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Assessment of Water Quality in a Nigerian Tertiary Hospital

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ABSTRACT

Water quality of a Nigerian tertiary Hospital with over three thousand staff and up to one thousand patients was investigated. The main source of water supply were the boreholes. Samples were collected from 6 Boreholes and two different brands of sachet water (packaged drinking water) and were tested for the following; pH, total solids, turbidity, total suspended solids, electrical conductivity, hardness, chloride, nitrate, sulphate, BOD, COD, DO, Iron, Copper, Lead, E. coli and Total coliform. The results of the evaluations were compared with the World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) to establish its suitability for human consumption. Statistical tests were conducted to compare experimental results with standards. From the tests conducted, five samples; A, C, D, E and G have higher mean values for lead (Pb) more than prescribed limit of 0.05mg/l by WHO. Microbial in Sample B, C, D, E, F, and G were above the required standard of 0cfu in 100ml. From all the analysis conducted only sample H was found to be in conformity with the WHO and NSDWQ standards in terms of both the physicochemical and the bacteriological analysis. Lead can be removed by reverse osmosis process and the microbial contaminants can be removed by either boiling or by disinfection using chlorine.

Keywords**:** water quality, boreholes, turbidity, total suspended solids, electrical conductivity

Introduction

Water is an indispensable commodity, which should be easily accessible, adequate, and free of contamination, safe, affordable, and available throughout the year in order to sustain life [1]**.** In developing countries, thousands of children under five years die every day due to drinking contaminated water Thus lack of safe drinking water supply, basic sanitation and hygienic practices is associated with high morbidity and mortality from excreta related diseases [2]. Water serves as a vehicle for the transmission of diseases like typhoid, cholera, rashes, diarrhea, dysentery, gastro-enteritis etc, it has caused stagnation of economic developments of nations [3]. About 22 African countries, including Malawi, fail to provide safe drinking water to half of their population [4], in Nigeria, 57million people do not have access to safe water. Safe (quality) drinking water is that which does not present any significant health risk over a life time consumption, including any sensitivities that may occur in different stages of life [5]. It is water which is free from pathogenic microbes, hazardous chemicals/substance and aesthetically acceptable (i.e. pleasing to sight, odourless and good taste). It is important that this type of water should not only be available, but also enough quantity all the time [6]. Water quality can be defined by a range of variables which limit water use, each use will have its own demands and influences on water quality, also, research finding showed physical parameters are responsible for seasonal variations in water quality in Benue. Research on water quality and pollution is very paramount, particularly in the developing countries like Nigeria where water availability to serve both domestic and industrial demands continues to be a problem of great concern. Therefore, continuous assessment of the quality of water supplied to the public is very important and necessary, in order to meet the United Nations' campaign for providing good quality drinking water for all by the twenty first century [8]. The quality of water plays an important role because its mere availability does not qualify it for use, Biswas, (1998) [9] reported that the qualities of water defines the extent of the uses it could be put. The main elements of water quality monitoring are: on-site measurements, the collection and analysis of water samples, the study and evaluation of the analytical results, and the reporting of the findings. The importance attached to quality depends on the actual and planned use or uses; water that is to be used for drinking should not contain any chemical or micro-organisms that could be hazardous to health. Borehole water is ground water deposited and found in the aquifer system [10] and derived through mechanical or electrical driven pumps [11;12;13]. Health institution stands for the health, safety, and wellbeing of human, it is important to ascertain the safety of drinking water as it is fundamental to the protection of public health [14].

The study seeks to investigate the portability of different water sources in a Nigerian Tertiary hospital; to assess the physico-chemical and microbial quality of borehole water and sachet water (packaged drinking water marketed by vendors), evaluate its compliance with World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) recommended standards, recommend feasible solutions to improve water quality to meet the expected standard.

Materials and methods

Study area

The study area is located between latitude 08^0 25'N and 08^0 32'N, longitude 04^0 30'E and 04^0 41'E. The hospital is a major hospital which trains medical students and offers health care services. The Hospital has over a thousand employees which include various professionals like Doctors, Nurses, Laboratory Scientists, Pharmacists, Physiotherapists, and Imaging Scientists.

Others are: social workers, Nutritionists, Caterers, Accountants, Administrators etc. Services such as security and cleaning are out sourced to private companies. The hospital renders health care services to an average of about one thousand patients per day.

