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Research Paper

Seasonal Variation Influence on Groundwater Quality of Selected Communities In Sagbama Lga Of Bayelsa State, Nigeria

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ABSTRACT
Groundwater is the most common source of water in rural communities and the quality is highly related to natural and anthropogenic activities around it. The study assessed seasonal variation influence on groundwater quality of selected communities in Sagbama LGA of Bayelsa State, Nigeria. Water samples were collected at the peak of two seasons (wet and dry seasons) from two points' sources along the hand dug wells (HDW) and boreholes (BH). Laboratory analysis was carried out on fourteen (14) physicochemical parameters such as pH, temperature, EC, TDS, TSS, TC, BC, Cl^-, SO_4^{2-}, NO_3^{2-}, Ca, Mg, K and P while descriptive and t-test statistics were used to determine possible contamination and variation in quality. The mean values of all parameters tested are within the permissible limit of WHO/ NSDWQ except for TC which indicated the presence of microbes and pathogenic microorganisms. The HDW showed a very strong correlation in wet and dry season physiochemical properties as well as no significant difference in the physiochemical properties of water at both seasons (r = 0.96, p= 0.313). Also, the BH showed a very strong correlation in wet and dry season physiochemical properties with no significant difference in the physiochemical properties of water at both seasons (r = 1.0, p= 0.069). The groundwater was deemed contaminated for both HDW and BH at all seasons; however, it could be used for various anthropogenic activities after treatment.
KEYWORDS: *Dry and Wet Season, Seasonal Variation, Groundwater Quality, Pollutants*

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I. INTRODUCTION

Groundwater provides one of the important sources of water for human (Taiwo *et al*, 2015; Woke & Umesi, 2018). However, groundwater quantity is as important as its quality. This is because the health profile of any community is dependent on quality of the water they use (Dick, *et al*, 2018). Many communities in Nigeria depend on surface and groundwater for their daily activities. Groundwater on the other hand, can be inform of hand-dug well or borehole and susceptible to impurities or pollutants due to various anthropogenic and natural activities. Although, boreholes are more protected but the chemical constituents is dependent on the permeable rocks that the water flow through which can influence the quality of the water (Sokpuwu, 2017). The quality of groundwater is highly related to local environmental and geological conditions, such as the quality of soil and rock types found in the area while in Nigeria, groundwater is the most common source of water in rural communities; it has proved to be the most reliable resource for meeting water demand in rural areas (Akoji, 2019). Groundwater has natural deposits of contamination; however, contamination can also arise from anthropogenic activities and from the surface and groundwater interaction also (Omole *et al*., 2017). Therefore, regular water quality monitoring is important to safeguard public health.

Considering the influence of anthropogenic activities on groundwater quality, Kenneth et al., (2019) noted that groundwater near slaughter houses poses environmental and health risk to the users if not treated as the parameters examined shows the lowering of the water quality and making the groundwater unhealthy for drinking and other uses while Omole *et al*., (2017) study showed that water samples from large faith-based campus had Cadmium (Cd) and Iron (Fe) that exceeded National Standard for Drinking Water Quality (NSDWQ) rendering the water high risk and required treatment before consumption. Sojobi (2016) study revealed that various anthropogenic activities contributed to the relative abundance of cations; Na > k > Ca > Mg> Zn > Pb and anions Cl^{-} > $PO4^{2-}$ > $SO4^{2-}$ > NO^{3-} in the boreholes and cations Ca>Na>K>Mg>Pb and anions $NO3^{-}$ > $PO4^{2-}$ > $SO4^{2-}$> Cl^{-} in the wells which all exceeded the WHO standard.

Aside anthropogenic activities, natural factors such as precipitation pattern, surface run-off, ground water flow, land use pattern, geological formation and infiltration rate influence the quality of groundwater (Gorthi and Mohan; 2015; Sharma and Chhipa, 2016; Mohamed and Zahir, 2017). Seasonal variation in groundwater quality of pre and post monsoon showed that parameters values were higher than the permeable standard for both season (Sharma and Chhipa, 2016). Mohamed and Zahir (2017) noted parameters such as EC, TDS, HCO_3, Cl, K, PO4, BOD, COD, and DO exceed the permissible limit of WHO in most of the groundwater sampling stations in summer and rainy seasons. This implies that people that rely on such water for their daily use are prone to water-related health risk. According to Ganiyu et al., (2018), regular assessment of groundwater quality is important to ascertain the quality for human consumption purpose as well as to provide an overall scenario about the sources of groundwater contamination, thereby open an avenue for better planning for sustainable management of groundwater. Hence, the aim of the study was to assess the seasonal variation influence on the water quality of selected communities in Sagbama LGA of Bayelsa state, Nigeria which in turn compared the parameters outcome with WHO, NSDWQ and NIS in order to ascertain its potability and the difference in parameters for the seasons (dry and wet season).

