coli	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feecal Streptococci	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomonas aeruginosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coliform	8.00	8.00	3.00	50.00	0.00	0.00	1.00	6.00	4.00	17.00	2.00	3.00	7.00	4.00	5.00
Yeast/Mold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 9 Physicochemical Properties of the water Samples (mg/L) from Abuja

Parameters/sites	A	B	C	D	E	F	G	H
Color (TCU)	2.00	13.00	1.00	1.00	1.00	13.00	9.00	5.00
pH	7.05	8.56	7.65	6.70	6.90	7.61	7.80	7.84
Chloride(mg/l)	60.00	100.00	0.01	0.01	0.01	60.00	35.00	60.00
Fluoride(mg/l)	0.11	0.21	0.82	0.52	0.41	0.86	1.02	0.32
Hardness(mg/l)	18.00	26.00	20.00	16.00	20.00	51.00	41.00	120.00
Sulphate (mg/l)	10.00	26.00	0.00	0.00	0.00	0.00	0.00	0.00
H ₂ S(mg/l)	0.00	0.01	0.00	0.01	0.02	0.01	0.01	0.03
Turbidity (NTU)	1.00	1.00	1.00	1.00	1.00	5.00	3.00	1.00
Nitrate (mg/l)	5.59	19.22	2.90	6.40	14.00	0.00	13.10	31.02
Nitrite (mg/l)	0.02	0.23	0.00	2.00	0.00	0.00	0.00	7.00
TDS (mg/l)	43.00	96.00	51.00	50.00	55.00	95.00	100.00	132.00
Conductivity (vs/cm)	85.00	183.00	475	69.00	72.00	103.00	71.00	172.00
Free Chlorine (mg/l)	0.05	0.13	0.01	0.01	0.01	0.00	0.06	0.03

Table 10 Metals concentration of water samples from Abuja (mg/L)

Parameters/sites	A	B	C	D	E	F	G	H
Pb	0.002	0.004	1.90	1.60	1.80	0.006	0.002	0.008
Cu	0.02	0.06	0.00	0.00	0.00	0.90	0.12	0.14
Mg	1.56	0.26	1.05	1.01	1.00	0.12	0.18	0.27
Mn	0.05	0.15	0.50	0.40	0.80	0.06	0.16	0.16
Fe	0.05	0.34	0.00	0.02	0.01	0.12	0.02	0.07
Zn	0.03	0.04	0.00	0.00	0.00	1.14	2.00	1.05
Hg	0.00	0.001	0.00	0.00	0.00	0.002	0.002	0.002
Cd	0.00	0.001	0.00	0.002	0.00	0.012	0.001	0.003
As	0.001	0.006	0.01	0.01	0.01	0.006	0.004	0.004
Cr	0.00	0.00	0.001	0.001	0.001	0.001	0.001	0.001
Ni	0.01	0.00	0.001	0.00	0.001	0.00	0.00	0.00

Table 11 Organic constituent of water samples from Abuja (mg/L)

Parameter/Sites	A	B	C	D	E	F	G	H
2-chlorodiphenol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4- dichlorophenol	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4,6-trichlorophenol	0.00	0.02	0.00	0.01	0.01	0.001	0.001	0.002
Trihalomethane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Phenol compounds	0.00	0.001	0.001	0.00	0.001	0.001	0.001	0.001
Pesticides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PAH	0.00	0.001	0.003	0.002	0.003	0.005	0.005	0.001
Detergent	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total organic carbon	0.00	0.01	0.28	0.28	0.20	1.05	0.65	1.05
Radionuclide (Bq/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mineral oil	0.00	0.00	0.00	0.001	0.001	0.002	0.001	0.001

Table 12 Result of microbiological status of water samples from Abuja (Cfu/mL)

Parameter/Sites	A	B	C	D	E	F	G	H
Clostridium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Perfringenes								
E.Coli	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feacal Streptococci	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomonas aeruginosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coliform	0.00	2.00	30.00	20.00	10.00	8.00	2.00	3.00
Yeast/Mold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

