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ASSESSMENT OF SEASONAL VARIATION OF GROUNDWATER QUALITY IN BAUCHI TOWN, NORTHEASTERN NIGERIA

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ABSTRACT

This study evaluated the quality of groundwater from Bauchi town, Northeastern Nigeria. The water samples were collected from borehole and hand-dug wells and evaluated for its suitability for human consumption using Water Quality Index (WQI) technique. The groundwater samples were collected from twelve different sites during wet and dry seasons, and subjected to physico-chemical analysis. Ten parameters including pH, electrical conductivity, dissolved solid, total dissolved solids, total suspend solids, nitrate, sulphate, chloride, calcium and magnesium were used for assessing the water quality. The results of Water Quality Index obtained from the water sources during both wet and dry seasons revealed that the water quality varied from good to excellent. The borehole water samples ranged from 21.68-30.59, excellent to good water quality, during wet season; and 39.11-45.27, indicating good water quality during dry season. Hand-dug wells water samples ranged from 26.02-38.05, implying good water quality class during both seasons. The results indicated that the groundwater samples analysed from borehole and hand dug wells were suitable for human consumption. There is a need for periodic monitoring of groundwater quality in order to quickly detect any changes.

Keywords: Assessment, groundwater, physico-chemical analysis, water quality index

INTRODUCTION

Water is one of the most important natural resource which forms about 80% constituent of the ecosystem. Water sources may be from rivers, lakes, glaciers, rain water and groundwater [1]. Groundwater remains a major source of water supply for drinking, agricultural and industrial purposes in most cities in Nigeria. There is growing demand for groundwater in virtually all parts

of Nigeria [2]. It is therefore necessary to determine the quality of groundwater. Quality of groundwater is determined by its composition and sources which eventually have effects on human. Studies show that about 80% of communicable diseases are either water related or water-borne which could be as a result introduction of foreign compounds into the water bodies or water supply system [3]. Groundwater protection is of environmental concern since the importance of water quality on human health has attracted a great deal of interest lately [4].

Assessment of Water Quality Index from groundwater source is to turn complex water quality data into information that is understandable and usable by the public [5]. It is used to indicate the overall quality of waters in terms of a single value at a certain location and time, based on several water quality parameters [6]. This present study was aimed to assess the quality of groundwater using WQI during wet and dry seasons in order to ascertain their suitability for consumption and other domestic purposes.

MATERIALS AND METHODS

Study area

The study area is Bauchi metropolis, in Bauchi State, Nigeria. It is situated on longitude 10018'N and latitude 9050'E in the North Eastern, Nigeria, with a total land area of 66,510,045 km^2. The climate is tropical with two distinct seasons: rainy (May-October) and dry (November-April) seasons. Temperatures at those times are usually between 23 ^oC and 40 ^oC, with the average rainfall of 1.0914mm^3. The daily humidity increases to 94% in the middle of the rainy season but drops to less than 10% during the dry season.