II. MATERIALS AND METHODS

2.1 Study Area

Sagbama LGA is one of the oldest LGA in old Rivers State, now Bayelsa State. It was created in 1996 with its headquarters at Sagbama town. Sagbama LGA is located between longitude 8.1-6.4° N and latitude 7.20-7.3° E. It has an area of 945 km² and a population of 21,448 according to 2006 census. The LGA shares boundary with Ekeremor, Kolokuma/ Opokuma, Yenagoa, Southern Ijaw LGAs in Bayelsa State and Patani LGA of Delta State (Figure 1). Sagbama LGA is made up of the Ijaw, Isoko and Urhobo ethnic nationalities. The Ijaws are dominant, making over 90% of the total population. The study area enjoys a tropical monsoon climate with lengthy and heavy rainy seasons from April to October ranging from 2000 to 2500 mm and short dry seasons. The temperature is high all around the year with a relatively constant high humidity.

2.2 Methods of Data Analysis

i. ***Sample Collection, Treatment and Preservation:*** Water samples was collected from hand-dug well and borehole from two communities; Otuan and Okumbiri in Sagbama LGA during the dry (March) and wet (July) seasons (Table 1). Sampling and preservation of samples were carried out as prescribed by APHA method (APHA, 1992). The samples were kept in pre-cleaned 1 liter polythene plastic bottle and acidified with Analar grade concentrated nitric acid to pH 1.5. The water samples were kept in ice chests and transported to the laboratory where they were stored in a freezer and analyzed the following day.

Table 1: *Coordinates of water source points*

Communities	Water Sources	Latitude	Longitude	Elevation (m)
Otuan (OT)	Well	4°52'54"N	6°07'61"E	3
	Borehole	4°52'59"N	6° 07'47"E	
Okumbiri (OK)	Well	5°05'85"N	6° 03'12"E	4
	Borehole	5°00'01"N	6° 03'17"E	

