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Seasonal Variations of Physico-Chemical Characteristics of Ground Water in a Developing Rural Community in Southern Guinea Savanna Ecological Zone Of Nigeria

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Abstract:*A critical factor in the way of civilization is the ability of man to provide reliable supplies of portable water, which is why the study of groundwater potential of an area is very important. This study was carried out to evaluate the physcio-chemical parameters of some selected boreholes and hand dug wells in Gidan-kwano community,Southern Guinea, for irrigation domestic and industrial purposes. Water samples were collected from different sources of boreholes and hand dug wells during the dry and wet seasons of the year 2015 and 2016 respectively within the Gidan-kwano community. The results of the analysis show that well in Gidan Kwano community W1 and W4 had the least value of pH of 6.15 and 6.18 respectively and bolehole in SAAT (B1) had highest value of pH of 7.83 during the dry season, while during the wet season, the average value of pH rose, with well W3 having the least value and B1 having the highest value. The conductivity values ranged from 345µS/cm to 716µS/cm for bole hole in CA B2 and well in GidanKwano community W4 respectively during the dry season while bolehole in SAAT B1 had the least value of 236µS/cm and well in GidanKwano community had the highest value of 578µS/cm during the wet season.The values of total hardness of the water samples ranged from 98mg/L to 266mg/L for dry season and 90mg/L to 222mg/L for wet season, with wells in Gidan Kwanu community W1, W3 and W4, observed to be higher than the recommended limits. Temperature ranged from 30^oC to 33^oC for dry season and it dropped, generally from 27^oC to 28^oC for wet season, which all were within the ambient temperature range. Calcium hardness and magnesium contents were within the recommended limits of a range of 79.50mg/L to 153.30mg/L and 0.004mg/L to 0.026mg/Lrespectively, during the dry season while during the wet season, it ranged from 63.00mg/L to 140.70mg/L for calcium hardness and 0.005mg/L to 0.018mg/L for magnesium. The general fluoride content within the dry season ranged from 0.11mg/L to 0.27mg/L and 0.09mg/L to 0.30mg/L for wet season. Chloride values, were well within the limits well in GidanKwano W4 to have the highest values of both dry and wet season, 105.714mg/L and 87.06mg/L respectively. Some water samples showed high level of total dissolved solids in them beyond the recommended limits when combining both seasons especially at bolehole CA (B2), girls' hostel (B3) and boys' hostel (B4) with values 581mg/L, 581mg/L and 921mg/L. The status of water in the study area are within the recommended standards of WHO (2004b) and NSDWQ (2007) desirable and maximum permissible limit except for Total Hardness values of wells for GK community, W1, W3 and W4 and Total Dissolved Solids (TDS) of boleholes, B2, B3 and B4 which appeared to be beyond the recommended limits, therefore there is need for improving the water quality and this can be done through low cost mini treatment plants that can serve the rural people.*

Keyword*: Ground water, physico-chemical characteristics, Southern Guinea Savannah, Nigeria*

1. Introduction

Water is an essential part of all living systems, in which life evolved and exists, which is why it is also known as the matrix of life(Asif *et al.,* 2011) Thus it is an essential component for the wellbeing and sustainable developmentof not only mankind, but plant and animal survival too and so the existence of all living being is dependent on water (Agrawal *et al.,* 2010). The challenges of accessibility to clean water still looms especially in developing world, whereby only one in every five residents has access to clean water (Cara, 2009). Thus, approximately 1.1 billion people have to cover more than 1km from their respective homes to sources of water that may even contain pathogens and bacteria, regularly and it could get worse. Reflection of statistics shows on a global scale that large areas of Africa, Asia and South America are threatened by increased population and climatic variation such as increased temperature and decreased precipitation which results to an increase in the demand of water and subsequently water stress related problems(Cara, 2009).