Sampling Points

Samples were taken from six supply boreholes and two available different brands of sachet water (Figures 1 and 2). Samples from boreholes located at;

A. latitude 8^0 32’17’’ longitude $4^0$38’55’’

B. latitude 8^0 32’24’’ longitude $4^0$38’40’’

C. latitude 8^0 32’11’’ longitude $4^0$38’51’’

D. latitude 8^0 32’13’’ longitude $4^0$38’53’’

E. latitude 8^0 32’15’’ longitude $4^0$38’43’’

F. latitude 8^0 32’18’’ longitude $4^0$38’39’’

Sachet water samples G and H were obtained from various outlets within the study area.

Fig.1: Borehole “F”

Fig. 2: Sachet water

Sampling Technique and Analysis

A case study research method was adopted for water samples for six existing supply boreholes and two brands of sachet water sold to staff and patients in the hospital. Plastic bottles of 0.75-liter capacity with stopper were used for collecting samples. Each bottle was washed with 2% Nitric acid and then rinsed three times with distilled water. The bottles were then preserved in a clean place. The bottles were filled leaving no air space, and then the bottles were sealed to prevent any leakage. Each sample was labelled according to the location, preserved at 4^0C and transported to the Chemistry Laboratory, University of Ilorin to determine the physical, chemical, and bacteriological parameters in each sample. The physical parameters evaluated include: Turbidity, Total solid, dissolved solid and Suspended solid while the chemical parameters include: pH, Dissolved oxygen, Nitrate, Chloride, Sulphate, Electric conductivity, Total Hardness, Calcium hardness, Magnesium hardness, Lead, Copper, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Iron. The bacteriological parameters include: Biological Oxygen Demand (BOD), E-coli and Total coliform using standard laboratory procedures. Some of the parameters were recorded in-situ at the point of sampling while the analyses of other various water quality parameters were conducted following standard analytical methods as described by Kodarkar *et al.*, (2008) and APHA (1998 [15,16]. The results of the evaluations were compared with the maximum values of the International standards for drinking water and Nigerian standards of water quality guidelines as specified by World Health Organization (WHO), 2007 and Nigerian Standard for Drinking Water Quality (NSDWQ) respectively to establish its suitability for human consumption. Three samples per location were collected on different days except for sample H, and the mean per location was calculated.

Statistical comparison of experimental results with standards

Experimental results were compared with standards to ascertain if there are significant discrepancies between the values. A T-test statistic was used to check whether the deviation between experiment and standard is due to chance or the water samples are polluted.

The T-statistic statistics is computed using equation (1) [17;18].

$$T = \frac{\overline{X} - \mu_0}{S/\sqrt{n}} \quad (1)$$

Where X is the average computed from the collected sample, μ_0 is the value from a specified standard, S is the standard deviation computed from the collected sample and n is the number of samples collected.

Under the null hypothesis, it is assumed that there is no significant difference between experimental results and the standards. If the computed value of the statistic using equation (1) falls in the critical region, the null hypothesis is rejected at the specified level of significance and it is concluded that there is significant discrepancy between experiment and standard [18]. A 5% level of significance was adopted for the tests in this study. For a two-tailed test using 3 sample points, the degree of freedom is 2 and the critical region is specified as $T_{\alpha/2} < -4.303$ and $T_{\alpha/2} > 4.303$.