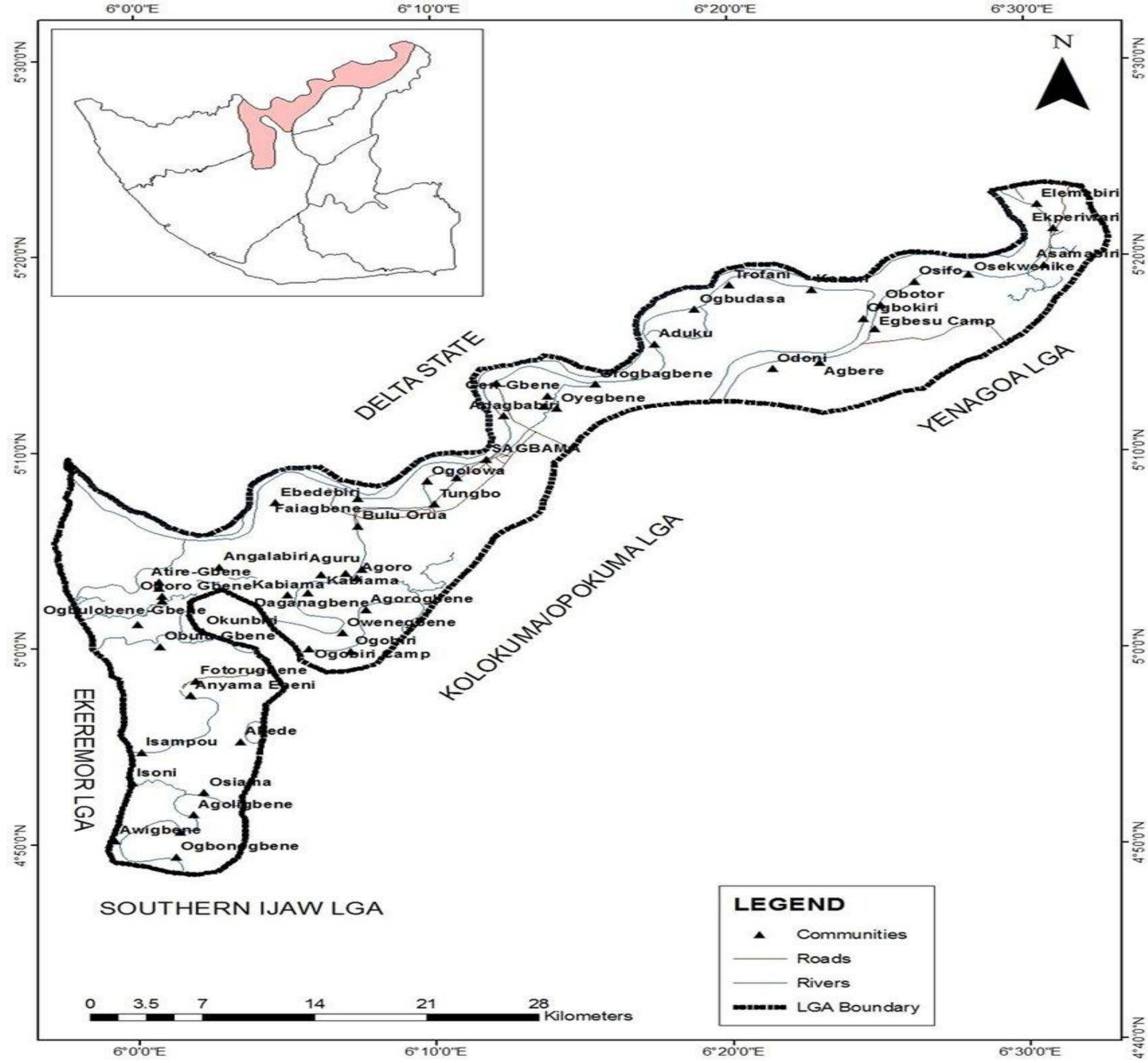

Figure 1: Sagbama LGA Showing Communities
(Source: Cartography and GIS Unit, Dept. of Geography and Env. Mgt. Uniport, 2021)

ii. ***Physico-Chemical Analysis****:* Water samples collected were analyzed by both classical and automated instrumental methods prescribed by standard methods for the analysis of water and wastewater and United State Environmental protection Agency (Standard Method, 1999). Laboratory analysis was carried out for physiochemical properties of water sourced from hand-dug wells and boreholes water of the communities in accordance with American Public Health Association (APHA) guidelines.

III. Results And Discussion

3.1 Physiochemical Properties

The physiochemical properties of hand-dug wells (HDW) and boreholes (BH) groundwater sourced from Otuan and Okumbiri communities during the dry and wet seasons was presented in Table 2 while the descriptive statistics of the properties as compared with the WHO permissible limit was presented in Table 3. Also, the seasonal variation of the physiochemical properties among the water sources during the seasons was tested with T-test and presented in Table 4. The outcome and variation in the parameters were discussed accordingly.

Table 2: *Physiochemical Properties of Hand-Dug Wells (HDW) and Boreholes (BH) from Studied Communities*