Majority of earth's water is marine water which cannot be consumed by human beings until it is being processed; leaving the only option, ground water, which is the only available fresh water that can be readily consumed, provided it is of high quality (Agrawal *et al.,* 2010). Groundwater which exists in soils and fissured rocks below the ground surface is considered the purest form of water and is the major source of drinking water in both urban and rural areasalso frequently used as an alternative source for both industrial and agricultural sector (Asif *et al.,* 2011). In Nigeria, groundwater is an important water resource, but unlike the rural regions, they are available through pipe-borne water in various cities in the urban areas while rural dwellers rely basically on hand-dug well forpotable water supply especially during the dry season when streams dry up (Adekunle *et al.,* 2007) thus this neglect of rural areas exposes the people to various health related problems such as water-borne diseases.As the population, increases, so is the demand for clean water, but the various needs of the rising populace have over time led to the deterioration of surface and sub-surface water (Fatombi *et al.,* 2012).

Typically, groundwater has a vast range of chemical composition in which the distribution of its quality parameters is controlled by a complex process (Asif *et al.,* 2011). Thus, these qualities, not only depends on only natural factors such as quality of recharge water, lithology of the aquifer and type of interaction between water and aquifer but also on anthropogenic activities, which have been known to alter the natural process of groundwater formation either polluting them or by changing the hydrological water cycle and once the ground water is contaminated from the dispersed pollutant of the subsurface environment, it becomes condemned for consumption and other uses.(Asif *et al.,* 2011;Musa and Ahanonu, 2013).Jehangir*et al.,*(2011) emphasized the need to understand the various human activities, responsible for influencing ground water quality in order to protect and sustain ground water resources.

The aim of this study is to examine the seasonal variations of physico-chemical parameters of groundwater quality and the objective is to determine the quality of water of some selected boreholes and hand dug well in GidanKwano community.

2. Materials And Method

2.1 Description of the Study Area.

Gidan-Kwano community is a major community where major agricultural activities are carried, located in Bosso Local Government Area of Minna,Niger State which is at the middle belt of Nigeria with a total rainfall between 1270mm and 1524mmfrom the month of April to October and the peak rainfall experienced in August. (Amadi *et al.,* 2011). The Latitude and Longitude of the borehole and well locations are presented in Table 1;

Table 1: Description of Latitude and Longitude of study area.

Location of study area		Latitude	Longitude
1.	Well in G.K community (W1)	09°32'25.27''	06°28'21.92''
2.	Well in G.K community (W2)	09°32'28.12''	06°28'20.32''
3.	Well in G.K community (W3)	09°32'26.10''	06°28'20.23''
4.	Well in G.K community (W4)	09°32'27.20''	06°28''22.64''
5.	Borehole in SAAT (B1)	09°31'57.21''	06°27'09.76''
6.	Borehole in CA (B2)	09°32'02.56''	06°27'05.81''
7.	Borehole in girls hostel (B3)	09°31'50.29''	06°26'30.82''
8.	Borehole in boys hostel (B4)	09°31'50.56''	06°26'34.16''

2.2 Sampling Collection /Procedures

A total of eight sets of water samples each were collected during the dry and wet season (from boreholes and hand dug well at different location within Gidan-kwano community with reference to information on Table 1,parameters such pH, electrical conductivity, chloride, total dissolved solid, calcium, total hardness, fluoride, phosphate and magnesium were all determined using standard methods of examination of water samples quality.The samples were collected using clean sterilized plastic bottles, which were labeled based on the season and location for ease of identification. This process of labeling and analysis of physiochemical parameters, followed method described byRajesh *et al.,*(2015).

3. Results and Discussions

The results from the water sample is given by Table 2 (Dry season) and Table 3 (wet season) for the physical and chemical analysis of some selected boreholes and hand dug well in Gidan-kwano community, Minna, Niger State.

Table2: Physio-chemical analysis of water samples for dry season (borehole and hand dug well).

	Samples and location								Water Quality Standard	
Parameters and Units	**W1**	**W2**	**W3**	**W4**	**B1**	**B2**	**B3**	**B4**	**WHO**	**NSDRQ**
pH	6.15	6.38	6.45	6.18	7.83	7.56	7.39	6.6	8.5	6.5 - 8.5
Electrical Conductivity (μS/cm)	562	489	625	716	452	345	519	377	1000	1000
Total Hardness (mg/L)	202	132	220	266	126	136	124	98	NS	150
Temperature (T^oC)	31	33	31	30	32	32	31	32	Ambient	Ambient
Calcium Hardness (mg/L)	123.9	88.2	128.1	153.3	79.8	78.75	103.95	79.8	250	NS
Magnesium (mg/L)	0.018	0.01	0.021	0.026	0.010	0.013	0.005	0.004	0.05	0.02
Fluoride (mg/L)	0.18	0.21	0.16	0.12	0.15	0.27	0.13	0.11	NS	1.5
Chloride (mg/L)	67.712	48.366	80.149	105.714	34.547	41.456	24.874	21.419	250	250
Total Dissolved Solid (mg/L)	163	122	307	62	137	581	581	921	NS	500

Table 3: Physio-chemical analysis of water samples for wet season (Borehole and hand dug well).