Results and discussion

The results of the study are presented in tables 1 to 6. Table 2 shows the mean values of physico-chemical parameters showed in table 1 and the comparative, acceptable global standards. pH is a measure of the intensity of acidity or alkalinity, and measures the concentration of hydrogen ions in water. All sampling points showed values within the acceptable limit by WHO and NSDWQ. Total Hardness in the study varied between 0.65 to 1.51, acceptable by comparative standards, however, acceptability also varies considerably from one community to another depending on local conditions. High concentrations of chloride give a salty taste to water and beverages. Taste thresholds for the chloride anion depend on the associated cation and are in the range of 200–300 mg/litre for sodium, potassium, and calcium chloride. Concentrations more than 250 mg/litre are increasingly likely to be detected by taste. In this study, the mean values gotten for chloride varied between 1.67 to 2.39mg/l which is within the permissible limit of 250mg/litre by comparative standards. Sulphates occur naturally in ground water and may be discharged into water through industrial wastes and atmospheric deposition. The presence of sulfate in drinking-water may also cause noticeable taste at concentrations above 250 mg/litre and may contribute to the corrosion of distribution systems (WHO, 2003). The sulphate mean values in this study varied between 28.20 to 38.02 mg/l which is within the permissible limit of 500 mg/litre. Conductivity is the degree to which a water sample can carry an electric current. The magnitude of the conductivity of a sample is a function of the number of ions present in the sample. High conductivity can be an indicator of excessive mineralization from either natural or industrial sources. The mean values gotten from this study ranged from 50.2 to 68.65 (µS/cm) which falls within the permissible limit of 1800 µS/cm. Turbidity measurement reflects the transparency of water. The appearance of water with turbidity less than 5 NTU is acceptable in compliance with WHO standard. The turbidity mean values in this study varies between 3.6 to 4.92. Total Dissolved Solid (TDS) may be considered as salinity indicator for classification of groundwater. The TDS in groundwater is due to the presence of Calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride and Sulphate ions. TDS in drinking-water originate from natural sources, sewage, urban runoff and industrial wastewater. The TDS mean value obtained within the hospital of study varied between 2.68 to 7.86mg/l which is within the permissible limit of 500mg/l.

The nitrate concentration in groundwater and is normally low but can reach high levels because of leaching or runoff from agricultural land or contamination from human or animal wastes as a consequence of the oxidation of ammonia and similar sources. Permissible limit for nitrate is 45 and 50 mg/litre as required by WHO and NSDWQ respectively. The mean value for d nitrate ion in this study ranged from 0.50 to 1.36 mg/litre. Dissolved oxygen content in water reflects the physical and biological processes prevailing in water and is influenced by aquatic vegetation. The mean values gotten from this study ranged from 29.40 to 38.43 mg/l for the water samples higher than the specified 5.0mg/l. Higher COD levels mean a greater amount of oxidable organic material in the sample, which will reduce dissolved oxygen (DO) level. From this study the mean values for the COD varied between 2.35 to 25.36 mg/l. Two samples have low mean values for COD which imply that there was less chemical activity in those water samples. BOD gives a quantitative index of the degradable organic substances in water and is used as a measure of waste strength. The BOD mean values varied between 17.67 to 24.83 mg/l.

SMU Medical Journal, Volume – 4, No. – 2, July, 2017 **Table (1-3) pages: P. 127 - 133**

Table 1: Characteristics of measured water parameters

Parameter	Sample A			Sample B			Sample C			Sample D			Sample E			Sample F			Sample G			Sample H
	A1	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**	**D1**	**D2**	**D3**	**E1**	**E2**	**E3**	**F1**	**F2**	**F3**	**G1**	**G2**	**G3**	
pH value	6.50	6.60	6.61	6.55	6.62	6.64	6.60	6.68	6.65	6.54	6.66	6.66	6.62	6.65	6.64	6.65	6.68	6.67	6.85	6.80	6.81	6.80
Total hardness (mg/l)	1.40	1.55	1.57	0.96	1.36	1.33	0.40	1.35	1.38	1.24	1.44	1.45	0.80	1.25	1.27	0.36	1.40	1.42	0.60	0.80	0.82	0.65
Calcium ion(mg/l)	0.60	0.84	0.85	0.56	0.78	0.78	0.22	0.66	0.65	0.54	0.56	0.58	0.05	0.68	0.66	0.18	0.62	0.64	0.32	0.30	0.31	0.33
Magnesium ion (mg/l)	0.80	0.71	0.72	0.40	0.58	0.55	0.18	0.69	0.73	0.70	0.88	0.87	0.03	0.51	0.61	0.18	0.78	0.78	0.28	0.50	0.51	0.32
Chloride ion (mg/l)	2.40	2.18	2.19	1.60	1.82	1.83	2.24	2.28	2.30	2.36	2.40	2.41	1.28	1.36	1.36	1.64	1.68	1.69	2.12	2.10	2.14	2.32
Sulphate ion(mg/l)	36.50	38.80	38.76	35.80	37.40	37.38	35.75	36.90	36.92	36.10	37.55	37.58	35.70	38.10	38.22	35.55	38.10	38.13	30.20	28.60	28.56	28.20
Electrical conductivity (μS/cm)	65.80	65.92	65.90	68.50	68.70	68.74	66.80	66.92	66.90	67.20	67.50	67.55	67.80	67.40	67.43	66.90	67.90	67.94	50.40	50.44	50.41	50.20