			Otuan Community				Okumbiri Community			
			HDW		BH		HDW		BH	
S/N	Parameters	Method	WS	DS	WS	DS	WS	DS	WS	DS
1	pH	APHA 4500-H^+B	7.45	6.67	6.98	6.54	5.44	6.89	7.22	6.88
2	Temperature (°C)	APHA 2550B	27.5	31.8	31.1	31.7	29.4	31.8	31.2	31.7
3	EC (µS/cm)	APHA 2510B	323	384	143.0	135.0	1143	861	132.8	124.8
4	TDS (mg/L)	APHA 2540C	208	192	111.6	67.5	543	431	66.6	62.4
5	TSS (mg/L)	APHA 2540D	0.021	0.008	0.0	0.062	0.021	0.036	0.054	0.006
6	TC (MPN/100ml)	APHA 9221C	>1600	49	1600	1600	>1600	>1600	80	47
7	Chloride (mg/L)	APHA 4500-Cl^-B	7.00	20.0	11.2	10.0	29.0	44.0	4.46	4.00
8	Sulphate (mg/L)	APHA 4500/SO_4^{2-}E	12.4	14.3	5.33	6.01	55.6	75.5	0.880	0.910
9	Nitrate (mg/L)	APHA 4500/NO_3^{2-}E	0.56	1.04	0.210	0.130	2.03	1.27	0.401	0.468
10	Bicarbonate (mg/L)	APHA 2320	100	110	56.0	37.0	100	208	52.0	56.0
11	Calcium (mg/L)	APHA 3111B	13.2	24.2	2.55	4.25	17.9	71.8	2.24	2.74
12	Magnesium (mg/L)	APHA 3111B	6.22	8.13	5.64	4.06	14.2	11.3	3.66	3.14
13	Potassium (mg/L)	APHA 3111B	4.32	7.05	4.33	4.39	3.42	12.2	2.01	2.16
14	Phosphorus (mg/L)	APHA 3111D	0.044	0.052	0.043	0.052	0.065	0.098	0.076	0.047

Remarks: EC= Electrical Conductivity, TDS = Total Dissolved Solids, TSS = Total Suspended Solid, TC = Total Coliform, HDW = Hand Dug Well, BH = Borehole

Table 3: *Descriptive Statistics of the Water Sourced during Wet and Dry Season*

		Hand-dug Well (HDW)				Borehole (BH)				
		Wet Season		Dry Season		Wet Season		Dry Season		
S/N	Parameters	Means	SD	Means	SD	Means	SD	Means	SD	WHO
1	pH	6.45	1.42	6.78	.16	7.10	.17	6.71	.24	6.5-8.9
2	Temperature (°C)	28.45	1.34	31.80	.00	31.15	.07	31.70	.00	
3	EC (µS/cm)	733.0	579.83	622.5	337.29	137.90	7.2	129.90	7.21	600
4	TDS (mg/L)	375.5	236.88	311.5	169.0	89.10	31.82	64.95	3.60	1000
5	TSS (mg/L)	.0210	.00	.022	.01980	.027	.039	.034	.04	5
6	TC (MPN/100ml)	1600.00	.00	824.5	1096.7	840.00	1074.8	823.50	1098.13	0/100
7	Bicarbonate (mg/L)	100.00	.00	159.0	69.30	54.00	2.83	46.50	13.44	200
8	Chloride (mg/L)	18.00	15.56	32.00	16.97	7.83	4.77	7.00	4.24	250
9	Sulphate (mg/L)	34.00	30.55	44.90	43.26	3.11	3.15	3.46	3.61	250
10	Nitrate (mg/L)	1.30	1.04	1.14	.18385	.31	.14	.30	.24	45
11	Calcium (mg/L)	15.55	3.32	48.00	33.66	2.40	.22	3.50	1.07	200
12	Magnesium (mg/L)	10.21	5.64	9.72	2.24	4.65	1.40	3.60	.65	150
13	Potassium (mg/L)	3.87	.64	9.63	3.64	3.17	1.64	3.28	1.58	20
14	Phosphorus (mg/L)	.055	.015	.075	.033	.060	.023	.05	.004	0.1

Remarks: EC= Electrical Conductivity, TDS = Total Dissolved Solids, TSS = Total Suspended Solid, TC = Total Coliform, HDW = Hand Dug Well, BH = Borehole

Table 4: *Paired-Samples T-test of the Water Sourced during Wet and Dry Season*

	Paired Correlations	Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
	Correlation				Lower	Upper			
HDW(WS) – HDW(DS)	.966	58.91707	210.12871	56.15926	-62.40764	180.24178	1.049	13	.313
BH(WS) – BH(DS)	1.000	4.02307	7.60932	2.03368	-.37042	8.41656	1.978	13	.069

pH

The mean pH values of the HDW during the wet and dry season showed 6.45 and 6.78 respectively at variation of 0.33 while the BH showed pH mean values of 7.10 and 6.71 during the wet and dry season respectively at variation of 0.39. However, the pH mean values of the water sources at different seasons are within the permissible limit of WHO of 6.5-8.9 (Ganiyu *et al*., 2018; Mohamed & Zair, 2017). The variation in value showed no abnormal change and low value pH has no harmful effect (Mohamed & Zair, 2017; Awan et al., 2012).