	Samples and location								Water Quality Standard	
PARAMETER	**W1**	**W2**	**W3**	**W4**	**B1**	**B2**	**B3**	**B4**	**WHO**	**NSDRQ**
pH	6.85	6.7	6.64	6.66	8.04	6.59	6.76	6.93	8.5	6.5 - 8.5
Electrical Conductivity (μS/cm)	424	315	455	578	236	287	367	245	1000	1000
Total Hardness (mg/L)	168	118	170	222	110	110	116	90	NS	150
Temperature (T^oC)	28	28	27	28	28	28	28	28	Ambient	Ambient
Calcium Hardness (mg/L)	105	73.5	115.5	140.7	69.3	67.2	94.5	63	250	NS
Magnesium (mg/L)	0.014	0.01	0.012	0.018	0.009	0.01	0.0048	0.006	0.05	0.02
Fluorine (mg/L)	0.3	0.22	0.2	0.15	0.1	0.21	0.09	0.1	NS	1.5
Chlorine (mg/L)	53.2	29.02	62.88	87.06	12.58	15.48	22.25	12.58	250	250
Total Dissolved Solid (mg/L)	120	80	180	40	80	40	60	120	NS	500

Where NS means Not Specified

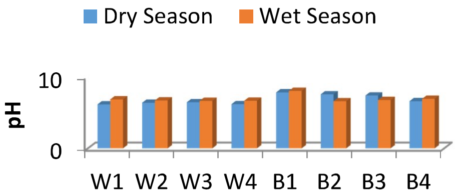

Figure 1: pH chart

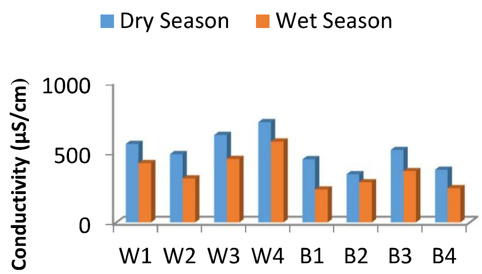

Figure 2: Conductivity (EC) chart

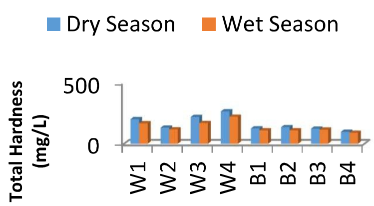

Figure 3: Total Hardness (TH) chart

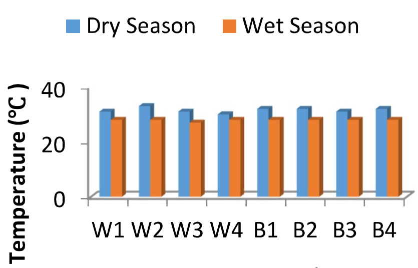

Figure 4: Temperature chart

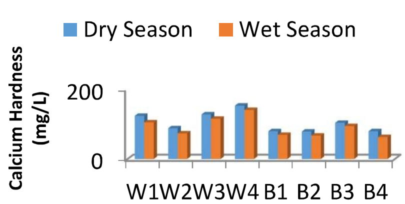

Figure 5: Calcium Hardness (Ca.H) chart

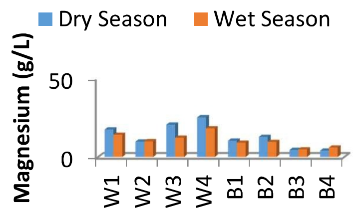

Figure 6: Magnesium chart

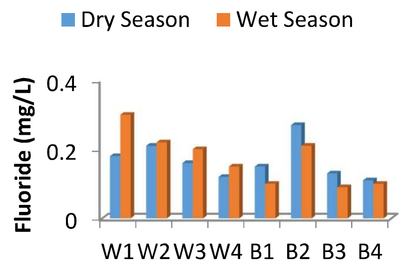

Figure 7: Fluoride chart

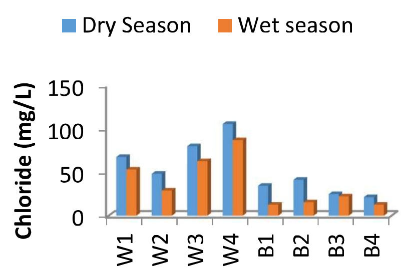

Figure 8: Chloride chart

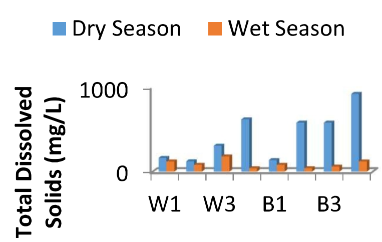

Figure 9: Total Dissolved Solids chart

3.1 pH

pH values at well in Gidankwano (G.K) community W1 and W4 were observed to have the lowest values of during the dry season with pH values 6.15 and 6.18 respectively, while during the wet season, bole hole in CA (B2) was recorded to have the lowest pH value of 6.59. The borehole in SAAT (B1) was observed to have the highest overall pH values (slightly alkaline) in this region especially during the wet season, this could be as a result of high concentration of Ca^{2+} and Mg^{2+} ions present in the water. The variation of pH values obtained from the eight samples were in agreement with the NSDWQ (2007) which ranges from 6.5-8.5 and WHO (2004b) standards which range "between" 7.0-8.5, it can be seen that the water sample for both the boreholes and wells were observed to be within the recommended standards.

3.2 Conductivity

Variations in electrical conductivity during dry season was observed to range between 345µS/cm and 716µS/cm while during the wet season the range dropped to 236 µS/cm and 578µS/cm. Well in GidanKwano (G.K) community (W4) was observed to have the highest electrical conductivity (EC) for both the dry and wet season.When the results were compared with recommended values of WHO (2004b) and NSWDQ (2007), the values were found to be far lower and are well within the limits of WHO and NSWDQ. This shows the low quantity of high salt content which supports electrical conductivity in the samples tested, therefore it may also be recommended for irrigation purposes.

3.3 Total Hardness