Turbidity (NTU)	4.86	4.94	4.96	4.30	4.85	4.86	4.10	4.52	4.54	4.45	4.45	4.48	4.40	4.38	4.36	3.90	4.32	4.34	3.40	3.92	3.90	3.60
Dissolved solid (mg/l)	7.65	7.96	7.98	5.80	6.90	6.91	7.00	7.20	7.22	6.60	6.88	6.89	5.96	6.30	6.27	5.15	5.86	5.88	2.20	2.94	2.90	2.84
Nitrate ion(mg/l)	1.35	1.35	1.38	1.20	1.26	1.25	1.25	1.27	1.27	1.30	1.33	1.32	1.32	1.30	1.31	1.25	1.26	1.26	0.48	0.60	0.62	0.50
Suspended solid(mg/l)	6.30	4.99	4.99	4.80	4.86	4.87	3.20	4.30	4.31	4.80	4.66	4.63	4.74	4.74	4.78	4.85	4.66	4.60	2.10	1.30	1.38	1.66
Total solid(mg/l)	13.95	12.94	12.97	10.60	11.76	11.87	10.20	11.50	11.53	11.40	11.54	11.52	10.70	11.04	11.05	10.00	10.52	10.48	4.30	4.29	4.28	4.50
DO (mg/l)	36.7	32.40	32.30	35.9	34.30	34.25	38.6	30.80	30.82	37.4	38.90	39.00	36.3	37.40	37.50	36.2	30.10	30.15	28.4	28.60	28.70	29.40
COD (mg/l)	25.60	23.66	24.65	25.40	24.44	23.45	26.10	22.48	27.50	26.20	24.50	22.50	25.30	23.46	23.48	25.30	21.38	22.35	2.80	2.12	2.14	2.60
BOD (mg/l)	21.20	20.10	24.20	25.60	25.50	23.40	25.40	23.30	22.10	24.30	23.10	22.10	23.10	23.70	26.10	25.70	24.41	23.10	19.90	17.60	15.5	20.1

Samples from boreholes are labeled sample A, sample B, sample C, sample D, sample E and sample F
Samples from sachet water are labeled sample G and sample H.

Table 2: Statistical values of measured water parameters

Parameter	**Sample A**			**Sample B**			**Sample C**			**Sample D**			**Sample E**		
	Std.	Tstat.	Concl.	Std.	Tstat.	Concl.	Std.	Tstat.	Concl.	Std.	Tstat.	Concl.	Std.	Tstat.	Concl.
pH value	WHO		==	WHO		==	WHO		==	WHO		==	WHO		==
	NSDWQ		==	NSDWQ		==	NSDWQ		==	NSDWQ		==	NSDWQ		==
Total hardness (mg/l)	WHO	-5564.24	<<	WHO	-2322.90	<<	WHO	-929.06	<<	WHO	-4366.20	<<	WHO	-1947.92	<<
	NSDWQ	-2768.08	<<	NSDWQ	-1156.72	<<	NSDWQ	-462.91	<<	NSDWQ	-2173.04	<<	NSDWQ	-970.36	<<

