WATER QUALITY INDEX OF WELL WATER SAMPLES OF BAJOGA AND ENVIRONS, FUNAKAYE LOCAL GOVERNMENT AREA, GOMBE STATE

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ABSTRACT

Safe drinking water is essential to humans; hence the quality of drinking water is of paramount importance. This study was aimed to evaluate the quality of drinking water from ten (10) different wells in Bajoga and environs in Funakaye Local Government Area (L.G.A) of Gombe state, Nigeria. The water samples were collected and analyzed for Water Quality Index (WQI). Ten physico-chemical parameters were used to calculate the WQI. These are pH, electrical conductivity, turbidity, chlorides, phosphate, calcium, magnesium, total hardness, total dissolved solids and total suspended solids. The results for the parameters analyzed showed 7.00-7.70 pH; 132.1-578µs/cm EC; 1.60-7.52NTU turbidity; 66.6-385ppm TDS; 0.77-95mg/L TSS; 254.95-566.65mg/L Hardness; 151.9-379.85mg/L chloride; 103.00-291.50mg/L calcium; 28.45-100.00mg/L magnesium and 0.50-6.45mg/L phosphate. The results of WQI obtained from different wells were found to fall between 27.60-95.80 which means some were good while some were very poor. It is therefore concluded that some of the water samples analyzed from the wells of Bajoga and Environs were suitable for drinking and for other domestic activities while most were not.

Keywords: Quality index, Well water, Physico-chemical properties, Bajoga

INTRODUCTION

Water forms about 80% constituent of the ecosystem. It is one of the most important natural resource. Water is essential to all forms of life and make up 50-97% by weight of all plants and animal and about 70% of human body (Sulaiman *et al*., 2018). Water is also a vital resource for agriculture, manufacturing and transportation. Despite its importance, water is the most poorly managed resource in the world (Akter *et al.* (2016). The public health significance of water cannot be over emphasized. Many infectious diseases are transmitted by water through the fecal oral route. Diseases contacted through drinking water kills about 5million people annually and make 1/6th of the world population sickness (WHO, 2004). Water is vital for the existence of life and its importance in our daily life makes it imperative that thorough microbial, physico-chemical and heavy metal examination of water should be conducted on water used for various purposes to reduce the risks of water borne diseases emanation from such water.

Water Quality Index (WQI)

Being one of the most effective ways to describe the quality of water, WQI is used to assess the suitability of water sources for human consumption. The quality of water of any specific area or specific source can be assessed using physical, chemical and biological parameters. The high concentrations of these parameters are harmful to human health if they occurred more than the standard limits. Therefore, WQI utilizes the water quality data and helps in the modification of the policies, which are formulated by various environmental monitoring agencies. It has been realized that the use of individual water quality variable in order to describe the water quality for common public is not easily understandable. That's why, WQI has the capability to reduce the bulk of the information into a single value to express the data in a simplified and logical form. It takes information from a number of sources and combines them to develop an overall status of a water system. They increase the understanding ability of highlighted water quality issues by the policy makers as well as for the general public as users of the water resources (Tyagi, *et al*., 2013).

Water quality index provides a single number that expresses the overall water quality at a certain location and time, based on several water quality parameters. The objective of water quality index is to turn complex water quality data into information that is understandable and usable by the public. Initially, WQI was developed by Horton in the year 1965 in United States by selecting 10 most commonly used water quality variables like dissolved oxygen (DO), pH, coliforms, specific conductance, alkalinity and chloride etc. and has been widely applied and accepted in European, African and Asian countries. The assigned weight reflected significance of a parameter for a particular use and has considerable impact on the index. Furthermore, a new WQI similar to Horton's index has also been developed by the group of Brown in 1970, which was based on weights to individual parameter.

MATERIALS AND METHODS

Study Area

Bajoga town is the headquarters of Funakaye Local Government Area of Gombe State. It is located on latitude $10^0$51'N and longitude $11^0$26'E. Funakaye is one of the eleven (11) local government areas of Gombe State situated in North Eastern Nigeria.

Sample Collection

Well water samples were collected from 10 different locations in Bajoga and environs. At the collection points, Sample containers were rinsed with relevant samples before sampling and then corked tightly according to method reported by (Etim *et al*., 2013).