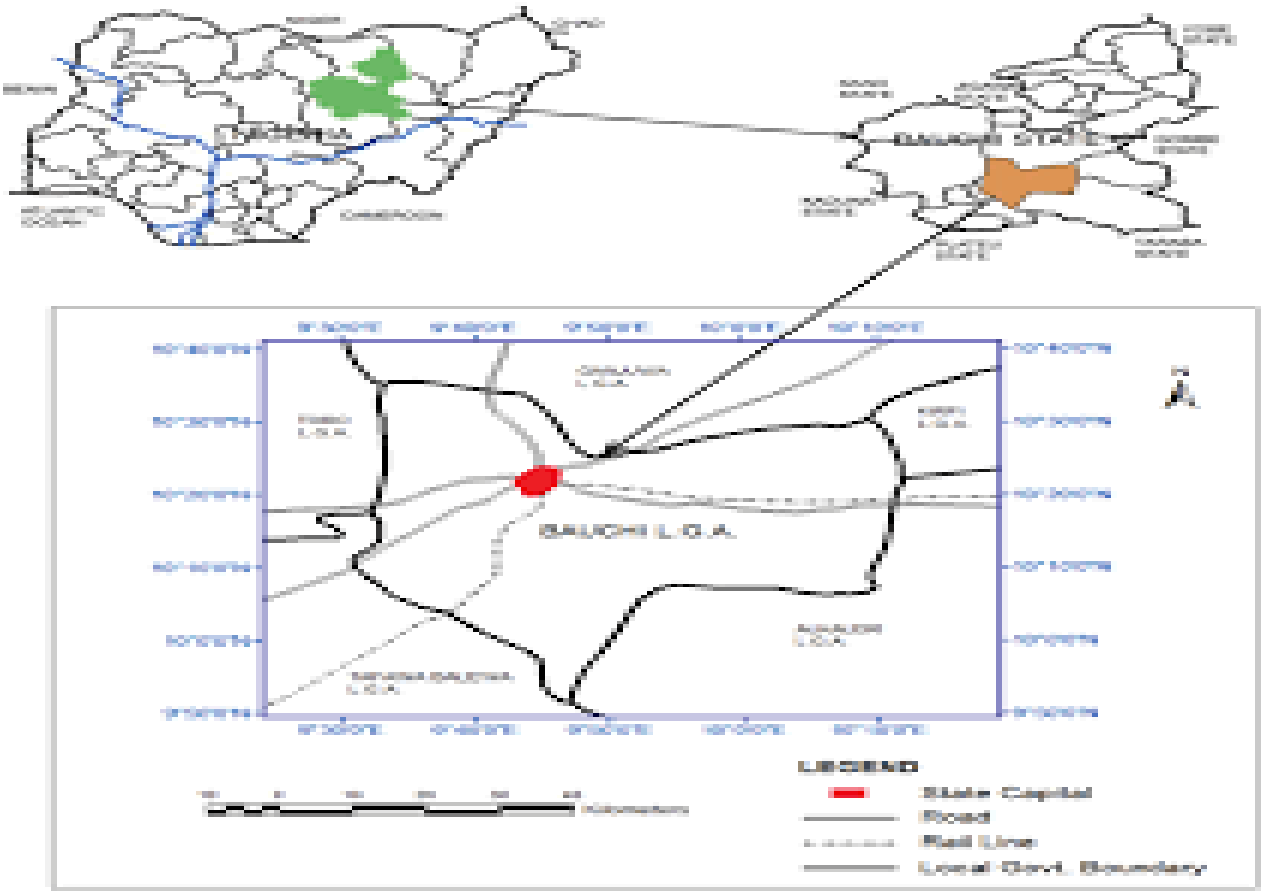

Fig. 1: Map of study area

Sample collection

The groundwater samples were collected from 12 different locations at two different sources, 6 boreholes and 6 hand-dug wells during wet and dry seasons into 100 ml sterile bottles and transported to the laboratory for analysis. A total of 72 samples were collected for the study.

Physico-chemical analysis

The physico-chemical parameters analyzed were pH and electrical conductivity (EC), which were directly measured on-site using a portable multipurpose field meter WTW pH Electrode. Chloride (Cl^-), calcium, magnesium and Dissolved oxygen (DO) were determined by titrimetric method. Total dissolved solids (TDS) and Total suspended solids (TSS) were determined gravimetrically. Nitrate (NO_3), and sulphate (SO_4) contents were analysed using a colorimeter [1].

Determination of water quality index

Water Quality Index is a powerful tool used to provide a clear picture of the qualitative variables of water, whether surface or groundwater [7], and was developed by [8] and [9].The WQI was evaluated using the standards of drinking water quality recommended by the World Health organization (WHO) [10] and the Nigerian Standard for Drinking Water Quality (NSDWQ) [11]. The quality rating (q_n) was calculated using the following expression:

$$q_n = \frac{100[V_n - V_o]}{[S_i - V_o]} \quad (1)$$

where q_n = Quality rating for the n^{th}water quality parameter,

V_n = Estimated value of the n^{th} parameter at a given water sampling station,

S_i = Standard permissible value of the n^{th} parameter,

V_o = Ideal value of n^{th} parameter in pure water (i.e. 0 for all other parameters except the pH and Dissolve oxygen (7.0 and 14.6 mg/l respectively).

The unit weight was calculated by a value inversely proportional to the recommended standard value S_i of the corresponding parameter.

$$W_n = \frac{K}{S_i} \quad (2)$$

where W_n = unit weight for n^{th} parameter,

S_i = standard permissible value for nth parameter,

K = constant of proportionality.

The sub index (SI) of measured parameters was calculated using the following expression:

$$SI = W_n \times q_n \quad (3)$$

where SI= Sub index of measured parameters,

W_n = Unit weight for n^{th} parameter,

q_n = Quality rating for the n^{th} water quality parameter.

The overall WQI is calculated with the following equation:

$$WQI = \sum_{i=1}^{n} SI_i \quad (4)$$

The following terminologies were used to describe water quality status by [1]: 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.