Calcium ion (mg/l)	WHO	-908.45	<<	WHO	-1013.09	<<	WHO	-513.62	<<	WHO	-6446.69	<<	WHO	-360.52	<<
	NSDWQ	-908.45	<<	NSDWQ	-1013.09	<<	NSDWQ	-513.62	<<	NSDWQ	-6446.69	<<	NSDWQ	-360.52	<<
Magnesium ion (mg/l)	WHO	-1027.27	<<	WHO	-529.66	<<	WHO	-166.44	<<	WHO	-499.67	<<	WHO	-165.45	<<
	NSDWQ	19.08	>>	NSDWQ	5.57	>>	NSDWQ	1.88	==	NSDWQ	10.56	>>	NSDWQ	1.02	==
Chloride ion (mg/l)	WHO	-3454.08	<<	WHO	-3307.55	<<	WHO	-14044.78	<<	WHO	-16209.88	<<	WHO	-9325.00	<<
	NSDWQ	-3454.08	<<	NSDWQ	-3307.55	<<	NSDWQ	-14044.78	<<	NSDWQ	-16209.88	<<	NSDWQ	-9325.00	<<
Sulphate ion (mg/l)	WHO	-213.11	<<	WHO	-307.79	<<	WHO	-422.74	<<	WHO	-333.58	<<	WHO	-198.19	<<
	NSDWQ	-81.54	<<	NSDWQ	-119.13	<<	NSDWQ	-164.15	<<	NSDWQ	-128.83	<<	NSDWQ	-76.35	<<
Electrical conductivity (µS/cm)	WHO	-14389.80	<<	WHO	-7157.54	<<	WHO	-14362.86	<<	WHO	-4873.09	<<	WHO	-4139.60	<<
	NSDWQ	-25166.12	<<	NSDWQ	-12545.70	<<	NSDWQ	-25139.17	<<	NSDWQ	-8533.06	<<	NSDWQ	-7249.41	<<
Turbidity (NTU)	WHO		==	WHO		==	WHO		==	WHO		==	WHO		==
	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS
Dissolved solid (mg/l)	WHO	-4607.04	<<	WHO	-1339.68	<<	WHO	-7017.03	<<	WHO	-5189.29	<<	WHO	-4543.87	<<
	NSDWQ	-4607.04	<<	NSDWQ	-1339.68	<<	NSDWQ	-7017.03	<<	NSDWQ	-5189.29	<<	NSDWQ	-4543.87	<<
Nitrate ion (mg/l)	WHO	-4364.00	<<	WHO	-2358.04	<<	WHO	-6560.50	<<	WHO	-4953.22	<<	WHO	-7567.33	<<
	NSDWQ	-4864.00	<<	NSDWQ	-2627.45	<<	NSDWQ	-7310.50	<<	NSDWQ	-5520.17	<<	NSDWQ	-8433.36	<<

Suspended solid (mg/l)	WHO	-1132.61	<<	WHO	-22653.21	<<	WHO	-1346.74	<<	WHO	-9454.62	<<	WHO	-37143.50	<<
	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS
Total solid (mg/l)	WHO		NS	WHO		NS	WHO		NS	WHO		NS	WHO		NS
	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS
DO (mg/l)	WHO	19.86	>>	WHO	55.03	>>	WHO	10.94	>>	WHO	64.61	>>	WHO	83.42	>>
	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS
COD (mg/l)	WHO	42.20	>>	WHO	41.62	>>	WHO	16.29	>>	WHO	21.88	>>	WHO	37.83	>>
	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS
BOD (mg/l)	WHO	13.74	>>	WHO	27.65	>>	WHO	19.29	>>	WHO	28.57	>>	WHO	21.06	>>
	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS	NSDWQ		NS

Table 2 (contd.): Statistical values of measured water parameters

Parameter	**Sample F**			**Sample G**			**Sample H**			**Standard**	**Standard**
	Std.	Tstat.	Concl.	Std.	Tstat.	Concl.	Std.	Tstat.	Concl.	**WHO**	**NSDWQ**
pH value	WHO		==	WHO		==	WHO			6.5-8.5	6.5-8.5
	NSDWQ		==	NSDWQ		==	NSDWQ				
Total hardness (mg/l)	WHO	-854.00	<<	WHO	-4260.68	<<	WHO			300	150
	NSDWQ	-425.48	<<	NSDWQ	-2125.07	<<	NSDWQ				
Calcium ion (mg/l)	WHO	-496.43	<<	WHO	-12936.69	<<	WHO			75	75