Hardness of expresses the summation of polyvalent cations present in water, magnesium and calcium are the most common cations expressed as an equivalent quantity of calcium carbonate ($CaCO_3$). The values from Table 1 (dry season) and Table 2 (wet season)shows the range of values from 98mg/L to 266mg/L and 90mg/L to 222mg/L respectively. The water samples from well in G.K community W1, W3 and W4 all have their values higher than the recommended limits of NSDWQ (2007) for both seasons, which is 150mg/L. This tends to render the water unusable for washing and bathing because of its capacity to precipitate soap, although according to NSDWQ (2007), it is said to have no health impact.

3.4 Temperature

Temperature is one of the most important ecological and physical factors which have profound influence on the abiotic and biotic components of the environment. Temperature helps in controlling the solubility of gases. During the dry season, the water was observed to experience the maximum temperature of 33°C, particularly at location W1. This may be as a result of many factors such as the heat of sun, the depth of the well and nature of soil properties. The water temperature of all the samples analyzed did not have many variations and was between 30°C – 33°C for dry season and 27°C – 28°C for rainy season and the temperatures were within the ambient temperature range, recommended by both WHO (2004b) and NSDWQ (2007).

3.5 Calcium Hardness (Ca^{2+}) and Magnesium (Mg^{2+})

The state of equilibrium in most waters is maintained by Ca^{2+} and Mg^{2+} ions. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions are associated with soil friability and soil aggregation but they are essential elements for all organisms and they are common in natural waters(Hameed *et al.,* 2010).The calcium hardness concentrations measured from all locations were farbelow the recommended value and are in line with standard suggested by WHO (2004b)but beyond this limit, it may cause heart and kidney problems, NSDWQ (2007) didn't specifyany standards.Well Location in G.K community (W4) had the highest value of calcium hardness for both seasons, 153.30mg/L during the dry season while the values dropped to 140.70mg/L during the wet season, borehole b4 had the lowest values of calcium hardness for both season. The magnesium values were also within the standard set by WHO (2004b) but not all of the locations met the standard forNSDWQ (2007) for consumers' acceptability. Well in GK community (W4) had the highest values for bothseasons (dry and wet), 0.025mg/L and 0.018mg/Lin which on the average it was slightly higher than the recommended value NSDWQ (2007). The values of calcium hardness during the dry season is greater than the values during the rainy season, this is as a result of low level of water and high level of evaporation. It may also be as a result of high concentration of Ca2+ and Mg2+ ions in irrigation water used in these locations andthe source of these ions is carbonate dissolution.