Table 1: Physico-chemical parameters and their standars

S/N	Parameters	NSDWQ (2015)	WHO (2011)	Unit weight (W_n)
1	pH	6.5-8.5*	6.5-8.5	0.133
2	EC(µS/cm)	1000*	1400	0.001
3	DO	NA	4*	0.250
4	TSS	NA	25-40*	0.031
5	TDS	500*	500	0.002
6	NO_3	50*	50	0.020
7	SO_4	250*	250	0.004
8	Cl	250*	250	0.004
9	Ca	NA	75*	0.013
10	Mg	20*	250	0.050
∑	----	----	----	0.258

NA = Not assign, * = Value used for calculation

RESULTS AND DISCUSSION

The mean values of physico-chemical parameters of water samples and calculated WQI are presented in Tables 2 and 3. Among all the physico-chemical parameters chosen for the Water Quality Index calculation, pH is a vital parameter which determines the suitability of water for diverse purposes. In this current study pH varied from 6.69-7.01 (wet season) and 6.28-6.55 (dry season) for boreholes, 6.89-7.39 (wet season) and 6.51-6.76 (dry season) for hand dug wells water samples. There is slight decrease in pH during the dry season compared to the wet season. In general the pH values obtained from this study were within the WHO/NSDWQ standard of 6.5-8.5. Electrical conductivity ranged from 89.56-99.24 µS/cm during wet season and 103.76-121.16 µS/cm during dry season for boreholes, 90.05-99.82 (wet season) and 108.80-128.89 µS/cm (dry season) for hand dug wells water samples. The concentration of dissolved oxygen regulates the circulation of fauna and flora. The current study indicated that the concentration of dissolved oxygen varied from 5.10-6.69 (wet season) and 4.45-5.34 mg/L (dry season) for boreholes, 5.79-6.25 (wet season) and 5.09-6.01 mg/L (dry season) for hand dug wells water samples. The total suspended solids (TSS) measure the physical observable dirtiness of a water

resource. They are those solids which can be filtered out on an asbestos mat or filter papers, i.e, suspended solids are non-filterable solids [12]. TheTSS varied from 0.47-0.71 (wet season) and 0.39-0.57 mg/L (dry season); and the total dissolved solids varied from 58.35-61.71 (wet season) and 53.07-58.87 mg/L (dry season) for boreholes. The TSS varied from 0.56-0.90 (wet season) and 0.43-0.76 mg/L (dry season); and the total dissolved solids varied from 68.15-72.70 (wet season) and 54.61-60.01 mg/L (dry season) for hand-dug wells water samples. They were all within WHO/NSDWQ standard. The concentrations of nitrate in water depend on the activity of nitrifying bacteria which are influenced by presence of dissolved oxygen [5]. The nitrate values obtained in this study varied from 1.71-1.93 (wet season) and 1.72-1.94 mg/L (dry season) for boreholes; 2.01-2.20 (wet season) and 2.01-3.00 mg/L (dry season) for dug well water samples. They were all within the recommended WHO/NSDWQ standards. The sulphate concentrations studied in the water samples varied from 2.07-2.51 (wet season) and 3.08-4.01 mg/L (dry season) for borehole; 2.22-2.91 (wet season) and 3.09-3.46 mg/L (dry season) for dug well water samples. Sulphate spreads a slightly milder taste to drinking water than chloride. No significant taste effects were detected below 300 mg/L [13]. Chloride is one of the essential parameters in assessing the water quality. The higher concentrations of chlorides may indicate higher degree of organic pollution. Inthe current study the concentration of chloride varied from 4.09-5.17 and 6.78-7.05 mg/L, for wet and dry seasons respectively for boreholes, and 4.82-5.79 and 8.03-9.09 mg/L, during wet and dry season respectively for hand dug wells water samples. While calcium varied from 12.15-14.94 and 16.78-18.00 mg/L, for wet and dry seasons respectively; magnessium varied from 5.25-6.30 and 5.65-6.72 mg/L for wet and dry seasons respectively for boreholes. Calcium varied from 11.78-13.95 and 14.57-16.02 mg/L for wet and dry seasons respectively; magnessium varied from 5.45-6.72 and 8.98-9.98 mg/L for wet and dry seasons respectively for hand dug wells. In general, the results of this study indicated that the values of most the parameters including pH, EC, TSS, TDS, DO, Cl, NO_3, SO_4, Ca and Mg, were within World Health Organization (WHO)/(NSDWQ) standards desirable limit for drinking purpose except for few ions.