Physico-chemical Analysis

The physico-chemical analysis of the well water samples was carried out and the following parameters were determined;

Temperature

Temperature was determined in-situ using mercury in glass thermometer. The thermometer was inserted into the sample and the reading was taken immediately. (Etim *et al*., 2013)

pH Measurement

pH was measured on site using a portable pH meter, pH-98081 model manufactured by RoHS. The pH meter was calibrated and rinsed with distilled water. It was then used for taking the pH of each sample and the results recorded (Suleiman *et al.,* 2018)

Conductivity Measurement

Conductivity was measured using a portable multipurpose field meter, model HI 9835 EC/TDS/NaCl meter. The water sample collected was decanted into a clean beaker, and conductivity of each sample was determined using conductivity meter. The electrode was inserted into the water and reading was recorded 2-3 times as described by (Nnachetam *et al*., 2017)

Turbidity Measurement

Turbidity was determined using a turbidity meter Wag-WT3020. The meter was calibrated with standard cuvettes and the cuvette was filled with the sample placed into the turbidity meter and the reading was recorded (APHA, 1998)

Chloride Determination

This was determined using Morh Method. This method is based on titration of chloride with standard silver nitrate in the presence of potassium chromate as indicator. The chloride concentration was calculated using formula below.

$$\text{Chloride (mg/l)} = \frac{A \times M \times 70900}{Sample\ volume}$$

A = volume of titrant used (cm^3)
M = Molarity of silver nitrate solution (0.0141 M)

Total Hardness

The total hardness was determined by EDTA titration using Eriochrome black T indicator as described in the standard analytical procedures for water analysis, SAP (1999).
The water sample was shaken thoroughly and 25 ml was taken and diluted to 50 ml with distilled water. 2 ml of buffer solution was added and then two drops of Eriochrome black T indicator was added immediately and titrated with EDTA. A blue colouration indicates the end point. The total hardness is then calculated as:

$$\text{Total hardness (mg } CaCO_3\text{/L)} = \frac{A \times B \times 1000}{ml\ of\ sample}$$

Where A = ml EDTA titrated for sample
B = mg $CaCO_3$ equivalent to 1.0 ml EDTA titrant

Total Suspended Solids (TSS) Determination

TSS was determined by pouring 500ml of water sample collected through a pre-weighed filter paper. The filter paper was then reweighed after drying. The difference in the weights of the paper before and after filtration gives the total suspended solids as:

$$TSS = W_2 - W_1$$

Where W_1 = pre-weight filter paper; W_2 = weight of dry filter paper

Total Dissolved Solids (TDS) Measurement

The TDS was determined using a portable multipurpose field meter model HI 9835 EC/TDS/NaCl meter. The sample was decanted in a clean beaker, total dissolved solid was determined by inserting the electrode in the water sample and the reading was recorded (Ademoroti, 1996)

Calcium Determination

This was determined by titrimetric method according to standard analytical procedure (1999). unto 50ml of water sample, 2ml NaOH solution was added followed by 0.2g indicator mixture. This was titrated against EDTA solution with continues mixing. A change in color from pink to purple indicate the end point.
Calculation:

$$\text{mg Ca/L} = \frac{A \times B \times 400.8}{ml\ sample}$$

Where A = ml titrant for sample
B = ml titrant for standard calcium solution and it can be obtained from the relationship:

$$B = \frac{ml\ of\ standard\ calcium\ solution\ taken\ for\ titration}{ml\ EDTA\ titrant}$$

Magnesium Determination

Magnesium was determined by calculation from total hardness and calcium as determined by the standard analytical procedure (1999).

mg Mg/L = *(TH $CaCO_3$ as mg $CaCO_3$/L- Calcium hardness as mg $CaCO_3$)*

Where TH = total Hardness, mg $CaCO_3$/L

Phosphate Determination

This was determined spectrophotometrically by adopting the method reported by (Sa'id and Mahmud, 2013). 50cm^3 of water sample was pipetted into 500cm^3 volumetric flask, 5cm^3 of Ammonium molybdate solution and 3.0cm^3 of ascorbic acid were added with swirling. The mixture was diluted to the mark with deionised water and allowed to stand for 30 minutes for maximum colour development. The absorbance was then read at 660nm including the blank. This was applied for the remaining samples and the standard solutions.