	NSDWQ	-496.43	<<	NSDWQ	-12936.69	<<	NSDWQ		
Magnesium ion (mg/l)	WHO	-147.10	<<	WHO	-393.97	<<	WHO	30	0.2
	NSDWQ	1.90	==	NSDWQ	3.06	==	NSDWQ		
Chloride ion (mg/l)	WHO	-16257.01	<<	WHO	-21467.04	<<	WHO	250	250
	NSDWQ	-16257.01	<<	NSDWQ	-21467.04	<<	NSDWQ		
Sulphate ion (mg/l)	WHO	-190.33	<<	WHO	-316.37	<<	WHO	200	100
	NSDWQ	-73.38	<<	NSDWQ	-131.23	<<	NSDWQ		
Electrical conductivity (µS/cm)	WHO	-1565.04	<<	WHO	-45728.10	<<	WHO	600	1000
	NSDWQ	-2740.83	<<	NSDWQ	-79010.11	<<	NSDWQ		
Turbidity (NTU)	WHO		==	WHO		==	WHO	1.0-5.0	NS
	NSDWQ		NS	NSDWQ		NS	NSDWQ		
Dissolved solid (mg/l)	WHO	-2059.28	<<	WHO	-2069.77	<<	WHO	500	500
	NSDWQ	-2059.28	<<	NSDWQ	-2069.77	<<	NSDWQ		
Nitrate ion (mg/l)	WHO	-13123.00	<<	WHO	-1016.40	<<	WHO	45	50
	NSDWQ	-14623.00	<<	NSDWQ	-1130.78	<<	NSDWQ		

Suspended solid (mg/l)	WHO	-6573.19	<<	WHO	-1959.27	<<	WHO	500	NS
	NSDWQ		NS	NSDWQ		NS	NSDWQ		
Total solid (mg/l)	WHO		NS	WHO		NS	WHO	NS	NS
	NSDWQ		NS	NSDWQ		NS	NSDWQ		
DO (mg/l)	WHO	13.41	>>	WHO	267.22	>>	WHO	5	NS
	NSDWQ		NS	NSDWQ		NS	NSDWQ		
COD (mg/l)	WHO	18.67	>>	WHO	6.06	>>	WHO	1	NS
	NSDWQ		NS	NSDWQ		NS	NSDWQ		
BOD (mg/l)	WHO	25.85	>>	WHO	9.97	>>	WHO	5	NS
	NSDWQ		NS	NSDWQ		NS	NSDWQ		

Key:
== Not significantly different from or falls within range
<< Significantly less than value specified by standard
>> Significantly greater than value specified by standard
NS: Not specified

Table 3: Mean values of physico-chemical parameters and comparative standards

Parameters	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G	Sample H	Standard WHO	Standard NSDWQ
pH value	6.57	6.60	6.64	6.62	6.64	6.67	6.82	6.80	6.5-8.5	6.5-8.5
Total hardness (mg/l)	1.51	1.22	1.04	1.38	1.11	1.06	0.74	0.65	300	150

Calcium ion(mg/l)	0.76	0.71	0.51	0.56	0.46	0.48	0.31	0.33	75	75
Magnesium ion (mg/l)	0.74	0.51	0.53	0.82	0.38	0.58	0.43	0.32	30	0.2
Chloride ion(mg/l)	2.26	1.75	2.27	2.39	1.33	1.67	2.12	2.32	250	250
Sulphate ion(mg/l)	38.02	36.86	36.52	37.08	37.34	37.26	29.12	28.20	200	100
Electrical conductivity (μS/cm)	65.87	68.65	66.87	67.42	67.54	67.58	50.42	50.20	600	1000
Turbidity (NTU)	4.92	4.67	4.39	4.46	4.38	4.19	3.74	3.60	1.0-5.0	NS
Dissolved solid (mg/l)	7.86	6.54	7.14	6.79	6.18	5.63	2.68	2.84	500	500
Nitrate ion(mg/l)	1.36	1.24	1.26	1.32	1.31	1.26	0.57	0.50	45	50
Suspended solid(mg/l)	5.43	4.84	3.94	4.70	4.75	4.70	1.59	1.66	500	NS
Total solid(mg/l)	13.29	11.41	11.08	11.49	10.93	10.33	4.29	4.50	NS	NS
DO (mg/l)	34.82	34.82	33.41	38.43	37.07	32.15	28.57	29.40	5.0	NS
COD (mg/l)	24.43	24.43	25.36	24.40	24.08	23.01	2.35	2.60	10	NS
BOD (mg/l)	24.83	24.83	23.60	23.17	24.30	24.40	17.67	20.10	5.0	NS