Table 2: Water Quality Index of borehole water samples during wet and dry season

		Wet season						**Dry season**					
S/N	Parameters	BH_1	BH_2	BH_3	BH_4	BH_5	BH_6	BH_1	BH_2	BH_3	BH_4	BH_5	BH_6
1	pH	6.95	7.01	6.69	7.10	7.07	6.98	6.35	6.54	6.24	6.38	6.55	6.28
2	EC (µS/cm)	89.56	99.14	97.06	99.24	94.85	89.67	103.76	110.06	121.16	109.07	108.67	103.98
3	DO	6.65	5.10	6.32	5.98	6.69	6.13	5.34	4.45	5.13	4.76	4.98	4.79
4	TSS	0.58	0.71	0.47	0.65	0. 70	0.57	0.49	0.57	0.39	0.53	0.57	0.48
5	TDS	56.60	58.35	61.71	59.15	61.19	58.76	53.07	56.87	58.03	56.01	58.79	53.89
6	NO_3	1.93	1.72	1.74	1.91	1.82	1.71	1.94	1.72	1.76	1.93	1.82	1.73
7	SO_4	2.32	2.07	2.35	2.51	2.35	2.23	3.75	3.08	3.60	4.01	3.69	3.76
8	Cl^-	4.09	5.17	4.79	4.21	4.41	5.00	7.01	6.78	7.06	6.97	7.05	6.89
9	Ca	14.94	12.57	12.70	13.78	12.88	12.15	17.50	16.81	18.00	16.98	16.78	17.01
10	Mg	6.16	6.30	5.25	5.60	6.45	6.24	9.76	10.01	9.58	8.89	9.66	9.58
WQI		21.68	24.69	22.81	22.97	30.59	24.13	42.15	39.11	45.27	43.05	41.63	45.08

Table 3: Water Quality Index of hand dug well water samples during wet and dry season

		Wet season						**Dry season**					
S/N	Parameters	WL_1	WL_2	WL_3	WL_4	WL_5	WL_6	WL_1	WL_2	WL_3	WL_4	WL_5	WL_6
1	pH	6.89	7.31	7.39	7.31	7.37	6.90	6.51	6.76	6.54	6.67	6.58	6.51
2	EC (µS/cm)	94.56	96.15	97.16	99.82	90.05	94.36	110.9	108.8	130.7	128.89	110.1	119.78
3	DO	6.25	6.10	5.92	6.17	5.79	6.43	5.09	5.76	5.17	5.89	5.09	6.01
4	TSS	0.68	0.67	0.57	0. 56	0. 90	0. 85	0.54	0.52	0.49	0.43	0.76	0.69
5	TDS	72.70	71.35	71.67	68.15	69.31	69.27	4.61	54.76	55.09	60.01	58.98	55.67
6	NO_3	2.13	2.02	2.07	2.10	2.20	2.01	2.15	2.08	2.09	3.00	2.21	2.01
7	SO_4	2.22	2.77	2.45	2.91	2.85	2.89	3.09	4.01	3.19	3.32	3.25	3.46
8	Cl^-	5.29	5.79	5.69	5.21	4.82	5.05	8.03	8.12	9.09	8.98	7.98	8.09
9	Ca	13.95	12.37	12.09	11.78	12.69	12.35	16.02	15.89	15.00	14.57	16.03	15.92
10	Mg	5.96	6.03	5.45	6.10	5.65	6.72	9.00	9.98	9.00	9.01	8.98	9.09
WQI		24.24	30.00	32.07	30.00	32.24	23.76	38.05	35.94	37.04	31.80	36.21	35.80

The WQI of the water samples were established from ten physico-chemical parameters. The computed grades of WQI values were categorized into five types for human consumption according to Sulaiman *et al* [1]. The results of water quality index obtained from the water samples in the different locations of study period varied. For boreholes, they were 21.68, 24.69, 22.81, 22.97, 30.59, 24.13 during wet season and 42.15, 39.11, 45.27, 43.05, 41.63, 45.05 during dry season; and for hand dug wells, they were 24.24, 30.00, 32.07, 30.00, 32.24, 23.76 during wet season and 38.05, 35.94, 37.04, 31.80, 36.21, 35.80 during dry season, which indicated the

excellent to good water quality for boreholes and good quality of water hand dug wells water samples. There was slight decline in the water quality during dry season compared with wet season in both boreholes and dug well water samples. This may be due to a decrease in water body during a dry season. This water quality rating study clearly shows that the water samples wer non-eutrophic and that they are suitable for the human consumption and other domestic activities.

CONCLUSION

The Water Quality Index of this study was calculated from important ten physio-chemical parameters in order to assess the suitability of water for domestic purposes. The calculated WQI showed that the status of the water samples in the study were suitable for domestic activities during both wet and dry seasons. The physico-chemical parameters were within WHO/NSDWQ standard guidelines for drinking water. However, there is need for regular monitoring of groundwater quality in order to promptly detect any change in physico-chemical parameters.

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