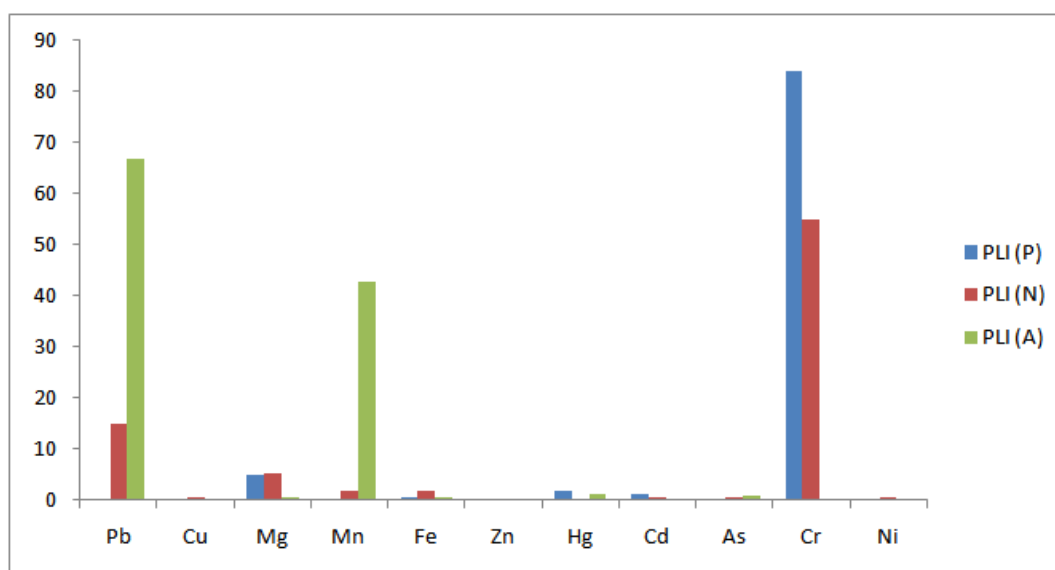


Figure 2 Pollution index

PLI (P) mean pollution index of water from Plateau state, PLI (N) mean pollution index from Nasarawa State and PLI (A) mean pollution index of water from Abuja.

The results of the physicochemical properties of the water from Plateau South Senatorial zone, Nasarawa State and Abuja are indicated in Table 1, 5 and 9. The water samples from Plateau have the highest pH value of 8.02 and least value of 3.95. Sample B (6.63), D (7.44), G (7.62), H (7.50), K (7.70), and L (8.02) fall within Nigeria Industrial Standard limit for portable drinking water of 6.5 – 8.5 (NIS 977:2017). While samples A (6.00), C (4.41), E (5.93), F (5.50), I (3.95) and J (3.99) have values below the recommended for portable drinking water. The samples from Nasarawa state reviewed the pH range from 3.37 to 9.15 among which samples A (6.50), D (8.14), E (7.49), G (7.11), H (7.35), K (6.55), N (6.56) and O (6.76) are within the standard while F (3.73), I (5.91), J (6.00) and M (4.25) are below the standard as samples B (8.52), C (9.15) and L (8.52) are above the standard. In the other hand samples from Abuja has the pH range from 6.70 to 8.56. The Abuja water samples generally were within the NIS 977:2017 standard with the exception of sample B (8.56) whose pH is slightly above the limit of 8.50. pH generally referred to the acidity or alkalinity of the water, those samples that are higher than 8.50 but less than 9.50 can be used for alkaline drinking water. pH play an important role in water treatment whether, disinfection, coagulation, chlorination, ozonation, aeration etc.

The variations in Chloride concentrations is indicated in Tables 1, 5 and 9. Samples from Plateau South Senatorial Zones is within the standard of 100mg/L except sample L with the concentration of 120mg/L, sample B and C of Nasarawa state were also above the standard having the concentrations of 140mg/L each while that of Abuja were all within the standard limit of 100mg/L for portable drinking water. Among the three states the highest Chloride concentration was 140mg/L which was reported for sample B and C in Nasarawa State followed by sample L in Plateau with the concentration of 120mg/L and least in samples from Abuja with concentrations of 0.01mg/L each for sample C, D and E. Still on Table 1, 5 and 9 it can be seen that the concentrations of Fluoride is from 0.10 to 1.20 for samples from Plateau South Senatorial Zones, all are within the standard limit of 1.00mg/L except sample I with the concentration of 1.20mg/L. For samples from Nasarawa State the concentration varies from 0.10 to 1.50mg/L, all are less than 1.00 except sample A with the value of 1.50mg/L. Meanwhile sample G in Abuja has the value of 1.02mg/L while other meets the standard of 1.00mg/L. The hardness which results from the presence of calcium and magnesium ions in water varies for the study areas: The samples from Plateau have the concentrations of A(11), B(340), C(140), D(33), E(152) F(155), G(15), H(20), I(2050), J(2000), K(95), L(32) all in mg/L, the samples A, D, G, H, K and L are within the guideline limit of 100mg/L but samples B, C, E, F, I and J are above the limit. For Nasarawa State, sample D(110), E(400), F(145), G(148), H(1500), J(285) and O(117) are above 100mg/L limit but sample A(15), B(30), C(34), I(80), K(98), L(24), M(60) and N(58) are within the guideline value of 100mg/L set by Nigeria Industrial Standard for portable drinking water (NIS 977:2017). Abuja samples have the concentrations of hardness from 16 – 120mg/L only sample H (120mg/L) that has the value higher the guideline value. The turbidity of Plateau, Abuja and Nasarawa samples are within the guideline values (1 – 5NTU). The Nitrate and Nitrites which causes eutrophication may be as a result of agricultural practices. The samples from Plateau have values of nitrate higher than 10mg/L set by NIS 977:2017 in sampling point C (123), E (132.80), F (132.80), I(69.50), and J(132.80). Samples from Nasarawa have values above this limit with the exception of samples I and K having 1.10mg/L each while Abuja have the following: sample A(5.59), C(2.90), D(6.40), and F(0.00) below the limit. For Nitrite the samples from Plateau have values higher than the limit of 0.02mg/L in sampling point B (11.00), K (32.00) and L (0.24) all in mg/L. For samples from Nasarawa only sample A and C have values of 3.0 and 0.22mg/L which is above the limit and Abuja samples have higher values in point B(0.23), D(2.00) and H(7.00). Those with higher values will need further treatment like disinfection and ion exchange before it can be used for portable drinking water. Fluoride which help in preventing tooth decay have values within the limit concentration for water Samples from Plateau have values within the limit of 1.00mg/L except sample I(1.20), sample from Nasarawa have higher values in sampling point A(1.50) while sample G(1.02) in Abuja have value above the limit. Sulphate and TDS of all the study areas are within the guidelines limits of 100mg/L and 1000us/cm.