3.6 Fluoride

The excess of fluoride (more than 1.5mg/L) is dangerous to health according to NSDWQ (2007), it is known to cause fluorosis, skeletal tissue morbidity (bones and teeth). The fluoride values of the sample ranged from 0.11mg/L to 0.27mg/L for dry season, with bolehole B2 having the highest value of 0.27mg/L, bolehole in boys' hostel B4 had the least value of 0.11mg/L. The range of values increased during the wet season on the average, from 0.10mg/L to 0.30mg/L. It was observed that well at GK community W1 had the highest fluoride value of 0.30mg/L while bolehole B1 and B4 had the lowest value of 0.10mg/L. The overall values of the fluoride from the water sample analysis was far below 1.5mg/L, it means that the boreholes and the hand dug wells are potentially safe for drinking and for other domestic activities.

3.7 Chloride

This is one of the most important elements in water; it has no adverse effect on health but imparts bad taste to drinking water when in excess. Chloride concentration in water is an indicator of pollution by domestic sewage such as human excreta and industrial contaminant, salt 'seeps' and oil field drainage (Musa and Ahanonu, 2013).The range of values of chloride were found to be from 21.419mg/L to 105.714mg/L during the dry season and from 12.58mg/L to 87.06mg/L was observed from water samples taken during the wet season in which well in GK community and bolehole b4 had the highest and lowest respectively. It was observed that the average values of chloride werehigher during the dry season than the wet season; this must have been as a result of increase in ground water as well as decease in concentration of chloride during the wet season. The overall values were in line with the recommended standard by WHO (2004b) and NSWDQ (2007).

3.8 Total Dissolved Solids (TDS)

High values of total dissolved solids influences the taste of the water, making it undesirable to drink, causes gastro-intestinal irritation and increases corrosive property of the water(Rajesh *et al., 2015)*. High values of total dissolved solids indicate that the well water is unfit for human consumption. The range of Total Dissolved Solids TDS was observed to be form 62mg/L to 921mg/L during the dry season and 180mg/L to 40mg/L during the wet season. BoleholeB2, B3 and B4 had high values of Total Dissolved Solid above the required limit set by NSWDQ (2007), with B4 having the highest Total Dissolved Solid of 921mg/L which makes water from these locations unfit for drinking. It was also observed that the values of wet season dropped when compared with values ofdry season on the average, this may be as a result of rise in the ground water during the wet season.

4 Conclusion

The location of bolehole and hand dug well is very important for the wellbeing of the water produced by the well; this is why, ground water, which provides the purest form of water because of the soil purification properties can easily be contaminated due to proximity to source of contaminant. These contaminants could be from nearby sewages dump, refuse dump sites, and agricultural farm sites. Improper planning and design of bole hole and wells can also contributed to the quality of water produced. Thus a good well location, controlled agricultural activities and good sanitation practices are very important in improving the ground water quality.

This study has provided information on the physic-chemical characteristics of ground water quality status of boreholes and hand dug wells in Gidan-Kwano community and the following was conclude;

1. The values obtain from the physico-chemical analysis of ground water (boreholes and hand dug wells) are within the recommended standards of WHO (2004b) and NSDWQ (2007) desirable and maximum permissible limit except for Total Hardness values of wells for GK community, W1, W3 and W4 and Total Dissolved Solids (TDS) ofboleholes, B2, B3 and B4which appeared to be beyond the recommended limits,therefore there is need for improving the water quality and this can be done through low cost mini treatment plants that can serve the rural people.
2. It is concluded from the observations that the values of all of the physico-chemical parameters changes from season to season (dry season and rainy season) due to weather conditions, anthropogenic activities and the ground water movement.

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