Heavy Metals

Table 4: Heavy metal values for the water samples

Sample	Copper (Cu) mg/l			Iron (Fe) mg/l			Lead (Pb) mg/l		
A	0.01	0.01	0.01	0.2	0	0	0	0.1	0.1
B	0.02	0	0	0.1	0	0	0	0	0
C	0.03	0	0	0.2	0	0	0	0.2	0.2
D	0.04	0	0	0.2	0	0	0.1	0.2	0.2
E	0.02	0	0	0.2	0	0	0.1	0.2	0.2
F	0.01	0	0	0.2	0	0	0	0	0
G	0.05	0	0	0.2	0	0	0.1	0	0
H	0.03			0.2			0		

Table 5: Mean values for Heavy metals

Sample	Copper (Cu)mg/l	Iron (Fe) mg/l	Lead (Pb) mg/l
A	0.01	0.067	0.067
B	0.007	0.033	0
C	0.01	0.067	0.133
D	0.013	0.067	0.167
E	0.007	0.067	0.167
F	0.003	0.067	0
G	0.017	0.067	0.033
H	0.03	0.2	0
WHO (max)	3.0	0.3	0.05
NSDWQ (max)	1.0	0.3	0.01

Microbial

Table 6: Microbial analysis

S/N	Sample label	E. Coli (cfu/ml)	Coliform (cfu/ml)
1.	A	0	0
2.	B	13	7
3.	C	8	3
4.	D	17	5
5.	E	19	9
6.	F	60	13
7.	G	50	19
8.	H	0	0
WHO (max)		0	0
NSDWQ (max)		0	0

Copper is essential for living organism including humans and in small amounts necessary in human diet to ensure good health, too much copper can cause adverse health effects [19;20]. The mean values for copper in this study varied between 0.003 to 0.017 mg/l. It is within the permissible limit of comparative standards. The mean values for iron in this study varied between 0.033- 0.2mg/l, which is within the permissible limit. The mean values for lead in the water samples varied between 0 and 0.167 mg/l. The WHO and NSDWQ standard for the required amount of lead is 0.05 mg/l and 0.01 mg/l respectively; samples A, C, D, E and G have mean values higher than the permissible limit. Excess amount of lead places adults at higher risk for cancer, stroke and hypertension. It is more harmful to children (young age); brain damage, lower IQ level in children, behavioral disorder [21;22;23;24].

The permissible standard for the number of E. coli and coliform is 0cfu in 100ml.

Microbial aid in digestion of food, but their presence in drinking can also result in illness [25;26]. In comparison with the WHO and NSDWQ standards, 6 samples were found to have microbial presence higher than the prescribed limit.

Conclusion and recommendation

Conclusion

Water serves many purposes depending on its usage. Determining the potability of water is mainly for the sole aim of seeing that the water sources are safe enough for drinking [27]. According to WHO, nearly 80% of all the diseases in human being are caused by water. Based on the result obtained for the physico-chemical and bacteriological analysis of the water samples, the following physico-chemical parameters; pH, total hardness, turbidity, total solids, total dissolved solid, total suspended solids, electrical conductivity, chloride, nitrate, sulphate, iron and copper were found to be in conformity with the WHO and NSDWQ guideline for drinking water in all the water samples. Five samples A, C, D, E and G have higher mean values for lead (Pb) more than prescribed limit. Microbial in Sample B, C, D, E, F, and G is higher than the required standard of 0cfu in 100ml. From all the analysis conducted only sample H is found to be in conformity with the permissible standards in terms of both the physicochemical analysis and the bacteriological analysis.

Recommendations

1. Acid-neutralizing filters can be installed to reduce water corrosivity by adding calcium and by increasing the pH of the water. Unlike other treatment options, these filters act to prevent lead from entering the water rather than removing it at the tap. In addition to reducing acidity, the added hardness produces a thin scale inside the pipes that reduces lead corrosion.
2. Reverse osmosis units and activated alumina filters could remove lead once it is in the water.
3. The presence of microbial in the water samples could be eliminated by boiling the water before drinking
4. Disinfection by chlorination is another method in eliminating microbial.

References

[1] Al- Khatib H, Kamal S, Taha G and Jaber H. (2003) Water Health relationship in developing countries. Internal Journal of Environmental Health Sciences. 4, 23 -25.

[2] WHO. (2004) Standard for drinking water

[3] Okoufu CA, Echafona NO and Ayeni OG. (1990)Bacteriological and physicochemical examination of well waters in Ahmadu Bello university (main campus), Zaria, Nigeria. Afr. J. Sci. Technol. B. 4, 40-44.