Calculation of Water Quality Index

For the calculation of water quality index in this study, ten parameters were used**.** The WQI was calculated by standards of drinking water quality recommended by the World Health Organization (WHO) and Nigeria Industrial Standards (NIS). The weighted arithmetic index method of Brown was used as reported by (Sulaiman *et al.*, 2018) for the calculation of WQI of the water samples.
The quality rating (qn) was calculated using the following expression

$$qn = \frac{100(Vn-Vo)}{(Sn-Vo)} \quad \text{……………..……… (1)}$$

Where; qn = Quality rating for the Water quality; Vn = Estimated value of a given water sample; Sn = Standard permissible value; Vo = Ideal value in pure water (i.e., 0 for all other parameters except the parameters pH and Dissolve oxygen (DO) [7.0 and 14.6 mg/L respectively]).
The unit weight, Wn was calculated by a value inversely proportional to the recommended standard value Sn of the corresponding parameter.

$$Wn = \frac{K}{Sn} \quad \text{……………………………..……… (2)}$$

Where; Wn = unit weight; Sn = standard permissible value; K = constant of proportionality which is assumed to be unity for simplicity, this value considered (1) here, also can calculate using the following equation:

$$K = \frac{1}{\sum(\frac{1}{Sn})} \quad \text{……………………………….. (3)}$$

The overall WQI was calculated using the following equation.

$$WQI = \frac{\sum qnWn}{\sum Wn} \quad \text{………………………… (4)}$$

The suitability of WQI values for human consumption according to (Chatterji and Raziuddin, 2002) are shown in Table 1.

Table 1: Water quality index and quality of water

Water Quality Index Level	Water Quality Status
0-25	Excellent water quality
26-50	Good water quality
51-75	Bad water quality
76-100	Very Bad water quality
> 100	Unfit water quality

Chatterji and Raziuddin, (2002)

Table 2: Drinking water standards, recommending agencies and unit weights

S/N	Parameters	Standards	Recommended Agencies	Unit weight (Wn)
1	pH	6.5-8.5	WHO/NIS	0.1176
2	EC	1000	WHO/NIS	0.0010
3	TBD	5	WHO/NIS	0.2000
4	Cl	250	WHO/NIS	0.0040
5	TDS	500	WHO/NIS	0.0020
6	PO4	5	WHO/NIS	0.2000
7	NO3	50	WHO	0.0200
8	TSS	500	WHO	0.0020
9	Ca	75	WHO	0.0133
10	Mg	100	WHO	0.0100
11	TH	500	WHO	0.0020

(Sulaiman *et al.,* 2018).

RESULTS

The physico-chemical parameter investigated in the well water sample of Bajoga and environs are shown in Table 3. The water quality index of the sample analyzed were calculated and the WQI values reported in Table 4.

Table 3: Physico-chemical parameters of well water samples in bajoga and environs

S/N	Parameter	WL_1	WL_2	WL_3	WL_4	WL_5	WL_6	WL_7	WL_8	WL_9	WL_{10}
1	pH	7.05	7.40	7.70	7.53	7.60	7.00	7.48	7.49	7.36	7.68
2	EC (µs/cm)	379	578	326	272.2	456	580	132.1	205	259.8	567
3	Turbidity (NTU)	1.90	2.83	7.5	4.36	1.70	6.04	1.84	1.60	2.19	7.52
4	TDS (ppm)	189	385	163	135.8	228	291	66.6	103.2	128	334
5	TSS (mg/L)	0.82	0.82	0.95	0.77	0.85	0.80	0.79	0.79	0.87	0.81
6	Hardness (mg/L)	549.95	499.95	351.65	268.3	484.8	416.65	254.95	288.15	348.3	566.65
7	Chloride (mg/L)	379.85	329.8	285.9	301.9	259.9	151.9	299.8	337.85	229.9	363.0
8	Calcium (mg/L)	291.5	151.4	222.6	113.6	211.26	196.9	137.85	103	151.45	218.1
9	Mg (mg/L)	87.10	84.68	70.47	37.59	42.17	53.39	28.45	44.99	47.83	100
10	PO_4 (mg/L)	6.45	3.57	3.01	1.31	2.28	4.52	1.79	0.5	0.6	2.33

WL= Well water samples

Table 4: Water quality index (wqi) and the quality status of well water samples from bajoga and environs

Sample	WQI	Water Quality Status
WL_1	73.90	Poor
WL_2	60.20	Poor
WL_3	95.80	Very Poor
WL_4	54.20	Poor
WL_5	47.10	Good
WL_6	84.90	Very Poor
WL_7	39.20	Good
WL_8	27.60	Good
WL_9	32.10	Good
WL_{10}	91.70	Very Poor

DISCUSSION

The test for pH of water was carried out to determine whether it is acidic or alkaline in nature. The minimum and maximum values for pH obtained from the water samples investigated as shown in Table (3) range from 6.87 to 7.70 which indicate that they are acidic to basic. Similar result was reported by (Halilu *et al*., 2011) in sachet water samples in Gombe metropolis. These values are within the permissible limit of WHO/SON, (2008). The values for electrical conductivity obtained from the well water samples as shown in Table (3) range from 132.1 to 580 µS/cm. Similar result was reported by (Oluyemi *et al*., 2010) in water sources in Ife north L.G.A of Osun State. The salinity values are less than 1000 mg/L set by the World Health Organization (WHO, 2017). This implies that the waters are not saline as explained by (Oluyemi *et al*., 2010).