Electrical Conductivity (EC)

The EC showed a value range of 733.0 to 622.5µS/cm during the wet and dry seasons for HDW and 137.90 to 129.90µS/cm for BH during the seasons respectively. The EC values for HDW indicated that it exceeded the permissible limit of 600µS/cm for both seasons (Mohamed & Zair, 2017) while the EC values for BH are within the permissible limit during the wet and dry seasons (Sharma & Chhipa, 2016). The extent of EC extent can be influence by natural weathering as well as anthropogenic activities and it's directly proportional to the TSS (Hameed *et al*., 2010).

Total Dissolve Solid (TDS)

The TDS values for HDW at dry and wet seasons were 375.5mg/L and 311.5mg/L respectively while BH values during the dry and wet seasons were 89.10mg/L and 64.95mg/L. The TDS values of all the seasons are within the permissible limit of 500mg/l (WHO, 2011). The finding showed similarities with the study conducted by Ganiyu et al. (2018). The TDS value of less than 1000mg/l implies that the water samples can be classified as freshwater (Adebayo et al., 2015; Ganiyu *et al*., 2018). High TDS concentration in water could lead to laxative or constipation effects (Leelavathi et al., 2016) and the concentration can be influence by anthropogenic activities such as untreated waste water and industrial discharge (Mohamed & Zair, 2017).

Total Suspended Solid (TSS)

The mean TSS values of the HDW during the wet and dry season showed 0.021mg/l and 0.022mg/l respectively while the BH showed TSS mean values of 0.027mg/l and 0.034 mg/l during the wet and dry season respectively. The TSS mean values of the water sources at different seasons are within the permissible limit of 5mg/l (WHO, 2011). However, the outcome differs from the similar study conducted in Niger Delta communities (Woke and Babatunde, 2015; Woke and Umesi, 2018) where their values exceeded the permissible limit. High value of TSS (mg/l) is an implication for the presence of silt, decaying plants and animal matter (Elenwo et al., 2019).

Total Coliform (TC)

The mean TC values of the HDW during the wet and dry season showed >1600MPN/100ml and 824.5MPN/100ml respectively at variation of 775.5MPN/100ml while the BH showed TC mean values of 840.0MPN/100ml and 823.50MPN/100ml during the wet and dry season respectively at variation of 16.5MPN/100ml. The finding showed that TC value was higher during the wet season for both HDW and BH than the dry season; however, all the values exceeded the permissible limit of 0/100mh/l (WHO, 2011). The finding showed similarity with the study conducted in Niger Delta communities (Woke and Babatunde, 2015; Dick et al., 2018) where the TC values exceeded the acceptable limit for drinking water. This finding indicated that the water from the communities irrespective of the sources and seasons have been contaminated with microbes and possible pathogenic microorganisms (Hosetti and Kumar 2002) which it source could be linked to human or animal origin. As noted by Woke and Babatunde (2015), high coliform counts seems to be attribute of rural areas water quality in Nigeria.

Bicarbonate

The mean Bicarbonate values showed that HDW had 100mg/l and 159mg/l during the wet and dry season respectively with variation of 59mg/l while the BH had 54mg/l and 46.50mg/l for the same seasons with variation of 7.5mg/l. the highest value of bicarbonate was recorded at HDW during dry season; however, none of the values exceeded the permissible limit of 150mg/l (WHO, 2011) except the HDW during the dry season. The extent of bicarbonate in water can be influenced by the activities of atmospheric CO_2 and CO_2 from decomposed organic materials (Umapathy, 2011).

Chloride

The mean values of Chloride are found in the range of 18.0mg/l and 32.0mg/l for HDW during the wet and dry seasons at variation of 14.0mg/l. The Chloride values for BH ranged from 7.83mg/l and 7.00mg/l for wet and dry season at variation of 0.83mg/l. The highest chloride value was recorded during the dry season of HDW; however, none of the water samples exceeded the permissible limit of 250mg/l (WHO, 2011). The finding showed similarities with the study conducted by Mohamed and Zair (2017) and Dick et al., (2018). According to Omole et al., (2017), chloride in drinking water is comparatively harmless. However, the extent of chloride in water could be influenced by natural and anthropogenic activities such as salt formation (Renn, 1970), application of inorganic fertilizer and industrial effluents (Bundela et al., 2012).