[4] Vinod K, Surindra S, Sandeep J and Aleenjeet S. (2008) Drinking water quality in villages of southern Hyrana. Water Research Journal. 5,11- 20.

[5] WHO. (2006) Guideline for Drinking –water Quality, 1st Addendum V1.1. Recommendations. 3rd Edition.

[6] Park's Textbook of Preventive and Social Medicine, 18th Edition. (2005) P. 519-541. M/s Banarsidas Bhanot publishers 1167, Prem Nagar, Jabalpur, India

[7] Eneji S, Onuche P Agada and Sha'Ato Rufus. (2012) Spatial and Temporal Variation in Water Quality of River Benue, Nigeria. Journal of Environmental Protection, 3 ,915-921.

[8] Knapp B, Ross S and McCree D. (1998) Challenges of the Natural Environment. Longman Group Essex.Maiduguri. Abuja, Nigeria

[9] Biswas AK. (1998) Water Resources: Environmental Planning Management and Development. McGraw Hill Publication Comp.

[10] Nwale C, Akaninwor J and Abbey B. (2007) Physiochemical parameters of monopumps. of groundwater. Quartely Journal of Engineering Geology. 30,179- 188.

[11] Hussain I, Sharma K and Ojha K. (2002) Flouride in drinking water and health hazardous : Some observations on flouride distribution.: Environmental scenario of 21st Century. New Delhi.

[12] Abdulaziz M. (2003) Spatial variation in water quality in Nguru Urban. University of Maiduguri. Abuja, Nigeria.

[13] Appelo CAJ and Posma DC. (2005) Geochemistry of Groundwater and Pollution Published by Balkema, Leiden.

[14] Pedley JL and Howard PC. (1997) The public health implication of microbiological contamination Publishers, Moscow, P. 20-23.

[15] Kodarkar MS, Diwan AD, Muruga N, Kulkarni KM and Anuradha R. (2008) Methodology for water analysis, Indian association of aquatic Biologist, IAAB. Publication. No. 2

[16] APHA. (1998) Standard method for examination of Water and wastewater, *American Public Health Association*, 20th Edition, New York.

[17] Richard JA and Gupta CB. (2006) Probability and Statistics for Engineers. Delhi, Miller and Freund's.

[18] Gupta SC. (2013) Fundamentals of statistics. Delhi, Himalaya Publishing House.

[19] Oyeku OT and Eludoyin AO. (2010) Heavy metal contamination of groundwater resources in a Nigeria urban settlement, African Journal of Environmental Science and Technology.2, 367-376

[20] Nwankwoala HO, Udom GT and Ugwu SA. (2011) Some heavy metal investigation in groundwater resources in Yenegoa, Bayelsa State Nigeria. Journal of Applied Technology in Environmental Sanitary. 1(2), 163-170.

[21] Abolude DS, Davis OA and Chia AM. (2009) Distribution and concentration of trace elements in Kubani Reservior in Northern Nigeria. Research Journal of Environment and Earth Sciences. 1(2), 39-44.

[22] Martin S and Griswold W. (2009) Human health effects of heavy metal. Environmental Science and Technology briefs for citizen, Kansas State University Centre for Hazardous substances Reseach, www.engg.ksu.ed/CHSRT

[23] Ocheri MI, Odoma LA and Umar ND. (2014) Groundwater Quality in Nigerian Urban Areas: A Review. Global Journal of Science Frontier Research: H. Environment & Earth Sciences. 14(3), 2249-4626.

[24] Sridhar MKC, Olawuyi JF, Adogame LA, kekearu IRO, Osajie CO and Aborka L. (1998) Lead in the Nigerian environment: problems and prospects. Department of Environmental Health College, College of Medicine, University of Ibadan.

[25] Ahmed H. (2003) Effect of sanitation on groundwater quality. International conference on Towards the Millennium Development Goal, P.183-185.

[26] Chukwu O. (2008) Analysis of groundwater pollution from abattoir in Minna, Nigeria. Research Journal of Dairy Sciences. 2, 74-77.

[27] WaterAid Nigeria. Available at http://www.wateraid.org/ng Accessed on 12th April 2017.

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