The values for turbidity obtained from the well water samples ranged from 1.60 to 7.52 NTU. Except for WL3, WL6 and WL10, all the values are within the permissible limit of WHO 2008. Turbidity measures the relative clarity of the water by the presence of organic and mineral suspended particles and color producing substances as reported by (Ameen 2019). The values for total dissolved solid obtained from the well water samples analysed ranged from 66.6 to 385 mg/L. The total dissolved solids (TDS) of the water

samples in the area are within the limit of 500mg/L set for drinking water by WHO 2008, and that makes it suitable for domestic purposes as reported by Oluyemi *et al*., 2010.
The minimum and maximum values for total hardness obtained from the well water samples ranged from 254.95 to 566.65 mg/L. All the values are within the permissible limits of WHO 2008. Hardness is a measure of the ability of water to cause precipitation of insoluble calcium and magnesium salts of higher fatty acids from soap solutions. From the present study, the minimum and maximum values for chloride obtained from the well water samples as shown in Table (3) ranged from 151.9 to 379.85 mg/L. Except WL9, WL6 and WL5 which are within the limit, all the other samples have values above the permissible limit of 250mg/L set by WHO 2008. According to Ameen (2019), chloride is one of the important water quality indicators and is widely found in nature in the form of salts of sodium (NaCl), potassium (KCl), and calcium ($CaCl_2$). There are numerous natural and anthropogenic factors that contribute to chloride levels in groundwater, including geological weathering, leaching from rocks, domestic effluent, irrigation discharge, agricultural use, etc.
The values of Ca^{2+} ranged from 151.45 to 291.5 mg/L. The values of Ca^{2+} at all the studied sites were greater than the permissible limit (75 mg/L) as put by the WHO 2008 standards. On the other hand, the Mg^{2+} values ranged from 28.45 to 100 mg/L. The results revealed that, the values of Mg^{2+} at all sampling sites did not exceed the permissible limit of 100 mg/L according to WHO 2008 standards. This variation in Ca^{2+} and Mg^{2+} levels might be related to the mineral content of each ion, such as: limestone, dolomite, gypsum, aragonite, feldspars amphibole and pyroxene, and the pH value of each source (Ameen 2019). Therefore, a simple physical treatment of the studied well water is preferable to minimize loads of these nutrients. The TSS obtained in this study ranged between 0.77 to 0.87g/L. All the values reported were below the acceptable limit set by WHO (500 mg/L). A similar result was obtained and reported by (Sulaiman *et al.*, 2018). The Total suspended solid (TSS) measures the physical observable dirtiness of a water resource and are those solids which can be filtered out on an asbestos mat or filter papers, i.e. suspended solids are non-filterable solids.
The minimum and maximum values for phosphate obtained from well water samples as shown in Table (3) range from 0.5 to 6.45. From the results it shows that all the sites had phosphate level above the recommended level set for drinking water by World Health Organization i.e. 0.03mg/L (WHO, 2017). According to Sa'id and Mahmud (2013), high level of phosphate ion in the drinking water is attributed to the proximity of the settlements to those places where farming activities is taking place all year around be it during the rainy season or the dry season. Another reason for the high concentration of phosphate ion in the drinking water is due to the fact that agricultural activities is the major source of income in these communities and this activity is only made possible through the application of both natural and synthetic fertilizers, and as a result, the residential areas closer to these farmlands are prone to this high level of phosphate particularly where leakage of waste water takes place, this produces drinking water that is enriched in phosphate and nitrate ion. From the result shown in Table 4, the water quality index for WL_1, WL_2, and WL_4 shows that the waters are poor; WL_{10}, WL_6, and WL_3 are very poor; WL_5, WL_7, WL_8, and WL_9 are good.

CONCLUSION

It was concluded that, the water quality index of the well water samples analyzed were mostly poor. This is due to higher values of physico-chemical parameters like turbidity, TDS, and TSS. It is recommended that the well waters investigated be subjected to further treatment such as filtration and boiling to reduce the turbidity, suspended particles concentrations and hardness.

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