Sulphate

The mean value of Sulphate showed that HDW had 34.0mg/l and 44.90mg/l during the wet and dry season while BH had 3.11mg/l and 3.46mg/l. The outcome showed that the highest value of sulphate was recorded during the dry season for both water sources; however, none of the values exceeded the permissible limit of 250mg/l (WHO, 2011). The finding corroborated with that of Omole et al., (2017). Higher values of sulphate could lead to intestinal disorder and odour under aerobic condition (Rehman and Rehman, 2014).

Nitrate

The mean value of 1.30mg/l and 1.14mg/l was recorded for HDW during the wet and dry seasons while 0.31mg/l and 0.30mg/l was recorded for BH during the wet and dry seasons. All the values are within the permissible limit of 45mg/l (WHO, 2011). The study found similarities with that of Ganiyu et al., (2018) and Mohamed and Zair (2017). Naturally, nitrate is found in soil and water; however, the concentration can increase as a result of anthropogenic activities such as industrial waste and domestic waste (Jameel and Hussain, 2011).

Calcium

The mean value Calcium for HDW during the wet and dry season was 15.55mg/l and 48.0mg/l with variation of 32.45mg/l while BH has mean values of 0.31mg/l and 0.31mg/l during the wet and dry season. All of the values are within the permissible limit of 200mg/l (WHO, 2011). The outcome corroborated with similar study conducted in Niger Delta communities (Dick et al., 2018) while the high concentration during the dry season of HDW could be attributed to reduction in water level attributed to high sunshine resulting in an increase concentration of calcium.

Magnesium

The mean value Magnesium for HDW during the wet and dry season was 10.21mg/l and 9.72mg/l while BH has mean values of 4.65mg/l and 3.60mg/l during the wet and dry season. All of the values are within the permissible limit of 150mg/l (WHO, 2011). The outcome corroborated with similar study conducted in Niger Delta communities (Dick et al., 2018).

Potassium

The mean value potassium for HDW during the wet and dry season was 3.87mg/l and 9.63mg/l with a seasonal variation of 5.76mg/l while BH has mean values of 3.17mg/l and 3.28mg/l during the wet and dry season. All of the values are within the permissible limit of 20mg/l (WHO, 2011). The outcome corroborated with similar study conducted by Ganiyu et al., (2018).

Phosphorus

The phosphorus mean value range from 0.055mg/l and 0.75mg/l for HDW during the wet and dry seasons and 0.06mg/l and 0.05mg/l for BH during the wet and dry seasons. All of the values are within the permissible limit of 0.1mg/l (WHO, 2011). The low values in phosphorus corroborate with the report of Ezeribe et al., (2012). The concentration of phosphorus in groundwater can be influenced by natural and anthropogenic activities such as weathering and percolation of domestic sewage (Mohamed & Zair, 2017).

3.2 Statistical Analysis

The HDW showed a very strong correlation in wet and dry season physiochemical properties as well as no significant difference in the physiochemical properties of groundwater at both seasons ($r = 0.96$, $p= 0.313$). Also, the BH showed a very strong correlation in wet and dry season physiochemical properties with no significant difference in the physiochemical properties of water at both seasons ($r = 1.0$, $p= 0.069$).

IV. CONCLUSION AND RECOMMENDATIONS

The present study has empirically examined the seasonal variation in the physiochemical properties of groundwater sourced from HDW and BH from communities in Sagbama LGA. Among the parameters, the seasonal variation was significant for Total Coliform, Bicarbonate, Chloride, Sulphate and Calcium at HDW and such variation can be attributed natural phenomenon as most variation occurred during the dry season. The study observed that the mean values of all parameters tested are within the permissible limit of WHO except for Total Coliform which indicated the presence of microbes and pathogenic microorganisms. The study concluded that seasonal variation has no influence on the groundwater quality of the studied area; however, the groundwater was deemed contaminated for both HDW and BH at all seasons. The water could be used for various anthropogenic activities after treatment. The study suggested continuous monitoring of groundwater quality as well as the anthropogenic activities to prevent further contamination.

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