For the elemental analysis, Table 2, 6 and 10 for samples from Plateau, Nasarawa and Abuja respectively. The results for lead (Pb) in Plateau as indicated in Table 2 shows all the study sites has the concentrations within the guidelines value of 0.01mg/L but for samples from Nasarawa sample D (0.16), E (0.26), F (0.31), G (0.39), H (0.45), I (0.23), J (0.28) and K (0.26) have values above the limit of 0.01mg/L as indicated in Table 6 while Abuja samples shows that sample C (1.90), D (0.60) and E (1.80) are above 0.01mg/L as shown in Table 10. The pollution index as indicated in Figure 2 shows that water samples from Nasarawa and Abuja are polluted with Lead (Pb) with the values of pollution index of 14.79 and 66.53 respectively. Other element with pollution index more than one are Mg (4.65), Hg (1.67), Cd (1.11) and Cr (83.67) in Plateau, Mg (4.49), Mn (1.50), Fe (1.70) and Cr (54.63) in Nasarawa and Mn (42.45) in Abuja as indicated in Figure 2. Abuja samples are less in pollution index and when their individual elemental concentration are observed closely as indicated in Table 10 all the concentrations of these metals are within the

guidelines limit for portable drinking water. For samples from Nasarawa the following samples has higher values of Mg, D (8.25), E (10.15), F (68.00), G (16.37), H (18.57), I (5.35), J (13.62) and K (6.17) all in mg/L as shown in Table 6. While for Plateau sample E (28.12), F (28.20), I (22.71), J (22.66) and K (8.43) in mg/L respectively. Iron (Fe) were more polluted in samples from Nasarawa with values higher than guidelines limit in sampling point B (0.32), C (0.34), D (0.82), E (1.31), F (0.63), G (1.07), J (0.92), K (0.72) and L (0.36) as against the limit of 0.30mg/L while for Abuja only sampling point B (0.34mg/L) has a value above the guideline limit. All other elements studied were within the maximum permissible limit for portable drinking water with the exception of Arsenic in sampling point L (0.04mg/L) as against the limit of 0.01mg/L and Chromium in sampling point E (10.00mg/L) as against 0.01 in Plateau as indicated in Table 2. Samples from Nasarawa shows contamination with Chromium in sampling point B (6.05) and L (2.12) as indicated in Table 6.

Generally from the results obtained from the organic constituents of water as from these three states, it shows the water are not polluted with organic constituents as shown in Table 3, 7 and 11.

The microbial results as indicated in Table 4, 8 and 12 showed the water is contaminated with coliform bacteria in sample A (20.00), B (15.00), C (2.00), D (7.00), E (3.00), F (2.00) and J (4.00) in Plateau, Nasarawa showed contamination with same coliform bacteria in sample A (8.00), B(8.00), C (3.00), D (50.00), G (1.00), H (6.00), I (4.00), J (17.00), K (2.00), L (3.00), M (7.00), N (4.00) and O (5.00) all in *Cfu/mL* while Abuja samples have coliform bacteria in all the samples investigated except sample A, other samples with coliform bacteria are B (2.00), C (30.00), D (20.00), E (10.00), F (8.00), G (2.00) and H (3.00), these are all above the recommended value of *0cfu/mL* by the Standard Organization of Nigeria stipulated in NIS 977:2017.

IV. Conclusion

The results of water quality from Plateau South Senatorial Zone, Nasarawa State and Abuja, suggests the water is polluted with coliform bacteria and some of the elementals whose concentration are higher than the recommended values, hence the water will need further purification methods like filtration and disinfection to reduce the elemental concentrations and to also destroyed the bacteria in order to serve as a good portable drinking water.

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